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Distributed cognition in home environments

The prospective memory and cognitive practices of older adults

By

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Abstract

In this thesis I explore how older people make use of, and interact with, their physical environment in home and near-by settings to manage cognitive situations, specifically prospective memory situations. Older adults have in past research been shown to perform better on prospective memory in real-life settings than what findings in laboratory-like settings predict. An explanation for this paradox is that older adults has a more developed skill of using the environment for prospective memory than younger adults. However, research investigating this explanation has primarily been based on self-reports.

I contribute to the understanding of this skill by doing two related things. First I introduce distributed cognition, a theoretical perspective that primarily has been used within professional and socio-technical environments, to the research field of prospective memory in everyday life. Second I present a cognitive ethnography conducted during two years across eight home, and near-by, environments and old-age retired persons, for which I have used theoretical concepts from distributed cognition to analyze observations.

The analysis shows rich variations in how participants use common cultural cognitive tools, invent their own cognitive tools, deliberately and incidentally shape more or less functional spaces, make use of other physical features, orient themselves toward and make sense of cognitive resources. I complement both prospective memory and distributed cognition research by describing both the intelligent shaping and use of space. Furthermore, by taking a distributed cognitive perspective I show that prospective memory processes in home environments involve properties, and the management, of a multipurpose environment.

Altogether this supports the understanding of distributed cognition as a perspective on all cognition. Distributed cognition is not a reflection of particular work practices, instead it is a formulation of the general features of human cognition. Prospective memory in everyday life can be understood as an ability persons have. However, in this thesis I show that prospective memory can also be understood as a process that takes place between persons, arrangements of space, and tools.

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Mattias Forsblad
Linköping, September 7, 2016

Contents

[Simonides] inferred that persons desiring to train this faculty (of memory) must select places and form ~~mental~~ images of the things they wish to remember and store those images in the places, so that the order of the places will preserve the order of the things, and the images of the things will denote the things themselves [...].

Cicero, *De Oratore*, II, lxxxvi, 351-354. Translation in Frances A. Yates (1966, p.2), *The Art of Memory*. Strikethrough added.

Chapter 1. Introduction

The cognitive management of everyday life is a fundamental aspect of human life. Every day we contemplate past experiences, plan our short-term and long-term future goals, and manage our ongoing and daily chores. When we do so we rely on our abilities to remember and often our abilities to remember what to do when and how to act to achieve our intended goals. The ability to remember what to do when is called prospective memory. Prospective remembering has been described, both in professional (see for instance Dismukes, 2012) and everyday settings (see for instance Einstein & McDaniel, 2005), as an important type of memory to function independently and to avoid unwanted incidents. Past research has found through experiments in laboratory-like settings that older adults typically perform worse than younger adults on measurements of prospective memory. Interestingly, however, research also often find that older adults perform on par with, and even sometimes better than, younger adults when measurements of prospective memory are taken place in real-life situations in home environments. This thesis sets off at this methodologically and theoretically complex paradox.

Remembering what to do and when to do is not just an ability individuals have; it is also a skill which we develop throughout life in relationship to circumstances we experience. Some attempts of explaining the previously-mentioned paradox deal with how people make use of their physical and social environment, where it is suggested that older adults are better at making use of the environment than younger adults, and therefore compensates for whatever setbacks they may display in laboratory-like settings. With few exceptions, explanations of this type have been based on research with two characteristics: first, the data is generally self-reported, and second, the theoretical descriptions of how the environment is used are underdeveloped. When it comes to cognitive aging, there is a certain negative connotation associated with memory, both in society and in research. But what the paradox suggests is that there also seems to be a positive skill to explore.

In this thesis I make use of a research perspective called distributed cognition. This perspective has traditionally been used primarily in highly technological and work settings. Here, however, I have introduced it into everyday life in order to explore how people make use of their physical environment. By using this perspective I contribute to research on cognition in everyday life environments by introducing a conceptual apparatus which has already started to explain principles for the interaction between people and their environments in real-life cognitive situations. Distributed cognition is currently an accepted perspective within cognitive science, which

emphasizes that cognitive accomplishments cannot be assigned a priori to some encapsulated entity, for instance the brain. Instead, to understand the mechanisms of cognition, i.e. informational flow and transformation, cognitive activities should be studied in the settings and circumstances in which they normally take place. Distributed cognition is therefore a commonly applied perspective to understand how cognition works between agents and the physical environment.

I use distributed cognition to analyze the empirical material which has been collected through a cognitive ethnography that was conducted across a number of older retired individuals and their home- and nearby environments. By using a combination of different types of interviews and observations in the cognitive ethnography I am able to go into more detail of the mechanisms in home and nearby environments than previous research on older adults has. Methodological discussions of the study of memory are not a new phenomenon. Memory was the capital case for the critique against laboratory studies within cognitive psychology that Ulric Neisser (1982) significantly supported at the end of the seventies, a critique which is compatible with the cornerstones of distributed cognition. This critique created a wave of methodological discussions that lasted at least one and a half decades, and which in parallel followed the burgeoning research endeavors of so called external memory aids. As with prospective memory in general, research on external memory aids among the older population is also a research paradigm which primarily uses self-reporting methodologies.

Despite the above endeavors the theoretical development and empirical investigations of external memory aids within cognitive psychology slowed down in the 90's. This happened at the same time as research on prospective memory started on a larger scale. Research on prospective memory started late in the history of memory research (Einstein & McDaniel, 1990; McDaniel, Einstein, & Jacoby, 2008), and this ability is still regarded to be poorly understood (c.f. Gonneaud et al., 2011; Uttl, 2008). Today prospective memory has primarily been researched within laboratory-based paradigms. This is how it started and this is how it is mostly done today, though a number of somewhat naturalistic experiments have emerged.

While theoretical descriptions of interactions between people and their environments have been well-developed within professional and complex domains, the theoretical concepts are, with few exceptions, not empirically scrutinized in any depth in relationship to actual home and nearby environments. Therefore, an important component of, and also a contribution of, this thesis is a an empirical description of cognitive systems that relate to home and nearby environments.

1.1 Objectives

Given the above background the goals for this thesis are two-fold:

- First, to theoretically and empirically introduce a research paradigm, distributed cognition, to the study of older adults' practices for the management of prospective memory in home and nearby real-life environments.
- Second, to contribute to the field of distributed cognition by empirically describing and theoretically characterizing the home environment with one operating agent as a distributed cognitive system.

Together these objectives attempt to create a bridge between two major fields of research that have the potential for a successful marriage.

1.2 Disposition

The content of the thesis is outlined as follow. Chapter 2 introduces prospective memory research and its relation to cognitive aging and external memory aids. The third chapter introduces distributed cognition and some of its adjacent theoretical concepts which will return in the empirical chapters. At the end of the third chapter I introduce the theoretical underpinnings for cognitive ethnography, which is a methodological consequence of using distributed cognition, and the methodological approach I have adopted.

Chapter 4 begins with a description of how I have conducted my field studies. It then goes on to serve as a prequel to the forthcoming chapters by introducing the participants in my empirical inquiries together with their home environments. Chapters 5, 6, and 7 are empirical chapters where I consider in turn three broad aspects of distributed cognition in everyday life for the management of prospective memory: cognitive tools, arrangement of resources, and routines and procedures.

In Chapter 8 I discuss the results from the previous empirical chapters together with the fields of research on prospective memory and external memory aids. Chapter 8 is a discussion on distributed cognition in home environments. In Chapter 10 I summarize my conclusions with a few concluding remarks.

Chapter 2. Prospective memory and cognitive aging

In this chapter I intend to show why research on prospective memory and using the external environment in everyday life can benefit from the introduction of new conceptual tools and a new kind of empirical groundwork. First I give a general introduction to prospective memory, and prospective memory and the age prospective memory paradox in particular. This introduction is a general introduction to the field in the sense that I aim to show that this field of research is wider and more complex than what this thesis will cover in the end. Later I review research on the topic which has addressed, or been conducted in, real-life settings, and specifically the research field on external memory aids in everyday life. These later sections are more focused on topics that relate to my contribution to the field.

2.1 A definition and types of tasks

Prospective memory (PM) is defined by Einstein and McDaniel (1990) as the general ability to remember future activities. In the wider literature PM is also documented as an amalgamation of several more specific abilities, including several cognitive core abilities. First, it can be divided into a prospective and retrospective component. The former is the ability to remember the intention of doing something at a point in time or space, and the latter is the ability to remember the content of what is to be done (Graf, 2005). There is therefore always an aspect of remembering past intentions and plans involved in the accomplishment of future objectives[1]. However, neurocognitive studies suggest that the prospective component is in part distinct from the retrospective component. Retrospective memory is associated with the medial temporal lobes (c.f. Nyberg, McIntosh, Houle, Nilsson, & Tulving, 1996) while prospective memory, which involves handling of intentions and goal management, is associated with executive functions and the prefrontal cortex (c.f. McDaniel, Glisky, Rubin, Guynn, & Routhieaux, 1999).

Tasks measuring prospective memory ability are often divided between so called event-based and time-based tasks. The former is a task where one is to remember to do something when something

[1] There are also neurocognitive studies which conclude that remembering the past shares neurological functioning with imagining the future. Within this idea is that remembering the past, similar to prospective remembering, is a reconstructive process (see Schacter & Addis, 2007)

else occurs, and the latter is to remember to do something at a specific point in time (Einstein & McDaniel, 1990). Conceptually the distinction between time-based and event-based PM is not obvious. This is because points in, and segments of, time can also be seen as events. In practical life, points or segments of time are also often instantiated as a physical situation (mornings and evenings, for instance). Despite overlaps between the types, they have nevertheless produced different results, and it turns out that the tasks that have been used to measure these two kinds of PM are relatively different.

Another category of task is habitual prospective memory tasks. These are tasks that are executed on a regular basis, which people in real-life often manage by relying on routines (Meacham & Singer, 1977; Uttl, 2008). Investigations of habitual prospective memory tasks have a low prevalence in literature (McDaniel et al., 2008). One possible reason for this is because testing in laboratory settings can seldom be regarded as habitual. Habits are formed over longer time-spans than experimental setups generally cover. There are studies claiming to have investigated habitual PM in the lab (see Vedhara et al., 2004) but Uttl (2008), however, finds in a meta-review of the field no existing laboratory habitual prospective memory experiments.

Habitual tasks can be naturally related to both time-based tasks and event-based tasks. This is because habitual tasks involve remembering to do something at some point in time or when something specific happens, in recurring cycles. Consider for instance taking a medicine every day at bedtime, which is regarded a classic habitual task (Uttl, 2011). Bedtime is related to some point in objective time but bedtime is also an event consisting of several event-based cues which can remind individuals to take the medicine. For an understanding of PM in real life situations habitual PM tasks are of great importance, because much of what we do in everyday life can be plotted on a scale from less to more habitual. Every situation we encounter contains a number of aspects which can be more or less related to habits. Habitual PM is also interesting in relationship to aging because for each cumulative day of our lives the likelihood of facing new situations decreases, and because of this the likelihood of that each situation can be framed in terms of earlier experiences of the same or similar situations increases. Older adults can therefore be expected to rely more on habits and experience than younger adults.

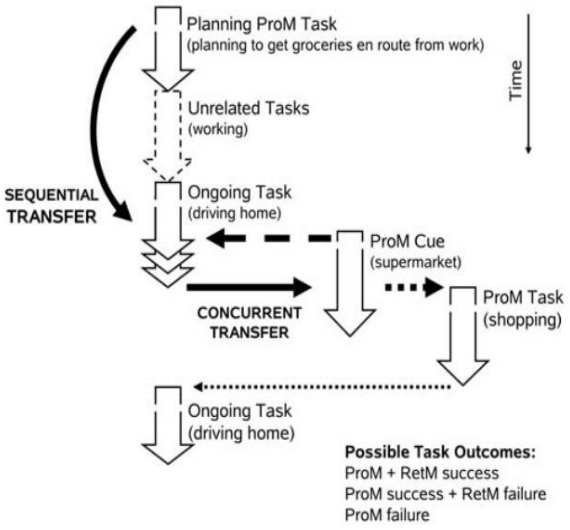


Figure 1: Proper prospective memory. Vigilance can be pictured without the "unrelated tasks". Adopted from Bob Uttl (2008, Plos One)

The three types of PM tasks can also be plotted across another dimension: that is the likelihood of consciously holding the information encoded during the retention interval. The difference is important because it can be assumed that the influence of external cues is more prominent when the plan is not consciously attended to. It is therefore common to distinguish between prospective memory proper and what is called vigilance or monitoring (Graf, 2005; Uttl, 2011). Proper prospective memory is about bringing previously formed plans

back into consciousness at an appropriate moment (Uttl, 2008, see Figure 1). Vigilance is about continuously holding a formed plan in consciousness from the time of the formation of a plan to the time of execution of the plan, for instance when one is having a conversation and one needs to remember what to say at the next turn.

The above defined dimensions of PM have been studied and measured, to my understanding, through four general groups of tests. Two of them are meant to be conducted in laboratory settings and two in the homes of the participants.

- The first is known as the Einstein and McDaniel (1990) paradigm (Kvavilashvili, Cockburn, & Kornbrot, 2013) and is a kind of testing often conducted through a computer interface. This is a testing where participants are engaged in some ongoing arbitrary task, and where there is a recurring prospective memory task embedded into the arbitrary task, which can be either time-based or event-based. For instance, at test of this type might be about categorizing words (the ongoing task) and to press a certain keyboard button when specific words occur (the prospective memory task).
- The second group of studies is a kind of testing that is incorporated as part of a test battery of other tasks (c.f. Mäntylä & Nilsson, 1997). It is often administered in longitudinal studies, and might, for instance, involve asking the participants to remind the test leader to do something at the end of a test series. This testing always comes in the form of an event-based task.
- The third group of studies are conducted in the homes of participants, and involve a task that is given at end of a test series outside of the home as a take-home task (c.f. Dobbs & Rule, 1987). This could for instance be about remembering to write date and time in a specific location on a questionnaire before posting it and sending it back to the researchers.
- The fourth is also a take-home task where participants are supposed to do something, often phone the researcher, when something occurs, or at specific points in time. This type of task has been administered to measure all types of PM proper (c.f. Maylor, 1990).

We will see below that these four types of tasks have yielded different results across the older and younger populations. Some of these types of tasks are often argued to be so called naturalistic tasks, while others are considered to be non-naturalistic. The results produced from studies that included these tasks are what led to the discovery of the paradox

2.2 The paradox across types of task

Findings within the experimental field of prospective memory suggest that older adults perform better in real-life settings than what might be expected based on older adults' performances on standardized tests of prospective memory (known as the prospective memory and aging paradox, Aberle, Rendell, Rose, McDaniel, & Kliegel, 2010; Bailey, Henry, Rendell, Phillips, & Kliegel, 2010; Kvavilashvili, Cockburn, & Kornbrot, 2013; Kvavilashvili & Fisher, 2007; Rendell & Thomson, 1999; Schnitzspahn, Ihle, Henry, Rendell, & Kliegel, 2011). Despite the fact that older adults appear to perform better in real-life settings than what is predicted from their performance in standardized testing in laboratory there are two extensive meta-reviews (Henry, MacLeod, Phillips, & Crawford, 2004; Uttl, 2008) that partly complicate these findings.

As people age, prospective memory appears to change differently across tests measuring vigilance, prospective memory proper, and habitual prospective memory proper. Both Henry et al. (2004) and Uttl (2008) find an age effect on proper event-based prospective memory in their respective meta-analysis. Specifically, there seems to be an average decline starting at the age of 60 (Uttl, 2008).

However, event-based vigilance and event-based proper prospective memory have not been thoroughly investigated in everyday settings and therefore there is little empirical evidence for a paradox (Uttl, 2008). Also, lab-based studies measuring event-based PM usually focus on vigilance rather than proper PM. Uttl (2008) defines the operationalization of tasks measuring proper prospective memory in laboratory studies as "tasks that included a time delay or intervening task between prospective memory instructions and commencement of an ongoing task" (p.10). Studies in everyday settings easily pass this because the instructions are either given in some context other than that in which the task is commenced or are given with a significant time lag. But the operationalization is not as easily seen in lab-based studies.

Consider for instance a lab-based study by Uttl, Graf, Miller and Tuokko (2001) that, according to Uttl (2008), measures proper event-based prospective memory in lab. In this study there were three prospective memory tasks, where each formation of intentions always took place just before the unrelated tasks. The three prospective memory tasks were always of the kind "when I say this is the end of the [unrelated] task" you should do [x]. The cues appeared approximately 5, 5 and 12 minutes after the formation of the intentions. Indeed, according to the operationalization by Uttl (2008) the unrelated tasks can be viewed as tasks between the intention formations and the cue appearances, but it can also be argued that since there are no real ongoing tasks in the study by Uttl et al. (2001) the unrelated tasks are in fact ongoing tasks. And hence the intentions cannot be assumed to have left consciousness. I think this shows that ambiguities which exist around the PM-paradox must be resolved both by using good quantitative measurements and by using good qualitative descriptions of the situations under study.

The paradox is further complicated when the few studies that measure proper event-cued PM in everyday settings do not display a consistent pattern. A recent study by Kvavilashvili et al. (2013) compared the age groups 18-30, 61-70, 71-80, for which they found no in-between significant differences for the prospective or the retrospective components in natural settings. When comparing between measures of processing speed, retrospective memory and two traditional laboratory-based PM event-based tasks within the same sample, they found significant age-related declines. Therefore, this study is in favor of the aging paradox in event-based tasks. But importantly, for the two event-based tasks in laboratory settings the authors note that they could not be certain that the intention had left consciousness before the introduction of the cue circa 10 minutes later. Kvavilashvili et al. (2013) therefore suggest that the inconsistent pattern within event-based PM is due to differences in ongoing task demands between studies measuring PM in lab and in natural settings, and across studies.

Another recent study produced results that favor a paradox is Niedźwieńska and Barzykowski (2012) which compared a laboratory-based proper prospective memory event-based task[2] with a proper event-based task in the home setting across the same participants. They found a negative age effect in lab-settings but no such effect in the home setting. The study by Niedźwieńska and Barzykowski (2012) is therefore in favor of a paradox. However, altogether the studies referred to above underscore the importance of qualitative descriptions of situations under study. My take on these results for event-cued tasks is that measures in event-based studies that are conducted in a laboratory setting cannot be readily compared with what is usually measured in everyday settings, and therefore the existence and non-existence of a paradox is not yet settled.

[2] It can be argued that the way unrelated cognitive tasks were placed in between instances of the ongoing task increased the likelihood of that the intention of the event-based and time-based tasks had left consciousness, at least for a majority of the cue occurrences.

For time-cued tasks the paradox is more prominent. Both Henry et al. (2004) and Uttl (2008) conclude that older adults perform worse than younger adults on time-cued prospective memory tasks in laboratory settings, and both conclude that older adults outperform younger adults in naturalistic settings (see also Kvavilashvili et al., 2013 for a shorter more recent review). Proof of the paradox for time-based tasks has also been found in studies using the same sample of participants in both the laboratory tasks and the tasks situated in everyday settings (Niedźwieńska & Barzykowski, 2012; Rendell & Thomson, 1999; Schnitzspahn, Ihle, et al., 2011). This is in contrast to some that suggest that time-based tasks should be more affected by aging than event-based tasks, because time-based tasks require more self-initiated processes (see Gonneaud et al., 2011 for a review).

Nevertheless, Uttl (2008) notes, with the current data, that time-based tasks in lab-based studies are not easily compared to event-based tasks or time-cued tasks in real-life settings. This is because studies claiming to investigate time-cued prospective memory were found by Uttl (2008) to be investigating time-cued vigilance, because as before, they did not ensure that the plan had left participants' consciousness. This is important since the differences due to aging seem to be greater for proper prospective memory than vigilance (Uttl, 2008). No studies appear to exist measuring time-based vigilance in everyday settings and therefore nothing can be established with regard to the paradox in that type of task (Uttl, 2008). However, paradox or not, older adults perform on par or better in real-life settings than younger adults.

There is also an empirical gap when it comes to habitual tasks, where again laboratory-based studies seem to have measured vigilance (Uttl, 2008, I also find that the same arguments go for more recent studies, e.g. Niedźwieńska & Barzykowski, 2012; Schnitzspahn et al., 2011). However, Uttl (2008) finds that older adults perform significantly better than younger adults on habitual tasks in natural settings.

Uttl (2008) also criticizes a large part of the prospective memory research field for not considering several methodological issues. For instance: (a) A close to ceiling effect is common in the younger population in many experiments and also sometimes for the older population. Therefore, it becomes impossible to evaluate the size of possible age differences. (b) Several experiments use binary scoring with one or a few cues, which decreases reliability. (c) Some studies compare very intelligent older adults with less intelligent younger adults. Prospective memory ability has been correlated with intelligence measures and therefore this confound could mask real age differences. (d) Many experiments using the Einstein and McDaniel-paradigm claim to investigate proper prospective memory but have often, as already mentioned, not controlled for the fact that they are not measuring vigilance. For more issues see Uttl (2008).

Overall, despite empirical gaps and nebulous proofs for paradoxes, the investigations of the notion of a paradox have concluded that older adults seem to outperform younger adults on a number of prospective memory tasks in real-life settings. While this does not show that older adults are spared from cognitive decline it does suggest that there appears to be something that at least some older adults do in real-life that younger people do not.

2.3 Measuring cognitive aging

An understanding of how effects related to aging are measured and methodologically discussed is vital for the understanding of the current state of knowledge about older adults and cognition: in particular, it is useful to how older adults interact with their physical environment for cognitive

means. Therefore, below I include a few words on some of the key methodological and theoretical issues of understanding cognitive aging.

Within cognitive psychology, cognitive aging is primarily an intra-individual process. However, it is not predominantly measured as such. For partially practical reasons, most of the time cognitive aging is measured by inferring intra-individual change from group-comparisons at one point in time (known as cross-sectional studies). The measurements are based on cohort data. For example, people born from 1940 to 1945 are compared with people born from 1990 to 1995. Problems with this approach have been discussed within cognitive aging research, and are still discussed today (Schaie, 1965, 2009). The overall problem is that cross-sectional studies do not allow the observation of intra-individual change (Schaie & Hofer, 2001). The collective opinion within cognitive aging research is therefore that longitudinal studies that follow the same cohorts across time are preferred (Ferrer & Ghisletta, 2011). Nevertheless, cross-sectional studies are widely used since they can be designed according to the contemporary theoretical understanding of cognition. Research on prospective memory is not an exception.

However, longitudinal studies, despite being more theoretically valid, are not without theoretical and methodological problems (see Ferrer & Ghisletta, 2011 and Schaie & Hofer, 2001). For example, the retesting effect (also known as the practice effect) shows that individuals will perform better at a task the more times they have previously done it. Therefore the retesting effect must be accounted for when interpreting longitudinal data (c.f. Rönnlund & Nilsson, 2008 for a way to tackle this). The discussion of the differences between cross-sectional studies and longitudinal studies has become important since they arrive at different conclusions regarding the pattern of cognitive decline. The discrepancy between cross-sectional and longitudinal studies is often explained by cohort effects. For instance, it has been found that total years of education is an important factor for cognitive performance (Nilsson, Sternäng, Rönnlund, & Nyberg, 2009), meaning that cohorts that have longer periods of education will perform better in standardized testing of cognition. This is often the case with more recently born cohorts compared to older cohorts. Therefore, if possible cohort effects are not accounted for, it is argued that the performance level does not reflect chronological cognitive aging per se (Baltes & Schaie, 1974).

Longitudinal studies of cognitive aging have been conducted since the 50's but an increase in such studies can be seen in the 80's. Therefore, there are a number of longitudinal studies to refer to when considering cognitive aging (Hultsch, 2004). The *Seattle Longitudinal Study* was one of the first longitudinal aging studies to consider cognitive change and became a methodological model for several later conducted longitudinal studies (Schaie, Willis, & Caskie, 2004). A subset of more recent studies includes the *Berlin Aging Study* (Lövdén, Ghisletta, & Lindenberger, 2004), the *Betula study* (Nilsson et al., 2004), the *Canberra Longitudinal Study* (Christensen et al., 2004), the *Canadian Study of Health and Aging* (McDowell, Xi, Lindsay, & Tuokko, 2004), the *Einstein Aging Studies* (Sliwinski & Buschke, 2004), the *Kungsholmen project* (Bäckman et al., 2004), the *University of Manchester Longitudinal Study of Cognition in Normal Healthy Old Age* (Rabbitt et al., 2004), and the *Victoria Longitudinal study* (Dixon & Frias, 2004, see Hultsch, 2004 and Schaie & Hofer, 2001 for more studies).

The *Betula study*, the *Victoria Longitudinal study* and the *Kungsholmen project* are interesting for this thesis because they all include a prospective memory task. On the other hand, to my knowledge no longitudinal data has been published from these measurements and therefore the review of prospective memory and aging is only based on cohort data. Longitudinal studies have, in line with memory research in general, focused on retrospective memory and thus there are more kinds of

data in that domain. The understanding of retrospective memory is important for the understanding of prospective memory because, as previously mentioned, to be able to remember to accomplish some objective one needs to remember what one intended and how to achieve it. However, what the above review shows is that there is no direct data on how the ability or skill to remember intentions develops throughout life.

The *Kungsholmen project* is, together with the *Victoria longitudinal study*, also of particular interest for this thesis since they have aimed to understand the compensatory processes and specific strategies for managing memory situations and problems in real-life settings. I return to some of these results below.

2.4 Ecological validity in everyday settings

Few studies in the field of prospective memory have investigated prospective memory in situations where both the settings and the tasks are natural. Most studies are laboratory-based and researcher-induced. A commonly used task that goes beyond the norm, in that it is used in home-based, time-based prospective memory experiments is medication adherence. This is an important everyday task to understand because a failure to take the correct amount of medicine can have serious consequences. But it is also a task that can be conveniently measured in real-life settings because the task can be focused on one container, making it is possible to use sensors to keep track of when the container is opened. With the exception of studies on medication adherence I would say that studies on prospective memory in real-life settings are subject to artificially imposed experimental control, at the expense of process descriptions and ecological validity.

Within prospective memory research there is a sub-group of studies referred to as naturalistic studies. Some studies in laboratory settings can of course be regarded as more natural than others. For instance, to remind someone of something is regarded as natural regardless of where it happens. But the subgroup of naturalistic studies is mostly defined by where studies are conducted, and occasionally by the materials that are used for accomplishing a task. For naturalistic tasks the location is usually in the home of the participants, and the materials used in the tasks are sometimes, but often not, of personal significance. Also, the literature suggests that currently for a study to count as naturalistic the task itself does not need to be a natural part of the lives of the participants.

Consider Phillips, Henry and Martin (2008) who categorize and discuss types of ecological validity in prospective memory studies and note that very few studies are what they call a type 1-study, a study that includes both an everyday setting and a natural task. A "natural task" is defined as: "[…] those [tasks] that would occur anyway in everyday life without the interference of the experimenter […]" (p.174). An artificial task is defined as: "[…] those [tasks] put in place by the experimenter" (p.174). Another definition they use for a natural task in the article is one in which "the actual intentions to be carried out must be part of the routine of the participant, with only observation of behavior rather than experimental intervention" (p.175). The authors do not expand on these definitions but they appear to me to be somewhat inconclusive. I think that a task that is part of an individuals' everyday routine is not necessarily the same thing as a task that would have occurred anyway without the interference of the experimenter. I return to this below.

Phillips, Henry and Martin (2008) continue their categorization according to familiarity of the task. For example, the reminding-the-researcher-task described above is a familiar task, but still an artificial task in a laboratory setting. Many tasks in laboratory settings are novel for the participants, and hence it can be argued that given our current understanding of cognitive aging, this increases the likelihood of finding an age decline (Phillips et al., 2008). Despite noting that relative novelty

or familiarity of a task is a continuum, Phillips et al. (2008), in their categories, implicitly exclude the possibility of tasks in an everyday setting that are novel, but natural. In everyday life novel tasks are not as common as familiar tasks, and for obvious reasons are hard to investigate, but they certainly exist. Take, for instance, moving in with someone else, where new prospective memory tasks will be orchestrated according to new divisions of labor and circumstances. Or, when someone has lived with a partner for a long time suddenly needs to live alone. Park and Minear (2004) conclude that cognitive decline as a consequence of aging should be most prominent in novel situations that occur in everyday life, because that is where novel laboratory tasks have found the largest declines. To my knowledge, there are no studies investigating novel prospective memory tasks in everyday life in the older population.

One study that claims to have measured a type-1 task, i.e. a task that occurs in both in an everyday setting and includes a natural task, is Bailey et al. (2010). Their participants consisted of one young group (M age= 19.8) and one old group (M age=74.5). They gave each participant a PDA, specifically a Palm Pilot®Z22 that was programmed to semi-randomly sound an alarm three times a day for five days. Two tasks were used to measure prospective memory. The first task was to remember to respond to the alarm by interacting with the PDA within an hour of the onset of the alarm; this also required the participants to remember to bring the PDA if leaving home. Responding to the alarm initiated a questionnaire. The second prospective memory task was to remember to press "#" when a question was written in uppercases. The researchers argued that the first task was self-controlled and the second was experimenter-controlled, because the former was part of participant's normally occurring ongoing tasks, while the latter was an experimenter-orchestrated ongoing task. Results indicated a significant age difference both for the self-controlled task, which favored older adults, and the experimenter-controlled task, which favored younger adults.

A questionnaire after the study regarding ongoing activities in relation to the onset of the alarm indicated that the difference in performance was not because of the older adults spent more time at home. The authors suggest that older adults perform better than younger adults on prospective memory tasks when they need to interrupt their ongoing everyday activities. On the other hand, the study did not contain any reports on the performance of the ongoing activities. It could be that the prospective memory task affected the performance of the ongoing task more for older adults than for younger adults. Nevertheless, this study is interesting because it points to the need to investigate prospective memory in the context of everyday ongoing tasks, and specifically the relationship between ongoing tasks and prospective memory tasks.

As noted above, Bailey et al. (2010) claim to meet the two criteria for a type-1 study. They paraphrase and refer to Phillips et al. (2008): "These are, first, that it be carried out within the daily life of participants and, secondly, that it be conducted over several days as opposed to the short period of a laboratory task." Here they actually operationalize the definition by Phillips et al. (2008) "being part of the routine of the participants" by stating that the task should be conducted over several days. First, this could be open to interpretation, but I do not see how being handed a PDA and asked to keep it near oneself for five days part of the normal routines of someone's everyday life. In fact, handing someone an interactive technological tool and demanding that they should interact with this tools at specific times is likely to be highly intrusive to their everyday life. This relates to the commonly known phenomenon called the task-artifact cycle, which states that tasks and artifacts coevolve (Carroll, Kellogg, & Rosson, 1991). Second, even if the PDA became integrated into the routines of the participants, the task itself is not one that normally occurs in the lives of the participants. Here I can use the first definition of a type-1 task employed by Phillips et

al. (2008): "those [tasks] that would occur anyway in everyday life without the interference of the experimenter […]" (p.174). So even if the initiation of the task when cued in Bailey et al.'s (2010) study is self-controlled the intention formation is not self-controlled and hence not natural according to the first definition by Phillips et al. (2008).

Of course "to go wild" when it comes to the intention formation part of prospective memory makes it harder to maintain experimental control. To be able to make generalizations it would be necessary to find people that form equivalent intentions by themselves. One recent study that is not part of the experimental paradigm but that did investigate naturally occurring intentions is Ihle, Schnitzspahn, Rendell, Luong and Kliegel (2012). They conducted an interview-based study where they interviewed each participant (20 young, age=19-27, and 19 old, age=61-75) on five consecutive days. The content of the interviews was rather structured and oriented around what the participants intended to do the next day, the importance of their tasks, and the accomplishment of intended activities on the current day.

They concluded that older adults were significantly more likely to fulfill their intentions than the younger group. But this was only true for intentions that were rated at a low or medium level of importance. For the intentions that had a high level of important, both younger and older participants performed almost perfectly. It should be noted that a ceiling effect could also be seen for older adults on medium-level important intentions. The authors discussed the possibility that older adults might view their intentions as more obligatory, and even more so when they have been described to a researcher. Additionally, a glance at the data in the article displays a large standard deviation for the performance of younger adults on the medium- (SD=24.3%) and lower-importance intentions (SD=27.9%), and also for the lower-importance intentions (SD=28.4%) for the older adults. This is not discussed by the authors but it hints at possible high-performing and low-performing groups within the sample, on tasks that are self-rated as medium- to low-importance. In other words, it suggests that there will be a group that does what they say they will do and a group that neglects the task, or implicitly postpones the accomplishment of the task when the task is not top priority. It should be noted that accomplishment of intentions was only counted as a failure when participants explicitly said that they had not done what they had intended without also providing information about rescheduling or changing their intentions.

Older adults were also significantly more likely to claim, with plausible reasons, that they had rescheduled or changed intentions. And interestingly, the occurrence of rescheduling and changing plans were strongly linked to the age effect and accomplishment of intentions. To think again about the two groups: those who do what they have said they would do are also more likely to sort the intentions they did not accomplish into some rational scheme. Older adults generally do what they have said they would do, and they therefore also use some rational scheme to sort the left-over intentions. Of course, this is an interview-based study, as the authors note, therefore it could be that older adults are more likely to use this rational scheme in front of the researchers. However, Niedźwieńska, Janik, and Jarczyńska (2013), in a study that used a fairly similar methodological approach as Ihle et al. (2012), suggest that the rational scheme is something that is created during the planning stages of intentions. Therefore, sorting intentions as not-as-important is not something that they only account for retrospectively. Specifically, Niedźwieńska, Janik, and Jarczyńska (2013) find that older individuals are more likely than younger adults to involve themselves in the planning of their intentions, where older adults display more detailed plans at the intention formation stage. Interestingly, the authors also show in a follow-up study that younger adults perform better than a control group when introduced to weekly intention-planning activities.

This suggests that older adults' good performance in real-life settings is due in part to their ability to plan, and that younger adults can benefit from involving themselves in similar activities.

Despite these studies that use a mix of experimental set-ups and natural observations the experimental paradigm is dominant in the field. Even when researchers go into the wild they do so by exerting control over situations so that factors can be quantifiable and generalizable. Phillips et al. (2008) sums up the gaps in the PM-field by saying: "Current understanding of the role of memory aids, motivation, practice, and lifestyle in both types of PM tasks is poor, and this needs to be addressed through the use of controlled manipulation of large-scale studies." I concur, but despite this claim I would also argue that there are almost no expanded studies of the *cognitive* types of memory resources and mechanisms for using them in real-life home settings. I do not think that large-scale studies are the best first steps to fill this knowledge gap, because the field needs a good understanding of what to measure before any such studies are undertaken.

2.5 Studying external memory aids

The use of external memory aids in everyday life is one of the current explanations for the age-prospective memory-paradox. There is ample evidence that older adults are more than younger adults to turn to environmental support to exert cognitive control over situations in everyday life (see, for instance, Lindenberger & Mayr, 2014; Mayr, Spieler, & Hutcheon, 2015). As early as the 1980s, Craik (1983, p.118) suggested that to meet such aspects of memory processing "it may be necessary to take interactions with the environment into account as inherent aspects of our models, rather than as qualifiers or modifiers of some fixed underlying reality" (see also Welford, 1958). However, despite an empirical move toward what are referred to as more naturalistic studies of prospective memory (PM) in real-life settings, there is still a tradition of using indirect methods (e.g. diaries or, open and structured sit-down interviews) to understand the functional use of external structures.

But this does not mean that there has been no accumulation of knowledge over the years. Previous research has, through self-reports, tried to answer questions such as: What memory aids are used in real-life settings? For what purposes or in what situations are they used? What is the estimated frequency of use of each memory aid? Who (in terms of age and gender) is using specific memory aids? For instance, studies show that: women report a more frequent use of external strategies than men do (Dixon, de Frias, & Bäckman, 2001; Harris, 1980), older adults report greater use of external memory aids than younger adults do (Bolla, Lindgren, Bonaccoray, & Bleecker, 1991; Bouazzaoui et al., 2010; Cavanaugh, Grady, & Perlmutter, 1983; Dixon & Hultsch, 1983; Loewen, Shaw, & Craik, 1990; Moscovitch, 1982; Schryer & Ross, 2013, see Ponds & Jolles, 1996 for an exception); external memory strategies are, across all adult ages, self-reportedly more common than internal strategies (Garrett, Grady, & Hasher, 2010; Harris, Barnier, Sutton, & Keil, 2014; Intons-Peterson & Fournier, 1986; Lovelace & Twohig, 1990, again see Ponds & Jolles, 1996 for an exception), perhaps because they are easier to report on, or perhaps simply because there are more external than internal aids to report.

2.5.1 Methodological development

There are a number of what I find to be methodological key studies on external memory aids and everyday life. Harris (1980) is one of the first that through an explorative approach wanted to understand which external and internal memory aids are used in everyday life. Specifically, Harris used a list of external memory aids during structured interviews with students and housewives to determine the self-reported prevalence of using each memory aid. Despite its explorative approach

his study did not include field studies. Harris instead reports using his own a priori knowledge of memory aids in combination with open interviewing data to establish the list of memory aids. This list has been used with iterative revisions in later studies – studies that again have used more or less structured interviews to confirm the validity of their lists (see, for instance, Intons-Peterson & Fournier, 1986, Jackson, Bogers, and Kerstholt, 1988). The creation of these lists was important for the start-up of a new empirical research area but they were not validated against observations in real life. Instead studies have turned to large-scale investigations, which is a necessary strategy if the goal is to understand a phenomenon across a population.

The Metamemory in Adulthood questionnaire (MIA, Dixon & Hultsch, 1983) uses a similar self-reporting approach, except that it does not use comprehensive lists of specific aids. The goal with MIA is to survey self-perceived tendencies to use external structures. MIA has been used on larger populations and includes five questions on external strategy use. In their development of questions, Dixon and Hultsch (1983) refer back to questionnaire and interview-based studies; for instance Perlmutter (1978), who in turn includes no source for his choice of memory aids. Five questions on external strategy use could be considered a small number of questions, but the questions were originally seen as part of the larger construct "metamemory" – the knowledge about one's own (internal) memory. Despite the fact that answers to the questions could point to tendencies to use external structures in general, MIA has a narrow descriptive prospect to understand the multitude of practices people use in real life.

These early studies – together with conceptual discussions on compensation (see for instance, Bäckman & Dixon, 1992) and findings from laboratory-based situations (see, for instance, Bäckman, 1989) – have been used to inform the development of the Memory Compensatory Questionnaire (MCQ, Dixon et al., 2001). MCQ, with its eight questions on external strategies, places a relatively large focus on external memory aids (see Dixon, Hopp, Cohen, de Frias, & Bäckman, 2003), and is, to my knowledge, the most widely used questionnaire that specifically addresses the uses of external structures to manage memory situations in real life (Dixon & de Frias, 2009; Schryer & Ross, 2013). Again, it can be argued that eight questions is a rather small number of questions, but "compensation" is more than just the use of external memory strategies, and a few simple questions are an effective approach for gathering a large amount of data (Dixon et al., 2001).

In line with the methodological discussions that characterized memory research in the eighties there has also been an ongoing methodological development for self-reports. For instance, to establish a group difference between younger and older adults Jackson et al. (1988) concluded that it is preferable to give participants explicit situations with which to match strategy use. Simply letting participants estimate the prevalence of memory aids by providing them with a list of memory aids is problematic, since the participants need to think of concrete everyday situations by themselves. Intons-Peterson and Fournier (1986) is an example of a comprehensive self-reporting study using situations in this way. An interesting aspect of their study is that the choice of memory aids for specific situations was open-ended, meaning that participants could pick more than one practice for a given situation. This approach taps into an aspect of individual differences, namely that an individual might stick to one practice or be broader in her choice of practices for a given situation. MIA and MCQ also give an everyday situation to think about but, in contrast to Intons-Peterson and Fournier, they constrain the choice of memory aid, by also specifying a particular memory aid next along with the situation. They therefore constrain important aspects of individual differences in managing situations.

These early studies and today's self-reports have resulted in several descriptive accounts, such as those previously mentioned, which are important for understanding everyday cognitive coping. However, they do not describe the interactional mechanisms that can come into play in specific situations, or that can be common throughout home environments.

2.5.2 Theoretical development

I also think that this lack of description of interactional practices has led to an imbalance in theoretical grounding that exists in current self-reports, between the use of internal strategies on the hand and the use of external strategies on the other. Traditionally research on internal strategies has used a differentiation between encoding (for instance the loci-method) and retrieval strategies (for instance the alphabet-strategy) (Jenkins, 1979). Encoding and retrieval situations have hence been extensively studied separately in laboratory-based situations, and they have later been fed into the structure of self-reports on memory aids. Harris (1980) for instance noted that internal memory aids were used in pure retrieval situations, and not in encoding situations. I do not, in past and current self-reports, see a similar theoretical enrichment for external strategies. Instead they are either phrased as encoding strategies, or are phrased in an ambiguous way so they do not specify the cognitive situation in which they are used. This is true despite the fact that one of the underlying research questions asked several times has been "In which situation is the external memory aid used?". Loewen et al. (1990), using MIA's five questions, partly answered this question by concluding that external aids are mostly used for planning future events. This is valuable knowledge but they could not (because of the characteristics of their questions) differentiate between encoding and retrieval uses. Intons-Peterson and Fournier (1986, study 3) investigated the differences between using external aids for encoding versus retrieval situations in an experimental setup, but did not ask about real-life situations.

Current self-reports risk assuming that just because a cognitive tool is used in an encoding situation it is also efficiently used in a retrieval situation. In fact, in previous reports in the field there are almost no elaborations on how people go about using external structures for retrieval situations. Jackson et al. (1988) note from a pilot study that some participants reported that they simply walked around among the shelves in the grocery store until they recognized the groceries they needed. Furthermore, Aronov et al. (2015) note that interventions for various subgroups in the older population need to cover both encoding and retrieval practices. Retrieval strategies have never been included in self-reports used on the normal population, nor have they been systematically observed. But this does not mean that they cannot be. A better description of the versatility of interactional mechanisms between person and environment will not only give a better descriptive account of using external memory aids, it can also inform the use of self-reports.

All of the previously mentioned studies that use indirect methods are constrained by their coarse level of description. To look into the importance of details consider the case of note taking as a remembering technique. In previous research reminder notes are the most commonly preferred strategy across and within various situations (Intons-Peterson & Fournier, 1986). Furthermore, West (1988) found that note writing was the self-reported strategy most associated with successful performance on a real-life experimental task. However, note taking can likely be orchestrated in a number of different ways, in terms of content, location, and retrieval practices.

2.5.3 Explaining performance

This use of indirect methods cannot explain performance in real-life settings. Consider again the age paradox and one early key study by Maylor (1990). Maylor asked her participants (aged 52 to 95) to phone the experimenter once a weekday for one week. At the end of the week participants

were asked how they remembered to make the phone calls. In line with the findings presented above Maylor found that the best performance was achieved by those who said that they engaged in planning their days in advance, or who said that they used a conjunction strategy and made the phone call in relation to some other routine. Those who said that they used external reminders such as calendars showed only intermediate performance. The worst performance was seen in those who claimed that they used internal strategies. Interestingly, the only age-related effects on performance found across these types of strategies was (1) for those who said that they used internal strategies, where the older adults performed significantly worse, and (2) for those who said that they used external reminders, where the older adults performed significantly better. This suggests that the use of external reminders alone does not explain older adults' better performance. Instead, older participants likely use their external reminders more efficiently.

Furthermore, among those who failed one or more times, the participants who said that they used external cues were more likely to state a reason for their failure than the ones who claimed to use internal cues. This suggests that it is easier to understand one's own mechanism for failure when the external environment is part of the mechanism. The findings also suggest that older adults benefit from a combination of routines and uses of external structures in their management of PM in real life. But since no observations were made, it is not known how the combination of routines and external structures works.

In an experiment that was somewhat similar to Maylor's work, Kvavilashvili and Fisher (2007) used the task of making a phone call at a specific time one week forward in the future. They compared a group of younger adults and a group of older adults. Interestingly, participants were asked not to use any explicit external mnemonic aids, such as calendars or notes. Participants were also asked to keep a diary of every instance when, and under what circumstances, they were reminded to make the phone call. First, older adults performed as well as the younger population, and both groups displayed the j-curve of reminders (as previously described by Harris & Wilkins, 1982), which means that individuals start the week with being reminded at some rate, a rate that slows down in the middle of the week and significantly increases as the target event approaches. Second, the analysis of the diaries suggested that participants were reminded without any apparent triggers. The authors therefore concluded that remembering to do something in the near future in this type of task is partly regulated by automatic processes that cannot be reported on. Also Kvavilashvili and Fisher (2007) did not find a more frequent use of external triggers as an explanation for the performance in older adults. The lack of apparent triggers in the diaries suggests that reporting on how one is being triggered is not a straightforward task.

Both the findings in the previous study and the findings in Maylor's study suggest that external reminders or external aids, despite being important, are not necessarily the only prominent factor in the explanation of older adults' performance. Real-life experiments are important because they allow participants to use resources and practices they would normally use to a much greater degree than laboratory-based studies. However, previous studies using real-life experiments have nevertheless used self-reports to record the use of external resources.

Self-reports can be improved, but there is always a risk that self-reports are not representing actual practices. Several authors have, on a number of occasions, pointed out possible risks associated with using self-reports to understand the use of external memory aids. For instance Dixon et al., (2003, p.383) note that "'self-reports' may vary in veridicality". But how self-reports on the use of external resources may vary in veridicality is usually never addressed. Schryer and Ross (2013), after reporting no correlation between the external component of MCQ and the observed use of external

aids in lab-based tasks, conclude that researchers should be cautious with interpreting MCQ as something that reflects actual practices in real-life situations. As previous research in cognitive psychology has established, what people say they do can reflect several things and not always actual practices (see, for instance, Nisbett & Wilson, 1977).

Since the self-rated measures of the tendencies of using specific aids have been administered to individuals there has also been a focus on individual differences. But inter- and intra-individual differences have not been addressed in any detail. Palen and Aaløkke (2006) is an exception. They documented how a number of older individuals shaped their physical environment to manage medication adherence. They also used an intra-individual perspective and noticed, for instance, that PM practices could change across time due to aspects of changing medicine prescriptions. I return to this particular study in the next chapter because they used a distributed perspective on cognition.

There are more studies within the experimental paradigm that have studied environmental-interactive practices in some detail. These exceptions deal with one type of memory task, which is time-based PM, and one type of cognitive tool, which is a clock. In those experiments the clock is often physically located in the experimental setup such that a visible turn of the head is required in order to check the time. Sometimes the checking of the clock is implemented as a digital solution where participants reveal the clock by pressing a key. With these setups, a time-based PM task introduces an interesting trade-off between watching the clock and managing ongoing task demands.

Consider an experiment by Mäntylä, Missier and Nilsson (2009) where participants (three age groups, 20-34, 36-56 and 64-81) at an initial low-demand occasion performed a listening task as an ongoing task, where they were asked to remember the content of a story. At a second high-demand occasion participants, as an ongoing task, performed standardized cognitive tests that were intended to tax the participants' cognitive abilities more than the listening task. During both occasions they were simultaneously performing a prospective memory task. The task was to press a specific key every five minutes (±10s was accepted for a positive scoring). Any time they wanted they could check a clock by pressing another key, but they were also asked to minimize the number of times. The results indicate that clock checking increases as a function of age and that older adults spend more time (relative to the high-demand condition) checking the clock during the low-demand task compared to the younger groups. They also found, as previous research has (Harris & Wilkins, 1982), a j-curve of clock watching frequency towards the target time across all age-groups. This suggests an accurate sense of time across all age groups. A j-curve of clock-watching has also been associated with successful performance in time-based tasks in the past (Harris & Wilkins, 1982). Despite an accurate sense of time Mäntylä et al. (2009) find a moderate but significant relationship between age and response accuracy on the prospective memory task ($r=-.35$), and between age and ongoing task performance ($r=-.37$). Importantly, they also find a cost for watching the clock for the oldest participants, but only in the low-demand condition. More clock checking in the low-demand condition results in a worse ongoing task performance for the oldest participants, but not for the younger participants. This experiment suggests that there is certainly a trade-off for the older participants between strategies employed to manage time-based prospective memory tasks, performance on ongoing tasks, and performance on prospective memory tasks.

Similar experiments on people's active use of the environment do not exist, to my knowledge, for other types of PM tasks. These studies are, however, conducted outside the home environment and use abstract tasks to measure performance.

2.5.4 The need for observations

Overall, the field lacks observations in real life. Saying, for instance, that someone uses reminder notes a lot is not necessarily predictive of their overall PM performance. Inter- and intra-individual differences in uses of external structures and specific strategy use are not among the prominent discussions in the field of cognitive aging and external memory aids. This is despite the fact that the notions of inter- and intra-individual variability are increasingly more important in the understanding of cognitive aging in general (see, for instance, MacDonald, Nyberg, & Bäckman, 2006; Papenberg et al., 2011). To some extent these differences can likely be captured through versions of self-reports, but there is also likely to be a need for more systematic observations.

Indeed, people can self-report on aspects of their physical environment and perhaps also on some environment-practice dependencies. Fink, Cartee and Pak (2014) even go so far as to claim that focus groups are just as good as field studies to capture the use of practices that aid memory in everyday life. However, I do not find the same level of description of contingencies and intra- and inter-individual differences in their report as for instance a study by Palen and Aaløkke (2006, see next chapter), and there are further limits on how detailed self-reports can be. As previously mentioned, experiments in home environments have suggested that people rely to some extent on automatic practices to manage PM situations, which cannot easily be reported on (Kvavilashvili & Fisher, 2007)

Using coarse self-reported practices as real uses of practices for remembering intentions is risky because it can have consequences for how conclusions are drawn. Consider the following example. With data from the Victoria longitudinal study (VLS), Dixon and de Frias (2004) found a six-year longitudinal relationship between self-reported use of external memory strategies and performance on standardized testing of memory abilities. Initial high-performers in standardized testing reported a higher use of external memory aids over time, while low-performers showed no such increase; instead they showed a decrease in their self-reported effort to remember. The authors concluded, "lower performers appear to give up" (ibid. p.372).

Since MCQ taps into subjective motivational factors, this conclusion is potentially valid. But if the practice of using external structures to remember is a skill that exists at different levels of description, we do not know if the low-performers turned to other practices and cognitive processes that are not covered by current self-reports. Based on what I reported on previously, low-performers might, for instance, turn to more automatic processes. It is also worth considering the motivated high-performers: just because someone is more motivated to shape their physical environment in a way that they believe makes a task more cognitively congenial (cf. Kirsh, 1996) does not mean that they are efficient users (or shapers) of the environments they are motivated to create. I return to specifics of shaping the environment in the next chapter.

Interestingly, 12-year longitudinal data from the VLS showed no longitudinal increase in the reported use of external strategies (Dixon & de Frias, 2009); therefore the findings from the six-year span described above were opposed to these results. Since the VLS only included people 55 years old or older, one explanation for this result might be that changes occur earlier in life, something that could be suggested by the differences between students and housewives that Harris (1980) found. Another interpretation might be that self-reports currently provide too coarse an instrument to capture actual changes in practice. Self-reports can capture aspects of practice-environment dependencies to some extent, but current self-reports are not the best strategy if the PM functionality is determined by more detailed interactional aspects between spaces and practices.

2.6 Chapter conclusions

A better understanding of real-life prospective memory situations is important in order to understand how older adults manage prospective memory tasks. Normal habits are not well understood in relation to the use of external structures for remembering. The use of external structures is a field of research that, despite theoretical and methodological development during the eighties, has ceased to develop in relation to research on normal cognitive aging and everyday life. A major conclusion from this chapter is that there is a need for new methodological approaches to the study of prospective memory in real life. There are several reasons for this.

First, most of the research on prospective memory has been carried out under experimental conditions in laboratory-like settings. Although this research has identified several underlying cognitive mechanisms for PM, transfer of this knowledge to real-life settings has just begun.

Second, when prospective memory ability is measured in real-life settings the task and/or the environmental support is often researcher-induced and not a normal part of the participants' lives. This is not only a problem of motivation; it is also a problem of habits since people usually have routines for managing typical intended tasks in real life.

Third, when the normal environmental-interactive mechanisms for managing prospective memory situations in everyday settings are studied, the methods used are indirect methods, such as sit-down interviews and questionnaires. In situ methods are seldom used. This runs the risk of missing practices that are complex and cannot easily be reported on. Such observations are more common for more specific cognitive cohorts, such as in the study of people with age-related neurocognitive diseases. For such groups the shape of a physical environment can be absolutely crucial for everyday performance (see, for instance, Vikström, Borell, Stigsdotter-Neely, & Josephsson, 2005). It can therefore be argued that the incentives for researching practices in some particular groups are stronger than those for research on the general younger and older population. Importantly though, interactional practices that serve some compensatory purpose in the case of atypical cognitive abilities are sometimes a continuation of practices established earlier in life (Bäckman & Dixon, 1992), therefore we must also have an understanding of people in general.

Another conclusion is that there is also a need for new theoretical tools for studying prospective memory in real life. In real life, prospective memory situations are always managed in relation to a physical and sometimes a social environment. Despite findings such as those listed in the above sections, previous research on PM has, on a conceptual level, categorically excluded environment-interactive practices that are likely to be important for management of intentions in everyday life. For example, foundational aspects of memory such as encoding and retrieval practices are only occasionally mentioned and studied in the literature. Instead, the norm is to use underdeveloped theoretical descriptions that do not account for mechanisms for cognition when extra-cranial resources are involved. In next chapter I will introduce a theoretical perspective and conceptual apparatus that has been used to understand environment-interactive mechanisms within performance-sensitive environments. This perspective has been the basis for my methodological approach and empirical analysis.

Chapter 3. Distributed cognition

In this chapter I introduce the theoretical foundations of distributed cognition. This introduction is primarily based on the description of distributed cognition developed by Hutchins (1995a) and colleagues (Hollan, Hutchins, & Kirsh, 2000). However, I will also embrace theoretically overlapping perspectives, such as situated cognition and embodied cognition, under the heading of distributed cognition[3].

When it is suitable I also address studies that have used distributed cognition to specifically understand prospective memory or everyday environments. At the end of the chapter I introduce the methodological foundations for distributed cognition that have guided my field studies.

3.1 Foundational principles

The foundation of distributed cognition can be understood in the light of the critique that Hutchins directs against deep-rooted assumptions in traditional cognitive science. The critique can be generalized to a characteristic of cognition that is often taken for granted: cognition as an internal process of natural and artificial agents. The problem with this assumption is described by Hutchins' (1995a, pp.359-370) re-analysis of the history and the dawn of classical theories in cognitive science.

Influenced by the development of computers Newel and Simon (1976) suggest in their *Physical Symbol System hypothesis* (PSS-hypothesis) that symbol transformations are necessary and sufficient means for intelligence. A predication from this is that humans do symbol transformation because they have intelligence, and computers, since they do symbol transformations, can also have intelligence. However, Hutchins proposes that cognitive science made a fundamental mistake in using the computer as the metaphor for cognition. In the course of using computers to understand human cognition, cognitive science started to cram every part of cognitive accomplishment into the brain, and in turn focus almost all research endeavors on individuals solving problems in resource-stripped experimental settings. Aspects of human cognition like social resources, cultural

[3] I find no theoretical problems with doing so because distributed cognition is a perspective on all cognition. However, I know that that this is not the standard way of categorizing. Instead, I find several authors who treat situated cognition as the genus for distributed cognition. See, for instance, Robbins and Aydede, 2008, and Roth (2013) both of which provide a thorough account of the development and expansion of the idea of situated cognition, where ideas that can be derived from distributed cognition are described as ideas within situated cognition.

resources, and sensory organs were nowhere to be found in early descriptions of cognitive accomplishment.

Through Hutchins' perspective, cognition is still the processing of symbols and information. Specifically, cognition is "...computation realized through the creation, transformation, and propagation of representational states."(1995a, p.49). He also notes that both humans and computers have sufficient architectures to do symbol transformation. However, distributed cognition holds that to understand cognitive accomplishment researchers should not *a priori* assume a specific unit or center of analysis (e.g. the brain or the computer, as early cognitive science did). Instead the main theoretical principle of distributed cognition is to focus the analysis of cognition on functional relationships between parts across disparate architectures that are involved in a given activity. The parts investigated are therefore not chosen according to some *a priori* preference of architecture. This general assumption about cognition is also the main reason that distributed cognition is a perspective on all cognition (Hutchins, 2013).

As an example of disparate architectures, consider the following example by Lave (1988). There are a number of ways to solve a given math problem, for instance, 75x114. One way is to use pen and paper and the placeholder strategy that is taught in school. A second way is to use a calculator, and a third way could be to ask a friend to help remember the results of steps of a calculation that you do in your head. Lave's point is that "the product may be the same – but the process has been given structure – ordered, divided into units and relations, in action – differently in each case." (p.98). Hence the cognitive processes are, from a distributed cognitive perspective, different.

In Hutchins' description cognition is also a type of cultural process. Cognition is a cultural process that provides solutions to frequently encountered problems (Hutchins, 1995a, p.354). As a consequence of viewing cognition as a cultural process, the first unit of analysis should always be the cultural-cognitive ecosystem (Hutchins, 2010a) because it is the cultural processes that have established solutions to problems and situations.

Hutchins (1995a) states that a consequence of embracing a distributed perspective is that what we know about individual cognition must be forgotten and described anew through what he calls cognitive ethnographies. In cognitive ethnographies, practices in real-life settings are the focus (this will be thoroughly described later). Only by doing research in *the wild*, in naturally occurring settings, can we account for what individuals actually do to accomplish goals. Despite this rather negative view of past research it is important to understand that distributed cognition also comprises individuals with abilities.

Soon after the release of *Cognition in the Wild,* Hutchins (1995a) was criticized for (among other things) minimizing the role of individuals, and attributing too much cognitive accomplishment to extra-individual sources (see description by Latour, 1995; and critique by, for instance, Nardi, 1996). Ironically, distributed cognition, and specifically Hutchins, was suddenly criticized for doing the same thing that Hutchins had criticized cognitive science for doing in its first decades, but in the opposite direction. But this was largely a misinterpretation of what distributed cognition was, namely a perspective on all cognition (Garbis, 2002; Hutchins, 2010b). Hutchins also explicitly suggests that an analysis according to distributed cognition should not start on an individual level if there are reasons to believe that some larger unit of analysis is more appropriate. But to have a complete description of a large socio-cultural system, the analysis should always at some point venture to the individual level (see Hutchins, 1995a, p.50), which is something Hutchins does in his analysis of the accomplishment of the navigation activity on a larger vessel at sea.

What past research on cognition, and so also prospective memory research, has focused on is individual abilities used in a specific cultural setting, the laboratory. This knowledge is not without benefits but should be used cautiously before assuming that the same mechanisms apply in other settings, for instance settings often ascribed to real-life. Therefore, in cultural settings for which an individual perspective traditionally has been applied, the research strategy of distributed cognition is instead to start assuming that individual abilities have potentially equal roles for cognitive accomplishment as any other resources in the setting under study. Only by doing this we can at the end understand individual contributions for information flow and transformation.

Even though distributed cognition does not assume a center or boundary for cognition in advance, it is both an empirical question and a relative matter if a specific center or boundary exists for some cognitive system, or if the system lacks a clear center, or has multiple centers. It is an empirical question because it is a function of the density of information flow between parts. It is a relative matter because the threshold for saying that information flow is enough for something to be included in the functional system is a matter of judging the relevance in relation to current research questions. As a consequence, the unit of analysis could therefore be confined to the brain, the brain and some tool, or some other social being, groups of people, or even environments.

Hutchins (2013) formulates two general principles (or, in fact, hypotheses) of cultural-cognitive ecosystems. First, a cognitive system does not have uniform connectivity. All intelligent systems (for instance, brains) have connections between their parts with a variety of higher and lower information densities. Second, there are formal principles that "operate at multiple scales in cognitive systems" (p.12). An example of such a principle is suggested by Clark (2013) where he argues that the brain is a hierarchical prediction machine. Hutchins (2013) suggests another such formal principle, namely that there are structures in the cultural world that can be exploited by individuals across time and generations.

Below I go further into principles for information flow. Most of the information flow principles mentioned below originate from Hutchins' (1995a) seminal book *Cognition in the Wild,* where he presents an extended analysis of a cognitive ethnography conducted onboard a U.S. Navy ship. Instead of limiting the analysis to competent individuals, as a traditional cognitive science study would have done, Hutchins finds the ship with its crew members and cognitive tools, specifically on the navigational bridge, to be a socially distributed cognitive system. The core conclusion is that how information flows between parts of the system, and how representations transform in the interaction between parts, is the essence of how activities on the navigational bridge are accomplished.

3.2 Information flow principles

There are a number of information flow principles (see Blandford & Furniss, 2006 for a condensed list of principles) which determine information flow and which can be used to determine cognitive accomplishment. The most basic principle is information movement or propagation. This is the most basic principle because information movement is what allows parts in a cognitive system to coordinate operations. Another principle is information transformation, which is when representations change. This can, for instance, occur when information moves from one part to another, or within parts of a system. An example of how information can be transformed across social architectures is the way that humans filter information when they re-tell information that they have previously heard or read from some source. How information is filtered can have direct consequences on cognitive performance, both good and bad.

Additional information principles include information buffering, information hubs, and information bandwidth. As mentioned previously, intelligent systems seldom have an even distribution of information content and flow, and therefore *information buffering* and *hubs* functionality can often be found. An information buffer is a medium that holds incoming information for later retrieval. Hutchins (1995a, p.194) describes how, for instance, information buffering can be used to communicate between individuals whose roles do not allow for instantaneous communication. Buffering can therefore be a crucial part of complex environments where information flows and transforms at a high pace.

Information buffering can be necessary in a cognitive system that has *information hubs* (Blandford & Furniss, 2006). Information hubs are parts in a cognitive system where several information channels meet. Buffering can therefore be necessary to manage large amounts of incoming information. Because of their access to, or gathering of information, hubs are potentially where most information of a system's cognitive states can be found. In Hutchins book the navigational bridge can for instance be seen as an informational hub that coordinates information from several sources.

Another principle is *information bandwidth,* which has an analytical focus on the richness of information flowing between parts in a system. Consider, for instance, a face-to-face communication situation in contrast to communication through a telephone line. Through the use of both verbal and non-verbal information, communication face-to-face can potentially be richer, in other words it can have a larger information bandwidth. Hutchins (1995a, pp.227-228) discusses how, for instance, communication about two landmarks between an operator and a recorder through restricted media can create problems. Specifically, if only one of the individuals can see the landmarks, the landmarks need to be translated into symbolic representations and communicated to the other individual.

Note that richer information should not be understood as something that is only positive. Hutchins describes (pp.229-230) how bandwidth should not have analytical precedence over informational content and representational shapes. On the ship most of communication is verbal, and therefore there are established practices for how to communicate verbally that establish robust information flow. Therefore, in many situations there is no need for face-to-face communication. In the case of the landmarks there is no fundamental reason to suppose that the possibility of using gestures to point at a landmark would lead to better cognitive accomplishment. But Hutchins also provides examples in which rich bandwidth and a shared world are important for performance. In one example (p.232), during a mismatch between navigation plots, a discussion between two individuals with a shared chart becomes necessary. In Hutchins' example, face-to-face communication in relation to the shared world was necessary to negotiate meaning, and to establish trust between parts of the system.

The examples above all operate on a relatively restricted temporal dimension. However, the functional relationships between parts in a system can additionally be viewed as operating on different spatial and temporal scales, which in practice means that a distributed cognitive analysis continuously shifts between different scales of description to explain cognitive accomplishment (Hutchins, 2013). Hollan, Hutchins, and Kirsh (2000) suggest three general spatial and temporal scales: across internal and physical resources, across the social environment, and across time. I will consider these three ways with concrete examples below, in turn. Note that the three ways in which cognition can be distributed are analytical tools for describing cognitive accomplishment through informational flow and transformation. In reality, they can be highly dependent on each other. For

instance, for some information to be transmitted across time the information needs some physical (e.g. book) or social vehicle (e.g. a teacher).

I start by describing distribution across time, which sets the premises for cognition as a process across different temporal scales.

3.3 Distribution across time

That cognition can be distributed across time means that the products of past events can shape future cognitive events (Hollan et al., 2000). From an individual developmental life-span perspective this is not strange and has been acknowledged for some time (Craik & Bialystok, 2008). But when viewing distribution across time from a distributed perspective it is not just individuals that change. It is also important to acknowledge how the cultural, material and social world which humans learn from and act upon changes. Rajkomar, Blandford, and Mayer, 2013 present a summary of the heterogenous uses of temporality within distributed cognition research. Below I consider a few of these uses.

Distribution across time can, for instance, be viewed as a social and material *individual* learning process. By borrowing the idea of *internalization* from Activity theory (Vygotsky, 1978) distributed cognition suggests that to a large extent cognition is, through development, an inter-individual process where individuals internalize parts of this cognitive process. Parts and processes that previously existed only in the external world become *internalized,* i.e. primarily intra-individual in nature. Similar ideas about the internalization of culturally-situated cognitive processes have also been seen in the work of Halbwachs (1980/1950) on social collective memory and Donald (1991) on cultural knowledge accumulation through the use of exograms. Halbwachs (1980/1950), for instance, discusses expertise among classical musicians, where he argues that their musical ability has not just developed as an ability to read the conventional musical notation system. Musicians have also assimilated the representational notation system, and through the process of assimilation transformed their intracranial cognitive processes. As mentioned in these cases, symbolic structures are first found in the cultural setting and only later (through, for instance, some learning process) located in the brain.

Distribution across time can also be viewed on a *collective or environmental* level, where it is the cognitive ecosystem that internalizes and learns new ways to handle situations. According to Hutchins, distribution across time works to "solve frequently encountered problems" that groups of individuals experience (Hutchins, 1995a). Consider, for instance, Hutchins and Hazlehurst (1991, see also Hazlehurst & Hutchins, 1998) who use a computer simulation to explore how the individual and collective reciprocate through the mediation of cognitive tools. The case for the simulation was how a community could learn the phases of the moon across generations. They conclude that information that is built into tools is the main contribution to collective learning. But for this to happen, the cultural process is dependent on individuals that build knowledge into tools, tools that keep on existing when individuals die (see also Salomon, 1993). Hazlehurst and Hutchins show that the collective could assimilate the phases of the moon better when individuals interacted with smart tools that earlier generations had developed.

The example above explores distribution across generations. But distribution across time can also be understood as changes across various temporal scales. De Léon (2003) makes an explicit point of this when focusing on the development of tools across three different temporal scales: 30 minutes (development of workspaces while cooking), 30 years (development of a spice shelf), and several hundred years (development of pistols). By conducting what he calls *cognitive biographies of*

things, a great deal can be said about the cognitive process across time. For instance, in one section de Léon focuses extensively on changes to a spice shelf and its cognitive consequences for cooking.

Different dimensions of distribution across time is also something that is highlighted in Hutchins' introductions to distributed cognition. Hutchins (1995a, p.372) describes how any human practice in a given moment can be understood across three developmental dimensions: the conduct of an activity, the development of the practitioners, and the development of the practice. For examples of each, consider Hutchins' seminal case: navigation.

In any moment when humans navigate there are plenty of interactions between humans and tools before reaching a destination. These interactions coordinate representational media and information in such a way that sub-goals, and eventually the goal of reaching a destination, are met. In Hutchins' model this is the conduct of the activity.

In the same moment, we can understand the conduct of the activity as deriving from the cultural specification of how to navigate. This specification has been transferred across generations of navigators through, for instance, the tools that are available to the navigators and the conventions that exist in a community of navigation. This is the development of the practice. The development of the practice is not as informationally reciprocal in the given moment as the conduct of the activity is. As a result, states of the practice do not change as fast as states across the conduct of an activity, but the practice still shapes any navigation activity.

Also in the same moment, we can understand the conduct of activity as deriving from the expertise of the navigators, which is also something that has developed across time. The three dimensions, according to Hutchins, all account for the development of human practice. When a goal or sub-goal has been reached in the conduct of navigation the practitioners and the practice may have also developed. However, the three dimensions do not develop equally fast. Practitioners and practices do not develop at the same rate as activities are accomplished. It takes years to become an expert navigator and it takes an even longer time to change the nature of navigation. A navigation activity, however, does not usually take years.

A recent empirical example of distribution across time that includes observations of prospective memory processes comes from Rajkomar, Blandford, and Mayer (2013), who report on a cognitive ethnography on home hemodialysis. They do not focus on human practice over longer timescales. Instead, they specifically look at the cognitive rationale of using time as a medium to reduce cognitive complexity across the conduct of the activity, and to some extent the development of the practice. They observed and interviewed nineteen patients and their home dialysis systems.

The authors note that time can serve a number of cognitive functions in short-term activities. For instance, repetitive points in time can be used as conceptual (and also to some extent external) cues for prospective memory tasks. Many participants assigned their weekly or monthly disinfection routine to a specific day, weekday, or day of the month. Some participants also distributed the temporal placeholder by marking their calendars. Marking the calendar seemed to be more important when the routines were not weekly, for instance, when they were every second week. The authors also note that temporal distribution of activities can be used to avoid omission of steps. One caregiver, for instance, initially started preparing to take the patient off the machine five minutes before the end of treatment. But after several experiences where steps were omitted he started initiating preparation 20 minutes in advance. This, he argued, lead to fewer omissions because he was less time-constrained and could give the steps more thought. Finally, the authors also note that space was used as a medium for distributing time. For example, people were observed

to place time-sensitive medicine in their home environment based on where they expected to be when it was time for each medicine.

Another perspective on cognition that also views the process of cognition across time on a systemic and collective level is Cognitive Systems Engineering (Hollnagel & Woods, 2005, 1983). CSE was developed in parallel to Hutchins' distributed cognition and shares many aspects with distributed cognition. Most notably, they share an expanded unit of analysis, and specifically a dynamic unit of analysis. But CSE, even more than distributed cognition, focuses its empirical efforts on complex high-risk environments and human-machine interaction. CSE developed in response to a desire for new theoretical tools as a consequence of major accidents, most notably Three Mile Island. Compared to distributed cognition this perspective has a more explicit focus on failures and negative incidents, and a motivation to proactively avoid larger failures. From a societal perspective, failures and negative incidents are less acceptable in complex, high-risk environments than in many of the domains that are studied under the heading of situated and distributed cognition.

In CSE the principal concept is "control" (borrowed from Cybernetics, Ashby, 1956) and how the cognitive system maintains control within acceptable boundaries over necessary functionalities. Interestingly, CSE initially (Hollnagel & Woods, 1983) kept to the information-processing paradigm of cognition. But in recent years (Hollnagel & Woods, 2005) the information-processing paradigm is no longer the primary one. The new paradigm uses a notion of joint cognitive systems that does not primarily focus on informational interaction between humans and machines, focus is instead on how they maintain control together, irrespective of whether there is information involved or not.

In CSE, control is analytically embodied through a number of theoretical models. The most common is COCOM (Contextual control model). COCOM views processes as control loops where each control loop represents a function of the cognitive system. Since CSE takes a systemic perspective, the parts of a cognitive system and the interactions between parts that account for a specific function often extend beyond a single individual. Functions are also hierarchical, meaning that that each overarching function has several minor functions that are needed to sustain control of the overarching function. The notion of levels of a cognitive system is not necessarily different from Hutchins' version of distributed functionality. For instance, in Hutchins' (1995b) article *How a cockpit remembers its speeds* the function specifically under scrutiny is part of a series of functions that are necessary for successful landing.

Another common element is that accountability cannot normally be assigned to specific individuals, either through a contemporary CSE or through a distributed cognitive perspective. CSE often holds that what is called the human factor or human error is in fact often not human error. Instead, the norm within CSE is to seek systemic properties to explain exceedances of accepted safety or performance boundaries. This model can also be used to understand prospective memory in everyday life. People's individual abilities to remember are likely to affect outcomes of attempts to remember something. However, when cognitive processes take place in dynamic physical and social environments, the outcomes are also derived from systemic properties larger than the individuals. It is in part an empirical question to determine which properties are relevant.

To summarize, cognition across time can be understood across a continuum of spatial and temporal ranges. Below I consider two types of spatial dimensions: physical and social architectures. Above I have already considered examples of how cognition can be distributed across social and physical architectures. In the example of how a community could learn the phases of the moon, cognition

was socially and physically distributed through the residual knowledge in cognitive tools that traveled across generations. Below I go into more detail of each, in turn.

3.4 Distribution across social architectures

The principles above are descriptive parts of how information flows in any cognitive system. The arenas and media through which information flows make up an important part of information flow as a whole. They establish the ecologies that allow information to be distributed and coordinated.

Blandford and Furniss (2006), for instance, acknowledge *informal communication* situations as social arenas that can facilitate information propagation across a cognitive system, even if the arena is not explicitly related to a task at hand. Communication ecologies that extend outside the pre-defined task execution is something that Hutchins also acknowledges. Hutchins (1995a, p.268) describes the notion of an agent being within a *horizon of observation*. Hutchins specifically mentions two ecological factors that widen the horizon of observation. First, the openness of communication lines or arenas, which allows novices to listen in on communication between more experienced crew members. Second, the openness of tools, which allows individuals to perceive current cognitive states without needing to communicate with others and possibly interrupt important ongoing processes. The navigation chart on the bridge is discussed as a general tool that provides a wider horizon of observation than smaller computer screens do. The horizon of observation is a basic characteristic that describes the potential for information to move across a system. If, for instance, an agent cannot hear or see some information, the agent cannot acquire that information.

Another type of ecology, and perhaps the clearest example of social distribution, is a team that works to solve problems. Teams are the subject of Hutchins' seminal example and have continued to be a common type of unit to study from a distributed perspective. Teams are interesting from a distributed perspective for several reasons. One reason has to do with the characteristics of teams. Each member of a team has a specific role in the pursuit of their team's objective (Orasanu & Salas, 1993). Because no single individual in a team can accomplish the goals by themselves, the members need to have some social and communication structure to accomplish the goals. Hence their overall cognitive accomplishments need to be distributed across the individuals. Note that Hutchins (1995a, p.198, and forward) mentions examples of what can be called the use of *behavioral trigger factors*, where members of a team do not always need shared goals, or need to communicate to perform in accordance with the team. Instead they are triggered to act in certain ways by the circumstances. As an analogy, they can be described as acting like an ant colony, where each individual is triggered by features of the environment in ways that are for the benefit of the colony.

An interesting case of distribution across disparate architectures, which includes teams and triggering factors, and which takes place outside of the highly technical and modern domain, appears in Tribble and Sutton's historical studies of cognition in early modern theatre companies (Tribble, 2005, 2011; Tribble & Sutton, 2011). They describe how individuals could perform up to six different plays in a week without the need for regular practice time or complete and constant access to manuscripts. How did individuals cope with such excessive memory demands? To some extent, ecological pressure shaped certain individual skills. She describes how individuals needed to practice what is referred to as *cognitive thrift*, which is "to learn exactly what was needed, and no more." (Tribble, 2011, p.58). But the theatre as a cognitive ecology is also shown to alleviate individuals from cognitive burden.

Characteristics such as designated entrance and exit doors, and an elaborate computational device in the form of a written plot of the ongoing play, which hung in preparatory areas, are described

as powerful social and physical tools that "maximize individual contributions" (Tribble, 2005). Tribble (2011, p.49) also describes how what are called internal exits are rarely mentioned in historical sources. An internal exit is when an actor exits a scene without a cue. Rather than this, the most common case is that actors are either cued by the dialogue to exit, or helped off the stage by fellow actors. It is also important to note that the use of metrics and verbal patterns in the manuscripts were necessary parts of the remembering process. The most important thing was not to present everything verbatim from the manuscript, rather, actors needed to follow the patterns of the manuscript and recognize cues for when to speak; in other words, they needed to deliver a smooth performance. In relation to this Tribble describes how Shakespeare's later plays used more irregular rhythms of lines, and more short and shared lines than his earlier plays. The task for the actor in his later plays therefore became more of a pattern-recognition task, which involved responding to the lines of fellow actors and the rhythm of a situation, rather than recalling long passages by oneself.

Tribble's examples show, first, that team characteristics are important for individual performance, but also that those team characteristics were built into the structures of manuscripts and plots of plays. To use an analogy from Hutchins' (1995b) paper *How a cockpit remembers its speeds*, it is the play itself and the physical and social structure of the theatre that remembers what actors should do and say.

The analogy of the *remembering theatre* can also be said to work in contemporary times. But by taking a distributed perspective Tribble also shows that contemporary theatres are a very different cognitive ecology than the theatres in Shakespearean times. In her own words (Tribble, 2005, p.148): "[the] 'general model of acting cognition' is bound very specifically to late-twentieth-century acting practices, which are in turn based on assumptions about character and subtext derived from modern acting theory. Moreover, these practices are the results of institutional conditions such as long rehearsal periods, a relative scarcity of new plays, and, finally, the exigencies of memorizing prose rather than verse." (See Noice et al., 2004 for descriptions of contemporary theatre practices.) Tribble's comparison emphasizes the general importance of understanding cognitive ecologies as socially and historically situated. Information flow and transformations can take significantly different forms as a consequence of institutional and social structures.

Schwartz and Martin also consider the various forms of distributed systems (Schwartz and Martin, 2008). They take learning situations as their primary case. Specifically, they consider the ability to learn by categorizing distributed cognition as something that can take place between stable/adaptable environments and stable/adaptable individuals, which they represent as a grid (see table 1 below).

Table 1: Four Quadrants of Distributed Cognition (adapted from Schwartz & Martin, 2006)

	Adaptable	(1) Induction	(4) Mutual Adaption
Individual	***Stable***	(2) Symbiotic Tuning	(3) Repurposing
		Stable	***Adaptable***

Physical and Social Environments

Using this grid they define types of learning processes. The authors give examples of each type of learning process.

An example of induction (quadrant 1) is the way that a student (adaptable) tries to make sense of a teacher's words (stable). Examples of symbiotic tuning (quadrant 2) come from Hutchins, and are, in fact, the primary type of learning situation presented in most of the literature on distributed cognition. In these examples the individual is a professional (stable) and the environment has been specifically designed to accomplish a specific task (stable). In such cases, learning is characterized as a process of increasing efficiency within the system and the interdependence of its components. Examples of repurposing (quadrant 3) are, for instance, what Kirsh (1996) talks about when someone arranges the environment to serve some function. For example, imagine a professional cook (stable) who plans a dinner in a non-professional kitchen (adaptable) in which she has never cooked before. In this case, she is likely to rearrange features of the environment so that the process becomes closer to symbiotic tuning. An example of mutual adaptation (quadrant 4) might be a home gardener (adaptable) constantly learning new things as the garden changes and some plants survive while others die (adaptable). (Schwartz & Martin, 2008)

The grid adds to traditional distributed cognition research because it gives structure to cognition as more than problem-solving that is done by professionals in intelligently-adjusted environments (Schwartz & Martin, 2008). In other words, it can be used as the basis for a discussion of types of cognitive systems. This is relevant for the purpose of this thesis since I analyze an environment that is not typical for a distributed cognitive analysis.

In distributed cognition, social structures are in themselves forms of cognitive architectures (Hollan et al., 2000), both when considering immediate direct communication and social structures that individuals have experienced in the past. This is because, like any cognitive architecture, they determine information trajectories and transformations. Consider the following example. In the paper *Professional Vision* Goodwin (1994) explores how members of a profession, through the examples of archeological field excavation and legal argumentation, observe the world in specific ways. At the foundation of Goodwin's concept is that the perception of reality is determined by properties of belonging to a social group (or groups). A profession is a kind of social group where social structures shape perception according to what it means to be a member of the profession. To become a member of a profession it is not just about adopting a way of thinking, it is also about adopting a way of perceiving the world.

Goodwin presents three ways professional vision is manifested in a profession: Coding, highlighting and graphic representations. To exemplify coding, Goodwin discusses the Munsell coding chart that is used world-wide by archeologists to color-code dirt. In the example, archeologists-in-training are scrutinized. Goodwin's point is that novices learn how to perceive dirt like a member of the profession. Despite the fact that the chart does not make the coding process trivial, the chart guides perception according to the profession. Highlighting can be exemplified in the same context. In other examples Goodwin observes how archeologists highlight aspects in the dirt by drawing lines to circumscribe relevant areas. Doing so causes the task of perceiving to be explicitly shared between members, and novices learn to see what the professionals see. For the final manifestation Goodwin discusses the practices within a profession that create and articulate graphical representations. In an example Goodwin describes how two archeologists create a map of the excavation grounds. The map includes several layers of information that are distinct to the archeologists' ability to see in their profession. The graphical representation is in itself a product of a specific profession, a specific visualization of the excavation grounds.

The social structures that determine and constitute professional vision are an architecture of cognition because they determine how information flows and transforms in those specific

situations when a member of a profession perceives the world. Even when a member of a profession is alone when perceiving, that person perceives the world as a member of the profession, and not only as an individual.

Hutchins (1995a) also has several sections that cover the specifics of social distribution, for instance, the occurrence of hierarchies and the reaching of consensus between members. Hierarchies and authority can be important in organizations where the nature of reality is socially defined, as in the case of courts (p.256, see also Goodwin, 1994). In other situations consensus might be required. Hutchins shows that the type of organizational structure (horizontal or vertical) has direct consequences on cognitive processing. Specifically, Hutchins (p.261) writes: "Where the power to define the reality of situations is widely distributed in a 'horizontal' structure, there is more potential for diversity of interpretation and more potential for indecision. Where the power is collected in the top of a 'vertical' structure, there is less potential for diversity of interpretation, but also more likelihood that some interpretation will find a great deal of confirmation and that disconfirming evidence will be disregarded." These different forms of distribution of power and cognition are something many organizations need to deal with, which can have important consequences for performance.

The social dimensions of distributed cognition also involve the specifics of communicative practices between agents. This is a vast area, but one study that looked specifically at older adults is Harris, Barnier, Sutton, and Keil (2014, see also Harris, Keil, Sutton, Barnier, & Mcilwain 2011). They studied a number of older couples, specifically investigating communication practices between couples in a sit-down situation, where the couples were supposed to collaboratively remember certain facts and past experiences together. Through an analysis of this process they find that the following communication practices inhibit performance: (a) Incompatible reference to expertise regarding a past experience, where, for instance, a partner is seen a priori as the memory expert. (b) Strategy disagreements, where, for instance, each partner interprets a question differently. (c) Corrections, where, for instance, one partner interrupts a story to correct details. They also find that the following three factors facilitate recall: (a) The occurrence of cueing. (b) Production of new information in response to cues. (c) Repetitions. (d) The occurrence of failed cues. For this last factor, Harris et al. (2011) propose that the willingness to cue is itself an important contributor to successful collaborative remembering.

These findings give some indication of the complexity of the process involved in having a successful socially-distributed memory system in non-work environments. But importantly, as the authors also note, the situation in the above case is experimental. Despite the fact that the couples being investigated are naturally-occurring couples and that we can therefore assume that their communication practices are somewhat similar to how they communicate in real life, we do not know how similar these experimental settings are to communication in normal everyday settings. Here it should also be noted that the social dimensions of distributed remembering in real life everyday situations is, to my knowledge, far more frequently researched than physical dimensions (see, for instance, Bietti, Stone, & Hirst, 2014; Hirst & Levine, 1985 for examples of such foci)[4].

Although Hutchins' original work includes many examples of how information flows and transforms that are social in their architecture, the same principles can be applied to understand flow and transformations across physical architectures. Principles such as information hubs and bandwidth can be seen and exploited in physical structures. In other words, when using a

[4] Since this thesis focuses primarily on the physical aspects of distributed cognition there is a large category of literature which I omit from this review.

distributed perspective there is often nothing special about social distribution in terms of principles of information flow, despite the fact that there can be special aspects of social interaction (as, for instance, was noted in the study by Harris et al (2014) described above). In many of the above examples the social distribution is also mediated by technological means. For example, as previously mentioned, the layout of the physical setting can have direct consequences for social distribution and cognitive accomplishment. The horizon of observations is one such principle. The physical ecology can also establish other practical situations. Hutchins (1995a, p.197), for instance, mentions an example where certain operations are impossible to manage for one individual because of the physical allocation of equipment, even though the operations would have been cognitively possible for the individual to manage if the equipment had been arranged differently.

A study on everyday life that combines the use of social and physical architectures is Wu et al. (2008), which uses a distributed cognitive perspective to understand how families cope with activities when a member has diagnosed memory problems. The authors report a number of practices that seem to have positive outcomes for performance: the use of redundant information, frequent and repetitive synchronization of information between family members, and instant and continuous awareness of updates. This list of practices is close to what is sometimes considered important for cognitive outcomes in professional settings (see, for instance, Hutchins, 2000; Lützhöft & Dekker, 2002).

Below I consider versions of physical distribution of cognition in more detail by considering the physical environment in relation to individuals.

3.5 Distribution across physical architectures

The descriptions that appear in the literature of the physical mode of distribution have most often not been described as distributed cognition. Instead, situated cognition has been the principal concept. This is because the empirical center is the individual and her immediate physical environment. There is general agreement between distributed and situated cognition that physical arrangements can alleviate internal cognition, and therefore can become coupling structures. However, there are a number of theoretical concepts within this notion that clarify cognitive mechanisms.

This section will, for instance, focus on the continuum of explicitness in representational functionality. Note that in the examples below the external structures will be material, but the principles could, in theory, also be used to understand distribution across the immediate social environment.

3.5.1 Situated and contextualizing agents

The core principle of situated cognition is situatedness, which has a specific focus on individual brains' directedness toward, and coordination with, external structures (Clark, 1997). This principle emphasizes moment-to-moment coupling with the external environment, which is reflected in the recent paper by Clark (2013) mentioned previously (3.1), where he argues that brains are, above all, prediction machines that constantly match incoming information with previously held expectations in order to support actions and perception (see also Clark, 1997, 2006)[5].

[5] Related concepts to the coupling idea include extended mind (Clark & Chalmers, 1998), embedded cognition (Rupert, 2004), and enactivism (Varela, Thompson, & Rosch, 1991), all which I omit from my review because I have not used them in my empirical analysis. However, some of these ideas are mentioned in my description of embodieness.

Humans are context-framing beings, which means that they are constantly in a dynamic relationship with their settings and the experience of being in those settings. This idea can, for instance, be seen in Clancey's (1997) definition of situated cognition: "To summarize, cognition is *situated*, on the one hand, by the way conceptualizing relates to sensorimotor coordination and, on the other hand, by the way conceptualization, in conscious beings, is about the agent's role, place, and values in society. Thus, situated cognition is both a theory about *mechanism* (intellectual skills are also perceptual-motor skills) and a theory about *content* (human activity is, first and foremost, organized by conceptualizing the self as a participant-actor, and this is always with respect to communities of practice)" (pp. 27–28).

To my knowledge, one of the first researcher to elaborate extensively on this idea of context-based framing from a cognitive science perspective was Jean Lave (see e.g. Lave, 1977, 1982, 1988; Lave, Murtaugh, & de la Rocha, 1984). From her perspective the mechanisms of cognition can never be understood if we refrain from studying them in their everyday habitats, where cognitive processes are seen as coupled with cultural and social orderings. This also means that how individuals interpret situations and settings is a consequence of their social and cultural experiences. This notion of individuals' connections to cultural context is close to schema-theories that, within psychology, were separately originally elaborated on by Piaget and Bartlett. This notion is also similar to Hutchins and Goodwin's cultural perspective on cognition, which states that humans perceive and think according to experiences they acquired through belonging to a certain group and physical setting.

Since humans are mentally connected with their immediate environment they are in the position of coordinating features of the environment with internal resources. The immediate coordination between internal and external processes has been extensively characterized and specified by David Kirsh and Andy Clark, in their respective writings. Clark (2008) pictures human thinking through what he calls the Principle of Ecological Assembly: a human being is a "canny cognizer [that] tends to recruit, on the spot, whatever mix of problem-solving resources will yield an acceptable result with a minimum of effort." (p.13). The principle suggests that the human (the canny cognizer) utilizes internal and external resources that are available in the specific situation without showing preference for the kind of resources used. If a human decides, deliberately or non-deliberately, that it is efficient to use the external world to manage information processing, then they will do so. At this point, we can already note that Clark's description of the situated human is a sketchy account that does not address the issues of coordinating internal and external resources. However, Clark's theoretical ideas emphasize in situ problem-solving and understanding of cognitive situations.

The idea of in situ problem-solving can be traced back to Lucy Suchman's (1985) concept of *situated action* and Jean Lave's (1988) studies on routines and arithmetic abilities in supermarkets. They criticize previous research within cognitive science, and specifically research on artificial intelligence, for emphasizing the importance of internal plans. In one example Suchman describes two humans trying to make sense of a copying machine. By contrasting this process against how problems were supposed to be handled according to the manual, she concludes that the path towards the objective was not met by following a pre-specified plan. Instead, the objective was met by acting on the changing physical and communication situations that took place during the process of understanding the machine. Through her analysis, Suchman re-specifies what plans (internal or external) are by stating that plans are a resource for, and not a controlling structure of, cognitive accomplishments. Suchman also specifies plans as weak resources that are necessarily vague, and that in retrospect filter out what actually happens in specific situations. I interpret this description primarily as a reaction against traditional cognitive science. I do not think that plans are irrevocably

weak or vague resources in principle. Rather, the weakness and vagueness is relative to situations, problem definition, and experiences of agents involved, all in accordance to foundational principles of situated cognition defined by, among others, Suchman.

Lave and colleagues (Lave, 1982, 1988; Lave et al., 1984) make extensive cases on the topic of education and arithmetic abilities. Specifically, she compares arithmetic abilities in more formal settings with less formal settings, such as apprentice-based tailor settings in Liberia and American women shopping in supermarkets. She concludes that arithmetic abilities, specifically how we cognitively solve arithmetic problems, cannot be generalized across these settings. When comparing in situ supermarket math tasks with formal math tasks she finds that the cognitive process is shaped, as in the case of in situ problem-solving in the previous section, by the resources available in each setting.

For instance, in formal settings an economic best-buy problem is usually solved by, for each product, dividing quantity by price and seeing which product has the lowest unit price. But in the supermarket it is observed, through think-aloud protocols, that when most participants compare two (or sometimes three) products they instead *estimate* if the $price^1/price^2$ quotient is larger or smaller than the $quantity^1/quantity^2$ quotient. Consider an example where product A costs 25 SEK and weighs 200g and product B costs 30 SEK and weighs 275g. In a formal setting the correct way of calculating the best buy is to calculate 200/25 and compare the result with the result of 275/30. Instead, what Lave finds is that people compare the ratio between 200 and 275 with the ratio between 25 and 30. In other words, the heuristic is: does the increase in cost somewhat pay for the increase in weight?

One possible reason for this strategy is that this is how information is presented in supermarkets. Price is compared with price, and quantities are secondary information that shoppers need to search for. This strategy works as long as the number of products is low, which is often the practical case in supermarkets. But what is taught in formal school is a universal method that works independently of the number of quotients quantified. Lave's message is that arithmetic performance, and cognitive performance in general, is significantly determined by the settings in which they operate. In another example she describes how a 12-year-old vendor (M) selling coconuts in Recife solves simple arithmetic problems in a market (Carraher, Carraher, & Schliemann, 1982 as qouted and discussed in Lave, 1988, p.65).

Customer: *How much is one coconut?*
M: *35.*
Customer: *I'd like ten. How much is that?*
M: (Pause.) *Three will be 105; with three more, that will be 210.* (Pause) *I need four more. That is…* (pause) *315… I think it is 350.*

The base of three used by the vendor is not what is being taught in formal schools, but it is a strategy that works in the market setting for this vendor because three is a common number of coconuts sold in a group. In the market it is also shown that five vendors together had a 99% correctness rate on arithmetic problems similar to the one above. In contrast, when they are measured on equivalent arithmetic tasks in formal settings with pen and paper the vendors have only a 74% correctness rate. Lave concludes that it is not just the available resources that shape and frame the cognitive process. The cognitive processes people employ are driven by people's experiences of being in similar situations. People tend to use pen and paper in school settings because that is how math is conducted in school.

In Lave's reasoning there are similarities to how distributed cognition has depicted professional settings. Similar to professional settings, the experience in a specific environment shapes how situations are perceived and which cognitive protocols that are used. The difference is that what we do in supermarkets is often not considered as a profession, because there is no formal education for supermarket shopping. But certainly, the participants Lave describes act and think in accordance with a social collective, which still shapes cognitive processing. She notes, for instance, that in supermarkets the best math solution is not the only determinant for strategy use. Specifically, she notes that math problems in supermarkets are often abandoned, and that strategies people employ can be determined by the socio-economic background individuals have.

An overall conclusion from Lave's research is that when we want to understand cognition we need to study activities in which cognitive situations occur, where the activity and setting-specific socio-interactional protocols of the people we study determine the cognitive process.

Lave makes an extensive point about the expectancies and routines of everyday life. In her definition of everyday life, people's expectations and routines are central. "*It is the routine character of activity, rich expectations generated over time about its shape, and settings designed for those activities and organized by them, that form the class of events which constitutes an object of analysis in theories of practice."* (Lave, 1988, p.15). Because of the rich experiences people have in their everyday environments outside of work, they are also involved in a rich cognitive coupling with their environments.

In relation to Suchman's notion of plans Lave raises issues of how we understand routines in everyday life. Lave (1988) notes that routines, as we experience them in everyday life, are in some part an illusion, and in fact always to some extent a complex improvisation. Most people have some kind of morning routine that can be more or less specific. But even if you have a very detailed and exact morning routine, the specifics of each day's morning activities are not constant. Lave (1988, p.188) uses the concept of "continuity by fiat" to describe that (cognitive) processes and products are often the same only because they are regarded as the same. For example, making juice from frozen fruit rather than fresh fruit could be regarded by some as routine, while by someone else it might be a violation of the normal activity of making breakfast, which might in turn significantly change the ways things are done cognitively in the morning and during the day. Naturally, Lave's and Suchman's perspectives have methodological consequences. For instance, retrospective descriptions of how an activity unfolds become problematic because they do not necessarily tap into what is going on.

Making use of Lave's notion of people's expectations about situations, it is possible to theorize about when in Clark's ideas of the human prediction machine (as mentioned earlier) the deliberate thought processes step in. According to my interpretation of Lave, it would be either when the routine is not as fixed from the start, or when violations of routines occur. A methodological consequence of this is that it is not just intra-individual variation that should be studied. Intra-activity-contextual variation in relation to the person acting must also be studied.

Both Lave and Suchman bolstered the development of new trajectories in cognitive science by explicitly contrasting their research to traditional cognitive science, and calling for situated theories of cognition[6]. But according to my reading, they did not formulate specific principles for information flow between agents and environments. Kirsh, however, has focused on providing

[6] This is also true for movements of enactivism, extended mind and embedded cognition which, as previously noted, I do not review.

principles for how and why cognition can be distributed within an individual's immediate environment, which I consider in the next section.

3.5.2 Types of resources

In one article Kirsh (2010) describes something that specifies Clark's idea of a canny cognizer. He describes the basics of internal-external coordination in terms of cost-structures. The reasoning goes like this. To solve a specific problem, humans can use internal processing. But they can also couple themselves with external structures to conduct external processing. Internal processing and external processing both come with costs, and a cognitive process will under normal circumstances flow wherever the total cost is lowest. As Clark also notes, for many situations humans will allocate processing to their immediate environment, but here Kirsh is more specific than Clark. Kirsh notes that the coupling process itself also comes with a cost. Kirsh's cost structures can be understood in relation to the foundational principles of distributed cognition where these three types of cost structures can be found in any cognitive system. Kirsh focuses on the intra- and extra-cranial integration processes, but we can also see that the same features exist within the brain. Consider, for example, what in recent years has been coined type 1 and type 2 thinking (Kahneman, 2011) where, for instance, type 1, the fast and automatic thinking, costs less in terms of internal resources, but can have unwanted consequences if used in the wrong cognitive situation. It is also reasonable to imagine that switching between automatic and deliberate processing would come with a cost.

A question that is related to the reasoning behind cost-structures is why individuals should couple themselves with their immediate environments, that is, why is it that the cost can be lower across external structures? Kirsh and others have, in a number of publications, addressed this and formulated a number of principles regarding how people reshape their environments and why the physical (social) environment can be coupled with the brain in a way that is efficient from a cost-perspective.

One mechanism is *jigging* (Kirsh, 1995). A jig is something in the environment that physically or informationally structures the environment in such a way that it reduces degrees of freedom in the process of meeting a goal. An example of informational structuring mentioned by Kirsh is how groceries and goods in supermarkets are structured so that some groceries will be perceived more than others. In this way visitors are provided with cues to act on. To exemplify physical structuring, we can also picture a supermarket where the visitors are constrained to walk a certain path to get to the checkout. In real life these two kinds of jigging often go hand in hand. Kirsh uses the example of the prevention of unhealthy snacking to illustrate this. One way to prevent unhealthy snacking is to constrain the number and kinds of choices present in the fridge. The individual is thus cued to eat healthily, but is also constrained from eating unhealthily. This works because human thinking works according to the very situated and cost-efficient principle "out of sight is also out of mind" (p.38).

This idea of "out of sight out of mind" is also the substance of the previously-mentioned principle *horizon of observation* (Hutchins, 1995a, p.268), which focuses on the fact that information can be physically available or out of perceptual reach. Maintaining a larger horizon of observation was shown by Hutchins to have positive outcomes for team accomplishment. In one example (1995, p.273-274), a communication error between two parties is spotted only because a third party is included in the phone line communication. In the example the third party notes that the second communication member misunderstands an utterance of the first member, whereupon the third party steps into the chain of communication with his own interpretation of the first member's utterance. This time the second member notices his misunderstanding and corrects himself. In a

similar way, this principle is applicable to the physical settings of everyday life, where, for instance, putting things in locations where you normally use and perceive them allows them to be within the horizon of observation, thereby increasing the likelihood that an object will act as a cue for an intention.

Intelligent uses of space

As shown above, physical arrangements can, depending on the specifics of the arrangement, tap into both team cognition and individual processes. Kirsh (1995), in the article *Intelligent Use of Space*, focuses specifically on individual cognition when he describes three general and several specific cognitive effects that spatial arrangements can have. They are as follow.

Spatial arrangements can through highlighting (see cueing) and displaying affordances (see constraining) simplify choice by (a) reducing perceived actions, (b) eliminating decision-points, and (c) off-loading heuristic properties. Imagine putting all the vegetables to be cut for dinner on one side of the sink. Since the vegetables to be cut have been grouped in space, the spatial arrangement has reduced the number of perceived vegetables to be cut to those specific vegetables. At the same time, given that the salad has been planned before grocery shopping, there are no decision points in the cooking process for which vegetables should be included in the salad and which in the stew. When the vegetables have been washed, the vegetables that are to be used in the stew are placed on the cutting board on the other side of the sink, while the ones that are to be used for the salad are placed next to the cutting board. By putting categories of vegetables in different locations the arrangement has heuristic properties in the form of temporal orderings of actions (see, for instance, Hydén, 2014 for how the above principles can assist people with a dementia diagnosis).

Spatial arrangements can simplify perception by (a) physically clustering, (b) grouping to categorize according to some relational property between objects, (c) using symbolic marking, and (d) using physical clustering to sharpen perceptual acuity. For instance, imagine solving a large jigsaw puzzle. Common strategies for solving the puzzle include the use of color- and edge-clustering. This is an efficient strategy because human perceptional acuity is otherwise not apt to perceive such a large jigsaw. Going back to the example of the vegetables above, putting the unwashed vegetables on one side of the sink and the washed ones on the other side is one example of using space to simplify perception of categories, because it is a categorization that would have been hard to perceive without the physical arrangement. It is also an arrangement that alleviates internal memory processes since there is no need to remember which vegetables were washed. Moreover, putting the vegetables for the stew on the cutting board simplifies perception since they then share the same relational perceptual property of being on the cutting board, which makes the search process for the vegetables for the stew easier. Symbol marking is characterized by some physical feature that must be interpreted in the form of some kind of understanding of what the symbol means. This could, for instance, be a string on an object that distinguishes it from an otherwise similar object.

Spatial arrangements can simplify internal computation by doing some of the computation in the world. Kirsh's best-known example is how proficient Tetris-players quickly rotate each zoid when it has entered the screen. They do so to offload mental rotation to the physical structure (Kirsh & Maglio, 1992). Kirsh and Maglio show this by measuring rotation time together with perception time and comparing this to what it would take to mentally rotate a zoid. It displays a better cost-structure to physically rotate zoids and perceive their matches, compared to mentally rotating and imagining where they would fit. Importantly, the player may still need to internally compute the best location for the zoid. But a part of the full computational process has been offloaded. Other

examples focus on situations where it is shown that humans can think better about novel interpretations when they have a physical representation to work with (Kirsh, 1995). One example of this is how we rearrange letters in Scrabble, where the computation is done both by internal processing and by externally shuffling letters.

A related concept to these forms of intelligent uses of space, especially on the topic of the ability to think in novel ways, is Clark's (2005) notion of *surrogate situations*. Clark describes a surrogate situation as a kind of representational structure that works as a stand-in for a situation that is not physically or temporally present[7]. It could, for instance, be a model, a diagram or a sketch. Clark (2010) discusses two ways that surrogate situations can assist cognitive processes. First, they often highlight key features by suppressing less relevant information. For instance, for certain kinds of decisions, 2D-drawings may be better suited than 3D-drawings (see Clark, 2005 and Kristensson et al., 2009). Second, they relax temporal constraints on reasoning. For instance, when building a house it is easier to figure out the location of the bathroom by using a blueprint before building the house, rather than deciding on the spot at the construction site. Having a surrogate situation allows more cognitive resources to be allocated to taxing tasks, such as, for instance, recalling intentions or producing novel ideas.

Partly overlapping with surrogate situations is Kirsh's (2010a) explanation of what is special about external representations (compared to internal representations) that allows them to empower cognitive processes. (a) They can serve as a more explicit shareable object of thoughts, which individuals can, for instance, refer to when communicating with others. (b) They are more persistent over time. (c) They can more easily be re-represented and changed in ways that make solutions and situations more transparent. (d) Often, an external representation can be a more natural form of representation than its internal counterpart (see naturalness principle above). (e) External representations can support a more explicit encoding of information. (f) They allow for the creation of more complex structures. (g) They help coordinate thought, and (h) they change the cost-structure of the cognitive process (potentially in a positive way for the individual). The reasons described above can, to some extent, be derived from the fact that external representations are not dependent on a brain-like architecture.

Many of his examples are from non-work environments. Kirsh's (1995) paper *Intelligent Use of Space* takes its empirical basis from a mixture of observations of professionals and other people in non-work life situations. The main point is that one essential characteristic of experts is that they shape their physical environment in intelligent ways, and that this is something that needs to be included in the modeling of cognition. The descriptions span a number of non-professional situations in domestic and non-domestic environments. Despite the fact that important theoretical points are made, and that the analysis of intelligently organized spaces in real-life situations is extensive, Kirsh's empirical descriptions are short and do not describe normal people acting in real-life settings. In fact, the actual *use* of space is hard to decipher from the descriptions provided. Since humans tend to have ample experiences of their home environments there are reasons to believe that the phenomena Kirsh reports on will bear out in reality. More extensive descriptions come from Lave, which I have described previously, but also from other studies on domestic environments.

[7] The definition and description of surrogate situations seems to mirror what within the study of the brain is called mental models (c.f. Gentner & Stevens, 1983; Johnson-Laird, 1983). Perhaps surrogate situations can be viewed as the external counterpart to mental models.

Empirical examples

First, empirical examples from everyday life of Kirsh's principles of the intelligent use of space comes from Palen and Aaløkke (2006), who report on a study of older adults and their strategies for managing medication. This study is highly relevant for this thesis because it is one of a few studies that takes the whole home as the unit of analysis to understand a cognitive activity which explicitly involves prospective memory requirements. Ethnographic methods were used, such as shadowing of health care workers and contextual interviews with the elderly participants. They also videotaped two participants preparing their medicine for the next day.

They describe how a number of older individuals proactively shape their physical environment to manage medication adherence. For instance, one participant kept medicine bottles in a linear order in the cabinet to provide a structure for remembering which medicines to take in what order. They also notice how the shapes of a space are congenial only in combination with specific routines. They found that changes in medicine routines reverberated into physical properties of the participants' homes. For instance, mealtime medicines were often located near where the food was eaten, but when the same medicine was meant to be taken at some other time one participant started to use a pillbox. She started to use a pillbox because she needed something that linked spatial and temporal orderings, and her mealtime routine could not do that any longer. In general, participants distributed their medicines across their homes based on the likelihood of being somewhere at a specific time of day.

Palen and Aaløkke (2006) also document what Tribble (see 3.4) calls cognitive thrift. Specifically, some participants only remembered the relevant information about the medicines that was necessary to properly take the medicines at the right point in time, and in combination with the correct circumstances. Other information was seen as superfluous. Palen and Aaløkke (2006) also identify other important aspects of participants' perspectives on their medication management. For instance, keeping medicines in a visible space also means that they openly display their illnesses. Therefore, some opted not to keep their medicines in an open space, even though visibility would decrease their cognitive burden. Instead, some participants preferred having a strong routine, for instance, opening the cabinet as part of their morning routine.

Two other studies, Crabtree and Rodden (2004) and Crabtree (2003), also take the home as their unit of analysis when they describe practices of intelligently shaping spaces. Specifically, they describe information flow in family homes and family routines for managing information and communication. While they do not directly refer to distributed cognition, they apply concepts that are similar to those employed by studies using distributed cognition. For instance, they consider a case of mail handling and how mail enters the home, is collected by a family member, and sorted and placed at some location by the same family member based on aspects such as relevance to other family members. By having various routines for mail handling, information flow between family members and actions among the family members are coordinated. The authors plot the general course for mail within the home ecology and define a number of manifestations of how communication is realized in space. They define three types of communication spaces (paraphrased from Crabtree & Rodden, 2004, p.205):

Ecological habitats are places where communication media live and where residents go in order to locate particular resources. These spaces (for instance the kitchen table) are fixed spaces in plain view, which are also described as spaces that family members do not need to search for. *Activity centers* are places where media are actively produced and consumed and where information is transformed. These are centers that differ to some extent from the previous type. Mail is, for

instance, handled on the porch though it is not a communicative habitat for family members. *Coordinate Displays* are places where media are displayed and made available to residents to coordinate their activities. For instance, mail might be placed at the very corner of the kitchen table so that it is not missed by other family members. Again, these displays overlap with previously mentioned spaces and I interpret coordinate displays as a type of ecological habitat that highlights more urgent information.

What is especially compelling with Crabtree and Rodden's (2004) approach is that they view routines and practices in domestic environments as complex and subtle phenomena, which is not very different from what occurs in work-settings.

There are also studies in professional settings that have directly considered the use of space and prospective memory. Grundgeiger, Sanderson, MacDougall, and Venkatesh (2009 see also Grundgeiger, Sanderson, MacDougall, & Venkatesh, 2010) use distributed cognition in their research on nurses and prospective memory. They present an analysis of video and interviews from nurses' practices in intensive care units. They describe three types of support nurses receive from their environment to perform intentions.

Passive representations are described as equipment that the nurses directly associate with a task. As an example, the authors mention how some nurses are reminded of a pre-transfusion procedure by looking at a label on the blood bag.

Active representations are described as features of the environment that have been designed, either by the nurses themselves or by a designer, to serve as a prospective memory reminder. Examples mentioned included post-it notes created by the nurses and visual cues for performing certain sequences at relevant places in the environment created by the organization.

Proactive representations are described as dynamic and adaptive resources that ensure that intentions are conducted. As an example of a human proactive resource they describe the use of an extra monitoring nurse in certain situations, even when only one nurse is necessary for performing in the situation. As an example of a non-human proactive resource they describe how, when setting the threshold for alarms on physiological monitoring equipment, the nurses choose values that are close to normal levels to make sure that the monitors are checked frequently.

Perception, projection, and imagination

In several of the above examples there are instances of what Kirsh calls *projection*. Projection is the ability to project internal representations onto physical structures (Kirsh, 2009). To explain projection, Kirsh describes a continuum for couplings with physical structures that runs from perception to projection to imagination (Kirsh, 2010b). A demonstrative example is three representational ways of playing tic-tac-toe. Imagination is necessary when you have no representational structure in front of you, where, for example, you need to internally remember your previously spoken moves. If, on the other hand, you have the regular tic-tac-toe grid with all previous moves in front you, then you can rely more on perception to help you remember. Projection is necessary when you have only a partial representational structure in front you. In the case of tic-tac-toe, this might be just the grid, but without the previous moves marked on it. The point is, having the grid provides a representational structure that internal representational entities can be projected onto. The grid helps to anchor thought processes.

Another study that demonstrates projection is one on professional dancers, where Kirsh (2010b) describes how the dancers are able to anchor their thought process by using bodily sequences that

are simplified versions of the intended, fully-realized sequences; this is called *marking*. By doing this the dancers can devote more energy to other processes, for instance the process of learning and remembering the choreography, before dancing the full routine. Just as when playing tic-tac-toe with a blank grid, the dancers are able to *project* their intracranial thought process onto an extra-cranial architecture, which in this case is the dancer's own body.

Hutchins describes something equivalent to projection when he talks about *projection of internal conceptual structures onto material anchors* (Hutchins, 2005, see also Fauconnier, 1997). An example from everyday life is the technique of remembering the number of days in the months throughout the year by projecting the names of the months onto the hand, using the knuckles and the spaces between. Other examples include how Micronesian navigators navigate by using properties of the stars to anchor mental images (Hutchins, 1983) and how we perceive groups of people standing in certain arrangements as lines and queues (Hutchins, 2013).

Despite the overlap with Kirsh, the analysis from a distributed cognitive perspective goes on to make an additional distinction about how an individual anchors intracranial thought-processes, between anchoring to extracranial structures and anchoring to *properties of the cognitive ecosystem* in which these anchoring processes exist. For instance, seeing a group of people first as *a line* and later as *a queue* is in part an individual accomplishment. Humans have the ability to mentally project a trajectory onto a spatial array. This is at the heart of Kirsh's description of projection. But why humans interpret these spatial arrays as queues is determined by a number of other practices. "First, there is a cooperative social practice of forming linear arrangements of bodies. Second, there are spatial material (and perhaps architectural) practices that designate some location as the source of service. Third, there is a socially shared individual mental practice of seeing the linear arrangement of bodies with respect to the service location as a queue." (Hutchins, 2013, p.6, see also the previously described notion of professional vision proposed by Goodwin, 1994). From Hutchins' description it becomes clear that to understand cognitive processes we need to view cognition on various levels. To describe what is going on in the head we need to account for properties of the larger cognitive ecosystem.

The first message here is again that a reciprocal process is taking place between representational structures in the world and representational structures in the head. Perhaps a more important message is that there are kinds of (representational) structures in the world that, when they are coupled with individuals, create various forms of cognitive processes. Because of this, Kirsh (2010a) criticizes the notion of external memory as something that is about offloading internal memory. The problem is that the notion of offloading memory only tells half of the story of what is going on. It is for instance true that the previous note taking relieves internal memory to some extent, but the note taking also transforms the cognitive process into something else that follow new causes and consequences (see also the previous discussion of the intelligent uses of space).

The reasoning that underlies the concept of projection suggests that there must be some semiotic connection between the physical structure and the solution of a problem. One model that focuses on types of couplings is Charles Sanders Peirce (1932) theoretical model for semiotics, which differentiates between symbols, indexes, and icons. Of the three categories, icons most closely resemble the things they represent. An icon could, for instance, be a picture of something. Indexes do not directly represent something, but they do directly point to some meaning. A dark cloud, for instance, increases the perceived likelihood of upcoming rain. Symbols are things that have become separated from the context to which they refer. Words are examples of symbols that can be used to refer to something which is not directly present. These different types of connections that

humans have with their environment are valuable for understanding the situated agent as it makes sense of its surroundings. Similarly to Kirsh, the different types of semiotic connections show that physical structures can play a significant part in the cognitive process whether there is a clear representational structure or not. There can, therefore, still be couplings between individuals and physical structures without symbols that move between (see also Norman's, 2011, description of *social signifiers*).

Although humans have the ability to interpret symbols, indexes, and icons, this does not mean that all types of structures or all versions of each category are equally preferred in all situations. Rather, there are additional principles that suggest which structures are preferable in a given situation. Norman's *perceptual principle* (Norman, 1993) suggests that "perceptual and spatial representations are more natural and therefore to be preferred over nonperceptual, nonspatial representations". Importantly, though, for this to work efficiently there must be a natural mapping between the representation and what it stands for (Norman, 1993, p.72). In accordance with this the *naturalness principle* (Norman, 1993) suggests that "experiential cognition is aided when the properties of the representation match the properties of the thing being represented" (p.72). For example, it might be easier to remember how and when to do something if it is represented as a pictorial schema of a sequence of actions, rather than as symbolic words describing what to do.

Norman's principles suggest that there is a certain potential cognitive empowerment associated with coupling information processes to external structures, but only if it is done right. To exemplify what it means to do it right, consider again the reasoning of cost structures and the costs of coupling when projecting thoughts onto the grid in tic-tac-toe. There are three major factors that influence the cost. First, the complexity of the task: projecting x's and o's onto a 3x3 grid comes with a lower cost than projecting x's and o's onto a 9x9 grid. Second, the expertise/experience of the agent: the more the expert someone is, the more complex computation she can do in her head. This is because if you are an expert you are also able to perceive more possibilities with less physical anchoring and less physical explicitness (see, for instance, Chabris & Hearst, 2003 for an example of chess). Third, the relatedness between structure and problem: in the game of tic-tac-toe the grid matches the structures of the game to a relatively high degree. If, for instance, we were to take away all horizontal lines the match between structure and problem would be lower.

I find projection to be a useful concept because it elucidates much of what it means to be a situated brain-perceptual system. To understand this better note that the examples above are clear problem situations. The dancers need to practice their choreography and tic-tac-toe players aim to win the game. But at the heart of the concept is something more basic than clear problem situations. Kirsh (2009) believes that a project-create-project cycle is at the heart of much sense-making, and that this becomes especially clear when humans are involved in problem-solving. But I also think that the role of projection becomes clear when the problem situation involves physical structures that have a connection to the problem at hand. It is convenient to project dancing onto a body, and it is convenient to project tic-tac-toe onto a tic-tac-toe grid, But there are likely less clear cases out in the real world.

Kirsh's project-create-project cycle can be further compared with Neisser's (1976) perceptual cycle. The perceptual cycle is a theoretical model that emphasizes the ongoing interpretation of input from the surroundings. In this model the agent's perception of the world modifies its mental model of the world, which in turn directs actions, which in turn leads to new information sampling of the world, etcetera. It is a fundamental cognitive mechanism that, in most cases, humans are sensitive to their present circumstances so that they can act on their present circumstances. The projection-

cycle, however, suggests something different: that it is the internal mechanics that determine what we sample when perceiving a physical structure, which in turn affects how we understand and act. These two cycles can be seen as complementary. First, humans need to perceive some external structure before projecting thoughts onto it. Second, in the perceptual cycle projection can be viewed as a type of action, a mental one, that is anchored to a physical structure. As the Kirsh's reasoning suggests, in a problem-solving situation we are likely to use a modified version of the perceptual cycle, in which we project thoughts onto the physical structures from which we sample information. When solving problems, there is a directedness of our mental process to make sense of present and future circumstances, because concrete problems often demand that we are directed in such a way.

This combination of cycles is similar to how I previously described the way that CSE views functions in cognitive systems. However, within CSE it is not just individuals that account for the cycles, it can also be a collection of individuals and tools that control specific functionality. In fact, COCOM is influenced by classical cybernetics feedback loops and Neisser's perception-cycle. In COCOM it can be the collection of parts of the system that perceive the world and modify the mental model of the world, which directs actions, and which in turn leads to new information sampling of the world. The same collection of parts is what predicts and projects understanding on top of what the world provides.

3.5.3 Embodiedness and the non-representational

The body is a special kind of cognitive vehicle that is with an organism from birth, which in recent decades has been proven to be intrinsically linked to mental life. Hollan, Hutchins, and Kirsh (2000) include embodiment (together with cognition as a cultural and social process) as a necessary tenet of distributed cognition, because it is what allows individuals to be coupled with their environments.

We have already seen an example of the role of the body in, for instance, how dancers use their bodies, not just for dancing, but also as a vehicle of thought. In this thesis, I will use the notion of bodily cognition to refer to the idea of the body as a necessary means for interaction and an opportunity for interaction with environments. Note, however, that the role of the body in cognition is not a unitary theoretical idea. Embodied cognition is a larger movement within cognitive science with goals that, to some extent, go beyond my use of the concept of body in this thesis. Therefore, I will pave the way with a brief discussion of what is meant by embodied cognition and the versions of this concept that I will use in my analysis.

Shapiro (2011) suggests three kinds of theoretical positions within embodied cognition: (a) conceptualization, (b) replacement, and (c) constitution.

Conceptualization theories can be boiled down to what is known as *the symbol grounding problem*. The symbol grounding problem is a formulation of the problem of how abstract symbols that are used in mental computation get their content and meaning (Harnad, 1990). Conceptualization theories within embodied cognition address this problem by holding that symbols get their content from bodily interactions with the world, which are, among other things, constrained by features of our bodies (see Miller & Johnson-Laird, 1976 for a model of conceptualization). The conclusion is that human thinking is more or less grounded in bodily experiences (see e.g. Barsalou, 1999; Lakoff & Johnson, 1999). An empirical example of conceptualization is Beilock and Goldin-Meadow (2010), who showed that gesturing adds content to mental representations in such a way that subsequent performance can be affected in tasks that use these mental representations. Anderson (2003) argues

that solving the symbol grounding problem is what truly delineates embodied cognition theories from situated cognition theories in general. Conceptualization has not been at the heart of my empirical research. Rather, my focus has primarily been on a combination of replacement and constitution aspects. However, understanding how individuals interpret their surroundings is important for any cognitive analysis, symbol grounding or not.

Replacement theories suggest that evolution has equipped humans with energy efficient processes that minimize the need for complex abstract computation. Instead of abstract computation, simple heuristics are used, which involve bodily interactions with the physical environment. A prime example is how humans catch a ball (and how many predators catch prey). Instead of computing the trajectory of the ball by including distance, velocity, angle, air resistance, etcetera. the human fixes her gaze on the ball and adjusts direction and running speed so that the angle of her gaze remains constant (McBeath, Shaffer, & Kaiser, 1995). Replacement theories have mainly focused on explaining situations in which the body is required for solving the problem, such as catching a ball (Shapiro, 2011), but in theory bodily heuristics could also replace non-body cognitive processing.

Constitution theories suggest that the body is part of cognitive processes. This is a less theoretically extreme form of embodied cognition, since it does not refute the notion of complex intracranial computations but instead suggests that the body is a resource that plays the same part in cognitive processes as other external resources. A prime example of this is how humans count on their fingers. Another example is Kirsh's (2010, see also section 3.5.2 above) study on professional dancers, where it is shown that the body can work as a representational vehicle of thought.

As a concept within cognitive science, embodied cognition is the latecomer of the perspectives presented in this chapter, but it originates from earlier philosophical ideas at the first half of the 20th century (see e.g. Heidegger, 1953; Merleau-Ponty, 2004) and Gibson's ecological approach in psychology, which started to take shape in the 1950s (Gibson, 1986). Together, these earlier theories (similar to Suchman, 1985) argued for the notion of actions as key to the understanding of human thinking and perception. Proponents of embodied cognition have also been inspired by connectionism, which started in the 80s and attempted to model cognition as parallel processing between simple units in a network (Churchland & Sejnowski, 1992), a process that to some extent was supposed to resemble the mechanisms of biological brains. Proponents of both connectionism and embodied cognition argue that we do not necessarily need symbols and representations for all cognitive processing. On the surface, this stands in contrast to Hutchins' original idea of distributed cognition, which maintains that cognition is primarily a symbol manipulation process.

However, based on my review of more individualistic perspectives I find it important, from a distributed cognitive perspective, to emphasize the non-symbolic features of cognition. I do not consider this to be at odds with Hutchins' formulation of distributed cognition. Recall that distributed cognition (Hutchins, 1995a) was born through a re-interpretation of the PSS-hypothesis as a sociocultural system. It allowed cognition to flow across more architectures than brains and computers. To some extent this also led to a new cognitive description of architectures. For instance, through this new perspective, social orderings must be seen as architectures for cognition, and as a part of cognition just as the architecture of the brain is. But empirically, research under the heading of distributed cognition has mainly focused on how explicit information *moves* across architectures and changes representational states. This focus on explicit information does not necessarily account for all types of cognitive processes.

Sutton (2006a) also writes that mainstream distributed cognition research treats external representations (or exograms, as coined by Donald, 1991) as "passive, stable, and medium independent" components, even though models of biological brains have, in recent decades, started to see biological representations as active and reconstructive. But as noted in several examples above, there is not always a movement of stable information across external media, nor are exograms stable in Hutchins' original descriptions. Reconstruction and re-interpretation of external information across cognitive tools during the navigational task is shown to be a necessity in order for the team to accomplish the navigational task.

Therefore, the move away from stable representational structures is not antithetical to what was reviewed under types of agent-environment connections, nor is it so to how Hutchins actually uses the symbol paradigm to understand his empirical material. In fact, he explicitly relaxes the concept of computation by specifying that "the actual implementation of many interesting computations is achieved by other than symbolic means. For our purposes, 'computation' will be taken, in a broad sense, to refer to the propagation of representational state across representational media. This definition encompasses what we think of as prototypical computations (such as arithmetic operations), as well as a range of other phenomena which I contend are fundamentally computational but which are not covered by a narrow view of computation" (Hutchins, 1995a, p.118).

Notably, what remains of the traditional definition of cognition after this is representational states across representational media. However, Hutchins also relaxes his definitions for representational media, and in this way actually ends up closer to embodied cognition than one might expect. For instance, in his listing of observable representational media for mapping the relationship of the ship to its environment and the position plotted on the chart, Hutchins (1995a, p.119) lists "the world" with its own heading. Hutchins specifies that the relationship between the ship and every object in the surrounding world is specifiable as a direction and a distance, and hence (my inference) is a representational medium. The way that Hutchins operationalizes representational media is close to how Brooks (1991) argues that for embodied and situated agents, the world is often its own best model for the agent to act upon which does not necessarily need to re-represented in the mind.

Sutton (2006a) describes a broad notion of distributed cognition that is in line with Hutchins' description of distributed cognition as a perspective on all cognition. First, as already noted in this description, cognitive systems can exist on different temporal and spatial scales where, for instance, it is explicit that distributed cognitive systems can exist momentarily before later ceasing to exist. Also, in line with connections described by Kirsh, representational structures in the world (or in the brain) are not always stable entities. Instead they are dynamic, and their functionality is reconstructive in a specific setting with a specific interpreter. A consequence of this perspective is that the symbol-grounding problem is as much a problem for external representations as for internal representations. Why humans come to interpret some representation or structure in the material world as meaningful must also be grounded in something.

Cognition across the body is an important analytical focus for understanding cognitive accomplishment. Constitution theories identify the body as a cognitive resource in general, and therefore constitution theories largely overlap with the theoretical principles mentioned in previous sections. But in combination with replacement theories, the body becomes a vehicle of thought that significantly shifts, or evens out, the center for the previous brain-centered cognitive system. This shift is in line with the foundational principles of distributed cognition. In practice the shift

leads to a decrease in the cognitive burdens that high-level cognitive processes in the brain would have without a body.

3.5.4 Epistemic actions and experts

The act of using the body for the creation of intelligent shapes in space can be understood via the notion of *epistemic actions*, which was first discussed by Kirsh and Maglio (1992, 1994) in their studies on expert Tetris players.

Epistemic actions are defined as actions that generate knowledge about solving a specific problem. This stands in contrast to *pragmatic actions*, which are defined as actions that get the individual closer to solving the same problem. Therefore, epistemic actions are often actions that make the world more congenial for solving a problem. In the case of the Tetris players it was an epistemic action to rotate the zoids in the world instead of in the head. In real life these two types of actions are not always easily discerned. A given action can be viewed both as an epistemic and as a pragmatic action at the same time. For example, putting an object at the door to remember to bring when leaving home is both an epistemic and a pragmatic action. It is epistemic because it alleviates internal remembering by replacing it with the simple perceptual task of noticing the object when crossing the boundary of the home. But it could also be argued that it is a pragmatic action because it gets the object in question closer to leaving home.

To understand the notions of epistemic and pragmatic more specifically it is possible to view them in relation to intentions and effects. The expert Tetris players rotated the zoids with the goal of alleviating internal computation, not primarily for the purpose of bringing the zoids closer to the goal. Hence, the action is an epistemic action. This was likely the original intention of Kirsh and Maglios' definition of the concepts (Nils Dahlbäck, personal correspondence). We can use the same reasoning to understand the action of putting an object to bring along in front of the door. It is an epistemic action if the agent puts the object there to alleviate internal computation in some way, for instance to alleviate remembering or perceptual processes. However, I think we can also understand any action from its epistemic consequences. If an individual has habits, without epistemic intentions, to put objects in certain spots that happen to have epistemic effects, those habits are of equal importance in a specific situation for cognitive accomplishment to the intentional epistemic actions. Although they are equally important for accomplishment, it is still important to understand when an action has an epistemic intent. For instance, if a practice exists with an epistemic intent it is likely that the agent has a certain motivation to maintain the positive outcomes of the action across time and circumstances. An epistemic intent is also an indication of expertise with regard to the cognitive environment. On the contrary, if a practice exists without some deliberate epistemic intent, the practice with the positive outcomes also risks giving way to new circumstances.

We have seen that the notion of in situ problem-solving focuses on the mechanisms for reciprocal causation between individuals and their environments to solve cognitive problems. This could consist of opportunistically harnessing resources at hand on a moment-to-moment basis, as emphasized by Clark. But it could also be, as emphasized by Kirsh, about pre-structuring one's environments so that coupling can be established later. Sometimes this pre-structuring is performed by the one who will use the structures, but it could also be performed by someone else, as in the case of the design of grocery stores. Overall, in situ problem-solving informs us that the establishment of couplings between individuals and their environments is sensitive to specific characteristics of the external (representational) structures.

In the characterization of distributed cognition I noted that research most often studies professional settings in which experts perform complex tasks. In this section I observe that certain elements of situated cognition also focus on professionalism. Kirsh states that "cognitive processes flow to wherever it is cheaper to perform" (2010a, p.442). Clark pictures human cognition as a "canny cognizer [that] tends to recruit, on the spot, whatever mix of problem-solving resources will yield an acceptable result with a minimum of effort." (2008, p.13). To make the point that human thinking is tightly coupled with its immediate environment, they describe something that can be interpreted as an ideal agent that cleverly calculates costs. In contrast, using Hutchins' version of distributed cognition, one could say that it is mainly a cultural process that calculates costs, and not primarily agents. Therefore, on an individual level in a given situation it is not necessarily the case that an efficient calculation is made by an individual alone.

To some extent I generalize Kirsh's and Clark's descriptions, but I think it is fair to say that situated cognition has focused to a large extent on showcasing the immediate environment as important, and theoretically part of cognitive processing. However, there is little empirical description of the hassle people have using and interpreting their immediate environments, something that was originally found in the works by Lave and Suchman. In their old theoretical versions of situated cognition nothing goes as planned, if there even is a plan. If there is a plan, or a routine, they are mere shadows of the cognitive mechanisms that explain cognitive accomplishment. Although individuals make use of their immediate environment for cognitive processing there is a constant hassle of sense-making and reframing of situations. Despite this difference, as clarified in the text above, at a glance these disparate strands of situated cognition are consequences of the goals of their respective publications, that is, to contrast against traditional cognitive science, and not necessarily theoretical oppositions. Of course, individuals need to make sense of the physical and social settings they confront.

3.5.5 Cognitive tools

When shapes of the environment such as, for example, a set of representations with specific cognitive functions are instantiated into "a thing", they become something that is often called a cognitive tool or artifact. Norman (1991) defines a cognitive tool (specifically, an artifact) as "those artificial devices that maintain, display, or operate upon information in order to serve a representational function and that affect human cognitive performance" (p.17). Professional settings, where distributed cognition has mostly been employed, are generally full of cognitive tools, and therefore cognitive tools have been given ample theoretical space. Specifically, what cognitive tools are and what they do has been defined in many ways throughout recent decades (see Garbis, 2002; Susi, 2006). I will not go into any theoretical discussion of such issues, but I note that cognitive tools rely on principles of human cognition as described in the previous section and also that they have significant roles in the evolution of human cognition. As was described in section 3.3, cognitive tools travel efficiently across generations and communicate knowledge and practices across and within generations, which determines cognitive processes.

In professional settings cognitive tools are mediators between agents and processes and are necessary tenets for accomplishing intended activities. Everyday life also involves cognitive tools and has, through the evolution of information technology, become more common than in the past. For prospective memory research, as was noted in the previous chapter, calendars and reminder notes are commonly used by most people in their everyday lives. From a distributed perspective these tools come with inherent cognitive properties. Calendars, for instance, come with representations of weeks or months, which delineates chunks of time. From a distributed perspective the properties and content of a calendar, in accordance with how they work in

professional settings, are mediators between agents which use the tool in some future, present, or past state of affairs. Tools can therefore be viewed both from the perspective of their inherent properties and also through the ways they are utilized.

An interesting study that looked at cognitive tools in everyday life that accounted for these two perspectives is de Léon (2003). He reports on cooking activities in the home environments of a number of participants. He brings attention to several manifestations of distributed cognition in relation to cooking. For instance, he describes how participants prepare and maintain their workspaces throughout the activity.

He also makes an extensive case regarding a spice shelf as a cognitive tool. He does so by mapping the historical development of one participant's (Robert) spice shelf. The historical development is shown to follow Robert's increasing interest in cooking, but it has also followed incidental factors, such as the shapes of the spice containers. In certain periods the shelf was more of a box where spices could only be viewed from the top without labels. At the time of the study the spices are categorized into cooking genres (for instance, "western"). One category with common spices he also shares with his wife, and therefore these spices are arranged in alphabetical order. Another category is called "on the way out", which are spices that he will not buy again.

The analysis of the different versions of Robert's spice shelf introduces interesting cognitive aspects of different designs. For instance, a deep shelf that can only display a fraction of spices up front taxes the user's cognition differently than one that only has one large, shallow display where all spices are always visible. From the analysis it is apparent that Robert remembers and makes decisions through probing, maintaining, and shaping the shelf. In the past when the shelf was a box Robert needed to act to gain access to information about the spices. Probing, maintaining and shaping was not as cognitively easy because back then Robert could not observe the spices at a glance. I see de Léon's contribution as important because he gives examples of Kirsh's principles of the intelligent shape of space and tool use through extensive empirical descriptions of how these practices can work in real life.

3.6 Distributed cognition as a framework

Several studies have used distributed cognition to understand aspects of prospective memory in professional settings. There are, based on the review above, reasons to believe that the theoretical principles of distributed cognition can also contribute to the understanding of everyday environments, and specifically the home environment as a cognitive system that shapes prospective memory processes. In fact, Hutchins (1995b), before turning to the technical environment of a cockpit, states that "many of the outcomes that concern us on a daily basis are produced by cognitive systems of this sort" (p.266). The general reason for this is that individuals in non-work environments still participate in everyday life. Kirsh (2008) further characterizes people in general as experts, or near experts, of their everyday environments. This is not a far-fetched idea because the word *everyday* signifies experience, and amount of experience in any environment is a factor for expertise (see for instance Ericsson & Charness, 1994). Kirsh's rationale is also that people's expertise has effect on their physical surroundings because people congenially structure their environments to fit their routines and internal cognitive processes in ways I described in previous sections. There are, as seen in the review above, indeed a few studies which look on either prospective memory or everyday life environments, or both, from a distributed perspective. But they are few, and they do not explicitly consider the home as a cognitive system as whole, established to deal with more than one task.

Below I summarize distributed cognition as an analytical framework. This framework is my view of distributed cognition; from which I have picked analytical tools for my analysis. The list is a summary of the review I have made above and refers to aspects of distributed cognition that can be studied.

There are other frameworks in the literature that aim to do something similar. For instance, in the healthcare domain Blandford and colleagues (Blandford & Furniss, 2006) have developed an analytical framework called *Distributed Cognition for Teamwork* (abbreviated DiCot and referred to in section 3.2). DiCot is a structured approach of listing principles of distributed cognition that are relevant to understanding teamwork in small teams (see Berndt et al., 2015; Furniss et al., 2011; Rajkomar, Blandford, & Mayer, 2013; Rybing, Nilsson, Jonson, & Bång, 2015 for examples of where DiCot has been applied).

The name DiCot embodies distributed cognition as research that has mainly been focused on the study of professional settings. It also characterizes distributed cognition as an analytical framework for teamwork activities, and not primarily as a perspective on all cognition. However, first, DiCot performs the important role of substantiating distributed cognition as a theoretical contribution to the study of cognition, and second, few of the principles listed in DiCot are not principles of teamwork, or even groups of people doing things together. In short, they are information-theoretic principles of information flow with an extended focus on how spaces are arranged.

I do not aim to make a formal comparison with, or add to, DiCot. But I note that I have included a few principles that focus on agents' mechanisms for coupling themselves with their environments which are not included in DiCot. Since distributed cognition is a perspective on all cognition, it can be argued that several analytical frameworks can be derived from this perspective, frameworks that are designed for the study of types of cognitive systems.

In the review above I presented a few studies using distributed cognition for the understanding of everyday environments and occasionally also prospective memory. Something that became clear from the study by Palen and Aaløkke (2006) was that participants' processes for managing medication were distributed across their environments, but also that each individual had their own solutions and that individuals could act in different ways on different days.

Everyday life does not necessarily have the same level of structured systems as the professional environments previously studied using distributed cognition. Everyday life can be expected to be less safety-critical, less based on training, less based on rules of conduct, and less based on commonly established procedures. However, this does not mean that everyday life cannot include features of professionalism for a number of reasons, for example, because these features are relevant, are experienced as relevant by an individual, or are regarded as relevant by a community for the management of some part of everyday life. In my analysis I will describe practices of the participants that can indeed be regarded as involving professionalism.

To account for variations across situations and times, I included elements in the framework for capturing the dynamics and stability of practices and resources. As previously stated, the framework below is a summary of my view of aspects that are usually studied with distributed cognition.

Table 2: Distributed cognition as analytical framework

Aspects of agents' practices
a. internal processing, knowledge and abilities (see mainly cognitive psychology but also section 3.5)
b. projection of internal information onto external structures (see, for instance, section 3.5.2)
c. interpretation of external structures and situations (see, for instance, section 3.4 and 3.5.2)
d. the use of the body to move and to find information (see, for instance, section 3.5.1)
e. shaping space and epistemic actions and consequences (see, for instance, section 3.5.2)
f. stability and dynamics of the above practices (see, for instance, section 3.4)
g. the goals for a given activity (see, for instance, section 3.4, 3.5.1 and 3.7.2)
Aspects of the physical and social environment
a. the nature of information flow and transformation (see, for instance, section 3.2)
b. arrangement of resources (see, for instance, section 3.5.2)
c. physical or symbolic constraints of actions (see, for instance, section 3.5.2)
d. stability and dynamics of resources (see, for instance, section 3.4)
Aspects of external resources
a. passive resources/incidental cues (see, for instance, section 3.5.1)
b. intentional (by someone) resources (see, for instance, section 3.5.1 and 3.5.2)
c. cognitive tools and their functionality and use (see, for instance, 3.5.3)
d. mapping between representation and what it stands for (see several sections)
e. complexity of resources and environment (see, for instance, section 3.4 and 3.5.2)
Aspects of time
a. the development of practices (see, for instance, section 3.3, 3.4 and 3.5.3)
b. the development of a single task (a task analysis) (see, for instance, section 3.2 and 3.3)
c. the development of the practitioners (see for instance section 3.3 and 3.5.2)

Based on the framework above I see five possible general media for cognitive processes: brain, body, material world, social world, and time. The body is a special kind of material architecture that was originally viewed as playing some role in distributed cognition (see Hollan et al., 2000). However, it was not explicitly acknowledged as somewhere cognition could flow. Also, the understanding of the brain is not at odds with distributed cognition. However, most research involving distributed cognition does not include an analysis of individuals' cognitive processes. This is possibly because people are educated in the roles and the researcher can thus assume certain practices and basic knowledge. But, as perhaps best represented by Clark (2013 and other publications), the brain is indeed a significant component in extra-cranial distributed processes.

I find it reasonable to recognize that connectivity (type and density) between the brain and the world, as with any cognitive system, can vary across mental states and cultural settings. Therefore, it can also vary to such an extent that the proper unit of analysis for a given research question is the brain alone, all of which is in accordance with the foundational principles of distributed cognition as a perspective on all cognition.

Because distributed cognition has a dynamic and wide notion of where cognitive processing can take place, Hutchins and his colleagues introduce a new methodological approach to address the wideness and dynamism of the perspective. I now turn to describing this approach, which is referred to as cognitive ethnography.

3.7 Cognitive ethnography

Cognitive ethnography is described by Hutchins (1995a) as the most important methodological tool for understanding cognition in real-life situations, and is also the method I have used in my fieldwork. I believe that Hutchins (1995a) regards cognitive ethnography as the most important methodological tool because he has argued that cognition must be re-understood through studying it in real-life situations. However, this does not mean that other methods are unnecessary. For instance, in Hollan et al. (2000) it is clarified that the relationship between ethnography and experiments within distributed cognition is such that results from ethnographies inform the creation of experiments. And in fact, in this thesis I also let results from experiments inform my ethnographic analysis, hence I use a two-way relationship between ethnography and experiments.

Below I describe my view of what a cognitive ethnography is in two steps. First I describe what ethnography is, and then what ethnography on cognition is. Even though cognitive ethnography is frequently used as a concept within distributed cognition, it is seldom specified what the term means. Even more seldom are attempts to describe differences and similarities between cognitive ethnography and contemporary ethnography within anthropology.

3.7.1 Ethnography

Ethnography has its origins within anthropology and can be imprecisely translated from Greek as a description of a culture or a group of people. More specifically, for instance, Sluka and Robben (2012) in a review of the field characterize ethnography as a micro-analytical case-study approach that aims to study people, groups or communities. Irrespectively of which group is studied the overarching object of study in ethnography is always aspects of culture. There are many definitions of culture within anthropology. One comes from Geertz (1973) which, by adopting the philosopher Max Webers description of humans, defines culture as the webs of significance humans collectively spin.

The notion of studying cultures and the establishment of ethnography as a scientific method was, and still is, highly influenced by Malinowski and his publication *Argonauts of the Western Pacific* (Malinowski, 1922). Malinowski declares that the primary goal of ethnography is to document a culture from the perspectives of its inhabitants (also called the emic or inside perspective). The inside perspective is in contrast to the outside perspective (also called the etic perspective). Ethnographic fieldwork is often metaphorically described as a balancing process between the inside and the outside perspectives (Agar, 2008/1996; Emerson, Fretz, & Shaw, 2011). In Malinowski's studies, the outside perspective is the perspective of western societies, in other words Malinowski's perspective.

For the researcher, the goal is not to reach a complete inside perspective, because becoming an insider could risk losing the ability to communicate the inside to the outside community. Nor is the goal to keep entirely to the outside perspective, because that would risk mistaking your own lifeworld for that of the participants. Instead it is an act that Agar, 2008/1996) depicts as one that should be like a *professional stranger*. Someone that systematically translates the inside perspective to outsiders, and hence aims to change the outsiders' view of the inside. This metaphor is at the heart of ethnographic fieldwork. Another way of understanding ethnographic fieldwork and being a professional stranger is to conceptualize it as a process that questions what is familiar to the researcher, and explains what is unfamiliar to the researcher. Although ethnography stresses this, it is not very different from the process of research in general.

To get the inside perspective of a culture Malinowski argues that ethnographers should use participant observations as their primary method. In practice this means that the researcher takes part, as much as possible, in the same activities the people being studied take part in. For Malinowski, and for many anthropologists, this also means that the ethnographers need to learn the language of the culture being studied. The rationale is that only by participating and interacting in the culture's own language can ethnographers properly document how webs of significances are spun (to adhere to Geertz, 1973 terminology), how inhabitants order and understand situations in their lives. Despite Malinowski's method for conducting an ethnography there are other ways of doing ethnography that emphasize other aspects of cultures. For instance, Franz Boas focused on collecting and bringing home stories and artifacts from the societies he studied, spent shorter periods in the field than Malinowski (Sluka & Robben, 2012, pp. 11-12), and also emphasized the interview as an important method (Agar, 2008/1996). The focus was to understand a culture by studying its products. Similar foci also exist within cognitive science. As mentioned, de Léon (2003) for instance scrutinized tools in the pursuit of unraveling underlying cognitive processes.

Another aspect of Malinowski that became a goal within anthropology was the documentation of all the parts of life in whole cultures. This was an ambitious project that, despite being an ideal, was difficult to attain. Ethnographies with similar objectives to Malinowski's are still conducted today, and in contemporary ethnography several aspects of Malinowski's perspective remain as ideals. Participant observations and the attempt to understand the inside perspective remains prominent. Ladner (2014), for instance, describes the goal of understanding the emic perspective as where fieldwork starts. However, there have been a number of developmental tracks within anthropology that clearly complicate other aspects of traditional ethnography.

One track deals with the understanding of culture. When Malinowski ventured to the islands in the Western Pacific he viewed the society as isolated from his and from other societies. Because of this there was something that could be described as an outer boundary of the whole culture. In contrast, for contemporary ethnography, boundaries are not as distinct and the concept of culture is more complex. For instance, ethnography is currently used to study some aspects of culture without attempting to frame a whole culture. The question of which aspects of the culture are interesting is guided by research questions and the purpose of going into the field (Agar, 2008/1996). One practical result of more malleable boundaries and question-oriented ethnographies is that ethnographies today are not necessarily as long as traditional ethnographies were (Sluka & Robben, 2012).

Another related developmental track is that contemporary ethnography no longer only studies cultures that are far away. Instead ethnographers can stay closer to their own homes, and also close to, and part of, their own webs of significances (Cole, 1977; Geertz, 1973). One practical result of this is that the need to learn the tongue of the participants is now often about understanding the vocabulary and the expressions of the respondents. Language is still a route to the meanings and orderings of the participants, but the ethnographer does not need to learn a completely new language.

Another result of studying nearby cultures, or sub-cultures of one's own culture, is that ethnographers nowadays study the mundane and the familiar to a greater extent. To some extent, traditional ethnography benefited from studying far-away cultures, because it focused on studying something (almost) completely new. Everything needed a translation to the outsiders, otherwise

the culture would not be understood[8]. In contemporary ethnography, the researcher risks taking the familiar for granted or risks remaining blind to the real inside perspective. Therefore, the role of the ethnographer as translator has partly shifted. Part of the role of the ethnographer is to make the unfamiliar understandable throughout the fieldwork and analysis. But it is also part of the role of the ethnographer in the field to systematically question the apparently familiar in light of new observations (Marcus, 1998).

The role of the ethnographer as a translator has led to ethnographic methods being used to translate between actors in society. Ladner (2014) describes how a result of this is that traditional boundaries between inside and outside perspectives acquire new meanings. There can now, for instance, be several distinct outside perspectives, for example, a company and its customers, where the company wants an ethnographer to grasp customer's perspectives on company matters.

Another track in the development of ethnography is that ethnographies are no longer bound to geography. Traditional fieldwork within anthropology has often meant fieldwork on a single site, where the notion of a culture is a phenomenon that is localized to that site. This made sense in part because traditional research often involved going to a civilization located at a site that had minimal communications with the rest of the world. Today ethnographic fieldwork is instead bound to other dynamic objects of study (Hannerz, 2003; Marcus, 1995). Marcus (1995) explains that this is because ethnography is no longer bound to anthropology. Instead, ethnography is a method that cuts through several interdisciplinary sciences. Marcus (1995) suggests a number of general objects that ethnographers can follow throughout the ethnographies. They are as follows: people, things, metaphors, stories, life, and conflicts. These objects are not bound to specific scientific traditions, and are not necessarily bound to single sites. Instead they are spread across sites.

Hannerz (2003) describes a similar contrast to single-sited research. He notes that multi-sited fieldwork, or in Hannerz's words translocal fieldwork, has become important because the human world has become more connected. Therefore, in contemporary ethnography relationships between sites are as important as relationships within sites. A methodological consequence of multi-sited fieldwork is that researchers need to select sites that grasp the current study objectives. Hannerz (2003) discusses how this selection can be a result of research design, but can also be a result of current circumstances in ongoing fieldwork. Also, site selection is often an impossible task because all sites that are relevant to the current object of study can hardly be scrutinized within a single ethnography. Nevertheless, similarly to Marcus, Hannerz posits that contemporary fieldwork is about following some object of study, to some extent independently of geographically-bounded sites.

There are several descriptions of how to conduct ethnographic fieldwork. As previously mentioned, to be able to move between the outside and inside perspectives, fieldwork in anthropology has traditionally opted for participant observations as its most important methodological approach. Participant observation is a natural method for obtaining these perspectives because participation yields a kind of experience that deepens the inside perspective and contrasts against the outside perspective. Czarniawska (2007) also notes that most ethnographic researchers have used participant observations. She therefore suggests that ethnographers need to contrast participant observations against non-participant observations more explicitly, using the term "shadowing" to refer to the latter type of observation. I note that there are many uses of participant observations within ethnography that also include shadowing

[8] Despite the study of the unfamiliar even Malinowski noted similarities between "primitive" cultures and western societies.

techniques to some extent. In fact, shadowing was likely what Malinowski did in many of the situations he observed. But I do find Czarniawska's categorization helpful for guidance on how to conduct fieldwork in practice. Much of ethnography is about accounting for different perspectives on the same object of study, and to be able to account for different perspectives, different observational techniques are important.

The various observational techniques are means to what Geertz (1973, borrowing the philosopher Gilbert Ryle's concept) argues to be the goal of ethnography: the production of *thick descriptions*. Thick descriptions, and hence ethnography, is defined as what produces "a stratified hierarchy of meaningful structures" (p.7). Consider two people that contracts their right eyelid (Ryle, 1968). At first sight the contractions appear to be very similar, but the contractions can mean several things. The twitch could for instance be a wink, but it could also be an involuntarily twitch. To understand which interpretation is more valid the researcher needs more information. For instance, they need descriptions of what happened before, what happened after the contraction, the possible social relationships between participants, cultural repertoires etcetera. The role of the thick description is to establish accounts for different interpretations. It is only with thick descriptions that ethnographic analysis can be conducted.

There are also several descriptions of how to conduct ethnographic analysis. Agar (2008/1996) describes this process as following a process of dynamic abduction. In other words, the ethnographic analysis iteratively accounts for observations by using the most likely explanation. Occasionally the analysis is followed by more fieldwork, and sometimes the analysis is conducted by consulting more information in the established descriptions. Kvale and Brinkmann (2013, p.268) describe a number of ways qualitative data can be validated, which is also applicable to ethnographic analysis: contrasting an observation against extreme cases, actively seeking contradictions to an observation, and getting feedback from participants in follow-up interviews are all ways to control and check for correctness of observation.

By using thick descriptions, Geertz argues that one goal of ethnography "is to draw large conclusions from small, but very densely textured facts; to support broad assertions about the role of culture in the construction of collective life by engaging them exactly with complex specifics" (p.28). This is an important point with ethnography, but it also an important point for case studies in general. It is a common misunderstanding that case studies cannot be used to draw conclusions about the collective, or be used to draw general conclusions (Flyvbjerg, 2006). Therefore, the ethnographic product is one that is a reasonably coherent story about culture. This also means that ethnographic products that are based on qualitative data can be analytically generalized to other settings (Kvale & Brinkmann, 2013).

In summary, ethnography is a methodological approach that aims to translate a group's perspectives on their situations to the outside world. The product of contemporary ethnography is, as for traditional ethnography, to study the patterns of meaning that exist in a community. But in contrast to traditional ethnography, contemporary ethnography is driven by a wider choice of research questions. This is partly because ethnography is now a common approach in more disciplines than anthropology. Irrespective of discipline, ethnographic analysis always seeks to find the most likely explanation for observed phenomenon.

3.7.2 Ethnography on cognition

Ethnography for the understanding of cognition became relevant for cognitive science in a number of publications. For instance, Lave (1988) made it clear that the perspectives of the participants,

and hence ethnography, were highly relevant for the understanding of cognitive processes taking place in supermarkets. Also, when Hutchins (1995a) defines cognition as a cultural process, ethnography become a natural methodological tool to capture cognition. Ethnography for the understanding of cognition is often referred to as cognitive ethnography.

Cognitive ethnography is used as an approach that does micro-analysis of the flow of information in specific activities. Since it is based on ethnography, the participants' perspectives are important. In practice this means that, as with contemporary ethnography, researchers use a mixture of observational and interviewing techniques. But within distributed cognition micro-analytical approaches are also used without necessarily capturing the participants' perspectives through interviews. This is the case when, for instance, observations are used to study non-human cognition. For example, Johnson (2010) discusses how observational techniques can be used to capture cognitive complexity in non-human primates and cetaceans. She describes how a mixture of qualitative and quantitative data can be derived from video documentation of the subjects' behavior. These kinds of data can be used to document detailed patterns of behavior that reveal important mechanisms in a species' cognition.

Despite descriptions in the literature of observational techniques there are a few explicit accounts of what a cognitive ethnography is. I find it relevant to briefly review them because I find that they partly focus on different aspects of cognition, aspects that I have considered in my analysis.

In *Cognition in the Wild,* Hutchins (1995, p.371) briefly describes cognitive ethnography as the descriptive enterprise of documenting cognitive task worlds. As ethnography in general, it is not a predictive enterprise, but also as ethnography, it is certainly explanatory. For cognitive science the point of this enterprise is to create functional specifications of cognitive systems, which can be used, for instance, for design and experiments.

To substantiate this description Hutchins describes how, in any given moment, any human practice can be understood across the three developmental dimensions I described in section 3.3: the conduct of an activity, the development of the practitioners, and the development of the practice.

Although distributed cognition, through cognitive ethnography in its original form, embodies all of the above processes, it is most often only the conduct of activity that is addressed in the contemporary literature. For instance, in their description of the analytical framework Distributed cognition for teamwork (DiCoT), Blandford and Furniss (2006) explicitly de-emphasize changes across time and the role of social architectures. It seems that cognition as a cultural process is often de-emphasized when distributed cognition is used in work settings, which seems to be the very opposite of what Hutchins and his co-workers intended. This could be because distributed cognition, as a theoretical framework in practice, has lost connection with central aspects of ethnography. For instance, one way to understand what a practice is about is to grasp the perspectives and objectives of participants, but such descriptions seldom exist when distributed cognition is applied. Instead, objectives are, for instance, provided in advance by the specification of the operation under scrutiny.

Through the description of Hutchins' three dimensions it becomes clear that cognitive ethnographies do not start with a specification of which cognitive aspect to study. Instead, they start with finding the objectives of the activity under scrutiny. This is in contrast to traditional cognitive science, which usually decides upon which aspect (abilities or components) of mind to pursue, such as memory, perception, decision-making, attention, executive functions, spatial cognition, etcetera. In cognitive ethnographies, descriptions of activities precede the cognitive

aspects. Of course, activities can overlap with aspects of mind to various extents. For instance, cognitive tests in laboratory-like settings are a special type of cultural activity that are often shaped to be activities about specific aspects of mind.

Although the descriptions of activities precede the cognitive aspects, several studies have adopted a distributed cognitive perspective on specific traditional aspects. One example is prospective memory in high-risk sociotechnical systems (Dismukes, 2012; Tobias Grundgeiger, Sanderson, & Dismukes, 2014). In such studies safety issues are the primary motivation for understanding a specific cognitive aspect, because forgetting one's intentions in high-risk environments can have severe consequences.

From a cognitive point of view, starting with activities makes sense because activities have goals. Activities exist to reach some concrete or abstract goal that can be evaluated from an information-theoretic perspective. From an ethnographic point of view it is important to understand that the goals for activities can be understood from several perspectives. There are, for instance, several reasons why navigation is meaningful on a US Navy ship. It is a logistical necessity, but its necessity has likely also been taught in the education of the US Navy.

Also note that although cognitive ethnographies start with activities, traditional cognitive aspects are not meaningless. Cognitive ethnographies both document the perspectives people have and practices people use, and how information is (see Neisser, 1967) transformed, reduced, elaborated, stored, recovered, and used. By having a distributed perspective researchers aim to minimize the risk of attributing those properties of cognition to the wrong subsystem (Hutchins, 1995a, p.356). This is also on par with the ethnographic bottom-up approach of going into the field with an open mind about whatever object is being studied.

I also find it important to point out that traditional aspects of mind can themselves be meaningful for people. This is not strange, since to a large extent the faculties of mind are derived from folk psychological ideas. In my ethnographic material I have observed several instances where the ability to remember became its own meaningful activity. I return to this in my analysis.

With the above background I find cognitive ethnography to be a way of doing contemporary ethnography, rather than a type of ethnography. Let me clarify. As we saw in the previous section, contemporary ethnography is not bound to specific physical sites, rather it is bound by some object of study. In principle, this object of study could be information processing in some activity that spans different architectures and sites. Cognitive ethnography is bound to understanding activities or processes because cognitive ethnography is bound to definitions of cognition as some kind of information processing that strives towards some goal. Therefore, I think cognitive ethnography is a way of doing contemporary ethnography because it is an ethnography about cognition. This is also my interpretation of Hutchins' use of the words. Hutchins' use of the words must be understood as a reaction against traditional cognitive science and the laboratory-based studies that had been dominant, but not as a special kind of ethnography. That said, this is not an established interpretation.

Williams (2006) makes the process of doing cognitive ethnography transparent by noting that cognitive ethnography is separate from traditional ethnography in a fundamental way. Traditional ethnography is described as being interested in the meanings that members of a culture create. In contrast, cognitive ethnography is interested in how these meanings and other knowledge "determine important outcomes" (p. 838). He uses the example of kinship. Traditional ethnography investigates the states of kinship. Cognitive ethnography would need to understand

the states of kinship before understanding a cognitive aspect, such as group decision-making. Therefore, when making this distinction Williams stresses that traditional ethnography is a necessary starting point for doing cognitive ethnography. I am sympathetic to the notion of making the process of ethnography transparent in this way, but I am not certain that the delineation should be between process and content.

At the beginning of the chapter in which Hutchins introduces cognitive ethnography, he begins by criticizing the distribution of labor in cognitive science (which was proposed by D'Andrade, 1981) for the sub-disciplines of anthropology and psychology. Psychologists were supposed to focus on cognitive processes, and anthropologists on cognitive content. I consider this distribution to be partly equivalent to Williams's separation between ethnography and cognitive ethnography. But there are several cases where anthropologists study processes without using cognition as a theoretical framework (see, for instance, Malinowski, 1922 and his account of the Kula trading ring). And there are several instances where cognitive scientists focus on content (see, for instance, Huth, de Heer, Griffiths, Theunissen, & Gallant, 2016) without focusing on process.

I find that viewing something as the content for some process can be clarified through Hutchins' three developmental processes: practice, practitioner, and activity (which I described in 3.3). If we study an instance of an activity, the nature of the practice can be considered content to the instance. But in this case, the definition of content is only an epistemological perspective. What counts as content is relative to what is considered the process. Recall from previous sections that, from a distributed cognitive perspective, cognition is a cultural process and culture is, to some extent, a cognitive process. Therefore, in retrospect even content can be understood from a process perspective; that is, how the content came to be. To use another example: friendship can both be viewed as a state and as a process. Humans do not only have friendship-based relationships, humans also make, maintain, and change friendship-based relationships.

In ethnography, the meanings that members of a culture create are orthogonal to, or even independent of, practices and activities. There is some unit of analysis that ethnography captures that is not encapsulated within one practice or activity, but that still can be a determinant for practices and activities.

Friendships and decision making can be used an example. The nature of friendships within a group of people is a set of meanings the people in the group have created. These sets of meanings can shape decision-making within the group, but they can still be studied independently of decision-making. I do not think that this suggests a branching of ethnography and cognitive ethnography. Instead, I view this as a natural extension of the original description of cognitive ethnography, i.e. as a description of the task world. Decisions and decision making can be viewed as a cognitive practice, but so can friendships and the creation of friendships. I can imagine a study where establishing friendships is considered a task, and cognitive ethnography is used to describe the task world for this.

In this thesis I use the term cognitive ethnography to describe an ethnography that is about cognition. The concept of "cognitive" in cognitive ethnography refers to distributed cognition as an alternative to traditional cognitive science. Therefore, it is not necessarily a special kind of ethnography. If we look at how ethnography is used today I believe we can see a versatile use of it that spans both the content and cognitive processes of what people do (see, for instance, Crabtree & Rodden, 2004). Sometimes cognitive ethnography is an ethnography that analytically focuses on constructs that are traditionally assigned to the mind, but that, initially in the empirical process, remains open to what architecture those constructs should be ascribed to.

I now turn to my own work of studying cognition through ethnographic methods. I have used a mixture of ethnographic approaches; whereof some have been used to capture participants' perspectives and some have focused more on capturing the details of various practices.

Chapter 4. Methods

The goal of this chapter is to describe the cognitive ethnography and analytical tools that I used to establish the empirical results of my analysis. As mentioned in the introduction I have used an explorative data-gathering approach to understand cognition in home environments. The main reason for using this approach is to contribute to research on prospective memory by using a different method from what is normally used in the field, and which can give a complementary perspective on cognitive mechanisms dealing with prospective remembering.

Below I will start by describing my objectives throughout my fieldwork and the type of ethnography I have conducted. Later I will describe the data gathering methods and analytical procedures in more detail. Finally, I give a short description of the environments and participants studied.

4.1 General objectives throughout fieldwork

Above all, my approach has been explorative. When I originally ventured into the field I did not start with a pre-formed idea about which aspects of cognition would become salient and prominent in my analysis. This inductive approach is common for all ethnographies. However, I did have incentives, which became more specific over the course of fieldwork as a result of new insights.

The first major objective was to study episodic memory practices in everyday life in the older population. This overarching objective has further been focused on a particular type of episodic memory, namely prospective memory. There are several reasons for focusing on memory and specifically on prospective memory. There is a tradition of using memory as a theoretical and empirical example within distributed cognition and its adjacent schools. Therefore, having a specific focus on remembering in my fieldwork allows me to do analytical comparisons with past research within distributed cognition. The incentives for the focus on prospective memory originate in research within cognitive psychology that has found contradictory results when comparing older and younger people, measured across laboratory and home environments, as discussed in Chapter 2.

The above foci have had the result that my fieldwork has, in certain periods, been oriented around this more individually-centered unit of analysis. At the beginning I was interested in what older people do to manage memory situations in everyday life. The home environment as the information-theoretic unit of analysis was something that was identified over time and not assumed from start. The analytical work was characterized by shifting between individuals' practices and

developing an understanding of the physical home environment from a cognitive and cultural perspective.

The initial focus on remembering practices motivated the choice of activities that were scrutinized. These activities were chosen because of their connection to remembering and keeping track of intentions (prospective memory). Despite this specific focus on one cognitive aspect, my analysis of these activities has, in line with distributed cognition, nevertheless been focused on the management of these activities, rather than coping with the cognitive aspect per se. Also in the fieldwork, I was interested in cognitive practices and activities as a whole because of the multi-component (see Chapter 2) model of prospective memory. This model suggests that some practices can shape the processing of prospective memory without initially being regarded as memory practices per se. Also, not focusing on memory practices per se is a natural consequence of using an inductive approach to documenting an information flow, because the description will not focus on specific cognitive faculties in advance, even though the final description of a cognitive ethnography will be a functional specification of what cognitive faculties are at play.

4.2 Type of ethnography

My ethnography is in part a multi-sited ethnography because I studied eight home environments to reach a general understanding of distributed cognition in home environments. Even though the sites can be viewed as distinct the questions that I brought to each site were iteratively shaped by my previous encounters at the other sites. I have sought to understand what connects the sites in relation to the goal of the research. As we will see when I describe the settings for my research, my participants live in separate ecologies, while at the same time they share aspects of the same cultural ecology. The participants live in a certain kind of home, are of a certain generation, and are of a certain age.

Another important aspect is that the environments are, from the perspective of 'homes of humans', no different from my own home. Nor are they much different from any homes I frequently encounter in my private life. This is an important aspect that has influenced my analysis. I cannot say that my fieldwork has completely ended when I leave the homes of my participants, because my understanding of the dynamics in the homes of others have influenced my understanding of my own home dynamics, not least my own micro-cognitive failures, which in turn have reflected back on the fieldwork. Nevertheless, an important difference between my inquiries in participants' homes and my private life is that I have attempted to be systematic in the documentation of participants. I have not documented myself in any systematic way, but the experiences I have had in my home have still been a resource in my understanding of cognition in home environments.

I do not see this influence as something negative, but it introduces challenges. The explicit and implicit scrutinizing of differences and similarities between my participant's homes and my own home has nurtured my iterative analysis and my ongoing visits in participants' homes. But to understand homes I have needed to question what I find familiar from my own home. Like any ethnographer, I have needed to make sure that my lifeworld is not misattributed to theirs.

4.3 Data gathering methods

My understanding of home environments has mainly been reached through one empirical source. This source is a cognitive ethnography on older adults who managed everyday life by themselves. The resulting set of empirical data is the major source for my current analysis, which is data that is analytically far away from the settings in which distributed cognition has traditionally been used.

This is because this empirical set has focused on individuals (not teams) in home environments (not professional settings).

All of the participants were approached and recruited from a local activity center for older adults, which is located in a medium-sized city in Sweden. The selection criteria for participants were based on age (+65) and on the participants' ability to manage everyday life by themselves without assistance from home healthcare services. All of the people who were interested in participating received a document with information on ethics, study objectives and contact information.

The study was framed as having a focus on the management of everyday activities, with a specific interest in any actions or tricks that a participant might use to make things easier for themselves. Nothing in the information referred to memory strategies or memory ability. The main reason for this was to keep to an ethnographic approach of focusing on events rather than on cognitive faculties. Whether memory practice is a meaningful concept in everyday activities is, in part, an empirical question. Another reason for not focusing on memory ability is that there is a certain stigma associated with memory in the older population. Therefore, specifically referring to memory could have framed participation in disadvantageous ways.

Despite that I de-emphasized a memory focus, it was an explicit aspect of the fieldwork. For instance, at the very first in-home meeting I had with each participant I always introduced myself, and to do that I had to introduce what cognition is. I made it clear that I was interested in strategies for remembering, but also that I was equally interested in other strategies and their experiences of everyday life, its activities and settings. Despite this one-time, one-way communication, my interests were a point of discussion on multiple occasions. This was a fruitful and effective approach because it made the participants part of the research. As in any ethnography, data was created in the interaction between participants and observers. I think it will be clear in the analysis that some findings would not have been there if participants had not been active in the research.

Furthermore, for three participants the focus on memory was more explicit. They were part of investigations that were conducted by the research assistant, S. Lindvall (hereafter referred to as Lindvall), whom I co-supervised for her Bachelor's thesis. She analytically compared ethnographic data from grocery shopping and cooking activities using a measure of memory ability (*Rey Auditory Verbal Learning Test*, Strauss, Sherman, & Spreen, 2006, pp.776-810) and a self-rated memory compensation questionnaire (MCQ, Dixon et al., 2003, described in 2.5), which was conducted two times, pre- and post-observation. For these participants, the focus on memory was salient from the first encounter. Her observations and what these participants answered in the MCQ will provide subject matter for parts of the chapters to come.

The overall data comes from five kinds of methods: (a) sit-down interviews, (b) standing and walking contextual interviews, (c) participant observations, (d) non-participant observations and (e) video recordings. In some cases, photos of parts of environments have been taken to complement fieldnotes. However, photos have not been used as a method for all participants. Instead I have used sketches and descriptions in words of what I have observed.

All interviews and observations took place in the homes of the participants or in nearby settings. In total the analysis is based on data collected from eight participants. Seven of the eight participants are women. I can, of course, speculate about the reasons for my group being so gender-unbalanced, but I find it more important to point out that this has shaped my fieldwork, and hence also the content of the analysis. Ethnography focuses on experiences and the meanings within

groups of people. The experiences and the meanings of the participants that I have documented are shaped by the fact that most of them are women of older generations.

From a quantitative perspective, eight participants is relatively few, but since the focus of my thesis is to characterize home environments in contrast to professional settings, and to deepen the understanding of cognitive processes in home environments, my eight participants displayed a reasonable level of variance (see Kvale & Brinkmann, 2013, pp. 129-131). Also, from the beginning the goal was to acquire detailed understandings of events in the participants' everyday lives. In line with these goals I chose to meet with the same participants over a number of occasions, and through this sought to reach a deep (rather than broad) understanding. All methods have focused on revealing patterns that account for cognitive processes in home environments. The goal has not been to say how common these patterns are within some population.

A number of meetings were conducted over roughly two years. The time for each meeting varied from one-and-a-half hours to four hours. When the meetings took place within the home environments audio recordings were used. These served as memory assistance so that I could focus my ongoing note taking on things that were not captured through audio. These could, for instance, be bodily actions or the features of the physical surroundings not covered by sound. After the meeting (directly or the next day), the ongoing note taking was integrated with the recording of the session into richer meeting notes. Transcriptions were only done when required for parts of the analysis or for the final result of the analysis. For some participants video observations were used, and in those cases the goal was to do micro-analysis of specific events.

Most of time, interviews and observations (video and personal) were conducted within the home environments of the participants, but for five participants, observations were also conducted outside of the home environment. This was not outside the scope of the analysis because many activities that take place outside the home environment start in, or at some point venture through, the home environment. Interviews and observations across four participants were also conducted by Lindvall. Her field notes have been integrated and contrasted with my own field notes across the same participants.

My understanding of home environments has also been influenced by parts of my master's thesis, for which I worked and observed within the home healthcare services, and interviewed healthcare recipients in my spare time (Kristiansson[9], 2011). Home healthcare is an interesting social experiment that involves many occurrences of coordinating issues that reveal aspects of practices in everyday life. Together with a master student I have also made (unpublished) initial analyses of video observations of two families before they leave their homes. None of this work directly applies to my current analysis, but has nevertheless influenced my understanding of home environments.

Below I focus on the main source of data and describe more specifics of how I have used interviews and observations to yield types of data and to validate data entry points.

4.3.1 Interviews and observations

Meetings spanned a range between being more interview-oriented and being more participant observation-oriented. All meetings took place during the day between 08:00 and 17:00. To be able to maintain a natural meeting platform the level of participation was seen as a dynamic property of the observations. What I mean by this is that for some activities, e.g., cooking, it is more suitable

[9] I have during the process changed name. Every time from now on when Kristiansson is listed as the author of something it is myself I refer to.

to observe and ask questions. For other activities, such as shopping, it would, for instance, not be suitable to not assist in carrying the groceries. In fact, some participants planned their grocery shopping in accordance with having extra hands.

Observations do not generate the same kind of data as interviews. Kvale and Brinkmann (2013, p. 132) note that if the goal is to understand interactions between individuals and their environments, observations and more informal dialogues are more suitable than non-contextual sit-down interviews. In line with this I have used sit-down interviews to get participants' perspectives on everyday matters, for analytical validation, and to add depth to observations. In the same way, I have used observations to validate interview-based data.

In the course of this validation, contradictions and non-coherences between interviews and observations were seen as reflecting interesting aspects of daily life and were used as subjects for interviews and observations. Contradictions or non-coherences are generally important in ethnographic fieldwork to establish thicker descriptions (Agar, 2008/1996). Contradictions are not necessarily logical contradictions. Instead, they can be understood as reflecting unspecified relationships in some description or continua between extremes, which may lead to further fieldwork.

Contradictions did not only occur in the comparison of interviews and observations. They also appeared between my descriptions and Lindvall's descriptions, which lead to more detailed inquiries. Non-coherences also occurred between interviews with the same participants. It is important to note that non-coherences do not only originate from the utterances of participants; they can also be a result of how questions are asked. It has therefore been important to ask questions from different perspectives.

Other similar aspects that have guided my inquiries include the understanding of unique or extreme cases in relation to the mundane, alternative explanations, and hypothesis-testing together with participants (Kvale & Brinkmann, 2013, p.268).

These strategies have shaped my style of asking questions during observations and interviews. The style could be described as ranging from fact extractions to discussions. What is suitable for a given situation and participant is a judgment I have needed to make in some situations. I tried to use discussions and sometimes blunt questions when addressing contradictions between interviews and observations. I think that a discussion approach has worked well because I have met with the same individuals several times and established relationships. This has also created an atmosphere where participants could naturally confront my descriptions from previous occasions. They are, after all, the experts on their everyday lives.

As I mentioned above, sit-down interviews were mainly used to cover participants' perspectives on various matters. This was especially important after participant observations. Participant observations provide an important inside perspective on an activity, but there is a risk of missing important aspects of what is going on. One reason for this is that in my inquiries, participant observations were, in many ways, a teamwork situation between two actors that had never previously worked together as a team. Although I did not take the cognitive lead, I participated in the practical matters of many activities. It was, therefore, often a relatively taxing moment for both me and the participant. This dynamical property is something that will be salient and important in the analysis to come, because it also shaped outcomes of events and highlighted the frailty of normally-occurring routines.

Interviews also worked as observations of everyday activities. Despite the fact that the interviews were intended to capture a participant's perspectives, they did not take place apart from ongoing everyday life, since they took place in home environments. For the meetings, the serving of coffee was a recurring chore, and just because an interview took place did not mean that the management and planning of activities paused. Telephone calls were common, for instance. I can also think of two other reasons that in-home interviews served as observations of everyday activities: First, questions regarding present tools, the physical structure and ongoing social interactions with others revealed information about activities and actions. An example of this is when a participant would describe their use of a specific calendar, and the participant and I would then pay attention to incomplete or missing information in the calendar. Events such as these often yielded meaningful information about the use of the calendar. Second, the act of visiting the same environment over several occasions allowed me to notice changes over time.

For two of the eight participants the analysis was based on video material that was collected and initially analyzed by another research assistant (R. Wiik, hereafter referred to as Wiik) that I co-supervised for his Bachelor's thesis. Video data is a special kind of data for several reasons. One is that it can be revisited repeatedly, which means that you can pay attention to multiple details in a way that in a non-video observation is often hard, sometimes impossible, to manage if you do not already know what to look for. In this thesis it is also a special kind of data because it is the only time observations were conducted without the presence of a researcher.

For the video recording, a head-mounted camera (the GoPro Hero 2) was used to separately capture video-recordings of the participants as they prepared to leave their homes for a number of different activities. This was repeated three times (approximately 30 minutes each) for each participant for a total of approximately three hours of video data. Before the first video recording, Wiik conducted in-home interviews of the participants regarding their habits. The interviews included open-ended questions about regular activities outside the home that the participants engaged in, as well as routines that they usually employed before leaving the home. At that time the camera was tested and three data recording sessions were scheduled with the participant. For each session Wiik arrived approximately one hour before the participant had estimated that she would leave home. The camera was attached and secured on top of the head. To capture hand actions the camera was tilted slightly downward towards the floor. After fitting the camera, Wiik left the individual's home and remained in the vicinity. After the participant had left her home Wiik met up with her to turn off and remove the camera.

Pre- and post-recording chats with one participant suggested that she had some issues with the idea of acting as she normally would have before leaving home. Indeed, the method of videotaping individuals in daily life implies a level of influence over how individuals act. In the case of this particular participant this might, for instance, explain the relatively high number of sub-activities she attends to in the apartment before leaving home. On the other hand, the activities that the participants were leaving home for were activities that they would have conducted with or without a video camera on the head. Therefore, the participants needed to have some reasonable level of performance in relation to the target activity.

4.3.2 Themes in the field

Regardless of the specific methodologies used, in studying the general process of understanding everyday life for each participant and the information flow between participants and their environments, I have followed a number of guiding themes throughout my fieldwork. Since my approach was explorative, some themes grew out of the inductive approach, while others were

there from the start. Since every inquiry with a participant was based on previous meetings, with the same and other participants, not all of the themes were balanced equally across participants. Some themes were naturally covered through interviews, some through observations, and some from both.

The first themes were derived from the initial encounters with new participants. These encounters always started with an open-ended interview on the life story and major experiences in the participant's life. Subjects that could be covered were: childhood, education, past and present occupations, previous and current residences, current and past relationships, and general health status. In this coverage, a mapping of the social surrounding was also included: family, friends, social activities and social encounters, and the reasons for these activities. To some extent all these subjects were covered for all participants, but not equally in breadth or depth. In these descriptions, accounts of values were often processed. These things were also important throughout all of the themes below.

A major theme has been a mapping of general routines across daily, weekly, and monthly cycles. Each time I met a participant I asked her to review the near past and near future. A side-effect of reviewing the past and future was that I came to understand aspects of calendar use. In these descriptions there was also a focus on non-frequent events. In fact, non-frequent events were what participants would most freely bring up by themselves. These events were often micro life-changing events that, from the participants' perspectives, often stood for something positive or negative. In contrast to general routines, observations and video data often revealed micro-management of events.

Several themes have been tied to activities. Activities that were covered either through interviews, observations or both included breakfast, cooking for oneself, cooking for others, planning for cooking and grocery shopping, hospital visits, traveling, leaving home, and attending to general matters in the home. For all activities, interaction with the physical environment was important. Questions in mind included: What are the orderings of things? What are your expectations of the environment? Which things and resources are used? Which things are not used on a daily basis? Are objects occasionally lost? If so, how do you find them? In these mappings of activities more direct cognitive aspects have also been important. For instance, how do you keep track of near past and near future events? Or, how are you planning for event x?

In the mapping of the physical environment, the unit of analysis has not always been activities. Occasionally the home environment has been used as the unit of analysis. This was, of course, suitable given the focus of this thesis, but I also found empirical reasons for this. Using the home as the unit of analysis is suitable because sometimes a discussion or a focus on physical aspects in the environment could reveal new, more specific activities not covered by my previous accounts of activities (a similar approach was used by de Léon, 2003). In this mapping of the physical environment I simply allowed the participants to relatively freely introduce rooms, spaces, objects and (cognitive) tools.

A final resource that I have found valuable in the field have been experiences from my own life. This has been especially valuable when asking for accounts of failures because my own experiences, including failures, have worked as ice-breakers in discussions of participants' negative experiences. Of course such method risks that my experiences become the participants' experiences. However, I have sought to make certain that participants' experiences are not copies of mine by asking for, and reviewing, details of their stories.

4.4 Analytical procedures

Something that is salient in the above descriptions of data-gathering is that when doing ethnography, the analytical procedures start during fieldwork. Analysis is what has guided my interviews and observations. Therefore, what I describe below is a general account of aspects of my analytical work and the analytical work that has been finalized into the chapters to come. However, in my analytical work, data from field notes and video were processed differently. The analytical work on field notes was closely tied to fieldwork, meaning that a shorter analysis of one occasion would inform the next fieldwork occasion. For the video data the data collection and analysis were more clearly separated, meaning that the analysis did not inform some upcoming video collection or longer, systematic interviews regarding these events[10]. Below I describe these processes in turn.

4.4.1 Analysis of fieldnotes

A general description of my analytical work on the field notes can be understood as a combination of *bricolage* (Kvale & Brinkmann, 2013) and a *funnel-approach* (Agar, 2008/1996). Bricolage is not a completely systematic approach. Instead of coding all of the material according to a set of specified codes, analytical tools are used more freely across the material (Kvale & Brinkmann, 2013). Bricolage is what I have done when I have noted patterns and themes, reviewed plausibility, concatenated, created analogies, counted, contrasted, and differentiated, created abstract factors of the phenomena observed, placed the data in a theoretical context, etcetera. Through my bricolage I have followed what (Agar, 2008/1996) calls the funnel-approach, which is the inductive process of focusing over time on specific and indicative aspects of the material. Using the funnel-approach means that the analysis will focus on some aspects, but will also leave other aspects behind. For me, this has also meant that at each point of settling on analytical themes the analysis has become more systematic. Specifically, this has meant going over the material in light of the selected themes for the sake of validating or contradicting.

To understand what I have observed and to go from notes to patterns and themes I have theorized about what I have observed. Next to my observational notes I have used what could be called analytical notes of observations. These theoretical accounts were derived from two sources: my understanding of distributed cognition as presented in 3.6., and previous observations in the fieldwork. These worked as pointers for further investigations of the other participants and their environments.

The two sources can be understood as working from two perspectives, a data-near perspective and a distributed theoretical perspective. Through the data-near notes I sought to capture some kind of variability or similarities across the environments and participants. The analytical note-taking and capturing of variability has also been important with regard to participants and specific environments, across situations and time. This type of analytical note-taking created minor hypotheses regarding what I had observed and the participants' perspectives on matters. By doing so, I sought to cover gaps in understanding that were not explicitly evident in the field notes, which could be validated in upcoming observations. These accounts of observations have been processed into categories, and then turned into themes.

To validate my fieldnotes, descriptions, and interpretations, I have also before finalizing the thesis discussed my descriptions with the participants themselves. This was conducted by allowing the

[10] There are definitely other ways of doing this that could have yielded a deeper understanding of the video material.

participants to individually read the passages, translated to Swedish, where they themselves occur, and later discuss the descriptions with me. I specifically asked them to at least look for misunderstandings and, if they wanted, aspects that could be of relevance of the descriptions, but which I had not included. These discussions have led to a number of additions to the descriptions and a few minor corrections. Despite attempts in contacting all participants this final meeting was only possible for four participants (Alice, Yvonne, Felicia, and Hannah).

From the theoretical perspective, the analysis of this thesis has focus on interactional aspects between parts in the environment. As a result, during my analysis I have had an ongoing focus on the use of cognitive tools, external representational and non-representational resources, the spatial layout of the environment and the layout's relationship to resources, and the social-informational transactions between me and the participants. To some extent, the distributed analytical approach laid dormant in initial fieldwork, but became more influential in later fieldwork and analysis. Although the distributed perspective has a theoretical basis, this analytical perspective has still been inductive in nature because I have inductively decided which principles of distributed cognition to use in the following empirical chapters.

As mentioned in a previous section, for three of the participants, observations and interviews were conducted by Lindvall as part of thesis work that I co-supervised. To a large extent, the coming analysis will be based on the meetings and analysis that I conducted, but it should be clear that the meetings conducted by Lindvall were conducted in parallel with my own, and have provided valuable analytical input to my own observations. Lindvall's inquiries have, in many ways, strengthened the thick description of some participants' homes and activities. The measures of memory ability and memory compensations were also valuable input to my understanding of the participants, and also the participants' understandings of themselves because they have seen the product of Lindvall's work. Also, as previously described, having two ethnographers across the same sites is a way of validating observations. However, for transparency I make the transitions between these data sets clear in the following chapters. I will treat Wiik's interviews in a similar way, but the video material is different because video is a medium that can be looked at over and over again. There is, therefore, an opportunity to reach consensus about what is going on in a given situation.

4.4.2 Analysis of video

As said, the video analysis in my ethnography has been handled differently from the rest of the ethnography. However, I could argue that analysis of video material also starts with fieldwork, for instance when one is placing the cameras, the process of video collection and video analysis has been more clearly temporally divided than for the rest of the ethnographic fieldwork and analysis. The video analysis has also been relatively systematic. An initial inductive approach established codes, which overlap with themes established in the analysis of the fieldnotes, were used to analyze the whole video material. The analysis started with a task-analysis of each occasion, which was compared with the other occasions. The analytical procedure of the video material, as outlined by Heath, Hindmarsh, and Luff (2010), has followed three steps.

The first step focused on basic aspects of the activities captured, such as current location, objects involved, spaces involved, activities, and general actions. The second step focused on bodily orientations to spaces and objects in relation to actions associated with the management of the process of leaving the home. Of particular importance were the objects-to-bring necessary for the planned non-domestic activity. As part of the third step of the analysis a detailed analysis, using the video-analytical software ELAN (Wittenberg, Brugman, Russel, Klassmann, & Sloetjes, 2006), was

conducted for two recorded sessions (one for each participant) and one specific sequence for one participant. During this step, the frequency and sequences of observable actions were charted to explore possible connections between the actions and the important spaces and objects. These sessions were chosen based on the results of the two initial steps, which identified sequences as potentially relevant to the bodily orientation to spaces and objects in these sessions. Four aspects were coded for in the third step: (a) the visible ongoing activity, (b) important space in view, (c) head turn towards important space, and (d) turn towards important space that leads to action(s) related to leaving home. Because this analysis was relatively systematic the rationales for each aspect are described in the box below. I have in a previous publication presented an almost equivalent description (see Kristiansson (Forsblad), Wiik, & Prytz, 2014).

Box 1: Codes of video-analysis. Adopted from Kristiansson (Forsblad), Wiik, and Prytz (2014).

The visible ongoing activity. Several simultaneous activities must often be managed in relation to the actions that are involved in leaving home. This was coded for in order to explore relationships between ongoing activities and actions, and to establish a task-analysis.

Important space in view. "Important space" was defined as any space that was observed where objects with which the participant later left home were located at some point during the recording. The objects could be keys, calendars, exercise clothes, etc. This meant that, to some extent, different important spaces existed for each of the different sessions. "In view" was defined as the part of the important space that was in the relative center of the camera picture. Although this does not mean that participants consciously attended to these spaces, it provides information about the constraints and possibilities of attending to spaces that resulted from the bodily orientation and physical environment layout.

Head turn towards important space. This category is a subset of important space in view because a head turn towards an important space will also result in said space being "in view". However, what is specific to this category is that a head turn is an action that is separated from the motion of the rest of the body. Although the head turn might be related to the overall ongoing activity of leaving home, it is less likely to be part of the currently-performed activity. For example, turning the head towards the clock could be related to the process of leaving home, but it is not necessarily directly related to the ongoing activity of walking to the hallway to collect an object. Therefore, the head turn can provide additional information about what the participants might have attended to than can be learned from general orientation alone.

Turn towards important space that leads to action(s) related to leaving home. This kind of action is initiated by a head turn or a full-body turn towards an important space, followed by some form of action related to leaving home. One example would be moving an object into a bag to be brought when the individual leaves home.

The video analysis was conducted in the middle of my ongoing fieldwork. Therefore, the above aspects were developed in part from watching the video material but also from my previous observations of other participants. The conclusions from the video analysis also served as input to my upcoming observations and interviews. Specifically, the video analysis captured new aspects that were hard to observe and that became key to parts of my analysis. For instance, the observation of how the participants oriented themselves in relation to spaces lead to physical orientation also becoming a focus of the personal observation and analysis of field notes.

4.5 Methods summary

In conclusion, my cognitive ethnography can be summarized as following an inductive approach. This is the case both for the choice of methods and for the analytical procedures. Some parts of the analysis were more systematic while other parts of analysis were characterized by bricolage. The ethnographic emphasis of my fieldwork has been to understand the perspectives of participants. The cognitive emphasis has been to capture information flow in the sites under scrutiny.

From the framework I presented of distributed cognition in 3.6, some themes have been selected to take the lead in the analysis, which I present in Chapters 5, 6, and 7, while others play roles within these major themes. This is both a result of the situations I have studied and the methods I have used. For instance, I have not observed much of a social ecology of distributed cognition because I have not studied such situations (except from my own involvement). Moreover, I have not used any methodology to present an historical account of home design, and therefore the long-term development of cognitive practices will not be a major story. Nor do I consider individuals' cognitive abilities as measured in lab settings in relation to their cognitive practices. This is not my major contribution to the field of prospective memory. Now, before turning to the empirical chapters, I turn to describing the participants and the environments.

4.6 The participants and the environments

There are distinct features of each home environment I have analyzed that makes it unique in comparison with the others, but there are also features that unify them as a type of home that is common within their culture. Some of these differences and similarities have to do with the residents living there, the participants, and some have to do with how homes are designed. The participants are, in short (in pseudonym), as follows:

Alice, 87 years
Beatrice, 88 years
Charles, 88 years
Moa, 82 years
Yvonne, 70 years
Felicia, 80 years
Greta, 70 years
Hannah, 71 years

Below I give a short introduction to each participant and their home and nearby environments. The accounts below are based on recurring aspects of discussions with, and observations of, the participants. Some descriptions focus more on the perspectives of the residents, some focus more on aspects of the environment, and some focus on both.

4.6.1 A two-roomer and Alice

Alice is 86 years old the first time I meet her and soon to be 90 when I meet her for the last occasion. She lives in an apartment in central areas of the city. When I meet her for the first time she has lived in the same apartment for five years. Before this she lived in a larger apartment in a building that did not have an elevator. The elevator and balcony were two important features when she decided to move to the current apartment. Although she has lived in the city in recent years she spent most of her life living in the country-side. She grew up in a larger country house at the outskirts of the municipality together with six siblings. She describes in detail how they took care of each other, supervised by their mother. This was essential for her mother's management of everyday life. This is made clear in her statement of that "things had to be in order" ("och då fick det vara ordning"). All of the siblings started working at the estate early in life. Later in life she educated herself to a child caretaker whereupon she worked as such, first among families, and later in orphanages in the city. On one occasion she summarizes her early life as leading to acquiring what she calls "a healthy view of life", which is to say that she in general does not dwell in a negative way on past events. From the point of marriage, she and her husband, lived on the countryside were they together managed a farm.

As a child she attended a six-year elementary school and through her life she has attended a number of courses, among them courses on various art forms. In a number of conversations she declares that she had wanted more education, and in our conversations there are recurring references to academics versus non-academics as people who are from different worlds. This is reflected in her interest in knowledge gaining activities. She regularly attends open lectures and meetings hosted by a number of associations, and she also often attends several cultural events at local scenes.

Her social life, aside from the associations, centers mostly around family. She has daily contact with her daughter who lives nearby. Alice also walks her daughter's dog daily. She also has friends that she sees regularly, but she says that many have passed away or live in institutional healthcare centers due to physical and/or cognitive issues. She still visits those friends, but does not see them as often as she used to. She also describes that she in recent years has started to socialize with friends of her daughter, which also enjoys similar cultural events as Alice.

I also interpret that knowing and seeing the surrounding world is important for Alice, where she often during interviews and observations points at features of the surrounding community that she finds inadequate for, for instance, the older population. For instance, she talks about the lack of proper bicycle paths, too small and too few waste bins, and problems with the situation of using the card machine in the local buses.

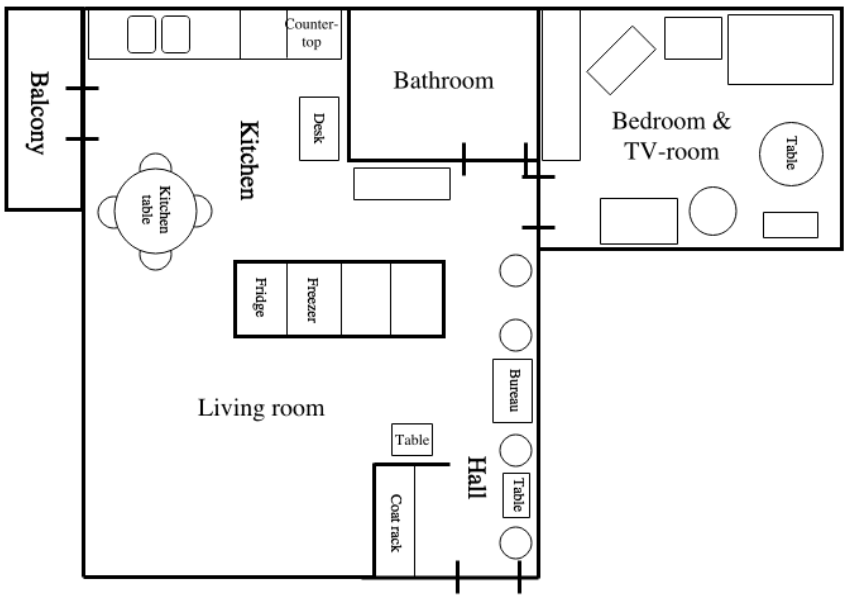


Figure 2: Alice's apartment. Details of, for thesis, less relevant parts have been excluded and proportions and segments are not exactly correct.

The apartment that Alice lives in is a large two-room apartment (see figure 2). When entering the apartment there is a small hallway. The hallway is relatively dark in comparison to the opening in front, which leads to the living room on the left, and forward to the continuation of the extended hallway. These openings are all bright from various windows in other rooms. The hallway lead further lead to a bathroom and a combined TV- and bedroom. The living room continues to the kitchen area, which together with the hallways creates a circle that connects the areas together. Off the kitchen there is a balcony. On most of the occasions when I visit, cognitive tools and external

representations can be found in the kitchen area and the combined TV- and bedroom. The hallway is at some occasion also an area where objects that are on its way out are located. The living room seems to be mostly used for representation and passage between kitchen area, and hallway and toilet.

When she moved here she says that she doubted the usefulness of the open kitchen/living room layout, for the reason that cooking and serving in the same room is a messy combination. Nowadays she is keener on preparing food before guests arrive than she was when living in an apartment with a separate kitchen and dining area. The kitchen is now also smaller than in her previous homes and she remembers how it was, and still is, tricky to prioritize which things to keep and not to keep.

4.6.2 A four-roomer and Beatrice

Beatrice is 88 years old and lives in an apartment in a central area of the city. She moved there eleven years ago, which was the year after her husband died. Before this, they lived together in a larger apartment nearby. They moved to the current city roughly 45 years ago because of an employment opportunity for her husband. She is a retired teacher of children with special needs.

Beatrice has always lived in cities and says that she appreciates the short distance between her current apartment and several important parts of the city. Although she appreciates the city, she has a small house in the countryside which she usually visits for a number of weeks every summer, and she plans for this during our meetings in April, May and June.

Keeping track of the past and the future is important for Beatrice. She has a number of cognitive tools that she uses to keep track of information in systematic ways. They are spread throughout the apartment, but the most commonly used ones are often localized in the kitchen area.

I will return to the specific uses of these tools in chapters to come, but for now I note that her reasons for having all of these tools can also be understood through her engagements and memberships in various associations. On one occasion she tells me that she has recently decreased the number of associations of which she is a member from 18 to 12. Most of the associations have meetings once a month, and managing 18 such meetings a month was too much for Beatrice.

Beatrice describes a similar social situation to Alice's. Many of her friends have passed away or live in institutional healthcare centers due to physical and/or cognitive reasons. Beatrice says that, though many friends have fallen away, many friends have also been added to her social network. Like Alice, during interviews and observations Beatrice often points at features of the surrounding community that she finds inadequate for, for instance, the older population.

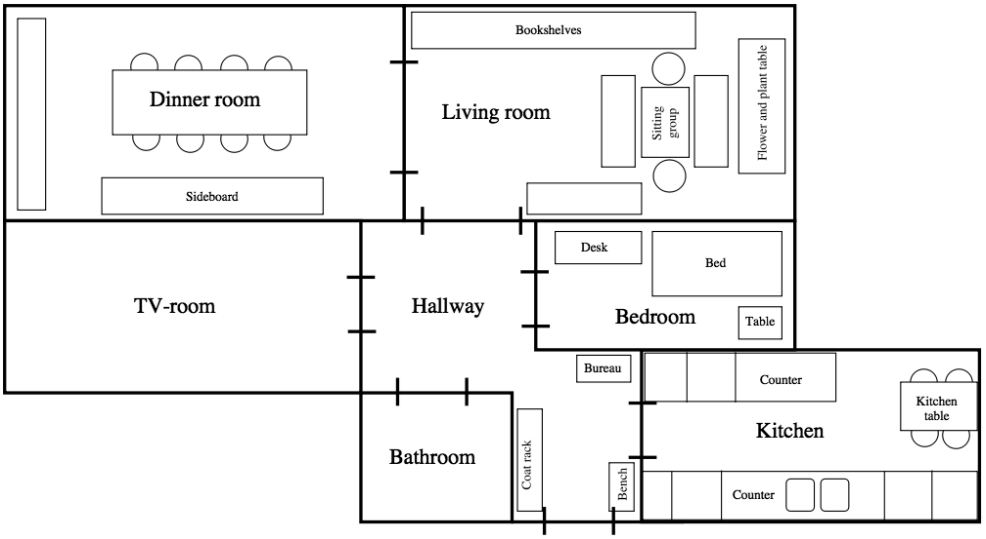


Figure 3: Beatrice's apartment. Details of, for thesis, less relevant parts have been excluded and proportions and segments are not exactly correct.

The apartment Beatrice lives in is a four-room apartment (see figure 3). When entering the apartment there is a small hallway section that quickly leads to the kitchen to the right, and later to a bathroom to the left. The whole hallway area extends further into the apartment and is the heart of the apartment, directly leading to all rooms except one. The rooms include one bedroom with a secretaire, one recreation room which she calls the TV-cubbyhole, one dining room, and one living room with low seats and several rows of bookshelves. She says that her current apartment is rather large for an older woman like her, but she gives no impression of wanting to move.

4.6.3 A one-roomer and Charles

Charles is 88 years old. Before retirement he worked with maintenance, repair, inspection and teaching of equipment in the army. He is a member of a couple of associations, whose lectures he occasionally attends. Before he moved to his current apartment he lived in a larger four-roomer with his wife. When she passed away he moved to his current home. He does not cook because he does not find any joy in cooking for one and eating alone. Instead he eats lunch out most days. Charles tries to walk roughly an hour each day and at least once a week he shops in one of two grocery stores nearby. He walks with a rollator and therefore prefers city areas.

My interpretation of my discussions with Charles is that family is important. He talks with his son almost daily when his son is traveling home from work. On one occasion he describes how he will later be picked up by his son to celebrate the birthday of his grandchild. He has previously bought a gift and expresses happiness when talking about the arrangements.

Because of eye problems he has trouble with depth perception and says that he is therefore generally uncomfortable in environments outside his home. Furthermore, his condition is slowly getting worse. He says that inside his home, actions work better because he has learned the distances between areas and objects. Outside his home he is more cautious.

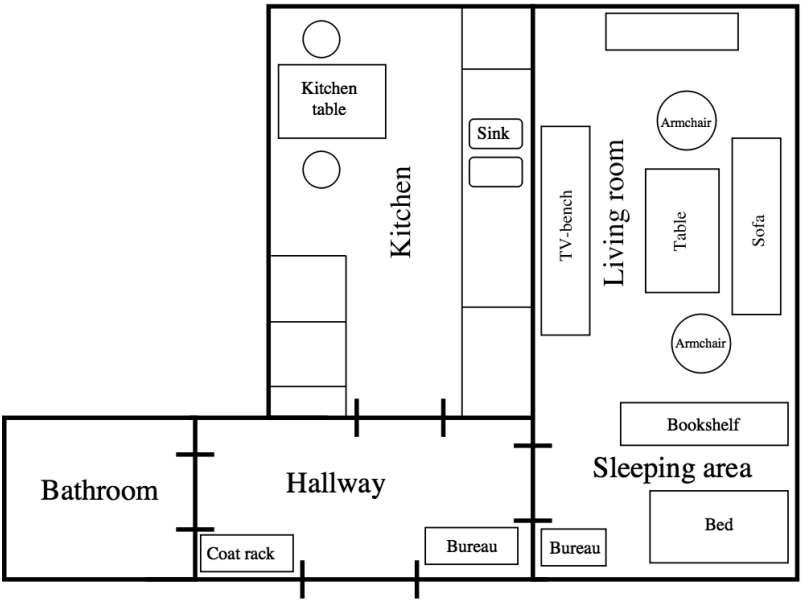


Figure 4: Charles' apartment: Details of, for thesis, less relevant parts have been excluded and proportions and segments are not exactly correct.

The apartment Charles lives in is a one-roomer located in a central area of the city. When entering the apartment there is a larger hallway that bridges all areas: with a combined living and bedroom to the right, the kitchen straight ahead, and a bathroom to the left (see picture 4.). Compared to Alice and Beatrice apartments there are more objects located openly around Charles' apartment. In some measure this is because this apartment is smaller. When, for instance, we take a look at the kitchen table he refers to it as his "desk". On the kitchen table he has, among other things, a calendar, letters, newspapers, and an attached reading lamp. He usually eats in the living room in front of the TV. Next to the armchair he also has a reading lamp. The reading lamps are important tools for his ability to see.

His living room is relatively dark due to the window blinds being down. All of the windows in his apartment are directed toward the south, making his apartment too hot or too bright if the blinds are not down. The angle of the light directly hits his eyes if he watches the TV in his armchair, where he normally sits while watching TV or listening to music. Watching TV is one of the things he mentions that he likes to do. But he also mentions that he sometimes thinks that he watches too much TV; whereupon he turns it off to do something else, such as solving crosswords, or listening to classical music or audiobooks. He used to read more in the past but due to the eye problem he is almost blind on one side, and therefore audio is preferred. The living and sleeping areas of the room are separated by a larger bookshelf. Cognitive tools are focused on the kitchen table, a shelf on the bookshelf next to his armchair, and the furniture directly to the right when entering the living room.

4.6.4 A three-roomer and Moa

Moa is 82 years old and has lived in the current city for roughly five years. She considers herself healthy and usually has some non-domestic activity planned each day. She attends a couple of weekly exercise sessions, which she travels to by bus. She has a number of friends who she sees

regularly. For instance, one recording session takes places before she leaves home to meet up with a friend to go to look at a car to possibly buy. On one occasion she also drinks coffee ("fika") with a friend in the living room before the recording starts, and on one occasion she leaves home to eat lunch at a friend's place.

When Wiik asks her if she uses a calendar she says that she does, but she considers her use of it to be rather sloppy because she does not write down routine activities, such as exercise sessions. She also says that remembering these activities works fine without the calendar.

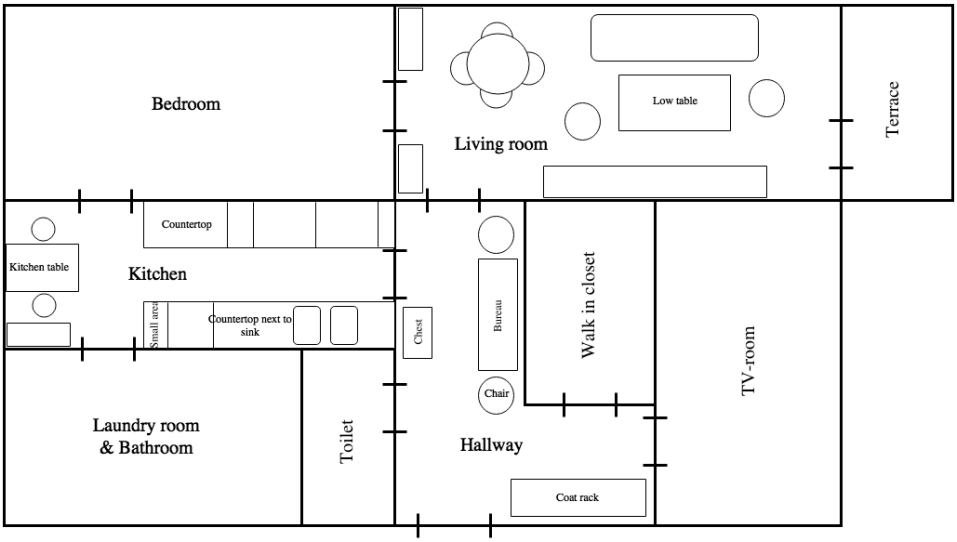


Figure 5: Moa's apartment. Details of, for thesis, less relevant parts have been excluded and proportions and segments are not exactly correct.

The apartment Moa lives in (see figure 5) is a three-roomer located just outside a central area of the city. When entering the apartment there is a hallway, which leads to a TV-room and walk-in-closet on the right, a toilet room on the left, and further along leads to a kitchen to the left, and a living room straight ahead. The hallway includes two offloading spaces on each side, and two chairs. Directly to the right inside the entrance there is a coat rack with shoes on the floor and jackets on the rack. Just opposite the rack is the door to the walk-in-closet which contains a variety of clothes and objects, such as more jackets. The TV-room includes a three-seat sofa opposite the TV. When entering from the hallway the kitchen is long and narrow at first, but then it broadens closer to the windows, where there is a seating area with a table and two chairs. At the broader part there is also a door to the left which leads to a bath- and laundry-room, and a (always open) door to the bedroom on the right. The bedroom includes a bed and a desk with a stationary computer.

From the bedroom there is also an entrance to the living room, which creates a circle of most passages in the apartment. The living room is bright, with one higher and one lower seating area and a larger bookshelf. From the living room there is a passage to a terrace.

4.6.5 A section of a house and Yvonne

Yvonne is 70 years old (73 years at our last meeting) and has an educational background of being a district nurse. During her working life she worked as a nurse, first at a hospital and later, and

most of her working life, at a school. She says that she usually plans things to do iteratively during the weeks. For instance, exercising or taking care of her grandchildren. The house naturally also takes time, she says. Most often she travels by bus to the city center, but occasionally she takes the car, depending on weather conditions and suitable parking spaces.

Regarding the activity of leaving home she mentions that she often feels minor stress before leaving home. The stress centers around collecting everything she needs with some extra lead time before actually leaving. During our last meeting she confirms the feeling of minor stress but also adds that this stress is not necessarily only about leaving home it can also be a general effect of that she constantly has things she would like to attend to and intentions she would like to fulfill, and hence constantly plans for the near future.

On the occasion of one recording she leaves home to attend a meeting for a group with specific medical conditions. She is responsible for several practical aspects of the meetings. In relation to these meeting she says that she uses her calendar often. For the other two recording occasions Yvonne leaves home to attend two kinds of exercises, chi gong and water gymnastics. For the water gymnastics she usually has bathing clothes and towel ready in a bag. She also often attends general gymnastics and arranged walks.

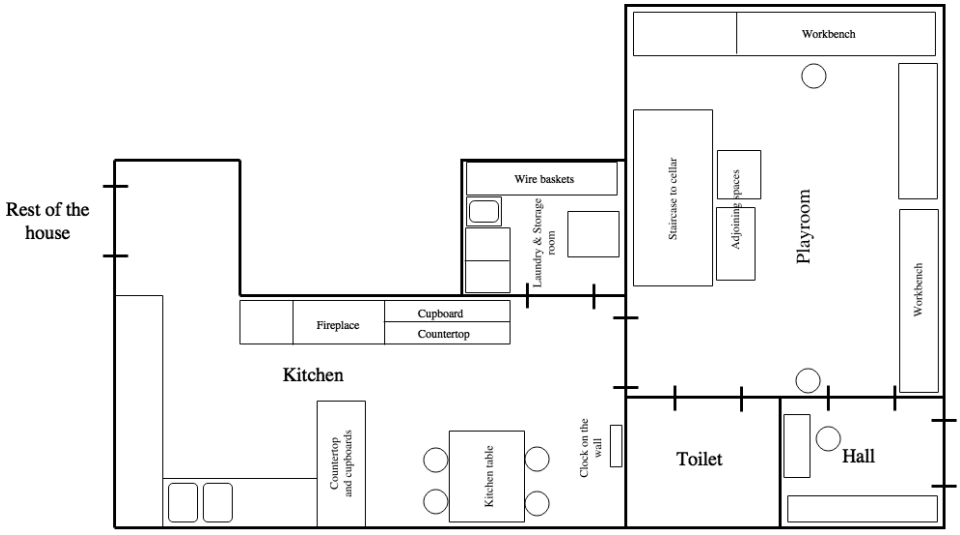


Figure 6: Yvonne's section of a house. Details of, for thesis, less relevant parts have been excluded and proportions and segments are not exactly correct.

Yvonne lives with her husband in a house in a minor town in the outskirts of the municipality. In this study only a part of the house is relevant for analysis (see figure 6). This part has an entrance with a small hall. This is not the main entrance to the house but it is the one that Yvonne primarily uses. This is where she keeps all outdoor clothes and shoes.

When walking through the small hall there is a larger foyer and an area for various activities, which Yvonne calls the playroom from the time her children were young. This area, for instance, includes two workbenches and a staircase to the basement. Connected to the foyer is a small toilet room. From the foyer a door passage takes you to the kitchen area which is divided by a kitchen counter and cupboard between an eating area and a cooking area. To the right in the kitchen a counter

stretches along the wall up to an open fireplace and a fridge. From the kitchen there is a door to a laundry room and another passage to the rest of the house.

4.6.6 A four-roomer and Felicia

Felicia is at the start of fieldwork 80 years old and has lived in her current apartment for five years. She moved here the year after her husband passed away six years ago. Before that they lived in a larger apartment closer to the city center. Despite living in the city in recent years she has lived most of her life in a larger house with stables outside of the city. She has an educational background in a 7-years elementary school (in swe. *grundskola*), one-year high school (in swe. *gymnanisum*), and half a year in rural domestic school. In her working life she worked for a company, mostly with administrative tasks. Later she became the CEO and worked there until retirement. At the point of retirement she says that she had a hard time adapting to not having something work-related to do, though she admits to having several chores to attend to in the house and the garden at the place where she lived back then.

She explains that because of her positions at the company she has always had a rich social life. As she describes, there have always been things happening around her. She still thinks she has a good social life, despite the fact that many friends have passed away. Today she regularly attends several meetings with a number of associations, for instance a reading club and a network related to her working life. At one point in a discussion she also mentions that despite the social richness she notes that she has few deep relationships. For instance, she misses having a partner to socialize with. Not that she does not like living alone, but in our discussion she continuously returns to the difficulty of finding a partner to spend time with regularly. On one occasion she says ironically that during her working life as a CEO there were too many men; but today at the age of 80 there are too few men.

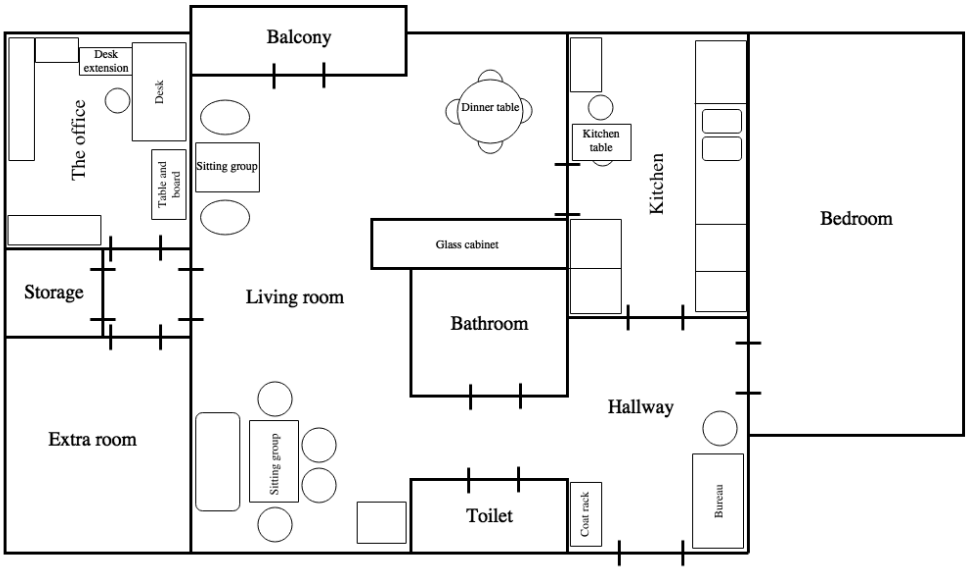


Figure 7: Felicia's apartment. Details of, for thesis, less relevant parts have been excluded and proportions and segments are not exactly correct.

The apartment that Felicia lives in is a large four-roomer (see figure 7) in a central area of the city. When entering the apartment there is a hallway with two closed doors, one leading to a small toilet and one to a bathroom. The hallway is relatively dark in comparison to the two rooms and the kitchen which it leads to. To the right the hallway goes into Felicia's bedroom, in which she has a TV. Forward from the entrance leads to a narrow kitchen which has a smaller sitting area. A larger eating area can be found on the other side of the wall in one part of the living room. The living room is large, which along with the eating area includes a minor low sitting area and larger low sitting area. The latter also has a TV on the wall. The living room leads to small hall which, in turn, leads to a room on the left and a room on the right.

The room on the right is used as an office. In the office Felicia keeps most of her written information, for instance, calendars and informational materials from associations. On a desk she also has a computer. The room on the left is described as a guest room, but during the occasions I visit Felicia it is used for a number of domestic projects, such as packing bags for an upcoming trip or managing dry laundry.

At the start of Lindvall's meetings with Felicia she says that the current apartment is too big for her to take care of and to pay for each month, but that she is too lazy to move to a new apartment. Half a year later, when I meet Felicia for the first time the tone has partly shifted. She is now determined to move to a smaller apartment and has initiated some actions in that direction. When I meet her, almost a year later, she has just moved to a new apartment in the same building. At this occasion objects and furniture are not settled in the new apartment. At the printing time for this thesis she, soon to be 84 years old, has settled in the new apartment. Segments of this move will occasionally be part of the analysis below, but the new apartment will not be the focus.

4.6.7 A two-roomer and Greta

Greta is 70 years old and has lived in her apartment for 12 years. She lives alone but says that she has a live-apart partner who occasionally visits. She summarizes her working life as comprised of a number of different caretaking professions. In chronological order they are: child caretaker, elderly- and disability-caretaker, youth welfare caretaker, caretaker within psychiatric institutions, and caretaker for younger adults with a dementia diagnosis.

When I meet her she is still involved with a couple of organizations related to her working life and the welfare of older adults. Greta is also a custodian for a younger individual, for whom she assists in, for instance, economic matters. To some extent her everyday life demands some level of routine. She describes aspects of her everyday life that are part of a routine. For instance, she eats the same breakfast every day. Bad weather means that she does not go out if it is not absolutely necessary. But she also describes herself as not being a person of routines. She gives examples, including that she gets out of bed at different times each day, and that she only eats when hungry. My interpretation of Greta's habits is that she indeed is routinized when it comes to how she does things, but not when she does things.

One reason for this is chronic issues with her muscles, which she has suffered from for roughly 30 years. A consequence of this condition is that she cannot always predict how she will feel on different days or in different situations. To cope with this, she, for example, often brings an extra pair of shoes when leaving home so that she can switch and alleviate some of her symptoms. She describes how she has learned to listen to her body, but she also admits that her social life, which she prioritizes, gets precedence over her aches. Outside of her organizational commitments her

social life centers around her friend, her children, and her grandchildren, who all live within the city center.

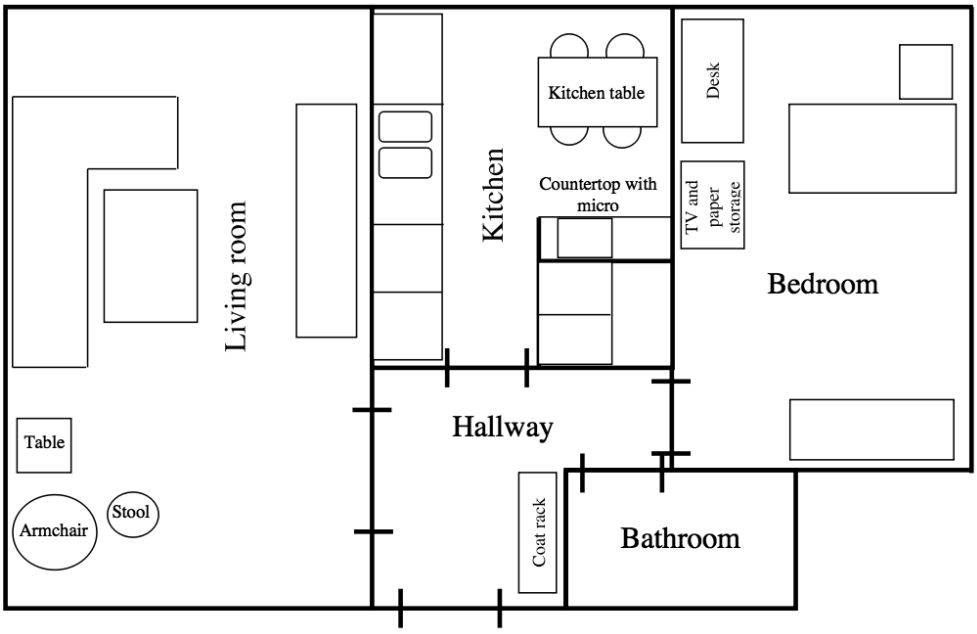


Figure 8: Greta's apartment. Details of, for thesis, less relevant parts have been excluded and proportions and segments are not exactly correct.

The apartment Greta lives in is a two-roomer in a central area of the city. When entering the apartment there is a hallway that, after a short narrow passageway, splits up into all the other rooms in the apartment. To the left is the living room. To the right is a short passageway that leads to the bedroom and the bathroom. Straight ahead is the kitchen, which begins with a narrow passageway that includes a calendar on the wall on the right side. The kitchen ends with a broader eating area with a kitchen table and four chairs. Next to the kitchen table is a counter that works as a paper and mail storage space. The bedroom includes a bed, a TV, and a desk with, on one occasion, for example, a file folder with papers regarding the person Greta works as a custodian for. The desk also has a space for papers that are less urgent than the ones in the kitchen. The living room is the largest room in the apartment. In one corner there is an armchair with a small table and a telephone in a charging device. Next to the phone there is a phone book. There is also a sofa and a larger TV in the living room.

4.6.8 A two-roomer and Hannah

The apartment Hannah lives in is a two-roomer in a central area of the city. She is 71 years old (74 years old at the last occasion). She has lived in the current apartment for two years, where she moved from another apartment in the building next door. Before moving to this area of the city she lived in a house. She has lived alone for a number of years but moved to the current city 44 years ago because of changed working conditions for her ex-husband.

Before she retired she worked as a cook for the school system. After seven year of elementary school she worked at her family's farm for some time before educating herself to a cook. Her

background as a cook is echoed in her description and execution of cooking activities when, for instance, she describes how she struggles with cooking smaller quantities and says she always has enough of the proper groceries at home to cook the base for several dishes. We will see in the next chapter that the way she cooks is relatively structured.

She eats porridge for breakfast each day, preferably never before 10 o'clock. However, she describes that she wakes early every morning, between five and six, but only at that point drinks coffee and tends to various aspects of the home. Nevertheless, if non-domestic activities demand earlier commitments she is adaptable.

A lot of Hannah's social life centers around her family, which she says she "lives for" and is her "pride". For instance, she speaks over the phone with one of her grandchildren every day. When Lindvall asks about leisure activities she says that there are not many activities that can be described as leisure activities in her everyday life, since much of her life is organized around family. When one of her grandchildren moved abroad she arranged, with help from relatives, to get a computer so that she could communicate with her grandchildren over Skype. Notably, she says that she dislikes computers and is not at all accustomed to using them. After the grandchild moved back she returned the computer. However, today, despite that she dislikes computers, she has a tablet which she for instance uses to read a number of newspapers every morning and checks updates on Instagram.

Family comes first in all situations, but in recent years she has also tried to engage in more extra-family activities. She wanted to be more than "just a babysitter". Today she has engagements in a union organization and two organizations focusing on the welfare of older adults. In one of these, she, at the first meetings with Lindvall, holds the position of vice president. She says that these commitments have recently demanded a lot of work from her.

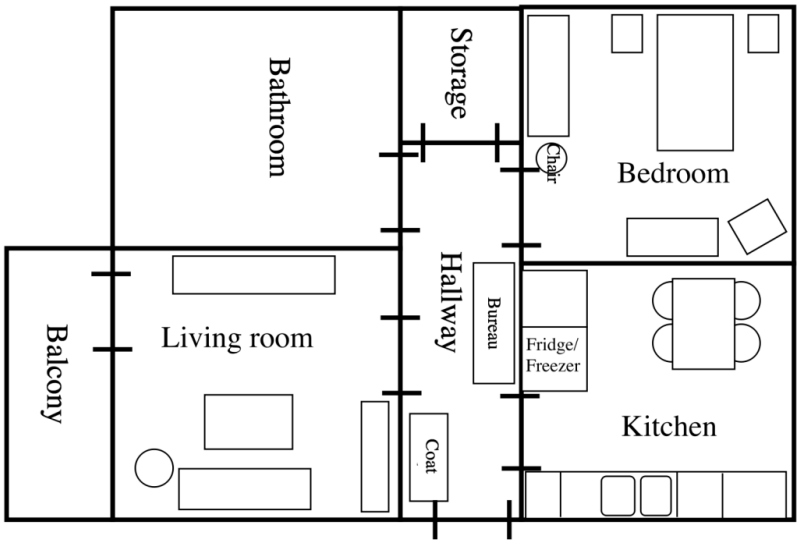


Figure 9: Hannah apartment. Details of, for thesis, less relevant parts have been excluded and proportions and segments are not exactly correct.

The apartment Hannah lives in is a two-roomer. When entering the apartment there is a narrow hallway which leads to all rooms and spaces. In the hallway there is a bureau that, for instance, is the location for the charging device for her small phone. She also has a second larger phone which

she keeps on the same bureau. The small phone is the one she uses most often because it is more suitable for pockets. The larger phone is only used for the app Viber, she describes. The kitchen is directly to the right which directly to the left has a wall calendar on the side of the fridge. Hannah describes that the kitchen has a bad design with, for instance, the washing-up sink just next to the stove.

On the fridge door she, among other things, keeps an ongoing shopping list. The living room has a TV and also includes a space where she usually keeps the tablet. The bedroom also includes a TV and is where she usually keeps her bag, which she usually brings when leaving home. The bag is also where she usually keeps her portable calendar.

4.7 Bringing the environments together

There are several aspects of the participants' lives that make them individuals with unique experiences. For instance, their working experiences are different. Though they all highly value social life they have, for instance, different relationships to, and different communication patterns with, their social networks. Their perspectives on everyday life are also different in, for instance, how they prioritize or how they receive input from the surrounding world.

However, the environments and the participants also share many ecological characteristics. For instance, all except two live near or very near the same city center. All except one, who lives in a house, live in small to medium-sized apartments, which means that there are relatively short distances between areas of relevance. Also, the physical layouts of the participants' homes are not very different from each other. Each home, for instance, has a distinct hallway area just after entry to the home. Commonalities and differences across the environments, and their cognitive consequences, is a topic which I return to in the chapters to come.

In the chapters to come I present the product of the analysis under three major chapter headings. These chapters are both theoretically motivated, based on distributed cognition, and empirically motivated, based on patterns across more minor themes.

The chapters are as follows:

In Chapter 5 I present an analysis of cognitive resources that exist in homes and nearby environments. Although this is an account of resources it is also an account of the participants' cognitive couplings to their environments and, specifically, their resources. Individuals' relationships to the resources are the basis for information flow and taxing of individuals.

In Chapter 6 I focus on the arrangements of cognitive resources. Here the focus will, in part, be on the intelligent uses of space and the practices individuals use to maintain stable environments. This chapter will also consider the dynamics of resources in the environments and their consequences for information flow and taxing of individuals.

In Chapter 7 I consider procedures and routines that individuals use to manage a few activities in everyday life by presenting two task-analyses. Here the properties of cognitive resources and the arrangements of those resources are analyzed in conjunction with analyses of participants' use of their bodies.

The empirical examples across the chapters are not completely separate from the foci of the other chapters, because several examples include descriptions of all three: the nature of resources, the arrangements of resources, and agents' procedures around and on resources.

Chapter 5. Cognitive resources

The cognitive resources I refer to in this chapter are resources that are located outside the brains of individuals. They are structures in the environment that become part of cognitive processing in some situations. In the history of cognitive science these resources have been given many names, which are grounded to some extent in their forms and purposes. Some specific examples include: external representations, cues, triggers, exograms, external [cognitive faculty] aid/support, and cognitive tools/artifacts. I first consider this last category, cognitive tools. Later I turn to objects and features, such as cueing structures, which are used by the residents as cognitive resources.

The analytical demarcation between tools and cueing devices is not strict. However, in the context of this thesis, cognitive tools are understood as structures in the environment that have been instantiated into a thing that holds representational content for some specific purpose. Since representations are, to some extent, conventionalized stand-ins for a thing or event, they are also apt to work as cognitive resources over time. Cueing devices, on the other hand, are objects and structures in the environment that work as cognitive cues and do not hold representational content. This second type of resource can range from serving as a reminder for a prospective memory to being opportunistically exploited as a resource in some situation for an ongoing or previously dormant objective. This delineation between proactively intended and non-intended cueing devices has a structure that is somewhat similar to the types of resources for prospective memory that Grundgeiger, Sanderson, MacDougall, and Venkatesh (2009) use when they differentiate between active and passive cueing devices (see 3.5.2).

5.1 Cognitive tools

All the homes I have studied include some cognitive tools that relate to prospective memory. People write reminder notes, use calendars, and have clocks, on the wall and elsewhere. All participants also make cognitive use of information they receive from newspapers and the organizations to which they belong. I return to some of these resources in the chapters to come because they are interesting in terms of how they are arranged and exploited as prospective memory resources. I first focus on characteristics of the various types of calendars participants have and the ways in which they are used by each person. Later I more closely examine one participant's cognitive tools. She is an interesting case because the system she has established in her home seems to involve several more tools than the other homes.

5.1.1 Calendars

The most common type of cognitive tools that people relate to in home environments, and specifically with regard to prospective memory, are calendars. Calendars are cultural tools that are pre-structured for tracking events across time. Time is often represented by days, but calendars can come in many other forms and sizes, all which can have different intended purposes. The use of calendars first requires picking a suitable calendar for the (vague or specific) intended use. The second step is to use it. Consider the disparate implementations and uses of calendars among the following six participants.

Hannah

Hannah tells Lindvall that she has two calendars. One of them is a pocket calendar which Hannah brings in her handbag wherever she goes: "I always bring it with me, always." During the first meeting with Lindvall, Hannah knows that they are supposed to book more meetings before the meeting ends. She has therefore placed her calendar on the kitchen table. Placing it on the kitchen table has both pragmatic and epistemic consequences: she makes the calendar physically available when she needs it and makes the calendar a congenial cueing device, for both Hannah and Lindvall, in a visible space (c.f. Kirsh & Maglio, 1994; Kirsh, 1995).

Despite the fact that she says that she always brings the calendar when leaving home, the contrary is the case when I over phone are about to book the last meeting with her. She explains that she did not bring the calendar at this occasions because it was both an unplanned activity and an activity short in time, from which she would return home from shortly. The calendar is also usually located in the bag which she usually brings, but, however, did not bring at this particular occasions. I return to issues of managing space and leaving home in the chapters to come but here I note that despite that Hannah sees the calendar as a very important tool it is not deemed to be necessary to bring for all non-domestic activities.

She describes her routine for consulting the calendar, which primarily takes place on Sunday evenings when she wants to get a grasp on the coming week. She says that on Sundays, it simply pops into her mind that she wants to consult the calendar. She cannot really say that she consults the calendar purely for the purpose of being reminded of future intentions in any other situation. This suggests that Hannah has a mental overview of the week and that this mental overview is deliberately updated on Sundays. Hannah is likely not alone in thinking of the upcoming week on a Sunday. It is probably a common time to reflect in societies where Sundays are the last day of the week and Monday is the first workday of the week. Also, Hannah's pocket calendar, as with many pocket calendars, facilitates this mental overview because every page turn shows a new week. Therefore, there is a natural mapping between what the representation stands for and the mental model with which it is coordinating (c.f. Norman, 1993).

Another reason for consulting the calendar on Sundays is because that it is the day she knows which days of the week she will have something planned, and which days are free for managing domestic activities. She says that she likes to do laundry once a week and wants to have a clear day for this purpose. After consulting the calendar on Sundays she therefore also makes the booking of the laundry facilities[11]. It therefore seems to be more cognitive incentives for checking the calendar than just keeping track of already established intentions.

[11] All apartment buildings in Sweden has laundry facilities, either within the individual apartments, or as in this case shared between tenants in a space in the apartment building.

Despite saying that she consults the calendar on Sundays for the sole purpose of checking on the future, she also adds that she often consults the calendar for other purposes during the week when she communicates and coordinates with other people. One interpretation of this is that on weekdays the reminders of future intentions come as a consequence of using the calendar with the intent of transferring new information into the calendar or communicating the content of the calendar to other people.

Hannah also has a wall calendar hanging in her kitchen, which she says she does not use in a thorough way. However, she has manually filled in the week numbers with ink because they are missing in the calendar's original format. Therefore, it seems that the week numbers are relevant information and that the calendars work as coordinating structures in some situations. In line with this, she says, relatively non-specifically, that she uses the wall calendar to get an overview of days and weeks. What this means in relation to her pocket calendar remains unclear, but the action of filling in the week numbers suggests, minimally, that it has some intended function.

Charles

In contrast to Hannah, Charles tells me that he used to have a calendar on the wall in the kitchen but "it was only there to look good", therefore he threw it away. However, Charles in fact has another, month-based, wall calendar, but this one is placed on the kitchen table under his reading lamp. Since Charles has problems with his eyes, the positioning under the reading lamp is convenient for all reading and writing activities.

He says to Lindvall that he thinks he consults the calendar at least every morning, both to keep track of the near future and the near past. For instance, he uses the calendar to decide if he needs a haircut: "If six weeks have passed, I better go". By using this practice, he has distributed the decision-making process between himself and the calendar and has also made the process of deciding to get a haircut a cycle-based routine. However, to initially consider his need for a haircut he still needs to be triggered by, for instance, his perception of the status of his hair or the idea that his most recent haircut was possibly a number of weeks ago.

A similar recurrent entry in his calendar, which solves the triggering aspects of the haircut task, is visits to the podiatrist, which occur every eight weeks. He has an appointment ahead of time for these visits. In February he tells Lindvall that he has visits booked until October, which is convenient because, he says, it is sometimes hard to get a time at the podiatrist, and he prefers to schedule a recurring visit. Booking ahead of time likely helps for the practical reasons Charles mentions, but it also alleviates strain on internal memory abilities and the need to interact with temporal planning. The reason for this is, first, that he needs to remember to book a time less often than he would have if he had booked after every visit, or in advance of each new appointment. Because he has arranged the temporal events in advance there are fewer critical situations (c.f. Rajkomar et al., 2013). Second, when he books ahead Charles also facilitates a socially distributed memory because his podiatrist is likely aware of his visiting cycles and can therefore facilitate a coordinated activity, keeping track of when the last booked occasion approaches. He also removes the need to pay attention to and assess the status of his feet on his own, which would be the case had he followed a similar strategy to the one he uses for managing haircuts. The feet are also a less visually available source of information than hair, which a person can see when they look into a mirror.

Comparing the examples of the feet and the hair reveals that Charles' use of his calendar is not equal across intentions, perhaps because of the circumstances of each intention. However, since

Charles has an idea of how often he should go for a haircut, the management could indeed become equal.

What is written into a calendar can also represent intentions. My second visit with Charles has been entered into the calendar at the time of arrival that we decided on over phone. Below the time it says "from uni". Below that line there are some thin lines that suggest that he perhaps intended to write more information but for some reason did not. At first glance this is a partial representation of what is going to happen. But consider other resources related to my visit. In the living room he shows me that in a drawer he has more thorough information from and about me, which he received previously from Lindvall and me. In showing us this he demonstrates that he has access to more information on what "from uni" means. "From uni" in the calendar is a sufficient temporal space holder to inform Charles of roughly when and what this event is. "From" also states a direction, which suggests that the meeting will not take place somewhere else; in other words, he is not going anywhere. Altogether the short phrase "from uni" captures what is important for Charles to prepare for the event. We will see below that this use of partial short phrases is common for other participants.

Of course we can expect that Charles could recall at least some information about the event just by reading the partial phrase in the calendar. However, for now, we can infer that the lack of contextual information about the meeting nevertheless taxes the persons' abilities more than if the information in the drawer had been physically integrated with the calendar. Because of the types of tools and resources in the home, there is an integration problem. For more on this problem, consider Alice.

Alice

Alice has a wall calendar in the kitchen that fits almost perfectly into the space between the kitchen counter and the desk between said kitchen counter and the fridge (see picture 1[12]).It hangs at a height that is too low to be ergonomic on one of two hooks designated for kitchen towels and mittens. Every time Alice looks at the calendar she either bends forward and pulls it towards her or unhooks it to read it in a different position. Occasionally the calendar is in front of the stack of items on the hook, but most often on my visits the picture on the calendar is partly covered by other objects. It seems that the calendar has not been given a prominent place in Alice's home. At our final meeting Alice says that calendar is where it is to make "as little ado as possible". Nevertheless, this does not mean that the calendar is not a prominent tool. The importance of the calendar is revealed when one considers the other sources of information that Alice uses remember future intentions, and how they relate to the content of the calendar.

[12] All pictures are used with permission from each participant.

Picture 1: Alice's calendar space.

Alice is a member of a number of associations. The meeting dates of the most important associations can be found in the original informational pamphlets; which Alice has placed on the fridge door or in the bedroom on a table next to the bed[13]. Charles also has informational materials that he has received by mail posted on the fridge. With some hesitance, Charles claims they are redundant to the information in the calendar. Alice gives some insights into what redundancy can mean with regard to the use of calendars. On a number of occasions Alice shows me these papers or explicitly refers to them, and spontaneously starts to talk about the meetings and lectures that she has visited and intends to visit. Occasionally she aids her storytelling by referring to the wall calendar: "Let's see, what did I do?" She also refers to the calendar to review her future intentions to attending lectures, etcetera. It seems that the informational documents do indeed reveal her preferences for certain lecture and meeting topics. She can easily tell me what content on the papers she finds interesting. However, her preferences do not necessarily match her intentions. The calendar works for prioritizing preferences of intentions and it seems to be where she records her decisions. The calendar is therefore not just a tool for aiding her memory; it is also a decision-making tool. However, as seen in the example above, the calendar can work as a fact checker, for both the past and the future, when she reviews her choices by reading the papers on the fridge door.

There is also a third main type of resource involved in Alice's system of tracking events across time. That is her mental model (c.f. Gentner & Stevens, 1983; Johnson-Laird, 1983) of the weekly chores that needs to be coordinated with the calendar – in Clark's (2010) words, the surrogate model. On one occasion she reviews her ongoing week, partly looking at me and partly looking at the calendar. Yesterday included two major events, she says. One meeting with an association and a walk with another organized group. Tomorrow, a Friday, is empty (they usually are she tells me), and "On Saturday me and my daughter usually do something with her garden." Here she stops

[13]Interestingly, these orderings seem apt to change: when I visit Alice the final occasion the fridge is instead covered with photos and the information pamphlets has instead been placed in paper piles on the desk in the kitchen.

when she sees on the calendar that she has planned a visit to a friend and her friend's husband on this particular Saturday. Note here that Alice has ascribed intentions to days of the week that go beyond the use of the calendar. Therefore, it seems that she has a mental model of normal weekly chores. The calendar, despite being the decision record, seems to more specifically manage intentions that are outside of the regular chores of the week. The example above also shows how the mental model can be projected onto the day-structure of the calendar (c.f. Kirsh, 2009b). However, in this particular case, the non-compatibility was spotted when the projection met with an obstacle. The example above shows the importance of occasionally coordinating the two resources.

The model of the weekly chores is nevertheless a powerful resource for Alice because it is the only calendar she uses that is portable. To deal with the issue of portability, Alice used to have a pocket calendar. However, she describes the beginning and the end of using it: "I started so valiantly in January […] but there is no discipline in me." This is an obvious example of the cost involved in the use of external resources (c.f. Kirsh, 2010a): that is, these resources sometimes demand extra maintenance, which in some cases is too great to be worth the effort.

When I ask what she does when she is not home and has to set a meeting time with someone, she replies: "Of course I'll remember." She also mentions that sometimes she makes notes with a pen and paper, but also that she usually does not bring paper in her handbag. Instead, pen and paper is for the most part only found next to the phone located on the kitchen counter area closest to the wall calendar. She also says that reminder notes are occasionally used and placed around the kitchen counter and the desk[14].

Altogether, her comment indicates that both her mental model of the normal weekly chores and the specific week's chores can be used in situations outside home. This is confirmed at one point when I phone Alice to book a new meeting when she is in [neighboring city], looking at flowers. She says if she does not phone me when she gets home, we will meet on Sunday at 1 pm. She does not contact me before we meet on the chosen Sunday. The task Alice refers to here is to remember to coordinate a specific time with the calendar at the point of coming home. This is something that taxes Alice's abilities, but the example also suggests that she is normally not in need of a portable calendar.

Also, in the descriptions above regarding regular chores, the example of garden work on Saturdays is an activity also sometimes related to the everyday life of her daughter. This means that reminders for activities with her daughter are potentially socially distributed, which is possibly a good thing, because, as noted above, these are intentions not redundantly represented across her calendars.

If one task is to coordinate calendars, as Alice demonstrates above, another task is to make sure information is transferred between calendars. This is not always the most straightforward task. Consider the following examples.

At one point towards the end of one of our meetings, before I am about to leave, I ask for the opportunity to meet her once more, whereupon she takes down the calendar from the wall and puts it on the kitchen table. We decide on a time while she consults the calendar. But instead of writing anything in the calendar she returns the calendar to its hook while we go on chatting for a few minutes more. Just before I am about to walk towards the hallway she recalls that she did not write down the time and goes back for the calendar to do so. This illustrates that the use of the calendar to represent future intentions can be divided into two processes. Much of what was seen

[14] However, I have, across my nine visits to her apartment, except from shopping lists, never seen a reminder note.

in the previous examples was a reading and coordination phase. But what is revealed in this example is a need for an information transformation phase, where the intention is, through a projection and writing process, transferred to the calendar. Just as it seemed that Charles did not write all that he intended when booking the meeting with me over phone, Alice, in the midst of a discussion (the ongoing task), did not write down the intention we settled on.

Furthermore, the creation of intentions in the calendars can also involve the management of practical issues regarding how to create the intention. Alice has during the first of our meetings recently received her first iPad and explains that she uses the iPad to send e-mails. She also tries to use it to visit various websites but finds it difficult to remember the addresses for the websites she often visits. It appears that she does not use search engines often because she does not know what keywords to search on to find what she is looking for. This demonstrates that it is a skill to know what to search for. However, she uses bookmarks for her most commonly visited websites. She explains that she has mastered the bookmark functionality on web browsers on personal computers but that it does not work the same way on the iPad. When we sit in front of the iPad together I find that she struggles to interpret symbols and menus on the iPad. The meaningful coupling between functionalities on the iPad and Alice's experience-based vision is yet to be formed.

She explains that at some point she intended to use the iPad as her calendar but she says, "I am not that good at entering information." On one occasion she asks for my help whereupon we sit down in front of her iPad at her desk in the kitchen. It is relevant to note that at that time, I had never used the calendar function on an iPad before, but I had some experience of the touch function. She says that a previous problem was that she was not able to open the calendar. Now when she tries, it works and she says: "That is how it works." When the calendar opens she sees an event that she had entered previously and says, "I was supposed to go there but that is now impossible." Her reason was perhaps that the event had passed or because it did not work with other activities.

It seems that starting to use a new calendar introduced some calendar issues because she did not have any natural coordinating practices in the way she seems to have for the other calendars.

She initiates the process of adding an event into the iPad calendar by saying, "Now I want to enter an event, how should I do it?" I aim to show her but I use the motions incorrectly and manage to unintentionally switch the week. Finally, I recall that one can tap-and-hold anywhere on the day of the event to open the enter-event window. She says that she recognizes this window and suggests that she should enter the time in what is actually the comments field. I tell her that this is not how it works and point at the selection list of numbers while saying that this is where you should enter the time. She sighs and says, "How am I supposed to remember this?" The interaction with the scroll function does not work smoothly for her, but finally she manages to set the numbers on the event starting time. Then I say that she also needs to repeat the steps for the end time of the event. She quickly responds with surprise: "But I can't know that." After this session she seems even more certain that she will keep using the wall calendar exclusively.

There are two major issues that account for the hassles Alice experiences with the iPad. First, there are interaction problems with the touch function because the iPad cannot manage her occasional inexact finger movements. This was likely also why she did not manage to open the app at a previous point in time. Increased intra-individual variations of finger movements is a normal development of aging (Sosnoff & Newell, 2006), and furthermore using the touch functionality is something people gets better at with training. Second, the calendar in the iPad does not completely map to the functionalities of the analogue wall calendar. The errors Alice makes originate from the

mismatch between the mental model of how to interact with a physical calendar and how to interact with a digital calendar. On a physical calendar one does not need to write an end time, or to choose points in time from a rolling list. Also, the comments function that appears initially seems like the blank space on her wall calendar, and therefore Alice's inclination to opt for writing in this space is not strange. It seems reasonable to enter information in the comments field. Altogether, the iPad's digital calendar introduces fundamental new ways of tactile interaction and also, perhaps even more importantly, fundamentally new forms of mental interaction. Although it provides some additional functions, the digital calendar is not relevant enough for Alice to be incorporated into her daily chores.

When I meet Alice the last occasion she has extended her use of the iPad to a number of various apps but nevertheless stands firm of her opinion and use of the calendar functionality.

Greta

Compared to the other participants, Greta has the most elaborate wall calendar. This wall calendar is found in her kitchen. She also has a pocket calendar she always brings when leaving home, but it seems that the wall calendar is the primary operational tool. The wall calendar is what is often called a "family calendar" where each row can represent a person. But instead of writing down names as headings she has six categories spread across each row based on domains of her everyday life. Four of them are associations for which she has responsibilities. One row deals with her private life: "my own stuff". The last row deals with children and grandchildren: "children/grandchildren".

Greta likes the calendar because it gives her an overview of events. It also works well, she explains, because she has poor vision: "I think this type allows one to see well." There are reasons why the pre-structure and her particular implementation of the calendar allows her to see well and get an overview. For instance, events are not cramped in a single square the way that they would be in a calendar without columns, and are therefore more easily distinguished as single events.

Additionally, for Greta, the headings, which denote segments of her life, signify more information than the calendar includes. This means that at the point of entering information she does not need to write as much each time as she would if the calendar were a normal type with one area per day. Here is an example. During a visit to Greta I pay attention to the calendar on the wall. Looking at one meeting on the calendar, I ask why she has not stated where the meeting takes place, as she has done for other meetings. Greta excuses herself, saying "it should say [location x], she phoned this morning [to name the location]". Her explanation for not writing the location is that she was tired when she received the phone call. But when I ask her if [location x] is where they usually meet she says "Yes, it is with the [association] and we usually are at [location x]." Therefore, Greta can rely on her knowledge of how things usually go to amend, what looks to me, as an outsider, to be an incomplete entry. Therefore, there is something that can be seen as an experience-based vision (c.f. professional vision, Goodwin, 1994) of the information in the calendar. To decrease her cognitive burden she includes information in the calendar that is not covered by her knowledge, that is, she records aspects of an activity that depart from the norm.

Greta tells me that she prefers having one event a day and Wednesdays free from responsibilities. This idea of weekly management guides her planning so that she is reminded not to do too much. But this mental idea together with her specific implementation of the calendar can also lead to problems because the calendar is not adapted to all relevant cognitive tasks. At one point she describes how she recently had a visit from her sister, who knows that she usually has Wednesdays free. The sister therefore suggested a Wednesday, whereupon Greta checked the calendar and indeed found that the Wednesday was empty and therefore agreed on the visit. But a visit from her

sister always means that she will stay overnight. And on this particular occasion the sister would not leave until 5 pm on Thursday. This created a conflict because Greta had two responsibilities on that Thursday scheduled for around midday, with two different associations.

She only realized the conflict later, which led to rescheduling the Thursday meetings so that someone else could manage her responsibilities. The calendar is suitable for providing an overview of Greta's everyday life and it likely helps her find information more quickly than if she had a calendar that did not differentiate between the categories of her everyday life. But it was perhaps not the best representation of a calendar for this particular task. Why is that? First, the structure of the calendar suggests that all events end the same day that they start because each box relates to one day only. This increases the risk that an event that extends across more than one day will not be checked for conflicts with events of other days. By using Norman's (1993) reasoning of representational structures, the structure gives no assistance for temporally ordering several events within days, or temporally ordering events which extend across days. This task is left for Greta to solve in some way. In the example above she does not solve it by marking the event as one which extends across segments of the calendar. Nor, it seems, is she triggered to initiate a perceptual scanning task and order the events mentally. A calendar that had, for instance, spatially represented all events on the same linear scale with a starting time and an end time would have been a better coordinating tool for this particular task.

This example can also be compared with the time Alice and I tried to use her iPad-calendar. Analogue calendars do not prompt users for an end-time for an event. For many events there is nothing wrong with this, and it can even be a good feature. But as the example from Greta indicates, some conflicts could be spotted if the calendar asked for an end time. Overall these examples show that a calendar structure that works for remembering some intentions does not necessarily work for other.

Felicia

Felicia normally has a calendar located on her desk next to the computer and telephone in her office (see picture 2). It has a rectangular shape and displays a week per page. Each morning, as she tells Lindvall, she goes to the office and checks the calendar: "I need to see that I don't forget anything." When Lindvall asks if she is in the office a lot Felicia says that she believes that she is not but also says "I think that an office should contain objects such as these" and that she may go to the office several times if she needs to be certain of something. My interpretation of this is that the office is not a room where Felicia spends quantitatively a lot of time, but it is a room she needs to visit relatively often to manage a number aspects of everyday life, such as checking the calendar and using the computer[15].

[15] Interestingly, when I meet Felicia the last occasion in the new apartment she no longer has an office-room and has divided the functionality of the office between the bedroom, where she has a desk, and the kitchen, where she now has the notice board.

Picture 2: Felicia's office

Felicia expresses dissatisfaction with the shape of the calendar. Though it does provide an overview of the week, it does not work well for recording non-domestic activities. Again, as was the case with Alice, this reveals a problem of portability. But unlike Alice, Felicia actually uses a smaller pocket calendar that is usually located in her handbag. However, she says she does not update it regularly. In other words, it does not match her desk calendar. When I ask her if she needs to keep it up to date she responds, "No, I know that I can check its correctness [later]." From this perspective she can use the smaller pocket calendar for entering information that she can later compare to her calendar at home. It therefore seems that she uses the calendar as a pen and paper tool but with the days and weeks structure.

There are also indications that Felicia to some extent keeps track several days ahead without the structure of the calendar. For instance, at one point when I am in Felicia's apartment I ask about her next week. She says that she receives the keys to her new apartment on Monday and that "there is something on Tuesday". When I ask her if it is okay if we meet she goes for her calendar. She realizes that Tuesday is not suitable. Felicia did not remember exactly what she was supposed to do on Tuesday but she sensed that this was a day that was marked for some activity. I know that this week is special for Felicia, because it is not every week one gets keys to a new apartment, and therefore she has her attention on the specifics of the days. Both Alice and Felicia has mentally marked days for particular activities. Alice has the tending to the garden on Saturdays and Felicia has a course she usually attends every Wednesday evening. But also, the example shows that people sometimes have mental models of specific days marked as busy without specification of the content. We saw something similar with Alice when she had mentally marked Sunday as non-busy. Here I can use Kirsh's (2009) notion of projection to hypothesize that it is easier and/or goes faster for Felicia, when she is not home, to remember which days are busy if she has the structure of a calendar in front of her. The calendar would act as an anchor for her mental remembering

processes. This suggests that bringing an empty pocket calendar can be better than just bringing pen and paper.

Felicia's calendar solutions work in most situations but she nevertheless believes that she should arrange some new tool. This is only a problem, she says, when she needs to arrange something with someone she meets, for instance, when she is downtown or is visiting a friend. She is not happy that she cannot be certain when she has an open spot in her calendar. Importantly, when I meet Felicia at the final occasion she no longer has the calendar on the desk, and now only uses a pocket calendar which she occasionally, but not always, brings when leaving home.

Furthermore, despite Felicia's ability to mentally keep track of the status of future days, the process is not always perfect. At another point, when we are scheduling a meeting over the phone, I ask her if she can meet late the next week. She responds quickly that she is free, but corrects herself when she sees on her calendar that Friday before noon and Wednesday evening do not work. I suggest Wednesday in the middle of the day. She says "yes" but also says that she should first check another source. She quickly responds that it works. My interpretation of this is that her primary source is the calendar but that she also consults some paper with information, possibly, as was the case with Alice, information from an association. First, the example displays a problem with her mental idea of the week that she resolves through reading the calendar. Second, the example shows that Felicia consults and coordinates several external resources for the tracking of future intentions, as do other participants like Beatrice.

Beatrice

Each time I have come to visit Beatrice, she has her primary calendar located next to the phone in the kitchen. This is a deliberate strategy, she says, because this is where most entries are made. The calendar is a larger pocket calendar that presents a week on each page. The calendar has some event every day for a couple of weeks into the future. After that, the information recorded comes from sources that are predictable across longer time-spans: birthdays, grandchildren's examination ceremonies, a summer course camp, and activities that Beatrice has previously decided are interesting from one of the twelve associations that she is a member of. She explains that these associations often plan over the course of a semester or a year at a time. This statement suggests that at each point information comes into the apartment, Beatrice transfers the relevant part of this information to the calendar.

The calendar has two bookmarks. One of them, a silk ribbon, is there because Beatrice needs to coordinate the calendar with another tool – the silk-ribbon marks the last occasion on which she wrote in her diary. Another bookmark, a red card from an organization, signifies the present. When I ask about them, I get the impression that their uses are not as strict as Beatrice first describes. Because the bookmarks are not used consistently across occasions. The red card is not always in the calendar and Beatrice seems to care little when it accidently falls out. Perhaps it was used to mark the present in some situations. However, the present can be traced through other means, for instance mental tracing or the newspaper.

The silk ribbon seems to be more important, but it is also to some extent redundant, as the diary naturally states the last entry. However, it seems to serve another function. Beatrice says that she estimates that she writes in the calendar roughly every fortnight. This is therefore not a strict routine. The reason for this fuzzy regularity is to not have too much to write on each occasion, and also to make sure that she can remember the circumstances at the point of entry. The silk-ribbon, when it is two pages from the present, therefore reminds Beatrice that she should write in her diary.

As mentioned in the methods chapter, for most occasions I asked the participants to inform me about their recent past and near future. I met Beatrice on a number of occasions, at approximately monthly intervals, and these conversations developed into a rather extensive story-telling activity of reviewing and remembering the past and elaborating on the near future. From these conversations it became clear that what people write in their calendars is not always the clearest information, even for the person herself.

On a number of occasions when she reviews her recent past with me she stops and asks herself what she actually means with the words written in the calendar. "What does it say I did… it only says the church." The event occurred a few weeks ago and after some seconds she recalls the specifics. The church, she tells me, was not the venue for the activity, it was only the meeting place where she met up with her friends before going to the actual venue. This writing is comparable to the example from Charles, "from uni", which also displayed partial information. But in both of these cases the most relevant information is there: where she or he should be, at a specific time, on a specific day.

At another place in Beatrice's calendar she again admits that her writing is partial. "What does it say I did on that Sunday, some obscure words here… yes, then it was a concert again." On a third occasion she brings her diary to validate her recollections about the scribbling in her calendar. To some extent the issues in these examples are due to unclear handwriting. But these examples can also be contrasted with Greta's calendar above, where information in the calendar makes contextual sense through Greta's categorization of everyday domains. Beatrice does not have such information.

I have no indication for saying that Beatrice's calendar does not work to remind her what to do in the future. But there seems to be some indication that it is not entirely the proper tool for the recent past. This is true despite the fact that it includes explicit, but partial, informational content. In fact, the information written in the calendars of all participants is most often incomplete, and he or she needs to interpret the meaning of their words.

Overall, the use of calendars is important for keeping track of events for all participants. As stated in the beginning, calendars are cultural tools that individuals do not need to invent from scratch. But something that is also clear from the previous descriptions is that the implementation and appropriation of calendars differs among people. To some extent the inter-individual differences of using and shaping calendars are consequences of the types of calendars participants use. The differences are also consequences of participants' ways of exploiting the structures of calendars, for instance, by coordinating the calendar with other resources, or by using practices and routines related to the calendars to interpret information in the calendar and to make sure relevant information is there.

Below I continue to describe Beatrice's cognitive environment in terms of tool use. She is the participant who seems to use the largest quantity of cognitive tools. Many of them she has developed by herself, but others she has appropriated from her cultural and social world.

5.1.2 Case: Beatrice's other tools

Beatrice has a pocket calendar, a wall calendar, a list of people who have invited her over and whom she should invite back, a card index system of dinner invitations, a diary, a catalogue and rating system for books she has read, a to-do list with six categories, a shopping list and more. Below I consider the functions and some of the mechanisms of the use of these tools.

The card index system for dinners is a tool for keeping track of all social dinners she has been responsible for. The index is sorted by last names, which means that each invitation may have entries across several cards. The index includes dates, invited guests, what she (and her husband) served, and comments. She explains that it goes back roughly 50 years. The idea, she remembers clearly, comes from the mother of a friend from her youth who used a similar card index system. "I found it really smart," she says, and adds that she started using the card index shortly after she married her husband, with the intention of not serving a guest the same meal twice. Today she describes herself as less creative in the use of new dishes and therefore she occasionally cooks and serves the same dish to someone who has tried it before. However, she still expresses amusement at the fact that she has control over this knowledge of the past. "Sometimes I tell my guests: I know that you have eaten this before, but I hope that you have as bad memory as I have so that you do not remember."

On a sheet of paper at the back of the calendar she has implemented another tool, which I call the *invitation debt card*. On the paper is a list of names. Beatrice says that the order of the list signifies the order in which she owes her friends an invitation. Some names have a cross next to them, which means that they have managed to invite her twice before she has had the opportunity to invite them back. Some names are crossed out, signifying that she has invited them back and that they are therefore even. Most often, she tells me, she only keeps track of her own social debts, and not the debts others owe to her.

Related to the list of names is another tool that I call the *dinner modeling tool*. Next to the list of names there is a space where Beatrice, with a slow updating rate, sketches out possible dinner party groupings for future invitations. Names from the list are transferred over to the constellations while she plans events. Currently there are two clusters of names that correspond to the list of names. Some names have arrows pointing to both groups, which signifies that they could work in either. In this way she models future dinners in her home (see Clark, 2005); a model that she can use to anchor her social engineering ideas.

Regarding social engineering, it is also evident that Beatrice has knowledge of her friends that goes beyond the information on the paper and which is crucial for creating the social constellations and tracking the social debts list. Some people have, for instance, issues with their health and cannot invite her back at the same rate as others. One couple only comes once a year and the plans should reflect that. She estimates that she meets roughly 30 people at regular intervals. Though many friends have passed away over the years, new friends have also been added to her network and she therefore says that she "can't really say that the number has decreased".

The previously described card index system also seems to work in combination with the list of names. At one point Beatrice says that a function of the card index system is that she can check how often and when a couple or some individuals were dinner guests at her home. This suggests that the source of names on the list is not only based on Beatrice remembering to write down her debt after being invited to someone's house. If she feels that a couple has been forgotten, she can also periodically check the card index for facts. The elaborate system of tools described above manages much of her social world. But she also has tools to manage the practical aspects of her personal life.

Beatrice has recently developed a *catalogue and rating system for books she has read*. It is a system that she feels she started using 70 years too late. The rating system covers books she has read and is what she calls a double index system. She keeps two books to track her reading. The first has information structured according to author and title, and includes a date and a rating from one to five stars, with five being the best. "If it is really bad, the book will not get a star at all," she clarifies.

She has a second, thicker book, which is linked to the first book by date. This list includes a summary of books she has read, chronologically ordered by the date of completion. At one point she demonstrates the system by finding a book she has read a month ago: "In February, this year apparently, no it can't be, yes it has to be, let us see if I find it now." She quickly finds the book and reads her summary, but when she reads the date, she seems to distrust what she has written. This suggests again, as was seen with the calendar content, that the use of external representation includes the interpretative agent that contextualizes, fill in gaps, trusts and distrusts information, despite the fact that it originates from her own pen.

Beatrice uses analogue *notebooks for her bank account and expenses*. Today she saves receipts and updates her notebook roughly every week, writes summaries every month and at the same time compares summaries from previous months. She wants to keep track of where the money goes, she says. This means that the products of the account book are incentives or guides for her near-future expenses. One could argue that Beatrice's recording of the past is for her pure enjoyment of remembering the past in detail. But both the example of keeping track of books she has read and keeping track of her past expenses suggest that the recording of the past can serve as input for future intentions, for instance, reading or not reading some book or having or not having some expense.

Beatrice adds to the description of how she keeps track of expenses by comparing it to how she used to keep track of expenses. On a couple of occasions we discuss the recently conducted 'excavation of the storage facilities', as she calls it, in the house where she once lived. When clearing things out she found an account notebook that was roughly 60 years old. She says that it reminded her that she used to keep notes at the item level. She believes she did so because they had a tight budget and she wanted to have more detailed control over their expenses. Her financial situation is now different, and she keeps notes on a category level. Today she has one row for expenses from the grocery store, one row for other places (such as the florist), and one row for what she calls her own expenses (such as hairdressing). Since Beatrice lives alone, I interpret the naming of the last category as a remnant from the past, when she managed a family budget. Beatrice says that she does not know when she shifted from items to categories. Given her precision in describing the moment when she developed other tools in the last ten years (see below), this suggests that the shift in budget recording did not happen in recent years. Her comparison between the past and the present shows how practical circumstances can shape what is represented in tools.

Why and when?

New cognitive tools are also developed when everyday activities shift from a collaborative effort to an individual enterprise. Most participants describe a situation in the past in which they lived as part of a couple. They describe the division of labor in their past relationships, but I cannot say how they actually coordinated the labor in the past. Nevertheless, it seems that new cognitive practices were established in the process of transitioning from living with a partner to living alone.

In one interview Beatrice says that she thinks she started using the planning tool for dinners and the to-do list with categories (see below) ten to fifteen years ago. Later in the same discussion she becomes more specific and says that it was more likely ten years ago because she does not believe she used these tools at her previous apartment, which she left after her husband passed away. Regarding the to-do list, she says that before moving from her house to an apartment she does not think they used notes as she does now. Instead she believes that she/they mainly used calendars. What this means is, of course, hard to decipher. It could mean that they used notes but in less structured ways, that she and her husband had a division of labor that taxed individuals less, or that

that they cued each other to keep track of ongoing circumstances. When I ask her about this last interpretation she says "yes", but does so with hesitance.

When I ask openly why she has all these self-made tools she has no direct answer, but hypothesizes that she finds them necessary due to loss of memory as a consequence of aging. Another interpretation, which is neither contradictory nor strengthening to her own hypothesis, is that moving to a new apartment after the recent loss of a life partner is a moment in life when new habits may arise. What seems to be a more dominant pattern revealed in the interviews and observations than memory lapses is that Beatrice prefers to have a high level of control over information that deals with her past and future activities. Descriptions of tools that she developed when she was younger suggest that for most of her life, Beatrice has catalogued and recorded aspects of her life with systematic practices. Beatrice also seems to enjoy ordering information in systematic ways. This tendency seemed to come alive again when she moved to her current apartment.

High control for Beatrice may, for instance, mean being certain that she will remember something: "If I write it down, then I do not need to make an effort to remember […] on the other hand, I cannot be certain that I will remember." This statement suggests that Beatrice, despite all her tools and props, is still not certain that she is in control. When we discuss the functionality of specific tools she specifies that they are precautions to ensure that she will not miss something important. "Important" here often, but not always, refers to Beatrice's social life. The social life is by all participants described as important and hence the intentions that relate to their social life are prioritized.

The case of Beatrice reveals a number of answers to the origin of cognitive practices: i.e. individual memory abilities, becoming alone, social incentives, interest in categorization, need for control, and inspiration from peers. Some of the tools seemed to originate from shifting to a single-individual household. Whatever the main reason for developing a cognitive tool, the tools Beatrice has developed have clear cognitive purposes. This is particularly true for the next tool, which, aside from her calendar, is possibly the most important every day operational tool she uses.

A to-do-sheet and note-taking practices

For Beatrice's final tool, I will start by describing the tool and later turn to a comparison between her tool and the way in which other participants externalize similar types of intentions.

Placed next to the phone in the kitchen is a *to-do list* that holds six categories: to buy, to visit, to phone, to write, to invite, and to fix. The "to invite" category is a different invitation list than the ones referred to previously. This is a list of individuals with whom she must plan a meeting that is not dinner. The "to visit" category, she explains, most often deals with people who live in in institutional healthcare settings and cannot visit her. There are currently five or six such friends, she says. She tells me that she tries to visit one of them each week.

The "to buy" category includes items that are necessary for managing some aspect of daily life but that do not, for Beatrice, count as a common grocery store item. For common grocery items she uses a *shopping list*, which she updates as needed. When I ask her if grocery store/not grocery store item is a correct functional breakdown of the two kinds of shopping lists, she says no relatively quickly. The breakdown should be everyday/not everyday items, she explains. In practice this means that an item noted on the to-do list may still be found in a grocery store. The delineation between the two lists may be a consequence of an externalization process of Beatrice's mental planning, which makes a distinction between what is more and less urgent. But it also means that

if Beatrice decides to buy something from the "to buy" list at a grocery store, she needs to do one of the following things: transfer the information from the to-do list to the shopping list, bring the to-do list along (which is not likely since it has a stable place in her home and includes additional information), or recall the extra item in the store. I do not know what Beatrice does, but as was true for a number of calendars users, Beatrice's tools demand coordination activities. Given that Beatrice opts for using external resources in general, I believe she transfers the item to the shopping list. Which by all means is also a task that needs to be remembered.

The "to phone" category is used when someone calls and Beatrice does not have the time or opportunity to talk. This happens once when I am there and she does not want to interrupt our meeting. She answers but interrupts quickly and asks if it is okay if she returns the call later, while at the same time writing the name of the caller on a row below the "to phone" category heading. The "to write" category is for letters she intends to write, and finally, the "to arrange" category includes miscellaneous intentions that do not fit in under the other categories.

Beatrice explains that over the years she has adapted the layout of the to-do list to leave the right amount of room for each category, based on her experience of how many items she has for each category before a new sheet is needed. For instance, she explains, this is why the "to write" category is given little space. Nowadays she seldom writes letters. She thinks one version of the sheet lasts a little less than a month. Over the course of the month the sheet is also an historical record of her near past, implemented as crossed-out intentions. Overall the to-do list is a buffer tool that channels Beatrice's intentions when they spring to mind. Furthermore, the categorization is an external model for which intentions need buffering service. So what kind of information is it? Compared to the information that all participants, including Beatrice, put in their calendars, the information on the to-do list holds intentions that have not been assigned a point in time. It holds intention that the other participants use pen and paper for, but the others have not categorized the information in a systematic way. Irrespective of Beatrice's categories, the buffering of intentions in a limited space creates a powerful tool for coordinating prospective memories.

Now consider how Felicia manages informational materials and notes. In her office she has notes in several spots but mostly on a notice board. On a couple of occasions when I do walking interviews in her apartment she is cued by notes on and around the board. For instance, on one occasion there is an information sheet on a table below the board. When we pass it, it works as a cue and she stops and says that she has forgotten to tell me about this event, which is something that she had planned to do. Putting written information and reminders in visible places is one way she uses external information to remind herself of things. However, what is visible is relative. From the perspective of being in the office, the spot for the cue is within the horizon of observation (c.f. Hutchins, 1995a) but when we are in the living room and kitchen area it is not within the horizon of observation.

Another way Felicia manages notes appears on another occasion when she and I sit down in her living room and talk about her recent activities. When Felicia browses through her calendar she suddenly finds a sticky note, far in the back. She reads it and quickly says that she has already finished this intention. Hence, putting information in less prominent places is another way that Felicia reminds herself of things. For this particular intention I do not know if the note was placed at the back of calendar at the point when the intention was accomplished.

A third kind of note-taking practice is observed when Felicia reviews her recent past, again, while reading the calendar. Just as with Beatrice and Alice, Felicia has occasional issues with interpreting her own scribblings. Consider this passage.

"It is so sloppily written that I can't read […] I was at the medical center, yes" and, "Ah, yes in November I did [X]." She goes on. "Now something is written, a phone number. [name], her name is. No, it means nothing to me." Whereupon I ask her: "Is it something that has happened or something that will happen?" She responds, "No, it is located slightly off [physically separated from the calendar content] so it can be something completely different." At our final meeting Felicia adds that despite that these occasions of not being able to interpret what she has written happens it is something rare if considering all occasions where she consults her calendar for future intentions, and that it is even more rarely if it is a note that is related to something which she has promised to do with someone else.

Nevertheless, here it seems that Felicia occasionally uses space in the calendar to note things not necessarily related to the days in the calendar. Felicia seems to have knowledge about her note-taking practices and decides that this information is irrelevant. It seems that since the calendar is often located next to her phone in the office, spaces on the calendar invite opportunistic note-taking practices.

Although Felicia uses written information a lot, and to some extent concentrates it in one room, her practices are not confined to one kind of note taking. Felicia therefore seems to have significant intra-individual differences regarding note-taking practices. This can be contrasted with Beatrice who had developed a tool to concentrate all future intentions not suitable for calendar functionality. Therefore, Beatrice seems to have more consistent practices for note-taking and managing new and spontaneous intentions.

Importantly, I have not observed any larger negative consequences of Felicia's disparate note-taking practices, although I expect that her practices tax individual resources more than Beatrice's practices. I will return to how Felicia manages intentions later because although she displays various ways of managing similar types of intentions, she also has practices to manage intentions when temporal resources become sparse and there is little room for mistakes.

5.2 Objects as cues

Objects are another kind of cognitive resource. As defined in the beginning of the chapter, they are cueing structures that do not have a cognitive function as their primary intent. Objects can have, but are not limited to, practical, aesthetic, and memory usages, but they can also be exploited as cognitive resources through semiotic processing. Cueing structures is a broad category, and is likely to be the most common cognitive resource in home environments. Below I first consider a few examples of what cueing structures can be and how they can work, and then I turn to how they can be coordinated with tools.

5.2.1 From non-intended to intended cueing devices

Plants and flowers are not placed in home environments for the primary purpose of remembering to keep them alive. But keeping them alive is nevertheless the goal for people who have plants and flowers in their homes. This is certainly the case for most of the participants. Consider, for instance, Beatrice, who has many plants and flowers in her living room and dining area, across deep window seats and other areas. The plants and flowers are important for Beatrice, especially every year when she plans for her summer in the countryside. On one occasion she says that some plants can go with her but some will not survive the trip and either need to be disposed of or tended to by someone else. The quantity of plants and her rich descriptions and expertise in tending to them suggest that the plants, for Beatrice, through a semiotic process, signify iterated care. Therefore, the plants are in themselves a prospective memory cue to act on. Of course this does not mean

that she will water the plants every time she perceives them. Consider the resources, which participants mention, involved in the process of tending to the plants. This is as much a decision-making process as a prospective memory process.

During one of our discussions I ask Beatrice how often she waters her plants and flowers and she hesitates briefly and approximates that she does so every second day. However, from her perspective this was a strange question. After her approximation she quickly adds that the watering is based on two sources of information: first, temperature, which is based both on the season and the fact that one side of her apartment is slightly warmer than the other, and second, observation, which is based on touching the soil and determining if each plant is in need of water. There is likely further expertise to Beatrice's understanding of when each plant needs water. Such expertise likely involves knowledge of acceptable dryness in different types of plants, and an insightful interpretation of the plant's appearance. It's often clear when a plant is about to wither, although it is possible that Beatrice's plants rarely reach that state.

On one occasion Felicia has recently bought tulips that she has placed on the dining table, however, they have begun to droop. When we pass the dining table she comments on them. She says that she does not know where she went wrong, "Apparently they did not like the light." What she expresses here is an uncertainty about what kind of mistake the drooping tulips signify. That the flowers have started to wither is clear. A wilted flower on the dining table signifies to her that she needs to tend to them, in this case by throwing away the wilted tulips. These three resources – the placement of plants in relation to the sun, the moisture of the soil, and the visual appearance – are reminders for Felicia and Beatrice that they should act on their plants. What these resources have in common is that they are found where they are for aesthetic reasons. However, the placement of the plants also means that, for instance, when a plant begins to wilt, it will be observable in plain sight to a person moving about their home.

The example above demonstrates that people have knowledge about their environment that makes structures in the environment signify particular actions. Another example of how past experiences create relationships between objects and actions comes from a shopping session with Greta. When Lindvall and Greta approach the checkout, Greta says that her arms hurt. When loading the conveyor belt with the groceries she tells Lindvall that it is important to turn the barcodes in the correct direction. She says in the past she has worked as a cashier and she knows the long-term consequences of such toil. In this example it is not just the past experience of working as a cashier that guides her perceptions and actions; her current experience of an aching body also directs her thoughts and understanding of the situation. I think this example is important because it shows that thought-processes are not only coupled with the visual world; in this case the visual world is integrated with the bodily and tactile world to signify the action of taking care with the orientation of the barcodes.

The fact that objects can act as cues for some thought process is not only related to features of the objects (or bodies), it also has to do with the ongoing activities of an interpreter. Consider, for instance, Felicia who, on one occasion when I meet her, has finally gotten hold of a contract for a new rental apartment. She will be moving to a smaller apartment and therefore needs to make adjustments to her collection of belongings. The planning is ongoing and in our discussions she constantly projects intentions on objects and pieces of furniture. The labels used in the discussion are: (a) want to keep them, (b) want to get rid of them, and (c) cannot move. Even if a person has had the experience of moving, there is no manual for laypersons for moving; each move is different and a person has to work out how to manage the activity. What to keep and what to bring are

processes that happen in Felicia's head during our visit, but importantly, the processes are anchored by the home environment as she scans her objects and pieces of furniture, to use Kirsh's (2009) concepts. She has made a few measurements in the new apartment that are guiding her decisions about what to keep. From the measuring she also came to the conclusion that she was able to keep most of her furniture in the bedroom, kitchen, and living room.

At one point she says that she will not label minor objects, that is, she will stop thinking of them, and instead simply bring them all and see what fits once her things are in the new apartment. By doing so she shifts from a complex projection process to a cognitive process where, in the words of Brooks (1991), the world to a larger extent can be its own best model.

If considering the cultural spread of the process Felicia goes through when planning, her move is, to some extent, a personal process. She is the one who is moving. She is the one who knows what objects in her apartment mean for her and therefore the goals of the activity are largely hers alone. But there are also expectations in home environments that are culturally broader than one individual. One such expectation is that a person will turn off the lights in their apartment when they leave home. Consider an occasion on which Moa, who has previously turned on the light in the hallway, was leaving home. At the point of leaving, Moa exits the apartment and turns to lock the door, whereupon she sees the lit light fixture. She quickly re-enters her home and turns off the lights in the hallway by pushing the switch just next to the door. One interpretation is that Moa misses the cue and forgets to do what she intended, what most people intend to do when they leave home. But I think that would be to simplify the circumstances.

First, leaving home and facing a lit hallway outside the apartment is a strong cue for turning off the lights. This is not just because the activity of leaving home together with a lit light is a clear index for pushing the switch. It is also because of the physical condition of being in the hallway compared to being in the stairwell and looking into the apartment. Moa's hallway is not a completely dark hallway, with or without a lit ceiling fixture. During the day there is natural light coming in from both the TV-room and the kitchen, which brings light to both ends of the hallway. The section that becomes slightly brighter with the lamp lit is the middle section where Moa usually puts on her shoes and other outdoor accessories. On this occasion Moa has also just opened the apartment door to chat with Wiik, and after re-entering the apartment she left the apartment door open. This let even more light into the section of the hallway where she stands. Therefore, at the point of exiting the apartment Moa has no light-based cue from the environment that she would need to push the switch. Also, in the hallway she is never looking up at the ceiling. In fact, participants are most commonly looking slightly down. The only time when Moa has the angle to easily perceive the condition of the lamp is when she has some distance from the lamp, for instance, if she is standing outside the apartment in the stairwell area or standing in the living room. The former is more common when leaving home.

The examples above show that the home is full of non-intended cueing devices, but the residents do not necessarily encounter them in the right situation. Also, how people come to interpret some structure in the environment as a cue for something can be a personal or a culturally broader process. Just as there are unintended cueing devices, participants also intentionally construct cueing devices to remind them about their intentions. Deliberate cueing devices, like cognitive tools, are deliberately formed in order to group information in relation to a cognitive task. For instance, compare Felicia's plan for moving her belongings with the way she uses her environment when packing for a trip abroad.

On one occasion Felicia has initiated her packing process for an upcoming trip abroad. In the spare room she has placed a suitcase that she is considering using. When I ask her how she packs, and whether she arranges items in any particular way she says, "Since it is only four days abroad items will just be thrown into the bag." Felicia is not concerned about making items fit in the bag, because, as she says, "Either way the bag won't be full." However, in our discussions she mentions several types of clothing she needs for particular activities and weather conditions.

When we talk over the phone the evening before she leaves she says that she has now packed "the basics" such as clothes for all the days that she will be away, and that she will pack "the rest", such as hygiene items, tomorrow morning. I did not observe the process of her packing in any detail but the way she reasons suggest that there is structure to Felicia's planning and packing for the trip. Packing for trip and planning a move to a new apartment are a similar types of activities. Both are about modeling future needs. But packing for a trip is different from moving to a new apartment for several reasons. One reason is that moving to a new apartment is likely more important than a short trip abroad. Another difference is that when packing for a trip the environment can more easily be arranged to serve as a mental projection. Collections of objects can be viewed as stand-ins for intended activities during the vacation. For instance, Felicia mentions that there will be plenty of walking and that she therefore needs good walking shoes. In this case the pair of walking shoes can act as stand-ins for her intention to walk a lot. The shoes and other objects to bring, anchor intentions in similar way Kirsh (2009) describes the grid in tic-tac-toe does for projecting x and o. Furthermore, Felicia's mental ideas of properties of intended activities can be projected onto the objects in front of her and for instance spot if something should be added.

At our last meeting she in part confirms the projection process by adding that she before trips occasionally places clothes and objects on a table (in the new apartment) for the sake of getting an overview of objects to bring. This is also similar to how she can project thoughts onto her belongings when moving to a new apartment. However, as shown in the example above in the case of the trip there is a larger degree of freedom in moving the objects involved.

Grouping objects like Felicia does with the clothes above is a way of combining features of space and objects as cues. Below is an example that explores in more detail the cognitive connections between space and object.

5.2.2 Case: a book on the French cuisine

Consider a thick book on the bureau in Alice's hallway (see picture 3). It is located on the right side of the top of the bureau with a small section of the book not touching the bureau. If it were a centerpiece of the space (ignoring the physical circumstances of other objects) I would have thought the book blended in with the aesthetic features of the space. After all, in retrospect, I I did not ask about the candelabras, which in this case primarily serve aesthetic functions. In my experience, books can serve several functions. Now this book on the bureau is an oddity that draws my attention.

When I ask about it, Alice says that it is a cookbook on French cuisine. It is on it is way out because as Alice explains, "There is absolutely nothing in it that one would want to cook today." What is it about the book and its placement that signify that it is on its way out?

First, because it hangs just slightly off the top of the space it is less likely to be mistaken for an aesthetic feature. But also, the combination of the size of the book and the layout of the bureau and the two tables, also seen in the picture, increases the chance of making it an oddity in the

circumstances. The chair between the bureau and the hallway table is designated for putting on shoes and is therefore not where she prefers to put a heavy book.

Picture 3: Alice's hallway.

Second, the book is not placed symmetrically with other objects on the bureau, which signals to me, a person with similar cultural experiences as Alice, to register the book as an object in transition. Third, the location in the hallway also suggests whether an object is on its way in or out. Altogether, these features of the physical environment suggest that an outsider can interpret some of the intentions regarding the book.

Imagine that Alice is assisted by the features described above so that the book is a highlighted object in a state of transition with a possible direction. Even if that were true, there is definitely more to what Alice sees than the properties referred to above. Alice has a recent history with the book. Recently she has decided to throw away the book and then placed it on the bureau, thus taking the initial pragmatic steps for the realization of the intention. With this history and her negative opinion of French cuisine there are reasons to believe that when Alice sees this book it not really in cognitive transition. When Alice sees the book she does not need a reminder of what to do with it. The book itself signifies that it is on its way out.

However, the placement ensures that she sees it when she is on her way out. For Alice, the placement introduces temporal constraints on catching sight of the book, and therefore the placement of the book is primarily a reminder of when to throw away the book. "When" in this case is not a specific point in time, instead "when" refers to a collection of space-time circumstances, specifically, when Alice is on her way out. The placement of the book is therefore

an epistemic action that makes the book and its place a coordination tool for the prospective memory of throwing away the book.

Just as there are meanings that exist between structures in home environment and its residents there are also couplings that are more difficult to form. That the book of the French cuisine meant throwing the book away is a fast interactive process between the book and Alice. If the goal is throwing away the book, the coupling between Alice and her book is strong. The same thing cannot, for instance, be said of the processes in previous descriptions when Alice interacts with her iPad. In those examples the structures in the iPad did not work as cueing structures for intentions and actions because there was an interpretative gap between her and the iPad; they therefore did not work together as a cognitive system.

A shopping trip with Beatrice raises two more examples of situations in which a cognitive coupling is not formed. Before entering the store, Beatrice does two things: she withdraws cash from an ATM and recycles bottles. Consider specifically the question of when she should trust her own knowledge of how to use these machines and when she should not.

> Before we enter the part of building where the grocery store is located we first enter another part to withdraw cash. There is also an ATM outdoors but it is raining persistently and therefore we decide on the indoor option. When she puts the card into the ATM it returns with a message on the screen reading something like, "The ATM could not read this card." She tries a number of times more but does so with slightly different tempos with her hand movement. I suspect that she has turned the card upside down (the way one was supposed to hold the card in some ATMs a few years ago). After a few times I say that she could try to turn it the other way around. It works.

Despite starting to mind her hand movements, she sticks to the overall strategy she started out using. I do not know if she would have resolved the issue without my interference but nevertheless, it initially seems that she thinks the issue is about how she micro-routinely puts in the card. She continues to try inserting it in this way instead of thinking of trying the card in another direction. She is also focused on the lit screen with the error message. This is not strange since it is, after all, lit and this is where information happens. But outside the lit screen area of the ATM, next to where the card goes is a schematic picture of how to turn the card. Her focus seems go from card to screen and back to card iteratively. My interpretation is that she becomes stressed when it does not work the first time. This is the same occasion as the incident in the disposal room. After the successful withdrawal she says that she used to turn the card the way that failed this time, but does not mention how long ago this was. Beatrice usually uses cash when buying groceries and therefore she has successfully withdrawn cash before. She says that it is a "wacky day".

> We enter the part of building with the grocery store, but before entering the actual store she steers me towards the PET-recycling machine. The plastic bottles are in a plastic bag in a wagon that I pull. When she puts the first bottle into the machine it is returned. A message on the small screen reads something like "The machine cannot manage this type of bottle." Again, she becomes uncertain but stops and carefully looks at the bottle and says that it should work. It works.

Here she seems to be more careful than with her credit card before putting the item back into the machine. Although the problems in these two situations are similar, the machines are different and the actions required of Beatrice are different. The recycling machines have not switched the mechanism for placing the bottle in recent years. The heavy side goes first, it always has. There is

therefore an historical consistency that does not exist for ATMs. The way Beatrice solves the problem at the recycling machine is to deliberately consider the appropriateness of the type of bottle. Beatrice likely did something similar at the ATM when she looked at her card but after doing so, she became captured by the strategy she had started out using. Another difference is that the ATM includes subtler actions of using a small, relatively uniform object that, in relation to the machine, has four degrees of freedom. The situation at the recycling machine includes putting a large object in the recycling machine that together with the machine has two degrees of freedom. The problem space at the recycling machine is therefore smaller and hence, in this case, an easier problem.

In both examples above Beatrice makes use of her practices of interacting with machines but in both situations she needs to deliberately solve issues when her practices do not work.

5.2.3 Comparison and coordination between tools and cueing devices

Exploiting objects as cues is in some respects a convenient cognitive resource. By exploiting objects directly one does not need a tool that represents anything; people are allowed to act on what they perceive. Even Beatrice, with all her tools, does not represent her plans for tending to plants on her to-do list. In fact, it seems that most things that are written on the to-do list deal with non-domestic tasks. In the home, she, as well as other participants, rely instead on their routines and abilities to perceive and interpret what some object signifies in relation to their personal objectives. In Beatrice's case the to-do list seems to be reserved for non-routine intentions and for future states of the world that have few perceptual resources in the present[16].

To clarify, consider what the resources present in the home are reminders of, for instance, the "to phone" category. Beatrice can perceive the phone as a reminder for phoning generally, but she cannot perceive a reminder of phoning "to whom". For this purpose the to-do list serves a complementary function. The phone has a one-to-many relationship between "what" and "whom". The plants, on the other hand, represent themselves and have a one-to-one relationship between "needs care" and "which plant". Nevertheless, what is not represented by the physical appearance of plants is what should be done; for Beatrice this is an empirical task based on expertise. But the same thing goes for the to-do list. Phoning someone with the help of the to-do list is both a matter of reading the information and thereby being reminded of the intention, and knowing how to make the phone call. By creating the to-do list for tasks such as phoning, Beatrice allocates parts of the process of calling a specific person to the environment. Therefore, I think tools such as the to-do list do make tasks more cognitively equivalent to the way in which Beatrice tends the plants.

However, the cost of maintaining a meaningful coupling to the to-do list is larger than maintaining a meaningful coupling with the plants. This is because the to-do list demands maintenance practices. Beatrice pinpoints this when I propose to Beatrice that having a cognitive tool does not lead to remembering information. She answers, "writing requires control" ("skrivandet förutsätter kontroll"). What she might mean by this is that she needs rigid procedures, not just to use the content of a tool, but also to ensure that information is transferred to the tool. For instance, in the case of her to-do list, she says that the use of it in part means starting a new sheet and transferring

[16] Interestingly tools in many professional settings have a somewhat similar purpose. They have functionalities to represent a process which the operators (of nuclear power plants, airplane cockpits, operation theatres etc.) cannot directly perceive; a process that is outside the perceptual or temporal horizon of observation or too complex to perceive.

leftover intentions when the current sheet is too cluttered, otherwise the purpose of the tool is at risk.

I think it is clear that tools and cueing devices are both necessary resources, but they are nevertheless different resources with different inherent uses. Also, in many cases tools and cueing devices must be coordinated. Consider an example that Greta describes to me on one occasion.

Greta says that when she goes to the city center to buy some specific item she often does not write a shopping list. For instance, when she enters a specific retail store she knows that she is there to buy what she intended at home, because that is why she decided to go to store. She thus claims that the store itself is a cueing device in relation to the objective she holds in her mind. But she has learned that sometimes she needs to write down the specifics of what she buying. She remembers one time when she went to a retail store to buy a light bulb and assumed she would be cued about which one to buy. She returned home empty handed, amazed by the number and complexity of options of light bulbs in the retail store. Instead of writing a note with the relevant information, she returned to the store with the old light bulb. Perhaps she was amazed by the complexity of the task, and wanted be make sure she had all the relevant information with her in the store.

Both writing a reminder note and bringing the bulb itself are ways of remembering which light bulb to buy. But the bulb itself, which also usually includes information about socket type, is a richer resource. In the retail store the bulb itself includes two types of cueing resources that can be used to confirm each other. The information about the type of socket that is printed on the bulb can be matched to the appearance and vice versa.

In this example it also seems that the information about what type of bulb to buy is something that Greta does not expect herself to remember. This is likely because Greta does not consider herself a light bulb expert, at least not after the time when she returned home empty-handed. She therefore needs to make sure that she has a proper and rich resource for buying the right light bulb. This can be compared to when she recalls the ingredients for thumb print cookies with raspberry jam. She does so without an external source. She still writes down the ingredients for the cookies when going to the store, but the process of transferring information to the shopping list is more efficient, because she can map her internal knowledge of ingredients to the contents of her cupboards without consulting a recipe. There are several situations in everyday life where the things to be remembered do not need to be represented on a to-do list. Instead the thing to be remembered can, in part, represent itself.

What, in the end, does and does not need to be represented is not just a matter of the cognitive aspects. It is, as can be understood from the light bulb and ingredients examples above, also a practical matter. One small bulb can be brought to the retail store. However, it is not convenient to bring all the packages for the ingredients of thumb print cookies to the grocery store. If Greta had intended to buy ten different light bulbs, I suspect she would have used pen and paper to ascertain which bulbs to buy, just as she does when grocery shopping. Furthermore, the consequence of buying the wrong socket size is more distinct than buying, for instance, the wrong potatoes. The wrong type of bulb may be totally useless for the intended lamp, but the wrong type of potatoes may simply be less desirable and somewhat inconvenient.

Greta and the other participants have a great deal of experience regarding the process of grocery shopping, which, though I have not observed it, I imagine is not as true for their light bulb buying practices. The participants present a fair amount of knowledge about what they are dealing with in the grocery store that has consequences for how they shape tools and coordinate the tools with the

resources in the store. Consider the passages below, describing grocery shopping trips with Greta (observer Lindvall) and Alice (observer me).

Greta's shopping trip

Lindvall notes that when Greta goes to the grocery store she does not write down specific items. Instead she writes more general categories such as bread, coffee, and potatoes. She can write down general categories because she trusts her ability to make specific decisions in the grocery store. Greta also says that she does not need specific items on the shopping list because she chooses differently each time based on the information in the store. Nevertheless, there seem to be some practices that extend beyond specific occasions. On this occasion she chooses the cheapest coffee because she usually does not drink coffee herself, but likes having some at home. After collecting the coffee, she goes to find potatoes. Greta tells Lindvall that she never uses the spade because she wants potatoes of roughly the same size, so she needs to take one at a time. If they are the same size they are easier to boil, she points out. The process, at glance, seems to be more structured around the resources available at the store than around the shopping list.

But in contrast, Greta says that she writes the items on her shopping list in the order she thinks they appear in the store. She describes her process of writing a shopping list as follows: She usually plans what to cook a fortnight at a turn. First she writes down what meal she will prepare each day and the necessary ingredients for each dish. She browses the contents of her cupboards during this step, determining which items she needs to purchase. The second step is to transfer the initial information to a shopping list. This is done by imagining sections of the grocery store and ordering her list accordingly. For example, she says that bread is first.

When Lindvall goes grocery shopping with Greta she has indeed written the shopping list in the order of items in the grocery store. With four exceptions, the order of the list matches the order in which she collects items. The first exception is a switch in the order of two items located near each other, which does not result in a longer walking distance. The reason for this might be because her mental model of the store structure is not accurate in every detail, therefore minor differences between her mental model and reality may occur. The second and third exceptions are the collection of items that were not on the list. First, just before leaving home she decides to purchase fish instead of meat. She did not bother changing the list when she made this decision. Second, in the store, when passing by a shelf, she is reminded that she needs brown beans for a dish. This example shows that the shopping list is not a perfect match for all the intentions Greta has, and that features of the store can serve as cueing devices. In the fourth exception, she fails to collect an item. Consider the fourth exception in more detail.

She has previously described how she always stops before reaching the checkout to confirm that items on the list match items in the carriage. When she does this she realizes that she did not collect vegetable broth, whereupon she goes back into the store to collect it. Why she misses it, we cannot say for certain. But there are indications: When Lindvall and Greta are at the spice section where vegetable broth is located, Greta wants to ask an employee a question about some spices she wanted to buy. The employee says that he will go and get another person, and after some time Greta decides that she does not want to wait – after all the spices were not that important. Lindvall and Greta leave this section of the store, which also means leaving the section where the vegetable broth is located. An interpretation of this situation is that when Greta decides to move on from the spices she decides to move on from the section of the store without consulting the shopping list. Greta is driven by her interactions with the social and physical environment in the store, and therefore she is more guided by the store than by the tool in this situation. Another conclusion

from this incident is that although the shopping list is organized in a way that maps the list to the store structure, there is no dynamic mapping between the shopping list and the ongoing grocery shopping. What I mean by this is that the shopping lists undergoes no representational transformation as a consequence of aspects of the ongoing activity. Greta does not, at least during this session, cross out groceries that she has collected, therefore she needs to project where she is in the process onto the list of items. In fact, of course, no analog shopping list does this by itself. Although the structure of the list aids the activity of shopping, the continuous dynamic mapping between list and store must be managed by Greta, and for the most part, she does so successfully.

Altogether, although the list is not the only source for items collected in the store, it certainly gives structure to the activity. Greta says during an interview that she does not like to shop for groceries anywhere other than this particular store, at least when she plans to buy much. "It is frustrating to muddle about", she says, when she cannot find the things she is looking for. One reason she desires efficiency is that Greta suffers from a physical condition that leaves her in chronic pain, with more and less severe days. During an interview she says that her issues started when she was around 40. This exemplifies how a physical condition can motivate the establishment of a specific tool, in this case, a tool that demands that Greta is knowledgeable about the store's structure.

Alice's shopping trip

Now consider Alice who, like Greta, has not written specific items on her list. Throughout the shopping trip Alice comments on what she is buying, and what she has in mind for some type of grocery item. Consider these examples.

(a) At the sugar section, Alice points out that there are so many kinds of sugar products nowadays. For instance, in the past there was no specific sugar for making jam: "Isn't it pectin in those?" (b) At the potato section, she talks positively about the availability of ready-washed potatoes. At the onions, she says that she prefers certain types of onions, which are not too intense in flavor. But she also states that the onions last longer if they are not as intense. (c) At the laundry detergents she says that there are many products to choose from. "I need to think. [pause] What is this? [referring to a piece of paper hanging on the stand] Is this some kind of discount? What do you think?" She finally goes for the discounted option. (d) At the meat section she says to me: "Now we will take a look at the meat." Here she consults a store assistant who is currently unpacking groceries nearby. She asks for non-sinewy meat for the particular dish she is making. After choosing an item, she moves on to a separate section with meat sold at a reduced price. She says that in her experience, there is often a margin to the "best before" date when the products end up in the reduced price section.

Both Alice and Greta present expertise regarding what they are interested in at the grocery store. But this expertise is not necessarily evenly distributed across all products. For instance, in the examples above, Alice's expertise on onions seems greater than her expertise on laundry detergents.

With this expertise they generally have no need for more specific representations on their shopping lists. An even more general representation comes from Felicia, who, during a shopping trip with Lindvall has simply written "dinner food" as one of seven items on the shopping list. She has not yet decided what to buy and therefore, in store, she elaborates on what she wants: She would like chicken, she says, but shortly thereafter decides she would prefer pork and potatoes with onion sauce. She reminds herself that she already has potatoes and onions at home, which leaves her needing to buy some pork. On the one hand, this is a relatively taxing cognitive process because she mentally finishes the assembly of a plan in the grocery store without the assistance of cupboards and pen and paper at home. On the other hand, she has in front of her in the store a rich resource

for inspiration, though the store structure has not physically been designed for mainly deciding what to eat. The store structure has instead mainly been designed for other reasons. For instance, it is designed to help shoppers find what they have planned to buy and to increase the likelihood that they will encounter other groceries that they might like to buy. To some extent Felicia's more opportunistic version of grocery shopping is possible because she needs to buy fewer items than Greta and Alice. She can therefore afford a less efficient walking route.

It seems that the expectations that a particular shopper has informs the structure of the representations on their shopping list. Greta prefers to walk the shortest distance from entrance to exit, which is reflected in her creation of a shopping list and her practices in the store. Alice also prefers an efficient walking pattern in the store but in her case, it is managed completely in the store. When we are about to enter the grocery store, Alice stops just before the mechanical doors. "One has to plan somewhat so that one does not need to go back so much. Now I am collecting what's in the first section. But every so often one forgets something and needs to go back." Alice checks the list frequently during the shopping trip, for instance, as we cross from one section to another. In this store, sections are distinct between, for example, vegetables and the next section in the store. It is not Alice's absolute priority to walk the shortest distance from entry to exit but she prefers not to walk more than she needs to. By contrast, Felicia has no a priori preferences for minimizing the risk of walking a longer path than necessary from entry to exit, which is reflected in both the structure and granularity of the items on her shopping list, and also in how she crisscrosses the aisles in the store. Felicia also says that she as a principle cycles to the city center every day and therefore often has few groceries to buy in the grocery store, and hence can, as said, afford an improvised process.

Overall, the descriptions of how the participants create and use shopping lists suggests that they are created and used with the resources that exist in the grocery store in mind.

5.3 Chapter discussion

In the sections above I have considered resources in everyday life by adopting a classic cognitive science separation between cognitive tools and cueing devices. However, at the end of the chapter I consider them together because some conclusions and cognitive couplings that the participants make with features in their environment are independent of this separation.

Objects, and to a lesser extent tools, are ubiquitous in home and everyday environments. Overall it seems that the perception of physical features in these environments assists the participants in several situations in everyday life. This makes the home environment a cognitively rich environment. From several examples above it becomes evident that the functional relationships between the agents and their environments are cueing processes, where structures (symbolic or not) trigger and provide the scaffold for thought processes. The interpretive process of these resources is facilitated by a user with some expertise, whom sometimes also is the one that has shaped the qualities of these resources. The quality of expertise the participants display is not strange: Over the course of years, people spend time and act in their home environments, so the objects that can be found in the home environment often have meaning in the eyes of the people living there. What an object, structure, or symbol signifies in the perception of some agent is in many ways an important component of coordinating resources in any cognitive activity. In the material above, a number of different relationships between these cueing structures and the participants have been observed, which potentially demand varying mental abilities.

First, as a perspective of distributed cognition predicts, participants have couplings with the environment on different temporal and spatial scales. Some couplings were established long ago and some are temporary solutions for managing something particular. Some couplings involve the participants and a single resource and some involve coordination of many resources.

Second, in the examples presented above there is a difference between objects that suddenly remind, and objects that have, to a greater or lesser extent, been deliberately placed to serve a cognitive function. They can both serve cognitive purposes, but one relies on opportunistic cueing processes while the other has been formed with the intent of increasing the likelihood of a relational cueing process to some target activity or activities. Either type of object can serve as a powerful anchor and coordinator for thought processes, but an object with an explicitly defined cognitive function will likely be placed somewhere that assists this function.

Third, it seems that there can be personal cognitive couplings between objects and a person that are not shared with others. However, these connections may also be shared across larger groups of people. Examples of the latter can be seen in many of the examples of professional vision that Goodwin (1994) reviews. In his descriptions, certain abilities to perceive structures in the world as meaningful are acquired in the process of becoming a member of a profession. There is therefore something unique about the way a member of a profession perceives things that demarcates the profession from other professions. Similar ways of reasoning can be fruitful in relation to other cultural practices of perceiving. For instance, that a phone signifies the functionality of phoning is perhaps not a professional perception, but it is an interpretation based on past experiences of phones and phoning, which in turn is a cultural practice. Everyday life is full of such perceptions that are taken for granted. But everyday life is also full of more culturally narrow perceptions, such as the terrible recipes in a French cookbook that for Alice are signified by the mere appearance of the book.

Note that despite the participants' rich ability to perceive their environments, the use of cognitive tools in the description above nevertheless suggests that the perception is potentially culturally wider when participants use culturally established symbols for intentions, including through cognitive tool use. Past research has also found that the creation of cognitive tools is an important component for passing knowledge across generations (Hutchins & Hazlehurst, 1991). Take, for instance, the participants' calendars. Despite the fact that their inscriptions are sometimes vague, incomplete, and established with indistinct personal handwriting, because of a calendars' inherent structures and the properties of the inscriptions, an outsider can understand parts of the occupations a person has. For instance, in Alice's case, one could also turn to the information sheets on the fridge door to add information to the shallow entries in Alice's calendar. Take also Beatrice's cognitive tools. They are indeed personal tools but their contents have meaning for someone outside Beatrice's home. This is especially true for her to-do list, which seems to be a cognitive tool with a potentially wider cultural horizon than her calendar, which in retrospect, even she finds ambiguous.

Compared to domains where distributed cognition has traditionally been used, the tools and resources used in everyday life show many similarities with those used in professional and highly technical settings. One conclusion is that, just as for professional and highly technical environments, participants create and appropriate tools with representational content for the sake of representing a process that they cannot directly perceive, because it is outside the perceptual (e.g. non-domestic activities) or temporal (e.g. the past or the future) horizon of observation, or is

too complex to perceive (such as the most efficient path in the grocery store) or imagine (such as dinner party groupings).

Overall, there is an expertise in the perception of the objects and symbolic structures in the residents' environments. To some extent, a level of expertise related to their own environment is necessary because, although many of the tools used were developed by previous generations, there is no predetermined method for using the resources that are present in the environments. The inter-individual and intra-individual differences are relatively large. This was clear in the use of calendars, where comparisons between participants revealed not just different types of calendars, but also different appropriation strategies. Calendars were also used differently in relation to other resources, which could be more or less useful in various situations. I will return to the types of complex cognitive relationships between participants and parts of their environments in the chapters to come.

Chapter 6. Arrangements of cognitive resources

In this chapter I consider how resources in home and near-home environments are arranged, and the cognitive consequences of these arrangements. As stated in the previous chapter, resources are understood as cognitive tools and cueing devices that participants interact with to accomplish various tasks in their daily lives. "Arrangement of resources" can therefore be understood as the arrangement of rooms, parts of rooms, tools, and objects, throughout the environment.

The spaces I consider in the sections below are, in most cases, smaller than rooms, but the functionality and arrangement of rooms can have cognitive consequences for spaces within rooms. For instance, the principle of the horizon of observation (Hutchins, 1995a) points out that the fact that rooms have physical walls provides the constraints for how individuals can monitor and become coupled with parts of the environment from specific locations. Rooms have also been assigned functionalities a priori by the residents. These assignments influence where resources are found in the house, and also what actions individuals are triggered to accomplish in each room[17].

To some extent, rooms are closed systems in which participants do certain everyday chores, and wherein individuals expect certain flows of information. This can be seen in how some participants reason about their apartment layouts. For instance, both Alice and Beatrice comment on the negative aspects of open concept kitchen and living room design when having guests over for dinner. They point out that the open layout sometimes makes cooking an unnecessary performance and does not allow for the same messiness that split-room solutions allow. Furthermore, they also point out that it is nicer for guests when the heat and smell from cooking is kept separate from the meal. Alice lives in an apartment with an open layout and Beatrice lives in an apartment with split-solution layout, which suggests that these opinions were established before they moved into their current apartments. Although these ways of reasoning do not directly point to cognitive

[17] There are also studies that suggest that humans treat the passaging through doors between rooms as the start of a new cognitive chapter. This is known as the doorway effect and some findings suggest that both younger and older adult's memory processes are disrupted when passing through a door (see for instance Radvansky, Pettijohn, & Kim, 2015).

consequences, they do suggest preferences regarding what types of information are available during specific activities.

Below I start by considering a few relatively stable cognitive functional spaces in the participants' homes. Later I turn to some practices that are used to maintain this stability, and finally I suggest a two-dimensional framework that I have found has the potential to predict how information flows in the whole system. This information in turn makes it possible to predict the cognitive abilities and practices required for individuals to manage certain activities.

6.1 Functional spaces

In the descriptions of cognitive tools and cueing objects above, the spaces that hold the resources often determine their usability. There are several reasons why the spaces themselves are important for the functionality of resources. One reason is that if resources have designated spaces they bring consistency to the home environment, and thus the home becomes a more predictable environment.

For instance, several participants keep calendars and writing materials near the telephone, because there is a high likelihood that entries will be made in the calendar or on paper when using the phone. This is likely a remnant from times when phones were attached to the wall through a cord and reaching for a pen and paper at another location would interrupt the conversation. Whatever the origin of the practice, current participants have pen and paper close by for reasons of convenience. But this also means that they do not need to search for writing materials if they need to take notes, which decreases the cognitive demands of the task.

In similar ways, resources have been designated to certain spaces in home environments. For prospective memory aspects of daily life, the hallway is an important area.

6.1.1 Spaces in hallways

All of the participants make deliberate choices about how to use the stable spaces in their hallways as "staging areas" for objects that they intend to bring with them when they are preparing to go out for some reason. They all have plans for where to put objects that they will bring when leaving home. Below, I consider this process across a number of examples, ranging from the basics of this deliberate process to specific situations in which complications arise.

Beatrice's adaption over time

On two occasions Beatrice describes how she manages the posting of letters. First through, a specific example.

For more than five years, Beatrice has been going to a week-long summer camp. Previously she had not thought that this was something for her but a friend convinced her to try it. She tells me that this is something she enjoys and now she goes on a yearly basis. Each year when the letter with information about the camp arrives, Beatrice seizes the opportunity and applies quickly. As soon as the letter arrives she says that she "throws herself for the stamps" and aims to post it at the next opportunity.

On another occasion she says that to manage posting letters, she used to place the letter on the bureau in the hallway (see figure 3, p.72). After some time she realized that it was not the best place for the objects she plans to bring when leaving home: "When the letters lay on the bureau I did not bring the letter as intended, therefore I moved the operation ["verksamheten"] to the bench." The bench, in contrast to the bureau, is located just next to the door and is therefore a space that

Beatrice always passes on her way to the exit. The bureau is not a space that Beatrice necessarily needs to pass to leave home. By moving the placement of letters (and other objects) closer to the door, Beatrice also increased the likelihood of a successful event-driven task by making cues central to ongoing tasks.

This is an example of how the practice of using space in hallways can become more routine and tuned in to other practices over time. Almost all participants have an offloading space in the hallway on which they place letters or objects that they intend to bring. Consider, for instance, another example from Felicia, who tends to concentrate information in her office.

Felicia's place for the "next thing"

On one occasion when we sit in the living room she tells me that her mobile phone is broken: "Nothing happens, it only turns off." Felicia has had ongoing issues with her mobile phone. Regarding her visits to her mobile phone company, which she now needs to visit again, she says: "I will soon be registered for living ["mantalskriven"] there." She also says that "This is something I need to do now; it is the next thing."

On the day of this utterance she has plenty of things going on. She has an upcoming trip abroad that we discuss a lot and for which she has a number of errands to do and other associated plans. When I arrive, she has just returned from looking at an apartment together with a friend that acted as a consultant. While I am there she does laundry in the basement facilities[18]. Later that day she is invited to a birthday party. In other words, this is a relatively hectic day with several ongoing activities.

She informs me about all of these activities upon my arrival, aside from the issues with the mobile phone. Those issues come up later in the conversation. This causes me to suspect that the broken mobile phone is not actually the next thing in Felicia's mind, instead it is a thing that she needs to do but had not planned for; the unwelcome detour in her elaborate plan for the day. The annoyance Felicia feels about her phone is likely bolstered by the fact that she recently disconnected her landline in the apartment because it was redundant. Her inability to make a phone call disrupts her planning for the trip. She tells me she discovered the issues with the phone when trying to call her son to ask a few questions and plan some practical matters about the trip.

The phone is supposed to be a tool which, in this case, mediates between Felicia and her intentions for planning and communicating about activities regarding the trip. But now the phone has instead become an activity in itself that interestingly demands its own mediational tool (c.f. Leontiev, 1978). Specifically, she mediates this new intention of fixing the phone by placing the phone on the bureau in the hallway (see picture 4). There are both intelligent (c.f. Kirsh, 1995) and circumstantial benefits of this placement.

[18] All apartment buildings in Sweden have laundry facilities, either within the individual apartments, or as in this case, shared between tenants in a space in the apartment building. The specifics of booking systems and individuals' practices around the shared facilities are sometimes a source for intricate social situations.

Picture 4: Felicia's hallway with broken phone.

First, the screen is constantly lit either because the screen is frozen or because the screensaver is turned off. This increases the likelihood that Felicia will notice the phone and remember to take it with her the next time she leaves home. Underneath the phone is a piece of paper with notes on what she needs to communicate about with her son. Because she was not able to call her son immediately, she had to create an information buffer in the midst of an intense day. The location of the paper underneath the phone signals to Felicia that, at the temporal point when she again has a working phone, these are the pieces of information that should continue their journey to their intended responder (c.f. Kirsh, 1995). The position of the paper in the hallway also facilitates a possible reminder when her son comes through the door, if she has not yet been able to speak to him over phone.

This is an interesting example in contrast to Felicia's usual management of written information, which she normally confines to the office, and that is also less structurally managed. For instance, she has a notice board in the office that holds information, but not a specific type of information. Information on the board can signify upcoming intentions that are redundant or information that provides context for the information in her calendar. She also posts pictures that remind of past events. Because of the way that Felicia manages objects and information, her hallway bureau is normally relatively clear of both objects related to cognitive activities and aesthetic objects. Therefore, things on the bureau tend to stand out in the visual field when one is in the hallway. They definitely stand out when Felicia reaches for her keys in the metal cup on the same space (see picture 4).

On another occasion she has a letter on the space with an urgent payment. On a third occasion she has a note on the space that has details about a call she must make to an auto mechanic. On that occasion, when she is about to make the phone call she first retrieves the note from the hallway and then goes to the office to make the phone call. It seems that when objects are located on the

hallway bureau in Felicia's home they are not necessarily objects that she will take when leaving home; rather, in line with Felicia's initial description, they are indeed the next urgent thing[19].

Moa's coat rack

Some spaces in hallways are occasionally placed there prior to residents moving in. These spaces can also be exploited as functional spaces. Rackets for jackets and other outdoor garments are for instance not just a practical space. They also group cueing devices relevant for leaving home. I have, for instance, not observed an instant where a participant forgets to put on a jacket before leaving home. It is simply unlikely since the racket scaffolds the process of putting on a jacket. The same thing goes for shoes. The racket also presents options and thereby limits choices (c.f. Kirsh, 1995); and further also invites individuals to reason about the weather.

For instance, past activities have left the jackets on Moa's rack sorted roughly by thickness. It is early spring and recent weeks have been sunny. The rack accordingly starts with the thinnest jackets closest to the door and finishes with the thickest jackets, suitable for very cold weather, on the hooks closest to the TV room. The jackets on the rack can therefore be seen as a record of the past, but the jackets are also a crude record of recent weather conditions. The jackets that are available on the rack and their order, in ethology, would sometimes be called *stigmergy* (Grasse, 1950 in Theraulaz & Bonabeau, 1999) or by the more general term *sematectonic* (Wilson, 1975, p.186). Both these concepts point at how structures in the world built by individuals can evoke responses (for instance work) in other individuals. Susi (2006), for instance, uses stigmergy to understand cognitive mechanisms in a team-based professional setting. But I also think the concept can be used to describe mechanisms within the same individual, but at different points in time. The reason for this is that individuals never model the world or their own actions in detail and therefore can benefit from being guided by the traces of their own actions.

The crude record of recent weather conditions means that during stable parts of seasons the jackets closest to the door present a list of options that are appropriate for current weather conditions. Of course the jackets are not the only source of information available for mapping clothes to weather, but the order of the jackets can be seen as a tool for making decisions about what Moa might wear in the current season (c.f. Kirsh, 1995).

One occasion when Alice and I leave her home

Consider again Alice's hallway. This hallway has two offloading spaces, one closer to the door and one located opposite from the opening to the living room. As mentioned previously, the latter has been arranged to primarily serve an aesthetic purpose but it occasionally holds objects that are on their way out of the house. The table closest to the exit is, however, a stable cognitively functional space for holding important objects that are on their way out.

On the occasion when Alice and I are about to go grocery shopping she has previously placed a letter on the table closest to the exit. This is a letter to be posted. When we later exit she almost forgets it because I am standing in front of the space that is designated for reminding her of things to bring when leaving home. It is easy to see how this would happen as the hallway is narrow and becomes relatively crowded when two people are exiting together.

[19] In the new apartment she adds that the next urgent thing can be found either in the hallway, just as in the old apartment, or on a desk in the bedroom which she now passes when walking from the bed every morning or after changing clothes.

The usefulness of the top of the table in the hallway becomes even clearer just after we exit the door, when she returns for the shopping list that she had left in the kitchen. After making the shopping list in the kitchen she had not moved it to the hallway, thus making it more likely that she'd forget it. I get the impression that Alice has more things going on than usual when she goes grocery shopping on this occasion. We carry papers to be thrown away when we leave home. They had been hard to manage when she left home yesterday, she explains. Alice also explains that she has worked a little bit extra with this shopping list: "I am little bit calculating, now since you are coming along, that you can carry extra groceries. I know that you were supposed to look at how I usually do grocery shopping but I instead made you useful for me." This is also an example of an intelligent use of resources, but it appears that on this occasion she does not make use of the hallway table the way she would prefer.

Because she had not left the list where she usually puts objects related to leaving home, Alice had to rely more on internal resources than would have been necessary if the shopping list had been placed next to the letter in the hallway. This is also true for the keys to her apartment, which she searches for in her handbag when she is about to lock up. She finds other keys but not her own. She makes an initial move to go back into the apartment before she finally finds the correct keys in her bag. She explains that the keys are usually in a bag or jacket that she used the last time she left home. This is likely where she was about to look when she turned to go back in.

The hallway is indeed a cognitively interesting area in the home environment. Forgetting something when leaving home has more irrevocable consequences than, for instance, forgetting something when walking from the living room to the kitchen. Therefore, effective cognitive processing has a much greater impact.

The two offloading spaces in Alice's hallway and the offloading spaces in other participants' hallways are functional spaces because they are constantly used for externalizing temporal constraints of intention reminders related to non-domestic activities (c.f. Kirsh, 1995).

Greta's door-handle

Greta provides another example of exploiting spaces in hallways, which also deals with bringing objects when leaving home. What makes this example different from the other participants' homes is that Greta does not have a table in the hallway. Earlier I mentioned that Greta has a physical condition that she has to manage. Occasionally, depending on the type of non-domestic activity and her current condition, she needs to bring an extra pair of shoes when she leaves home so she can switch if necessary. This is important for Greta, but it is also something that she says she is prone to forget. "Prone" in this case does not mean that it happens often, only that it does happen, and that it is an unpleasant experience. The extra pair of shoes is not an object she always brings when leaving home, and they are not necessary for the target non-domestic activity.

In recent years Greta has started hanging a bag with the shoes on the door handle in the hallway immediately after establishing the intention to bring them so she is sure not to forget them. She does not trust herself to remember them and does not want to risk placing them someplace where there is a possibility she will not notice them.

She tells me that this practice of hanging objects on the door handle is something she also uses to remember to bring her handbag. However, the handbag can be located either on the door handle and on a chair next to the kitchen table. It is an object that Greta almost always brings when leaving home, therefore she can leave it in one of several key locations.

Like a coat rack, the door handle is a pre-installed structure in the home environment. Although all the participants make use of racks and tables, to my knowledge, only Greta makes use of the door handle; this is possibly because she does not have tables in her hallway. Also, shoes in a plastic bag are a suitable object to hang, and they do not fit into a normal sized handbag. They are not, therefore, like the letter that Alice had placed on her hallway table, which could not be hung on the door handle directly. Unlike the other hallway spaces, it is impossible to leave home without moving or touching something that's hanging from the door handle. In fact, the door handle is likely the least cognitively taxing functional space for holding reminders in hallways.

In one sense, an object hanging on the door handle is cognitively similar to keys to the apartment. Locking the door is a highly routine practice, so the keys become an object that a person seldom forgets, even if they do not know where they are. Both using the keys and hanging something on a door handle are physically tied to the act of leaving home. Unlike the keys, the things hanging on the handle must be physically managed in order for a person to leave home. Hanging the bag on the door handle is what Hollnagel (1999, see also Kirsh, 1995) calls a "functional barrier" because it sets up a pre-condition, in this case, that the bag must be taken by hand from the handle before the door can be opened.

Charles' change purse

Charles describes a similar type of intention to Greta's. Charles needs to bring his heart medicine every time he leaves home. Charles shows me that he keeps the medicine, which is dispensed via an inhaler, in a change purse that also contains coins.

This an intelligent use of space, first because Charles has physically tied the intention of bringing the medicine with the intention of bringing coins, which are necessary, for instance, to get a shopping cart at the grocery store (c.f. Kirsh, 1995). It is also intelligent because the change purse is an object that Charles seems to have either in his pants pockets or on the bureau in the hallway just next to the door. These two spaces are both connected to the activity of leaving home. Charles says that he prefers to keep the purse in his pants pocket. Unlike Greta's extra pair of shoes, the inhaler is something that Charles may also suddenly need when he is home. Charles can feel when the purse is in his pocket, and it is easily reached when needed.

There are further differences between Charles' heart medicine and Greta's extra pair of shoes. The change purse is an object that Charles intends to bring every time he leaves home. Bringing the purse is for Charles what bringing a mobile phone is for other people: a highly routine practice. Greta, on the hand, needs to manage the irregularity of not always needing to bring an extra pair of shoes.

6.1.2 Managing incoming information

The hallway is also interesting because it is one of few information channels in the participants' homes where information flows from outside to inside. For instance, there is information coming through the letter slot. Charles describes how he tends to wake every morning around four o'clock to the sound of the local newspaper being pushed through the metal slot in the door and thumping down onto the carpet. He knows that it is usually around four because he sometimes hears the clock on the wall striking four times when he wakes. Beatrice also says that she usually hears the mail arrive. However, when I am there on one occasion she does not notice the mail's arrival due to our discussion in the living room, which is the greatest distance in the apartment from the letter slot. She is probably not usually in the living room when the mail arrives, and perhaps she does not normally engage in discussions when the mail arrives. But during our visit, Beatrice only realizes

that the mail has arrived after the fact, when she notices a white letter on the dark floor as we walk to the kitchen to make coffee. The information that flows in these examples is not part of any critical cognitive activity. What is perhaps more important is how mail is managed after the point at which it has been noticed. Consider how Greta does this.

Greta has at least three functional spaces in the kitchen and at least two spaces in the combined bedroom and office that are related to the management of mail. On the counter next to the kitchen table there are two spaces that hold papers. One is to the left, next to the microwave. She puts papers that she deems more important here, for instance, bills that do not need immediate actions. At this point in the information flow Greta makes no distinction between her own bills and the person for whom she is a custodian (below referred to as "her client"). Instead, she separates the mail once a month when she makes transactions through her computer. At that point she divides it into one pile for herself and one pile for the client. After being marked as "Bet" (=payed), she puts the papers related to the client in a separate file folder while her own papers end up on a space on the desk. Transactions regarding the individual are also documented in a separate account book. Such thorough practices, she says, are not necessary for her own papers.

She says that she used to save important papers for a long time, but that last week she changed her habits and now she only saves papers from the last three months. She had heard that this was sufficient for security reasons. Last week she therefore spent two to three hours sorting all the papers in and on her desk. She could not throw things away without deliberation because some of the papers included important information that she wanted to keep.

On the counter next to the kitchen table Greta also has a functional space to the right, between the wall and the microwave. Here she vertically places informational materials such as "brochures, vacation programs, and functional support information". This space, like the previous space, works as an information hub, but in this case the information is less important. There is some material that she throws away immediately when it comes through the letter slot. Therefore, although she has a hub for less important information, that does not mean that the information is not relevant. She says that roughly once a month she goes through all the information and decides upon actions, for instance, whether she should throw away or further pursue some information. Note that because the space between the microwave and the wall is fixed, the space has an inherent barrier that reminds Greta to go through the information. The physical cueing device seems to work, because when I ask her if she ever needs to move the microwave she says "no" while laughing.

Greta places the most urgent papers, which cannot be managed at the end of the month, on the kitchen table. Normally, she says, she only places aesthetic items and a telephone on the kitchen table, but once in while she also puts something more urgent there. Lastly, Greta has a board next to the fridge and a calendar where she posts moderately important information. She also uses the space on the fridge for the same purpose. These spaces hold information that must be visible to serve as a reminder, such as programs for associations. The trade-off between saving and not saving information is a recurrent theme in conversations with Greta. Some information she has clear rules for: She always keeps and documents information regarding her client. She also always keeps advertisement from the nearest grocery store.

Greta has a fairly advanced system for keeping and managing mail. To some extent is because she works as a custodian. The system has a functional breakdown based on the type of representational content. These spaces can be seen as cognitive tools in their own right because they involve a physical structure that holds representational content.

As with Beatrice's to-do list, this is a system that relies on Greta's practices for sorting information (in this case mail) under the right category (in this case the right pile). For Greta it is also an issue of saving relevant information without saving too much information. This is not always the easiest of tasks. Consider the following example.

Greta says that she recently placed an order on the internet and she intended to use a gift voucher to receive a discount. But when she entered the information from the gift voucher, it was not included in the total sum. She says that she called customer service and they said that the discount would be included on the bill. She believed that she understood the situation and trusted the customer service representative, so she threw away the voucher. When she received the bill she noticed that that the sum was still wrong. She called customer service once again and they asked for the number of the voucher that she had already thrown away. In her mental model of the situation, the voucher was no longer necessary as soon as she believed that it has been processed in the system. From an economic point of view, the voucher is in some sense equivalent to marking a bill she had already paid "Bet". But these two types of economic papers are not treated in equivalent ways in Greta's functional system of spaces. If they had been, the voucher would have remained at her desk for at least three months before being thrown away.

Greta's story makes it clear that although functional spaces are shaped to manage certain cognitive tasks, the practices around the spaces, or the categorization of the spaces, may not be capable of dealing with new or unforeseen circumstances. It is also worth noting that knowing what information may be important at a later date can help shape the practices around the space. From now on Greta will likely always keep vouchers for at least three months.

6.1.3 Hands and non-domestic environments

Hands are a special and very useful functional space. They are a space that always follows its user. Hands are also visible and tactile. One downside to using one's hands as a functional space is that they are used for so many things in daily life. For instance, people often make more use of other spaces to manage holding objects temporarily because they need their hands to do other things. However, there are also situations in everyday life when there are no other visible spaces available, for instance during non-domestic activities.

Posting a letter

Previously I described a shopping trip with Alice, during which she brought along a letter to be posted. At one point on our way to the grocery store she reminds herself verbally to post the letter and says to me, "It is easy to forget when things are in my bag." When we arrive at the grocery store we pass the yellow mailbox without posting the letter. When she takes out her shopping list from her bag she notices the letter and notes that "we forgot" to post it. After she has collected her groceries and gone to the checkout aisle, she notices the letter once again when taking out her wallet: "Now I have to remember." When she puts down her wallet she takes out the letter and says, "Now I will keep it in my hand." Because I am packing her groceries, she can hold the letter in her hand after the point of payment. By putting the letter in her hand she creates a cueing device that is anchored both visually and cueing in a tactile manner. She also creates a functional barrier (c.f. Hollnagel, 1999) because she obstructs her ability to do something else with her hand before removing the item from her hand.

An incident in the garbage room

The lack of extra hands and good functional spaces during non-domestic activities also led to a more serious consequence in an episode with Beatrice. Before Beatrice and I go grocery shopping

on one occasion, Beatrice has decided that we should first go to the storage room to put away a traveling bag, and then go to the garbage disposal room to throw away newspapers. Both these places are located in the basement of the building she lives in. I help her carry the bag with the papers and the wagon that she has decided to bring for the shopping session. She carries the bag for the storage room in one hand and keys in the other. When we arrive at the disposal room she opens the door with the keys and puts the keys in the lock on the inside, whereupon I quickly slip in and throw away the newspapers. When I exit Beatrice lets go of the door, whereupon it automatically closes with the keys still inside. The situation becomes tense for both Beatrice and me when we realize what has happened. Everything is eventually sorted out with a help from a neighbor.

When we come back from grocery shopping I discuss the incident with Beatrice. She explains that she usually puts the keys on the inside so she knows where they are. Normally when she enters the room and puts the keys in the keyhole, the door closes behind her. When she exits after she's finished sorting garbage, she sees the keys in the keyhole. The keys fit in the door and this is certainly an intelligent use of space (c.f. Kirsh, 1995).

This strategy is not entirely different from many of the strategies participants use when leaving home: they put an object in a spot where the likelihood of perceiving it at a later point in the process is high. The routine is perfect if one does not have pockets, Beatrice explains, but she also now sees that this practice does not always turn out well when there are two people collaborating. I think it is important to note that the incident described above is rather coincidental. If we had had a different division of labor, where, for instance, I had carried the bag for the storage room and she had carried the papers, her practice of managing the keys would have turned out well.

Beatrice's practice of putting the keys on the inside of the door seems to be a highly automated reaction to the act of opening the door to the garbage room. This highlights something general about the intelligent use of space: over time very good decisions can become so routine that they are not re-evaluated when the circumstances change. Putting objects in certain logical spots is therefore something that people do without deliberating on each occasion, which can at times become a problem, even if the habit began with a considered decision.

A complete understanding of the origin of Beatrice's practice is unknown but some aspect of it can be understood when considering how papers are discarded in this particular garbage room. When I was throwing away the newspapers, I swung the papers into the container with one arm. But I am taller than Beatrice. She would likely need two arms to get it over the rim. She is also a woman and may be wearing clothes without pockets (she cited this as a factor when describing why she uses this practice). Also note that this particular disposal room is designed to ensure that it is possible to exit the room from within without the personal key by using a door-integrated lock. So what are Beatrice's options in this particular context?

She could have left the keys in the lock on the outside, but someone might steal them, or, because of the lack of a visual cue, she might forget them herself. She could have kept the keys in her hand and risked discomfort from the pressure of holding them while also holding the papers, but with that option came a risk that the keys might slip from her fingers and end up in the container with the papers. She could have used some extra prop that would allow her to wear the keys despite non-functional clothing, for instance, a lanyard, but she would have to take that off when unlocking the room. A lanyard is also a commonly stigmatized object related to aging, and it would significantly increase the volume of her keys. She could throw the keys on the floor but that would have been equivalent to putting the keys in the keyhole, with additional downsides. Putting the keys

in the lock on the inside of the door does not seem a very bad option after all. But this option calls for attentiveness when new circumstances appear. In our chat afterwards she explains that this particular problem has never occurred before.

Beatrice and I discuss other situations with keys and self-locking doors that have occurred in both of our lives. This discussion and the examples above lead me to believe that the home environment is a rather forgiving environment, but as soon as one steps outside of it, incidents with significant consequences are likely to increase. For comparison consider another instance when Beatrice and I are talking at the low table in her living room and she says that it is time for coffee.

She gets up from the sitting position and walks to the kitchen. I walk with her. After brief initial preparations, she walks toward the dining room to collect a cake knife. On the large dining table she has a jigsaw puzzle placed on top of a puzzle roll-up mat. We start talking about the puzzle, which is the primary feature we notice when entering the dining area. She tells me she needs the roll up function to be able to temporarily remove it when she has guests over for dinner. She also tells me that she has more puzzles in the TV-room that are the same series as the one she is currently working on, and she walks to the TV-room to show me. Our chat continues for some time. When we have finished talking about jigsaw puzzles a few minutes later, we leave the TV-room and walk to the kitchen to continue the preparations. A moment later she recalls her original reason for entering the dining room. She went there to collect a cake knife from one of drawers in a sideboard, which she proceeds to do.

This is an example of the forgiving nature of memory slips in the home environment. As soon as we entered the dining room we both got involved in the discussion about jigsaw puzzles. The discussion went on for some time and included moving to another room, which was a distraction from Beatrice's original reasons for walking to the dining area. But in this case the visible environment allowed Beatrice to react to various situations and distractions. Beatrice could not serve the cake without her cake knife, so she would have recollected that she needed it at some point before it was time to slice the cake. Compared to the situation in the garbage disposal room, there was no crucial process point that required actions to happen in a specific order. Since I had made it clear that I was interested in the activities of her daily life, talking about jigsaw puzzles for a few minutes made perfect sense.

Altogether, these examples demonstrate that participants exploit the visible aspects of spaces in their homes before leaving home. I will return to the subject of leaving home later and examine in more detail how the participants make use of spaces, how they address some of the cognitive limitations of space, and also look at some complications that might arise in individual cases.

6.2 Position properties of objects and resources

In the previous section I described how the participants shape properties of their environments to increase the likelihood for certain patterns of informational flow and transformation. Shapes of information and structures in domestic environments can increase the likelihood that structures are noticed by the agent, but the opposite can also occur if the structures do not match the practices of the moving agent. This match between the moving agent and properties of the environment is a focus for the chapter to come.

In this section I turn to, what relates to the match between the agent and resources, the way in which resources are positioned. The position of an object is often a consequence of the object's role in previous activities, where the object's position is determined by the acts of an agent using the object. Below I intend to demonstrate the way in which an object's position is relevant to

information flow and transformation. To demonstrate this I will use two analytical dimensions: static/dynamic positions and visible/hidden positions. Two aspects will be highlighted in relation to these dimensions: how the objects ended up where they are and which adaptive cognitive practices of the agent are needed for the successful completion of activities. Most of my previous descriptions of cognitive situations in the participants' home environments have dealt with the parts of the environments that are easily accessible by the residents, but of course, the locations of objects and tools can vary. To briefly illustrate what is meant by these dimensions, recall, for instance, the way that Beatrice deals with reminder notes in contrast to how Felicia deals with them.

Beatrice's list with categories means that there are not many reminder notes spread around her home. Also, because every type of future intention has a designated external location that is spatially close to the other kinds, the sheet of paper works as a good overview tool. First, this shows that the specifics of external representations shape coordination of internal processes and external structures, just as previous research within work settings does (see, for instance, Hutchins, 1995). Second, it also shows that the specifics of how reminder notes are used can partly determine their functionality. Overall, what is apparent from the observations of Felicia and Beatrice is that in terms of note taking there are significant inter-individual differences between them. My observations also show that Felicia has a higher intra-individual variation in her practices for using reminder notes than Beatrice. Specifically, Felicia's reminder notes can be found in different types of spaces in her home. Some of these spaces are hidden from direct visual observation. Their positions are also dynamic, since they are often determined by the situation in which they were last used.

Below I consider the continuum from the static to the dynamic and the cognitive situations that these features impose on the residents.

6.2.1 Static and dynamic positions

The contrast between the static and the dynamic is a topic of discussion with several participants, and also the subject of a number of sessions in which we observe them in their daily lives. For instance, Charles tells Lindvall that it is important to have special places for objects; he thereby expresses a need to have control of the environment by minimizing stochastic aspects of structures in the environment. However important it is that each thing has its own place, the home environment is not necessarily an easily predictable environment with stable structures.

Managing keys

Consider Charles' management of keys. He explains, both to Lindvall and to me on separate occasions, that he always puts his apartment keys on the high bureau next to the apartment door. However, during one visit the keys are not on the bureau. When Lindvall notices this Charles says in a comical voice that Lindvall has found him out ("Nu kom du på mig"). On another occasion when I give examples of times that I have mistakenly put my keys in places that I later considered unwise, he starts doing the same thing. Once when he came home after grocery shopping the keys ended up in a plastic bag, which in turn ended up under the sink in the kitchen. The day after, he says, he had to put in some effort to find them. He knew that they were in the home since he had obviously unlocked the door. The keys and the medicine, which Charles needs to bring each time he leaves home, in fact have several common locations, in addition to the bureau in the hallway they can be found on an offloading space of the bookshelf next to his armchair in the living room and in the jacket he used the last time he went outdoors. But from Charles' point of view, at least when talking to us as researchers, he expects himself to put the keys on the bureau in the hallway.

He describes something similar for his reading glasses: "I usually put them on the bureau there [points at bureau] in the mornings, but if I [am absent-minded] they can end up anywhere." I believe "anywhere" should not be understood to mean anywhere but instead, just as for the keys, in some spot where he usually uses them.

The way that Charles reasons about his keys and reading glasses is likely both a consequence of peer expectations about how to do things in everyday life and expectations of oneself. "Each thing should have its own place" is a general way of framing order in home environments. Many of one's expectations of oneself are likely to come from experiences of other people's practices. However, this also potentially personally important for Charles because he has severe problems with his sight in one eye. That an object has a designated place, and that it is constantly kept in this location when not being used, increases the likelihood of correctly predicting its location without the need for a complicated perceptual search process. But it is also important to bear in mind that in single-person households it is most often the resident herself who has placed the object in its current location. Therefore, this is also a factor in the ability to predict an object's location. Another factor is the amount of time since last use. One conclusion that may be drawn from Charles' account is that it is not a big problem that the keys to the household could be in a number of locations, as long as they do not end up under the sink.

Greta describes a different situation than Charles, but one that nevertheless has the same consequences. As I described previously, she does not have tables or bureaus in her hallway. Instead, she says that the keys always end up in the jacket she used the last time she was outdoors. When she comes home, she says, her routine is: "I unlock, keys in pocket." To some extent this an efficient strategy from the perspective of coming home, since in the case of holding bags or other objects you need to put the keys somewhere. Having such a clear routine when coming home minimizes the risk of the keys ending up in less predictable locations. A pocket in a jacket is therefore a safe spot. In fact, although the keys could objectively be in a number of different jacket positions, when she first describes this situation she explains it as if she keeps the keys in a specific spot. Indeed, it is a specific spot from the perspective of coming home, but not from the perspective of leaving home.

Felicia uses a different solution to address the different perspectives one has on leaving and returning to the home. As previously noted, she has a metal cup for her household keys on the bureau in the hallway. All other keys can be found in a key cabinet located in the same hallway. She prefers the metal cup because, among other things, she finds the key cabinet unnecessarily difficult to open. I am told that in the cabinet are car keys, cycle keys, and other keys. But regarding the cycle keys she adds that "[they] can linger [in the pockets], yes they can". Putting one's keys in the pocket of a jacket after locking the cycle is convenient, but it increases the likelihood of a more taxing situation the next time one plans to use the cycle.

However, the practice of putting the keys to the cycle in a specific spot in the home is a more taxing task than putting the apartment keys in a specific spot. This is because there is a larger physical and temporal gap between the locking of the cycle and the location for the cycle keys than there is between the unlocking of the apartment door and the location for the apartment keys. The point is that, in Felicia's case, it is a more cognitively taxing task to remember to put the cycle keys in their correct location than it is to remember to put the apartment keys in the metal cup.

Also regarding the metal cup she describes what can be understood as something more of a multisensorial routine: "…and there I chimes them down". Coming home is therefore related to the sound of keys which goes into a metal cup. A slightly taxing search process in the relatively

confined space "the hallway" is perhaps not motivated to trade for developing a habit of emptying all pockets on the point of coming home.

Interestingly, at the occasion of our last meeting in the new apartment it seems that her habits of managing keys have changed. She still has the metal cup on the hallway bureau but nowadays uses the key cabinet more systematically. This change of habits is not something which she has deliberately thought about and is instead something which just happened. However, possible reasons for this change of habits is that the key cabinet physical relationship to the metal cup now has changed. In the first apartment the key cabinet was placed on the wall on the same wall as the entry-door on a head-level height (see top of picture 5, p.116). In the second apartment the key cabinet is placed on an arm-level height directly above the metal cup (see picture 5). From the point of entry, putting keys in cabinet in the first apartment was ergonomically more complicated than putting keys in metal cup. In the second apartment there is first some distance between entry, with jackets etcetera, and hallway bureau with metal cup and key cabinet, and second, a shorter distance between metal cup and the key cabinet. She also now describes a practice where she, at the point of entry, first walks over to the hallway bureau and puts keys, and content of pockets, on the top of the hallway bureau and then walks back to the entrance area, where she takes off her shoes and jacket. Keys are after this sorted into the key cabinet.

Picture 5: Felicia's new key solution

Dynamic positions – a typical feature

Irrespective of Felicia's new more consistent practice, I think that the effort of managing the dynamics of an object's location by using a search process is often deemed acceptable for many objects of everyday life. Greta provides the example of keeping track of her glasses. She describes the issues like this: she has two types of glasses, normal and reading glasses. Since she has a TV both in the living room and in the bedroom, she reads things with her reading glasses on in various locations in the apartment that overlap in part with TV locations.

To find the glasses, she describes what can be understood as a hierarchical search process in a small two-roomer with a limited search space. The search process usually starts in the kitchen because

that is where she often needs them. She always continues with the bedroom and then moves to the living room. It is possible that Greta does not really need to keep track of her glasses because she can easily find them when needed. There may also be situations when Greta would prefer finding the glasses more quickly than she can, as well as times when her health status would make it preferable to have the glasses where she needs them. However, it seems that it is not really worth the extra effort, in terms of cost (c.f. Kirsh, 2010a), to bother putting the glasses in a designated spot after using them every time.

One conclusion that can be drawn from the examples above is that an object's location, and whether that location is dynamic or static, has consequences for what is cognitively required of the residents in their pursuit of finding and using it. However, although they have seen that this is true, in many cases the participants do not seem to mind that the environment includes objects with dynamic locations.

6.2.2 Visible and hidden positions

Much of the usability of the previously referred to resources is due to their placement in relatively visible spaces that the participants often pass by. However, there are also objects and resources that are usually hidden, for which individuals need to either use a search process or an internal remembering process.

Some objects are often hidden as a consequence of their previous use. For instance, as mentioned previously, Greta's apartment keys always end up in the jacket she is wearing when she comes home, which ends up on the rack in the hallway. She says that she only "sometimes remember[s] the specific coat" she used the last time she came home. Regardless of whether she remembers or not, identifying the location of keys can be described as a physical search problem where the location changes from occasion to occasion. There are important differences between this and the previously described problem of searching for Greta's glasses. For instance, the glasses can be identified visually without manual intervention, and therefore it can be argued that there is a continuous close cognitive coupling between Greta and the environment during the search. Because of the properties of their location, the glasses could also have been seen on some other occasion before the actual search starts. Therefore, the coupling between Greta and her glasses can extend beyond the time frame of an actual deliberate search.

In the case of the keys, on the other hand, there cannot be any non-search occurrence of perceiving the object because the keys are hidden. However, the environment, in the form of coat racks, decreases the degrees of freedom of possible locations. The rack in the hallway is a designated space for jackets, where the linear structure of the rack orders and limits the number of jackets, and hence also defines a finite search problem. The degrees of freedom for the glasses are greater because there is no such definite limited space where the glasses could be located. The origin of the greater degrees of freedom can be understood by understanding how reading glasses are used. Greta has one pair of reading glasses that she uses to manage a number of reading activities across a number of spaces, which results in a large number of potential locations. Therefore, the reading glasses are an object that is likely to be lost.

Also, as mentioned previously, it is interesting that Greta never describes the keys, which move from jacket to jacket, as an object that can be lost. One possible reason for this is that in the cognitive ecosystem of specific structures and practices, the keys are unlikely to be lost. This indicates that the information flow between Greta, the keys, and the structures around the keys

have reached something that could be described as an energy harmony, where the process of locating the keys is never so energy-intensive as to be perceived as a search process.

From an individual cognitive perspective the thing that she must remember to locate the keys is that she normally puts them in a pocket in a jacket. In contrast, in the search for the glasses she needs to remember a collection of her own reoccurring normal reading activities, and according to the locations she lists, there are a number of reading activities that she must account for. Therefore, the kind of meta-knowledge she requires to find the glasses is more complex than for the keys. So although her keys are hidden and have objectively dynamic locations, their location does not tax her internal resources that much.

Hiddenness is not just about where objects are, it can also be about what information they emit. Recall, for instance, how Felicia perceives her tulips as wilted. This information is easily perceivable in her home environment. The same thing cannot be said about the dryness of plants in general. As previously mentioned, Beatrice describes in an interview how she identifies plants' need for water by touching the soil during her late-morning routine, wandering through her apartment. Early in the biological withering process the plants' dryness is hidden from visual identification, and without deliberate top-down guidance, the interaction between Beatrice and the tactile features in her home-environment have no natural connectivity. In other words, Beatrice needs a procedure where she checks the plants' status. Hidden information can then be handled through appropriate practices.

Although hidden objects in home environments are not bad by definition, objects that were not in plain sight have been the primary cause of the negative cognitive incidents I have observed and been told about. Recall, for instance, the situation when Beatrice locked her keys in the garbage disposal room, and Charles' story of placing his keys in a plastic bag that ended up under the sink. In both of these examples, objects ended up in locations that are normally hidden from the fields of vision of the residents, and where the residents did not imagine the objects could be at some point in time.

A story that I have not described previously, which also suggests that hiddenness is a factor in negative incidents, is Alice's management of her keys. On one occasion she describes how her relatives scold her for not keeping track of her keys. Her relatives are not concerned with the situation at home where, as previously described, she usually finds the keys on the hallway table, in a bag, or in a jacket. However, she tells me about an occasion when she lost her keys during a visit at her daughter's. She recollects a relatively hectic day: at the occasion she had been responsible for serving food to a number of guests. She noticed the fact that the keys were lost when she returned home for the evening and consequently had to return. When she was unable to locate the keys, Alice used the spare key to her apartment which was, proactively and for practical reasons, kept at her daughter's home. Later, in consultation with her granddaughter, she recalled that she had placed her keys in a flowerpot for the very purpose of remembering them when she was leaving. Her granddaughter reminded her that she had used this particular strategy in the past.

This is a classic story where individuals place objects in very special locations in order to find them later when they need them, but fail to do so. Winograd and Soloway (1986) suggest that the following two factors contribute to such failures: first, that the person believes the location to be memorable, and second that the person believes that the location for the object is unlikely. A better strategy is to rely on associative processes, for instance the fact that reading glasses can be found where one usually reads, and place the object in a likely spot, for instance where similar objects that are used usually end up.

When I discuss the above example with Alice during our last meeting she thinks that her practices of putting keys in flower pots came from not having proper pockets for the keys; and thus she seems to describe a similar rationale as Beatrice mentioned for managing keys in the disposal room.

Most of the cognitive issues the participants told me about dealt with information and objects that were necessary for the completion of a task, which were located outside the participants' fields of vision. These issues deal not only with objects, they are also about visual access to whole activities. Recall Felicia's hectic day when I arrived in the middle of numerous intentions and activities in progress. A few minutes after my arrival her friend returned and reminded Felicia that she had laundry in the basement facilities. "Oh, right!" ("Ja just det!") She excused herself and immediately left the apartment, returning approximately ten minutes later with a full laundry bag, which she put in the spare room. In one hand she held an item that was still damp and needed to be hung to dry. The point is that the laundry room is also a hidden object, in this case, an activity. The completion of the activity in this case benefited from an external cue, which in this case was Felicia's friend. The friend was likely aware that Felicia had many things going on and would benefit from a reminder.

After this, Felicia is reminded of two more occasions when she has forgotten her laundry. One time a friend of hers had booked the time slot after her and reminded Felicia. On the more recent occasion the landlord had recently installed a digital system that did not allow Felicia to enter the laundry room after the end of her booking, and neither Felicia nor anyone else could see who had booked time slots in the booking system. Felicia had washed items other than clothes on this particular occasion, so she decided to go after them another day. When Felicia finally went down to collect the items they had been stolen. Therefore, she is not very fond of the new system, but also sees that there are positive aspects of the system, of for instance decreasing the risk for theft overall. However, in the past, issues with laundry booking or forgetfulness could be resolved quickly through social channels. With the new system, the cognitive situation can no longer be managed through a socially distributed system. The laundry activity has become even more hidden from perceptual reach.

Finally, hiddenness can also cause actions to have unintended consequences. Just before Greta and Lindvall leave home for a shopping trip, Greta puts her reading glasses in the handbag which has been placed on the chair just next to the apartment door. Shortly thereafter she concludes that she does not need to bring the handbag, her wallet is enough. She takes out the wallet and puts it in one the bags that she brings for packing the groceries after shopping. When they arrive at the store, Greta recalls that she had placed the reading glasses in the handbag that was left at home. She says she is lucky that she has written in larger letters and that Lindvall is with her. In spite of the fact that Greta would have preferred having her glasses along, the shopping trip goes fine and Greta manages to read her shopping list without the glasses.

Altogether, hiddenness of information has negative consequences for the participants in many situations. In the descriptions above I have focused primarily on describing the consequences of information being hidden from the agent. I have devoted less space to describing the practices revolving around visible resources. This will be a topic for the next chapter, but below I first consider how the participants create physical settings and exploit features of the physical environment to make one particular task, cooking, a more visible process.

6.2.3 Case: cooking

Cooking is one of the few activities for which home environments, a priori, have a special room. In many cases every object related to cooking can be found in the kitchen area, that is in its drawers and cupboards, and on countertops. Importantly, though, kitchens are also arranged by the residents to suit cognitive, perceptual and motoric needs. Some of these arrangements are more or less permanent installations by the residents, while others are arrangements that are made for specific cooking sessions.

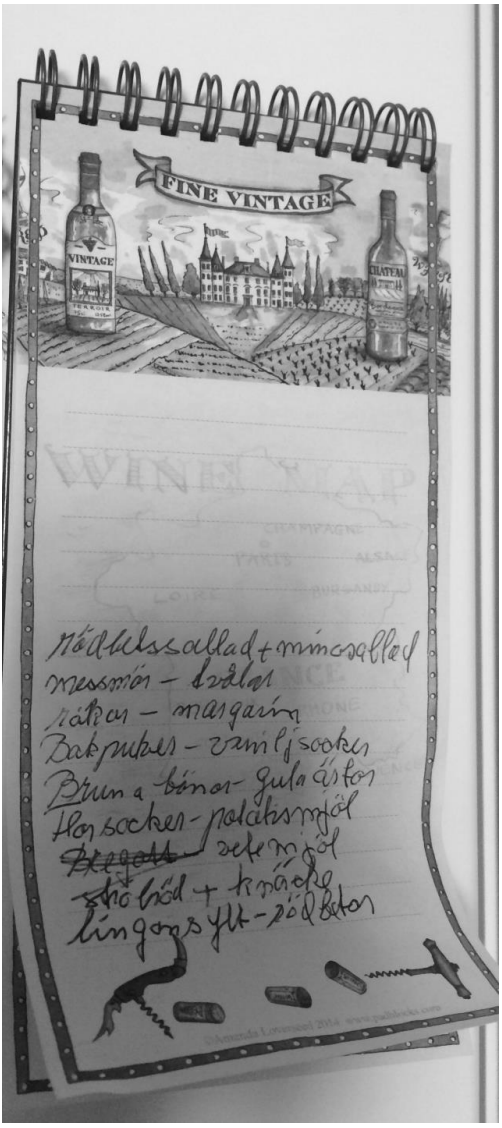
These installations and the ways that residents use them can vary broadly. Beatrice, for instance. keeps her most often-used spices on the lowest shelf in the spice rack, thereby both providing a perceptually condensed field of options and a reachable distance to the spices that she needs most often when she cooks (c.f. de Léon, 2003; Kirsh, 1995). At one point she says to me that nowadays, one should have spices in drawers with specially designed insets. She says that she thinks she would prefer such a solution. Spices in a drawer would allow her to more easily reach a wider variety of spices without standing on her toes and stretching or climbing up on a stool. It would also allow her to more easily get a perceptual overview of all of her spices without bending her neck backwards. However, as is the case with many of the participants, space in a kitchen is at a premium. Beatrice's kitchen is too small, she says at one point, while kneeling down to reach for a pot in the lower cupboards. Therefore, she explains, she cannot sacrifice a drawer for spices.

Although the kitchen is designed for cooking and some spaces have been pre-arranged by the residents, spaces and objects can be shaped and acted upon during a cooking session in a number of ways that are cognitively more and less beneficial. Five of the participants were studied while cooking, and something that became clear from these observations is that the residents move objects around to better suit their cognitive needs.

Preparations

When Lindvall arrives at Hannah's home to observe a cooking session Hannah has prepared the spaces for an efficient process. She explains that the reasons for these extra preparations is that she has a meeting that was scheduled unexpectedly and could therefore not wait for Lindvall to observe the full process. She is cooking fried fish with potatoes, sauce and a salad. Hannah has already made the sauce before the beginning of the observation. Beatrice describes a similar strategy when inviting people over for dinner. Specifically, she tries to choose recipes that allow her to prepare several steps of the dish the day before.

Hannah has a well-thought-out preparatory process for cooking and grocery management. First, she has, what she calls, a base of groceries at home. For instance, she always has groceries for baking and salmon in the freezer. When a type of grocery is about to run out she writes it down on the ongoing shopping list on the fridge door (see picture 6). She then buys all these groceries in a bulk when shopping roughly every fifth week. These preparatory practices make sure that she can, in most cases, rely on more reactive cognition than reflective cognition (c.f. Norman, 1993) because she minimizes the number of instances when she needs to remember aspects of cooking and shopping without a prominent cue.



Picture 6: Hannah ongoing shopping list

Another way to prepare cooking is to allocate time for the task. Beatrice describes that she sometimes plans a dinner with pen and paper. She uses a sheet of paper to sketch a time schedule for subtasks of the cooking and preparations. She does this by estimating how long each subtask will take. A task could, for instance, be "peeling potatoes" or "setting the table". To set on a starting time for the cooking she summarizes the estimations and adds an hour to have extra lead time. If her schedule allows, she completes certain subtasks the day before. On the day that she explains this system to me she has, just before my arrival, peeled potatoes for eight people for a dinner the next day. This took 20 minutes, she says.

When I ask why she uses this planning tool she explains: "In the old days it worked differently, I usually say that one could whip with one hand, stir with the other, and cut with the third. Nowadays I need to do one thing at a time. Otherwise things become messy, things are scorched, and all sorts of strange things happen."

She thinks that she started using this practice ten to fifteen years ago. She believes that this is also when she started using some of the other elaborate tools for maintaining control that I have described previously (see section 5.1.2). Although she prefers this planning of the process, when I observe Beatrice cooking on one occasion she has not prepared any steps beforehand. This could be because the cooking session with me was the primary social purpose of our meeting. When she has guests over, she explains, the primary social event is the dinner in the dining room and not the cooking taking place in the kitchen, and therefore the cooking should be as efficient as possible.

As I observe Beatrice cooking, I realize that there is another reason that she usually prepares part of the cooking beforehand, and why she says that she picks recipes that enable her to do so. After accounting for the always-present washed utensils, food processor, kettle and more, the amount of free space is limited. I note that while Beatrice is cooking, the space is relatively chaotic. For instance, when she whips ingredients she does so down in the washing-up sink. This is for reasons of cleanliness, but it is also smart way of allowing space for other objects.

Mise en place or willy nilly?

Upon Lindvall's arrival Hannah has also placed all of the vegetables (non-peeled potatoes included) together next to the sink. The tomatoes are wet after having been rinsed in the sink. The fish, breadcrumbs, cracked eggs in a bowl, and salt and pepper are found next to the stove where a pan has already been placed. Finally, she has already pre-heated the oven for the possible necessity of keeping the fish warm while waiting for the potatoes to boil. These pre-arrangements not only allow for an efficient process, they also allow for an easier cognitive and perceptual process for Hannah (c.f. Kirsh, 1995). The objects are arranged according to their associated processes. The objects related to the pan are meant to be assembled in a particular order before being put in the pan. The objects related to the salad are all supposed to be cut before ending up in the salad bowl located on the kitchen table. When Lindvall asks Hannah if she usually does it like this she responds: "If I'd had the time that I would have preferred to have, who knows if I would have done it like this." It seems that Hannah has a number of cognitive practices related to cooking, but just because she has these practices does not mean that she will use them every time she cooks.

At the last meeting, Hannah also says that her kitchen is short on space and that she therefore cannot put all relevant objects on the countertops beforehand. This means that she cannot have parts of the cooking activity constantly visible. Instead she usually finishes shorter steps of the cooking activity and aims at keeping spaces clean. Often she prepares steps of later cooking activities during her morning routine of tending to the home. By doing so she minimizes the number of steps necessary during more time-constrained parts of the cooking and therefore also decrease the mental workload during the cooking activity, which for instance can be used for keeping track of what to do next and what objects to move from hidden to visible positions.

As previously mentioned, Hannah has a background as a cook and therefore she can be expected to have a number of practices for managing particular situations. However, all of the participants that were observed cooking had their own ways of doing specific tasks. For instance, when Lindvall observes Greta preparing potatoes she does not peel them under running water. Instead, she rinses them after she has finished peeling them. This, she says, saves water. She adds that she lives in a rental apartment with water included in the rent, and therefore she does not need to prepare potatoes in this particular way for economic reasons. Instead, Greta speculates that this habit originates from a summer, decades ago, when there was a public water shortage and people where not even allowed to water plants. If something similar were to happen again, she says she is prepared. Here it also seems that experiences of being part of a collective, in the present or in the past, act as mental pointers for specific practices. Recall that this was also the case when she positioned the barcodes in an ergonomic way when loading the groceries onto the conveyor belt.

Alice arranges things in advance in a way that is similar to Hannah when I arrive to observe a cooking activity. The dish is almost equivalent to Hannah's dish and Alice has similar reasons for preparing in advance: her daughter is coming over and she is in hurry. Alice has already spiced the fish and turned the pieces in flour. Both Hannah and Alice immediately start peeling potatoes when Lindvall and I respectively arrive. The potatoes establish the scaffold for the time frames for all other subtasks.

One difference between professional settings and everyday cooking is that everyday cooking does not always require efficiency, and hence does not need mise en place every time.

Although the participants have spatially pre-arranged their cooking sessions, objects are also rearranged as the cooking progresses. For instance, when Felicia starts preparing to make a thick pancake she brings all of the necessary ingredients from the fridge to the kitchen countertop. She

continuously checks the recipe in a cookbook, which she previously brought from the office to the kitchen. Overall, Felicia checks the recipe a number of times but she also improvises, for instance adding an extra egg. She starts pouring cream into a bowl, throws away the package when it runs out, and then continues pouring, this time with milk. She uses cream mixed with milk because she had some leftover cream that she wanted to get rid of. She does not bring out the ovenware until the pancake mixture is finished. Even Alice, who has pre-arranged her physical setting, does not take down a bowl for her cold sauce until it is time to mix the ingredients together. By using such practices, Felicia and Alice keep the limited space clear of unnecessary objects.

Since Felicia's physical setting has not been pre-arranged there are also some insights to be drawn from the process of picking utensils and ingredients. When she takes out a bowl for the milk and cream she quickly puts it back after seeing that it has no measuring lines on the inside. She chooses another bowl in which to mix the milk and cream. Later, however, she actually takes out the first bowl again to whip the milk mixture together with flour and eggs. At the end of the session Felicia says to Lindvall that she is "not that logical, it is all a little willy-nilly". However, she says to me at the last occasion that she is less logical when cooking for herself than what she is when she preparing for guests.

A monitoring and reactive process

Although Felicia does not consider herself to be very structured, to some extent daily cooking in the kitchen allows residents to be reactive and not plan everything in detail. One example of reactive cognition is Greta, who realizes when she takes down a bowl with spices that she will need her glasses to read the packages, at which point she goes to get them. Consider also the process of how Hannah cuts the cucumber for a salad during the session with Lindvall.

> Hannah starts cutting the cucumber. Stops cutting. Puts the fish in the pan. Continues with the cucumber. Stops cutting. Checks the status of the potatoes. Seasons the fish and lowers the heat on the plate. Stirs the sauce. Rinses the plate that held the fish before it was put into the pan. Continues with the cucumber until it is done and puts the pieces in the bowl that had previously been on the kitchen table. Puts away the breadcrumbs. Turns the fish. Puts away the bowl with the cracked eggs.

What is seen in this example is how Hannah prioritizes subtasks, thereby determining which processes will place demands on her attentional and reactive processes. Of course, as with all of the residents, there is plenty of knowledge going into Hannah's cooking practices regarding how things should be done, and in what order. But it is also a process that the residents can monitor and react to without sticking to their mental idea of how things should be done. Hannah is constantly cued by the things that are going on in the pots and pans on the stove. Cutting the cucumber is something she can master without her full attention. The status of the cucumber is also something that, in contrast to the things on the stove, is a direct result of her own actions. It is therefore reasonable to prioritize the processes on the stove, which is what she does. The other subtasks, such as cleaning spaces and cutting the cucumber, can wait.

Another example of the constant availability of information and the forgiving nature of the home environment is an episode that occurs while I am observing Alice as she is cooking. During the session we are constantly chatting about cooking in general and about her experiences of various related aspects of her daily life. Early in the process she also has the radio switched on, but she says that since she is talking so much she needs to turn it off. Our talking works to some extent as a natural distraction from her cooking.

> Suddenly she stops her story and our chat about growing potatoes and says that she also has to do some cooking while she talks. She turns on the stove burner for the pan, meanwhile continuing with the potato story. For some time she does other things, for instance preparing the cold sauce, and also continues with our chat. She also does some chopping of vegetables. Her chat with me is continuously ongoing. After roughly 12 minutes she says aloud, "I'd better turn it [the burner] on", but discovers that she has already turned it on.

Alice's discovery suggests that when she first turned on the burner she did so almost automatically as part of starting the cooking. When she later reminds herself that she has to turn the burner on she is roughly five minutes from frying the fish. At this moment, her daughter calls on the phone, saying that she is downstairs.

Using timers or perceiving?

Another group of examples that show how residents combine their knowledge of cooking with constant access to monitored processes is their non-use of timers. Greta says that she uses a timer when baking and when boiling eggs. Hannah says that she only uses timers when cooking in the oven and boiling egg. When Felicia first puts the meat in the oven for some pre-frying, Lindvall asks if she sets a timer, whereupon Felicia suggests that she does not by answering, "It should only get some color." During Lindvall and Felicia's conversation she ventures to the kitchen to check the meat but returns. A little bit later Felicia suddenly says that she can smell the meat now and she goes out to check. She says: "Ooh, now it's happened, what a color that suddenly appeared." After she has added the mixture, again Felicia does not set a timer. Instead, she looks at her watch when she puts the dish into the oven. She says aloud that it is now "twenty to" and reminds herself that it is supposed to be in the oven for thirty minutes. But interestingly, it seems that she does not watch the clock to determine when it is finished. Instead, she suddenly says that it is likely finished now and then goes to the kitchen to take out the finished pancake.

I observe something similar on one occasion when I meet with Felicia at her home. She has planned to heat up cinnamon buns. The package says that they should be in the oven for about eight minutes, but despite noting the time on the package she does not set a timer because, she says, the buns are not that sensitive. Instead, we sit in her living room talking while the buns heat up, seated so that Felicia can see the oven, but from a distance that does not allow her to directly observe the status of the buns. In a sense, the oven itself serves to remind Felicia that she will eventually need to take the cinnamon buns out. She does so after roughly twenty minutes.

One interpretation of this situation is that Felicia is involved in the primary ongoing activity, the conversation, and therefore neglects the buns that are, nevertheless, not that sensitive. Indeed, observation bears out the fact that the buns were not that sensitive. There is also some evidence that the conversation captured her attention, because she seized the opportunity to check on the buns when our discussion came to a minor halt. The context of our meeting was primarily structured as an interview situation, and therefore it was natural that she was deeply involved in the conversation. This example in combination with the cooking session with Felicia suggests that she deliberately allocates her mental resources to the aspects of the environment that are relevant to the primary intent of the meeting. She can risk preparing buns that are slightly too dark during a conversational activity, but she wants to avoid burning the meat for the pancakes.

Felicia is not the only one who trusts her senses instead of a timer when deciding if something is finished. Beatrice also uses a timer for things in the oven, but says that she always sets it a little before what the recipe says because she does not trust the recipes. But fish in oven, which she is

making for one occasion, is an exception since it cooks fast, she says. As Beatrice is about to put the fish in the ovenware she feels that it is too wet, and instead the puts the pieces on paper towels for a few moments. While the fish is in the oven she decides when it is ready by feeling its texture. On this occasion she is not happy with the result because the fish was ready before it developed color. She makes it clear that color is not worth the loss of serving an over-cooked fish. Beatrice treats fish in the same way that she treats potatoes, by feeling whether they are ready. Also, when tasting the sauce she explains that something is missing: "Brandy!" which she adds. A dominant class of actions during Beatrice's cooking is sensing by feeling and tasting. She does not need measuring cups and timers to know how to use ingredients or to decide when something is ready.

To a large extent, cooking in home environments is an activity that relies on perceptual and reactive processes. However, it is also an activity that can have significantly different forms which, for instance, is reflected in their preparatory processes and their intelligent uses of space.

6.3 Chapter discussion

To some extent, the home has ready-made functional spaces, but to a larger extent spaces that are functional for cognitive purposes are shaped and managed by the residents themselves. The most important conclusion from the examples above is that spaces and the information within spaces work as mediating tools between the participants and their objectives, as well as their management of many everyday activities.

How objects and resources are arranged in the physical environment affects information flow across the cognitive system for the activities of daily life. Specifically, if a resource, object, or activity has a position that is dynamic or static, visible or hidden, this has consequences for the flow of information and the cognitive demands that are placed on the person managing the activity. This is primarily a conclusion regarding distributed cognition in home environments and not conclusion that is only about prospective memory processes. However, where objects can be found on these dimensions have consequences for the usability of these objects as cues for prospective memory processes.

Another conclusion is that there are certain tendencies among the participants to aim for a stable environment, where each thing has its own place. However, this is more often an ideal than the actual reality. Instead, participants manage the dynamics of their environment by, again, drawing from their expertise about themselves and their environment. Furthermore, the property of hiddenness seems to be a clear factor for the negative incidents I have observed. Hiddenness taxes individuals more because the person's coupling processes have nowhere to anchor.

A comparison with professional and team-based settings suggests that cognition in home environments more often involves requiring an individual to deal with objects that are hidden from visual perception. I have no exact quantification of this, but consider, for instance, the kitchens that I discussed above. Kitchens contain hundreds of objects, many of which are located in drawers and cupboards. A relatively small number of the total number of kitchen items can be found in an open space. To some extent this is a consequence of small kitchens with fewer open spaces than visually closed ones, but it is also because home environments are multifunctional devices that cannot display all of the objects that are relevant to all activities at once. This can be contrasted against professional cooking environments, which usually have many more kitchen tools in open, pre-determined spaces that are easily reached when needed. This feature in professional environments is not just a physical ergonomic property, it is also a cognitive (ergonomic) property. Information flow between an agent and the environment is facilitated if the information in the

environment is within a horizon of observation for agents in a given activity (c.f. Hutchins, 1995a). However, despite these differences between professional and everyday kitchens, the participants were observed reshaping their spaces to the extent that it was possible and necessary, thereby turning the cooking process into a more perceptually oriented task.

Finally, just as in the previous chapter, there are inter- and intra-individual differences in how resources are arranged. Some arrangements are temporary solutions for managing minor situations, while others are installations that resemble cognitive tools with clear functional specifications. The demands of multifunctional spaces will be a topic of the next chapter; in which I consider the procedures that participants have for managing activities of everyday life.

Chapter 7. Procedures and routines for managing cognitive tasks

In previous chapters I have described what could be called domain aspects of information management in everyday life, in particular regarding the home environment. In this chapter I will consider procedures that the participants employ for managing intentions and memory in everyday life. Procedures have also been part of many of the descriptions above, but in this chapter I will go into more detail on how events unfold regarding one particular activity: leaving home. I will present two detailed task analyses of one participant, Moa, where the first is an account of what she does during the 25 minutes before leaving home on one occasion, and the second is an analysis of how, on a different occasion, she handles a situation in which she is unable to find an object that is important for the process of leaving home. In the analyses of these tasks I will use examples from Yvonne, the other participant who has been studied specifically in relation to leaving home, as well as other situations observed across other participants.

7.1 Leaving home

There are a number of reasons that people need to leave their homes. The main reasons I have observed are grocery shopping, three types of exercise, laundry, lunch with a friend, buying a car, and attending a meeting of an association. During my observations, there were numerous additional minor objectives that the participants were either managing while preparing to leave home, or which they planned to manage while they were out. Each reason for leaving home has its own characteristics in terms of what is planned and what those plans will require, for instance, which objects are needed to achieve the particular objectives. For example, exercise might require a different bag than a meeting with a friend would. At the same time, there are objects that participants often or always bring with them when they leave home, for instance, the calendar and phone. Different objectives also have different time requirements and demands of exactitude. For instance, with only one exception, grocery shopping had few temporal demands, while leaving home for exercise had more specific time requirements.

Moa and Yvonne were specifically studied in relation to leaving home[20]. Just as for the participants above, Moa and Yvonne have long-established functional spaces in their homes that they exploit and trust in the process of leaving home. In our analysis of the six segments of video material, we put particular focus on functional spaces that at some point held objects or information related to the current reason for leaving home (see sections marked in the apartment maps below). These occasions also show how the principles of information flow discussed in previous chapters are employed when examining an activity in detail.

The occasion I will consider in detail below is the occasion when Moa leaves home for lunch with a friend.

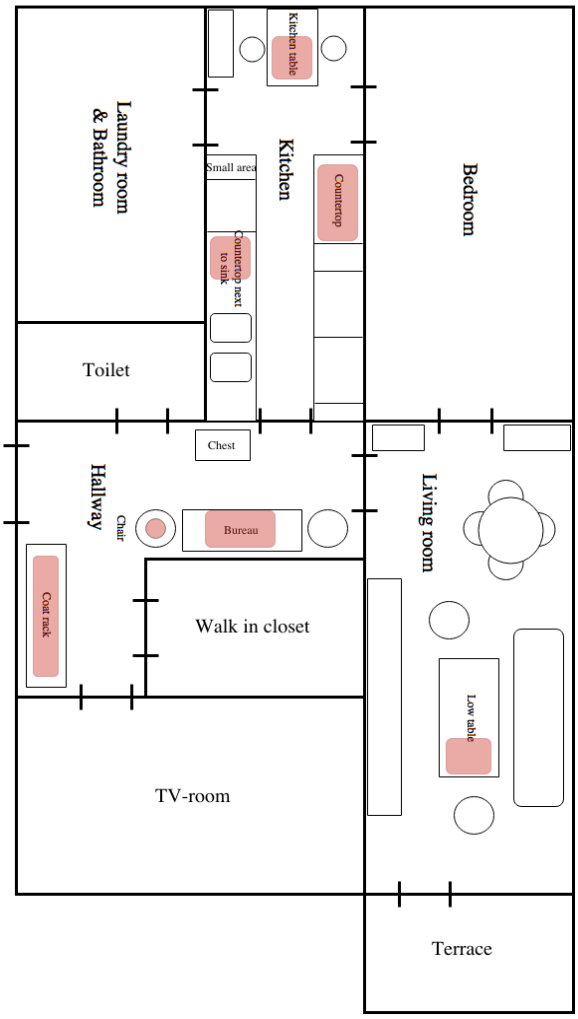


Figure 10: Moa's apartment. Spaces marked with red are spaces where objects related to leaving home was located during the recordings.

[20] I have also published sections and versions of descriptions below elsewhere (Kristiansson et al., 2014)

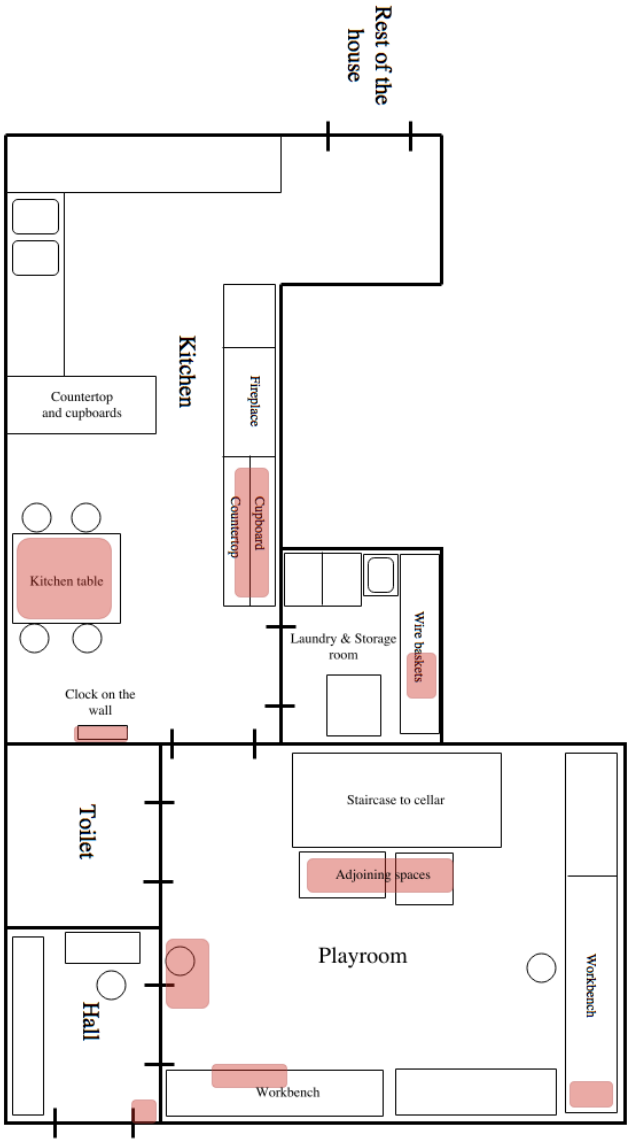


Figure 11: Yvonne's section of a house. Spaces marked with red are spaces where objects related to leaving home was located during the recordings.

7.2 Moa leaving home for a lunch with a friend

When the recording starts, at around 10 am, Moa has just finished a *fika* in her apartment with a friend. Roughly 25 minutes from this she leaves home to see another friend for lunch in a nearby building. There are a number of aspects of this instance of leaving home that she needs to manage. In the schematic figures 12 and 13 below, I have represented the process of actions for each sub-activity separately. They are abstracted to either functionally deal with the process of leaving home (figure 12) or with some other aspect of the home environment (figure 13), where each activity is

followed by sub-activities and/or a number of actions. Actions are chronologically ordered and represented as a box which either has an outward bound arrow or drawn line underneath, where the latter signifies the ending of a sequence. In figure 14 I have chronologically ordered all activities seen in figure 12 and 13.

The main activities are the following.

Activities dealing with leaving home: (a) bringing intended objects, (b) managing personal appearance and hygiene, (c) getting dressed for leaving home, (d) keeping track of time, and (e) checking status with researcher.

Activities dealing with the home environment: (a) gathering and cleaning up after fika, (b) arranging items and cleaning, and (c) watering plants.

As can be seen when comparing the actions dealing with each general category of activities, there are more actions that deal with the home environment than there are actions that deal with leaving home. This is to some extent because she recently had a visit from a friend and has to clean up from the visit, but it is also a consequence of killing time by arranging items. I will consider these types of maintenance practices in section 7.2.1 below.

Another observation is that there are a number of items that she makes sure to bring: a calendar, money, a pen, a vanity case, and the bag she will take, into which all other objects are placed during the process. She also interacts with a mobile phone, which she does not bring along for this occasion. However, this is an object that she brings along for one other occasion and is therefore an object that is potentially associated with leaving home.

Below I will consider a number of cognitive aspects of the process of managing the activity.

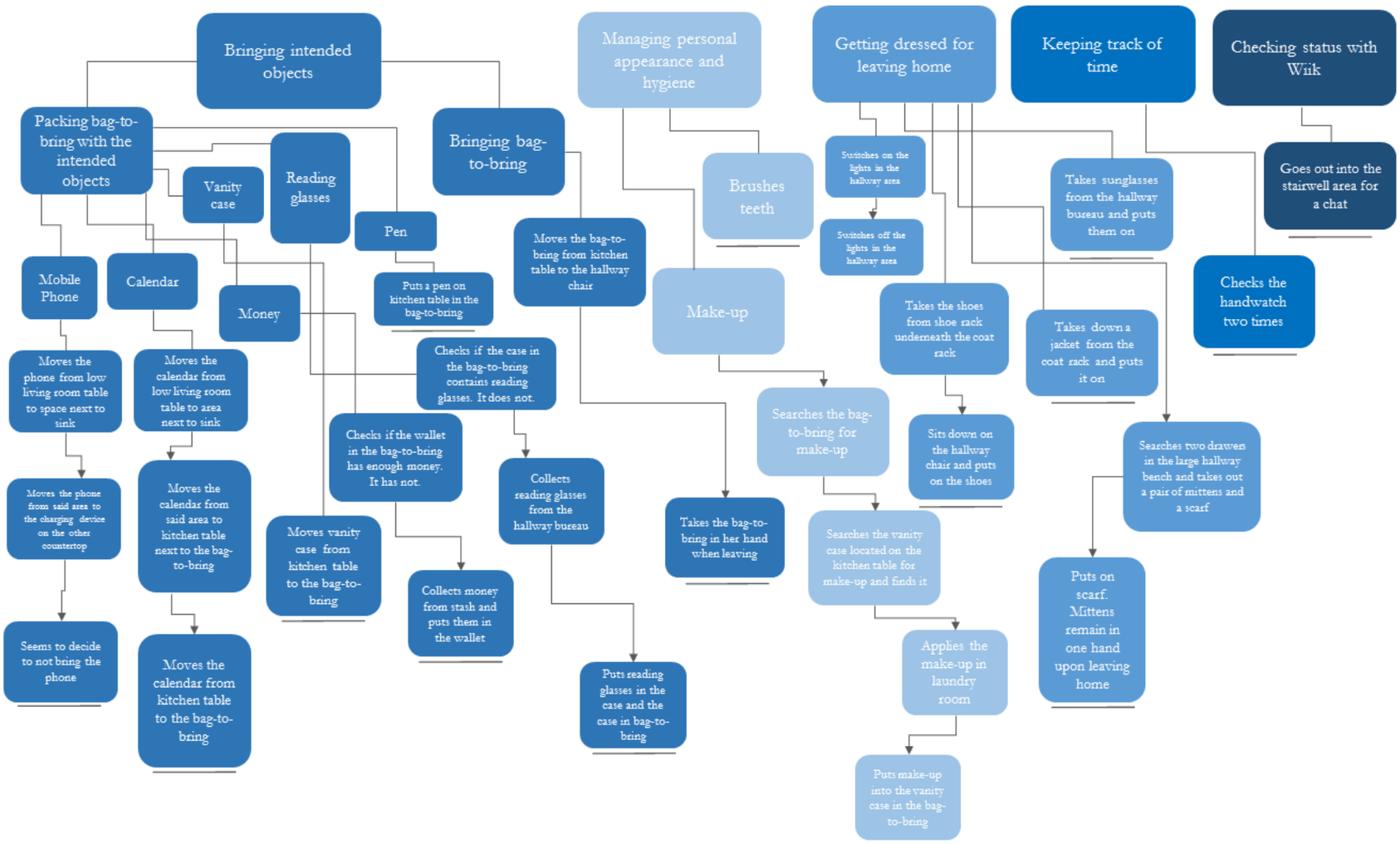


Figure 12: Moa leaving home for a lunch with a friend. Sub-activities and actions related to leaving home. Actions are chronologically ordered and represented as a box which either has an outward bound arrow or drawn line underneath. The latter signifies the end of a sub-activity.

Figure 13: Moa leaving home for a lunch with a friend. Sub-activities and actions non-related to leaving home. Actions are chronologically ordered and represented as a box which either has an outward bound arrow or drawn line underneath. The latter signifies the end of a sub-activity.

Figure 14: Moa leaving home for a lunch with a friend. Actions chronologically ordered. Green boxes indicate action non-related to leaving home and blue boxes indicate actions related to leaving home.

7.2.1 Multi-tasking

Moa seemed to find it strange when Wiik explained to her that she was supposed to act as she normally would before leaving home. We do not know whether Moa acted as she normally does before leaving home, but we do know that on all three occasions she attended to various chores in her home environment that were not related to leaving home, for instance, vacuum cleaning, watering plants, etcetera.

In figure 14 above, the actions found in previous functional representations have been placed in the temporal order in which they occur. Something that is striking in this description is that actions that can be grouped by functionality, as I have done in figure 12 and 13, do not always occur together temporally. For instance, the actions related to gathering and cleaning up from fika do not happen in a series. Nor do the actions related to packing a bag occur in one series of actions. In fact, the only activities where it can be argued that all actions occur in one series are watering the plants and dusting spaces in the living room with a cloth. These actions are not interrupted by some other activity and they seem to follow a clear procedure of which action to continue with after finishing the previous one. Furthermore, interestingly, these are the only two activities during the occasion that demand that she constantly hold an object in her hand. This could mean that there is a clear constraint on what she is doing. I am not saying that she has no clue what she does in general; on the contrary, she initiates a number of new activities without a clear cue prompting her toward the activity, therefore the processes are driven by top-down initiations. However, the instances when she does not hold something in her hand seem to invite her to initiate new activities or to resume an activity she previously started.

How can she manage so many interruptions? First, the most obvious answer to this is that she conducts activities with which she is highly familiar. The only hassle she seems to experience is when she overturns a candle and tries to once again make it fit in the candle holder. The way she moves objects related to leaving home also offers an answer to this question (see next section). Yet another answer can be found by looking at the circumstances in which she switches between tasks. These circumstances are characterized by one of the following two features.

First, switches occur when Moa seizes the opportunity to integrate an action for one task with an action for another task. For instance, this happens when she moves the calendar and the mobile phone from the living room to the kitchen countertop next to the sink, which she does along with moving leftovers from the fika. It also happens when she checks to see how much money she has in her wallet and seizes the moment to remove a receipt from the wallet. In these situations the primary ongoing task is not completely interrupted.

Second, switches occur when she is at least partly cued by a feature of the environment that points to the activity she switches to. For instance, during the first 20 minutes, every time she initiates an action related to leaving home she does so while her head is turned toward an obvious cue. For instance, when she has brushed her teeth she exits the laundry room, thereby facing the bag she will bring; when she moves the butter knife from the large kitchen countertop to the sink, she is in the kitchen, facing the calendar and mobile phone on the counter next to the sink.

She seems to manage the multi-tasking situation by attending to the spaces and objects that she passes by.

7.2.2 Moving objects

Looking at how Moa moves objects also explains something about why the activity unfolds so well. These descriptions show how Moa makes use of both long-established and temporary functional spaces. Consider, for instance, how Moa moves objects around at the occasion (figure 12 and text below), which eventually leads her to place the objects she is bringing into the bag she will carry. The description below stretches over approximately 25 minutes, and has been edited to only include the moving of objects.

> Moa takes mobile phone and calendar from the low table in the living room and puts them down on top of a pile of magazines on the kitchen countertop next to the sink. Takes wallet out of the bag-to-bring. Opens it. Puts it down. Takes money from secret location and puts it in the wallet, which is put back into the bag. Opens a glasses case located on the kitchen table. Closes it and puts it back on the table. Takes phone and calendar from the countertop next to the sink. Puts the calendar just next to the bag-to-bring on the kitchen table. Takes charger from the corner of kitchen countertop and places it in the center front of the same space, and puts phone in the charger. Slightly moves glasses into a more symmetrical position on the large hallway bureau. Takes calendar and puts it in the bag-to-bring. Takes out another glasses case from the bag. Puts it down on the large kitchen countertop. Gets the glasses that were repositioned previously. Puts them in the case that was placed on the kitchen countertop. Puts the case in the bag-to-bring. Grabs a vanity case next to the bag and puts it in the bag. Opens the case and takes out lipstick. Takes the lipstick to bathroom. Returns the lipstick to the case. Takes bag-to-bring and puts it down on the hallway chair. Opens drawer in hallway bureau. Closes the drawer. Opens another drawer in the hallway bureau. Closes the drawer. Opens the first drawer again. Takes out a scarf and mittens and puts them on top of the hallway bureau. Puts on scarf. Takes mittens, sunglasses, and keys from the hallway bureau. Puts on sunglasses. Keys go into a pocket. Puts on a jacket from the rack. Takes the bag-to-bring and puts it on herself. Exits the door. Returns indoors again. Turns of the light in the hallway. Closes the door and locks.

In the example above it becomes clear that, from the start, Moa has placed the bag she is bringing at a location that is close to other objects that she might also bring. Those things are usually found in the kitchen, but this does not mean that Moa will find all relevant objects in the kitchen on every occasion. For instance, on this particular occasion Moa has placed her calendar in the living room earlier, for a meeting with a friend that ended upon Wiik's arrival. When Moa cleans the spaces after the coffee and meeting, she brings the calendar to the kitchen area. But instead of placing it directly in the bag she will bring, she places it on top of a number of magazines located on the kitchen countertop next to the sink. Shortly after that, she moves the calendar a second time, bringing it one step closer to the bag, and a third action moves it to the bag.

From a rational perspective on the activity of leaving home with the appropriate objects, several of the above actions were relatively inefficient, but an important conclusion to draw from this observation is that packing for leaving home is not a truly efficient process when viewing it only in terms of this activity. There are several activities going on before Moa leaves home. When Moa moves objects from the living room, the moving of objects is both part of the leaving home activity centered on the kitchen table and a washing up activity centered on the kitchen sink. In this situation, the washing up activity is more immediate than the leaving home activity. Moa's actions seem to prioritize getting things done rather than optimizing the process of remembering to bring the calendar. From the perspective of Moa having several ongoing activities before leaving home, the actions turn out to be more efficient than they do only from the perspective of a single activity.

Furthermore, the sequences of actions are also efficient enough because objects are moved closer to their target locations, thereby increasing the likelihood that they will eventually be seen before leaving. It is an intelligent use of space because the arrangement presents choices of objects to bring (c.f. Kirsh, 1995). It is also notable that Moa acts opportunistically when she sees objects related to leaving home and consequentially moves them closer to the target locations. One exception is the glasses on the hallway bureau which, after finding the case in her bag, Moa seems to remember or find relevant and she goes back for them. Since she has recently interacted with the glasses they are easily located.

Overall, when the objects-to-bring are located near the bag-to-bring, the packing of the bag also becomes a visual recognition process in which Moa can associate the objects as things that should go into the bag (c.f. Kirsh, 1995). The calendar and the vanity case were both placed in this way. The mobile phone was not brought along when Moa left home, but it was placed on a relatively clean space that Moa could easily consult before leaving. Much of what Moa did when she moved objects about on each occasion of leaving home led to an increased likelihood of spotting the objects at a later stage in the process. Therefore, Moa facilitated reactive cognition (c.f. Norman, 1993). This is also the case for Yvonne.

Yvonne has three general locations in the playroom area where the rucksack she usually brings is located, two of which she packs her bag on each occasion when she leaves home. One location is at a hock on the side of a school desk at the two adjoining spaces. This is where the rucksack is located before Yvonne starts to pack. Another location is on top of the adjoining spaces, a school desk and a chest. The other location is on the floor or on the stool next to the small hallway. On two of the occasions Yvonne leaves home with a rucksack that, at first, is located at the two adjoining spaces and is later transferred to the floor space that is closest to the hallway. Most of the packing takes place at the two adjoining spaces, and the move to the hallway seems to be made to increase the likelihood of noticing the rucksack when leaving home. There is also likely a practical reason, since the position on the floor is easily reached after she has put her shoes on. On one occasion she instead brings a tote bag with exercise clothes. She explains during the last meeting that some activities take place nearby and for those activities she does not need to bring the rucksack or the small leather bag that is almost always located in the rucksack; which contains wallet, pen and paper, etcetera.

Similarly to Moa, Yvonne moves her objects in steps. For instance, consider how she moves her car key and door keys when she is leaving home to exercise.

> The car key is taken from a hook on the inside of the door of a cupboard above the kitchen counter and placed on the workbench in playroom area closest to the exit. She puts on a cardigan which she had previously placed on the workbench. Picks up the car key and places it on a stool close to the hallway in the playroom area (just next to the previously described space on the floor). She does other things before later sitting down on another stool in the hallway. She puts on shoes, a scarf, and a jacket. Picks up the car key, mittens, and a cap and holds all three items in her left hand. Opens the door. Looks at the alarm unit. Takes down house keys from their hook, goes out onto the porch, and places the keys in the keyhole on the outside of the door. Goes back in. Sets the alarm. Grabs the tote bag and leaves.

As with Moa, every time Yvonne moves objects, she increases the likelihood that she will encounter them as she continues the process of leaving home. Also like Moa, Yvonne's car key did not travel the direct route to leaving home, but Yvonne made certain that it followed her at each step all the

way to the door. In this process, spaces were opportunistically exploited to hold objects while Yvonne did other things with her hands. Yvonne confirms during the last meeting that objects are moved closer to the hallway by being placed on the stool close to the hallway in the playroom, on the workbench closest to the exit, or on, or around the adjoining spaces. However, which object, keys, cardigan, etcetera., that ends up on which space can vary from occasion to occasion.

The availability of her hands also became crucial just before Yvonne left home. Since her left hand was full of items she could not hold the house keys while setting the alarm. Instead of first setting the alarm and then taking down the keys, she takes the keys from their hook and places them in the keyhole. Leaving home with the intended objects is not an activity that is planned in detail. In fact, few cognitive activities in real-life settings are (c.f. Lave, 1988; Suchman, 1985). Yvonne seems to be clear on which objects she needs when leaving home, but that does not mean she has planned exactly how these objects should make their way out. In the example above, Yvonne finds herself in a situation where her hands are full. She solves the problem by freeing one hand by placing the house keys on the outside of the door, a space that, in accordance with both Moa and Yvonne's actions, is closer to leaving home.

7.2.3 Maintenance practices

Tools and spaces can be viewed as serving specific functional purposes. However, as seen in previous sections, their functionality is naturally determined by how they are exploited in the process of certain activities. Another factor is that there is both a start and end when using tools and objects in specific activities. Where an object or tool is found at the beginning of its use is not necessarily where it lands when it is no longer necessary. In fact, as noted in the previous chapter, many objects in the home environments I have studied do not have strict locations, which is not necessarily the same thing as saying that objects do not have intended locations. One way that residents deal with the variability of object locations is the use of maintenance practices. A maintenance practice can be understood as actions that are not naturally part of an ongoing activity, but that increase the residents' cognitive connectivity with their physical settings in a later activity.

Consider, for instance, the actions and activities that Moa performs in between moving objects that are relevant to her primary ongoing activity of preparing to leave home. Below is an expanded transcript of Moa's activities while she packs her bag as previously described but with other actions in italics.

> Takes phone and calendar from the countertop next to the sink. Puts the calendar just next to the bag-to-bring on the kitchen table. Takes charger from the corner of kitchen countertop and places it in the center front of the same space, and puts phone in the charger. *Takes the scissors located on the same kitchen countertop and puts them in top drawer in the counter next to the sink.* Slightly moves glasses into a more symmetrical position on the hallway bureau. *Slightly moves another pair of glasses. Moves a piece of paper from the top of a pile of magazines to the side. Browses through the pile of magazines. Puts the piece of paper back on top of the magazines. Moves the glasses slightly closer to the pile. Picks up a tiny piece of jewelry from the bureau in the hallway and puts it down on the bedside table in the bedroom. Picks up a vase and a plastic container containing a bottle from the floor in the bedroom. Puts the plastic container down on the small countertop area next to the stove. Puts the vase in cupboard in the laundry room. Picks up a paper bag in the kitchen. Looks into it and places it on the small area between door to bedroom and kitchen countertop. Picks up another vase and two plastic containers on the floor in the bedroom and places them in the cupboard in the laundry room.* Takes calendar and puts it in the bag-to-bring. Takes out another glasses case from the bag. Puts it down on the kitchen countertop.

Many of the actions that Moa performs in the passage above can be understood as actions that normalize the physical structures in her home. It seems that Moa has a specific space for vases, but her vases are not always found there and therefore the vases require maintenance practices. By moving the vases into the cupboard she limits the anomalies of this physical categorization. It also seems that jewelry is preferably kept in the bedroom and not on the hallway bureau, but can occasionally be found in the hallway as a result of removing it from the body when coming home. The scissors are preferably kept in the drawer but can occasionally be found on countertops in the kitchen as a result of using them, in this case for preparing fika. These maintenance practices bring order to the dynamic uses of home environments.

Another conclusion from the passage above is that, to a large extent, Moa's maintenance practices are reactive to what is presented in front of her. Specifically, several of the maintenance actions spring from being in the area where a previous action ended, maintenance or otherwise: from the hallway, to the bedroom, to the laundry room, to the kitchen. This is also the case when interacting with tools and objects related to leaving home. For instance, when Moa checks her wallet to see how much money she has she finds a receipt, which she puts down on the kitchen table. Moa's wallet holds objects related to previous non-domestic activities that are not necessarily relevant to future non-domestic activities. There are also proactive instances in the passage above, for instance when Moa returns to the bedroom to clear the bedroom floor of vases and containers.

Yvonne is also observed to perform maintenance practices while preparing to leave home. For instance, on one occasion when leaving home, she is seen over a number of sequences to move pens from the kitchen table to a glass for pens on the kitchen countertop next to the fireplace. One of the pens is deemed important for the particular occasion of leaving home and ends up in the bag-to-bring.

During all sessions, Moa and Yvonne performed what can be seen as informational cleaning of important spaces. In everyday language, they are tidying up their belongings, sometimes as part of packing the bag, but sometimes as a seemingly separate activity to use available time. These kinds of actions, along with some static features of their environments, facilitate the efficient use of important spaces as prospective memory aids since it simplifies perception and increases cue distinctiveness (c.f. Cohen, Dixon, Lindsay, & Masson, 2003; Kirsh, 1995). Maintenance work is not always directly for the sake of boosting cognitive performance, it is also pragmatic in relation to keeping things neat and tidy. Both Yvonne and Moa relocate objects *as if* they prefer to keep things neat and tidy, which can also be understood as a result of cultural pressure to keep things neat and tidy. Yvonne says in an interview with Wiik that it was awkward that she did not have her items in a better order for the filming. She also confirms, during the last meeting, that she prefers having things neat and tidy, but that neat and tidiness is seldom the case. She also describes herself a collector of objects which she says potentially decreases the level of order in the home. But importantly, when I ask her if she can think of any situations where the lack of neat and tidiness have had any negative consequences, like for instance that she cannot find a particular object, she cannot. It seems that she has practices that nevertheless deal with what is, for her, most important.

However, the patterns of actions that the participants employ are also sometimes actions that have epistemic consequences. The clearest examples are the many moves of objects to be brought when leaving home, which increases the likelihood that the objects will be perceived at a later stage, but some indices also suggest that maintenance practices are there to serve cognitive purposes. Every move of objects that Moa and Yvonne made before leaving home led to the objects either being grouped together with process-associated objects or structures, or placed in more symmetrical

positioning to other nearby objects. Not a single move of objects can be seen as increasing the environments' categorical inconsistency.

Of course, since these actions exist, the participants must also employ practices that reduce the consistency of the environment. Otherwise, objects would not have ended up in positions from which they could be brought to a consistency-increasing position. This was not observed in the video data, but in the interviews, several participants did describe examples of times that disorder was created that lead to an increase in cognitive taxation (as described in the previous chapter).

7.2.4 Dealing with the visible: scanning, browsing, and orienting

There is one group of actions that was not included in the representations of the above task-analysis of Moa leaving home. This type of action is how participants use their bodies when they are not moving objects. Both Moa and Yvonne, as well as other participants, are seen orienting themselves toward important spaces in their homes, spaces where relevant resources and objects can occasionally be found.

To some extent, the way the participants move their bodies is a result of characteristics of their environments. For instance, Moa's apartment (see figure 10) has a narrow kitchen and hallway and there is really no one place that allows for the immediate observation of all relevant spaces in the home. We will see below that Moa has particular ways of getting an overview of these narrow passages. The physical layouts are also important when we consider that Moa packs her bag on the kitchen table, which is the point in the kitchen that is located furthest away from the apartment entrance. This means that when Moa takes her bag to leave, she will need to pass through all of the important spaces in the narrow kitchen and hallway.

Being oriented

How often and in what way people are oriented to particular spaces in their home environments is a consequence of the activities they conduct. For instance, Moa has more activities that involve the whole home than Yvonne, therefore she crosses more spaces and does so more often. For instance, she crosses rooms 61 times during the first recording. It is important here to note that walking bodily through the environment with objects and spaces provides experience. For instance, almost every time she goes from the kitchen to the living room, depending on the turn and downward tilt of her neck, Moa has the bureau in the hallway in view and hence also keys, glasses and various other objects. On the first occasion, Moa is in the hallway 22 separate times, but often she is just passing through. One reason that Moa has her keys in view so many times is partly because of the location of the hallway bureau, but also because so many activities involve walking from the kitchen to the living room and from the kitchen to the TV room.

The kitchen is an area that is important for all occasions for both participants. On the first occasion Moa spends approximately 14 minutes in the kitchen, and on the third occasion Yvonne spends approximately 18.5 minutes in the kitchen. In both cases, this accounts for roughly half of the recording time. Moa conducts the packing of her backpack on the kitchen table and as a result she has her backpack in view more times than Yvonne has. Moa's bags are always packed at the kitchen table and are only moved into the hallway just before leaving home. On the third occasion, Yvonne's backpack is placed on the floor next to the hall, an area that she is less likely to pass, given her movement patterns. Also, Yvonne's packing area changes on all three occasions. On the third occasion, Yvonne actually forgets to bring her backpack when leaving, but realizes it in time and goes back for it. Yvonne thinks she forgot the rucksack because she was stressed, and adds

that since she usually always brings the rucksack when leaving home she very seldom forgets the rucksack like this.

Because Yvonne places the bag near the hallway area she does not necessarily interact with it just before leaving, therefore she has fewer moments than Moa does in which she can be reminded of the bag by cueing processes. This is because she spends time in the kitchen. So despite having the backpack in view a couple of times during the third occasion, while getting dressed, it is not part of Yvonne's action sequences before leaving home.

This shows that where residents do some activities can have consequences for other activities. Perhaps a clearer example of this is the first observation of Moa, when she moves her calendar from the living room table to the kitchen countertop next to the sink, and later to the bag. Because of ongoing activities, while the calendar is located next the sink it is in view approximately 20 separate times. In this way, Moa structures her objects in space so that the process of assembling the bag becomes physically and cognitively more efficient (c. f. Kirsh, 1995). The calendar becomes a less likely object to forget.

Overall, during the in-detail coded occasions Moa has a relevant space in view 125 times and Yvonne has an important space in view 156 times. The important thing here is not the exact numbers, instead the numbers are an illustration of how cognitively rich the home environment becomes in combination with the practices of the residents.

The orientation to important spaces can be understood as a resource for coping with the complexity of the home environment and ongoing activities. This can also be seen when observing more deliberate strategies. One case of this is when Yvonne, on her second occasion, suddenly moves to sit on a different side the kitchen table, orienting herself so that she can see the clock on the wall when reading the newspaper. This to provide herself with an easier opportunity to keep track of the time.

Scanning and browsing

As described, being oriented to a space can be a consequence of activity-based circumstances. A sub-group of such practices is when people turn to spaces without directly interacting with the space they have oriented to. These situations can be called scanning or browsing practices, and can be observed at the level of head movements.

Head movements (a kind of orientation) toward visible spaces, either when objects are located there or when they are not, are a recurrent practice when Moa and Yvonne walk from one point to another in their homes. One example is when Moa is walking around the apartment watering flowers and quickly turns her head towards her bed as she passes by. On top of the bed is a sheet of paper that she probably put there earlier the same day. The sheet of paper is not related to the activity of watering flowers or the activity of leaving home. The head orientation to information-carrying spaces happens nevertheless. This kind of head movement, i.e., unrelated to the ongoing activity, is common for Moa. Counting the number of times she turns her head toward spaces that are important for the first occasion of leaving home, the total comes to 43.

The head turns seem to be a type of browsing practice, and therefore also a kind of maintenance practice. They are browsing practices because the head turns occur even when the important objects have already been moved to another space or have not yet been placed in the relevant space. It seems that head turns occur because the spaces are hot spots for the management of everyday chores. One illustration of this is, once again, Moa's calendar on the countertop next to the sink,

where Moa continues to scan the countertop after she has placed the calendar on the kitchen table next to her bag. Of Moa's 43 head turns to relevant spaces on the first occasion, 12 of them are towards the countertop next to the sink. In fact, every time Moa passes this area on her way from the kitchen table towards the hallway she will, as a rule, first turn her neck towards the kitchen countertop to the left and then turn to the countertop next to the sink.

Interestingly, the consistency of this routine is unique to the first recording occasion for Moa. This is also the only occasion on which the kitchen counter next to the sink is used as an offloading space. On this occasion, along with the calendar, there are also a couple of magazines located on the space that could potentially draw attention. The other times, the routine of browsing of spaces in the kitchen only occurs toward the other kitchen countertop which always is used as an offloading space. This suggests that actions can be specific to occasions and that they do not necessarily transfer to other occasions in the same environment. This also points to the adaptability of actions to the present circumstances. Deliberate or not, browsing the environment for relevant information assists the residents in the cognitive aspects of their chores.

In contrast to browsing, there are also practices that can be described as scanning practices. This is when head turns occur for the purpose of finding a category of objects. Of course, it is difficult to know which head turns are browsing and which are scanning for something specific. An indication that one of Moa's head turns toward a relevant space is in fact scanning is when, just before leaving home, she brings her bag to the hallway and then makes a final scan of the spaces in the kitchen, as if checking to see if something has been missed. On the occasions described in the task-analysis above, after the final scan she pauses briefly in front of the mobile phone and seems to decide not to take it with her.

Clock checking

Clock checking is something in between scanning and browsing. A clock is an object with inherent dynamic properties that displays linear time throughout a day. In relation to leaving home at an appropriate time, keeping track of the status of a clock is, to some extent, similar to how Moa keeps track of the relevant spaces in her kitchen. Just as Moa turns to spaces to see if their states match some of her plans of bringing certain objects, people turn to the clock to see if its state matches their intention of when to leave home. Of course, the resources are different for a number of reasons.

For instance, time moves forward without the residents' interference. The same cannot be said about the objects in the relevant spaces, where the residents themselves are, of course, responsible for any state change. However, a clock is still an object in space and therefore also an object that needs to be attended to, often while managing other activities simultaneously.

In the material there are a number instances where the participants keep track of time. Perhaps the most clear example is Yvonne (also presented in Kristiansson, Wiik, & Prytz, 2014). On all occasions before Yvonne leaves home she is a frequent clock checker. In the preparatory interview she says that she considers time to be important and prefers keeping track of time. On all three occasions of leaving home she reads newspapers while sitting at her kitchen table. On most occasions she does this with her back to the clock on the wall. This is true except for one point towards the end of the second occasion, where she decides to move to the other side of the kitchen table, thereby creating a situation where clock checking is physically easier. By doing so she also creates a more constant cognitive coupling between her and the clock. Now the person who would like to keep track of time also has constant access to the clock, which creates a habit strengthening situation.

When I during the last meeting discusses this sequence with Yvonne she reflects on the peculiars of her actions. First she says that she automatically sits down on the side of the kitchen table with her back to the clock, because that has been her place at the table for years, this despite the fact that she prefers having access to the clock. Second, she also adds that she always wears a wristwatch, but when being at home seldom uses it. Instead she relies on the clock on the wall or occasionally the clock on the microwave located on the kitchen counter closest to the passage to the rest of the house.

For Yvonne, many of the head turns toward relevant spaces are about clock checking. On the third occasion, of the 22 times Yvonne turned her head toward relevant spaces, 9 were toward the clock on the wall in kitchen. In fact she seldom passes from the kitchen to the hallway without quickly turning her head toward the clock. One interpretation of this is that these actions serve to reduce the cognitive load by allowing the spaces to act as reminders of actions. For both Yvonne and Moa, it was also observed that head turns toward relevant spaces slightly increased in frequency for both participants during the final ten minutes before leaving home. This suggests that these actions are important for the process of leaving home and are not only part of a more general practice of browsing for information. Rather, they are potentially part of practices of scanning for information regarding the activity of leaving home. An increased frequency of clock checking closer to the target event is a pattern that has been observed in laboratory studies investigating time-based prospective memory (Harris & Wilkins, 1982), and these observations may be an expression of this phenomenon that extends to important spaces in general (Kristiansson et al., 2014).

The functionality of scanning and browsing

To some extent, head turns towards relevant spaces are simply because heads need to be turned somewhere. However, when walking in an environment that is highly predictable for the subject, the head can be turned some other direction to allow for more efficient management of the ongoing tasks. In relation to the descriptions above, one could question whether these actions are deliberate or more part of the automatic micro-management of interpreting and understanding the home environment. Head turns are a relatively cheap resource if one does not have physical issues with the neck. They can potentially serve a number of different cognitive functions, for instance, a redundant control function, reducing the cognitive load of ongoing activities. In previous memory studies, this type of redundancy has been observed for communication practices in families. See, for instance, Wu et al., 2008, which describes how iterations of similar information across different media can prove beneficial for the remembering process in a family, or Harris et al. (2014), which notes that repetition in a communicative remembering process within couples is a positive factor for collaborative remembering. However, it is not usually considered in relation to the physical environment. Based on what I have observed, browsing and scanning practices seem to increase the opportunities for being anchored by the immediate environment.

Scanning of the environment becomes even more apparent when considering an activity within a narrow space with several time-constrained ongoing sub-activities. One such activity is cooking, which was described in the previous chapter. Cooking is conducted within a relatively limited space that includes several simultaneous ongoing sub-activities. When, for instance, Hannah is cooking, she constantly scans pots and groceries. She does so visually, through smell, by tasting, and through tactile means. Scanning during cooking works as a way of maintaining awareness of ongoing sub-activities (something that was also observed in the cases of Alice and Beatrice). When observing cooking, it becomes more apparent that there are several ongoing feedback (e.g. smelling or hearing) and feedforward (e.g. checking the consistency of the fish) loops across the whole activity.

Cooking is also time-constrained, therefore there is a reason for ongoing feedback and feedforward loops.

This can be compared to other situations in the home environment. For instance, Charles says that when he recharges his mobile phone there is often no feedforward process of checking to see if it is finished, instead he describes it as a more random process in which, if he happens to see the phone connected to the charger, he will check its status. If Charles did not browse and interpret his environment, his phone would never be checked.

In general, it turns out that for many activities in the home environment, if one is in the habit of turning to spaces for guidance in specific situations then there is no need to have top-down routines that define what to do and when to do it. Such retrieval practices facilitate shaping of practices that are not always perfect and that need to be conducted in multi-tasking situations, such as when Moa moves objects that are related to leaving home closer to their end-destination in multiple steps.

Of course, this is not an entirely positive story. Both shaping practices and retrieval practices can have negative consequences if they are not overridden in certain situations. A clear example was when Beatrice placed her keys on the inside of the door to the disposal room. It was apparent that this was something Beatrice did automatically without considering its relevance to the current situation. Something similar was also seen in the previous case of Hannah which keeps her calendar in the bag which she usually, but not always, brings.

7.2.5 Dealing with the hidden

Hidden objects are, as mentioned in the previous chapter, tricky resources. This is also true when a person is leaving their home, particularly if the person's needs vary based on the reason for leaving home. Consider again an extended version (in italics) of the observation in which Yvonne leaves home for an exercise session.

> The car key is taken from a hook on the inside of the door of a cupboard above the kitchen counter and placed on the workbench in the playroom area closest to the exit. She puts on a cardigan which she had previously placed on the workbench. Picks up the car key and places it on a stool close to the hallway in the playroom area (just next to the previously described space on the floor). She does other things before later sitting down on another stool in the hallway. She puts on shoes, a scarf, and a jacket. Picks up the car key, mittens, and a cap and holds all three items in her left hand. Opens the door. Looks at the alarm unit. Takes down house keys from their hook, goes out on the porch, and places the keys in the keyhole on the outside of the door. Goes back in. Sets the alarm. Grabs the tote bag and leaves. *Closes the door. Opens the door. Goes to the two adjoining spaces in the playroom area. Picks up the rucksack. Opens the outer pocket. Takes out leather bag which contains wallet. Puts down the rucksack. Keeps the leather bag in her left hand when leaving, closing, and locking the door.*

First, Yvonne seems certain about where to find the wallet. The issue here is about dealing with an occasion that is not the most common situation when she leaves home. On the other two occasions she leaves home with her rucksack, which is the primary object-to-bring when Yvonne leaves home. This fact, in combination with the fact that the object is hidden, increases the potential for forgetting the object. Since important objects such as her wallet and calendar can often be found in the rucksack it seems that, for occasions when Yvonne leaves home for non-rucksack activities and when she also needs her wallet or calendar, she needs a practice of interacting with the rucksack to ascertain that she has not forgotten anything important. In this case, however, she instead keeps track of the circumstances through mental processing.

At the above example it at glance seems that Yvonne forgets to transfer the leather bag to the tote bag before leaving home. However, this is likely only part true. When I discuss this situation with Yvonne she describes, as I described previously, that for many activities which are nearby she does need to bring the leather bag with wallet and calendar. But occasionally she decides that she will take the road by the local grocery store on her way back home, and in those cases she needs her wallet. So what instead likely happened in the above example is that she suddenly formed the intention of that she needed to buy something, and consequently realized that she needed to bring the wallet.

Independent of the exact circumstances of the above example, the example displays that dealing with hidden objects, which cannot always be kept on a specific location, can be taxing for the person that needs the object. In next section I consider another situation which deals with hidden features of home environments; a search process by Moa.

7.3 Finding lost objects: a case in point

The above example of Yvonne's wallet in her rucksack suggests that the wallet has a relatively static position in the rucksack because she so frequently uses the rucksack for non-domestic activities. This is probably why she finds the wallet as fast as she does when re-entering the house. Based on the descriptions above, one could hypothesize that it could be a very taxing situation for the residents to attempt to find an object that is not used every time for a kind of activity, is normally hidden, and has a changeable position in the home environment due to the nature of how it is used. In this section I will consider, in some depth, one case where these conditions are met.

Five minutes before Moa leaves home for an exercise session she searches for something. She is looking for two cards, one that looks like a bus card and one that looks like an exercise card, both of which she needs for the current occasion of leaving home. This search is interesting because it highlights a cognitive process involving physical resources that are out of plain sight, the location of which is a consequence of previous occasions of similar activities, wherein Moa needs to use a combination of opportunistic search actions and deliberate memory and decision resources in a stressful situation to gain knowledge of her own cognitive couplings with her environment.

A number of objects and spaces are involved in the search (see figure 15): (a) the pockets of a small handbag located on a chair in the kitchen, (b) the pockets of a medium sized shoulder bag for exercise located on the kitchen table, (c) pockets on a number of jackets located on the rack in the hallway, (d) the top of the kitchen countertop, (e) the top of a portion of the kitchen counter next to the sink, and (f) the top of the hallway bureau.

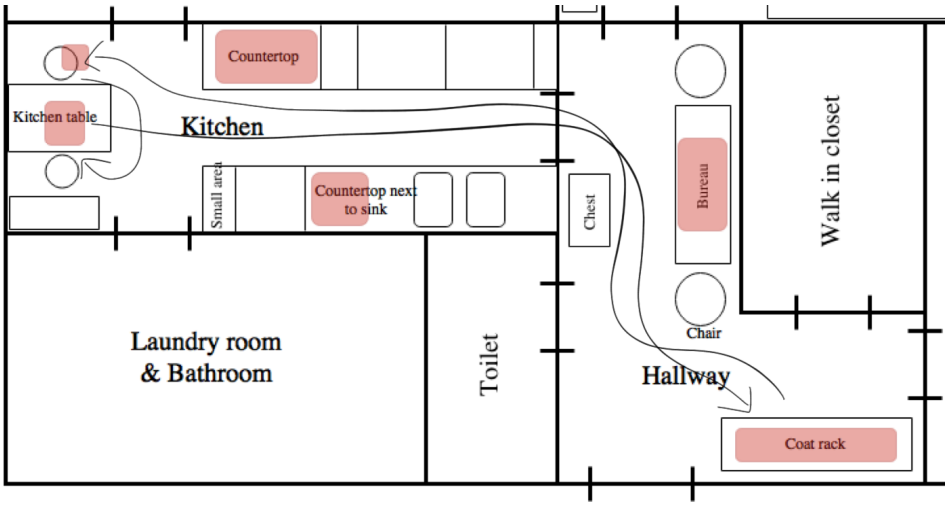


Figure 15: Moa's overall movements during the search

The complete search goes in this order: Moa starts with the shoulder bag, then past the top of the spaces over to the rack, and back to the kitchen past the same spaces, then the handbag, and finally the shoulder bag once again where she finally finds the cards. The entire search takes about two minutes. During this short episode the top surfaces were quickly visually inspected as she passed by. Below I will focus on the part of the process in which she searches the hidden spaces: pockets of shoulder bag, handbag, and jackets.

The black shoulder bag where she eventually finds the cards has six pockets: a large pocket, a large side pocket and four small side pockets (see figure 16 and 17 below). The precondition of the pockets from the start of the search is that all pockets are open except small side pocket 2 and the large side pocket, which are closed. It is important to bear in mind when reading the passages below that when Moa searches the shoulder bag the first time she has previously, about five to ten minutes ago, interacted with the bag several times for other reasons related to the packing of the bag. These previous interactions have been with the large pocket and the large side pocket. This is probably the main reason that certain parts of the search are less thorough. The opposite is the case for the jackets.

Also, compared to other actions during the sessions with Moa, the two minutes described below are one of the most fast-paced sequences across the recordings of Moa. It is also notable that Moa's pace of searching the pockets increases over these two minutes. Below I go through the search of each hidden space in the order in which they occurred.

A. Shoulder bag: first occasion

Figure 16 is a sketch of the actions taken, in what order and for which pockets. When Moa searches the bag she starts by opening the large side pocket and looks into it by stretching the opening with both of her hands. Then, gripping the bag at a point close to small side pocket 2, she slightly tilts the bag so that the closed small side pocket 2 slightly turns toward her head. After searching other pockets with her hands she will again interact with this pocket by quickly touching the pocket. It appears that she makes micro-decisions as she goes along. Small side pocket 2 and the large pocket

are the only pockets for which she does not use her hands to search. As can be seen in the figure, Moa does not search the large pocket with her hands but looks into it. Of course, these pockets have physical aspects (tightness) that make it possible to look into some while others can only be searched using one's hands. After this sequence she walks to the hallway to search the jackets.

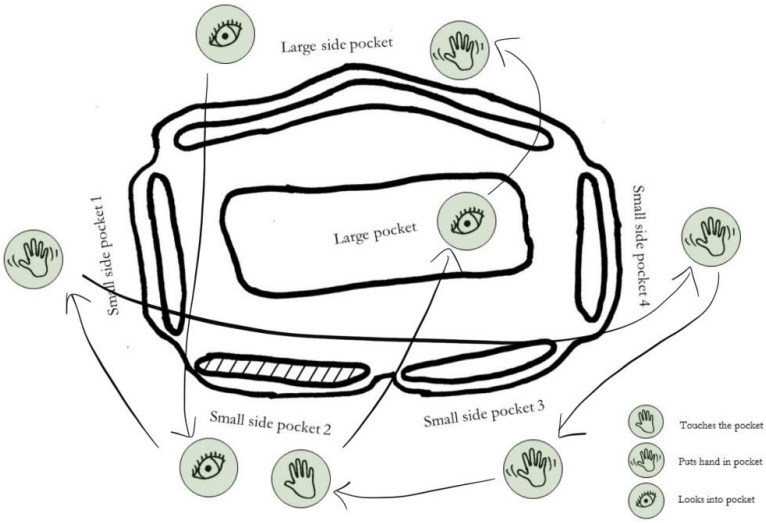


Figure 16: Moa's first search of the shoulder bag

B. The jackets

There are seven jackets located on the rack at this time. Before turning to the jackets Moa switches on the lights in the hallway, which is otherwise dimly lit. Facing the front of the jackets she starts reaching, from her perspective, with her right hand into the left pocket of the jacket that is closest to the apartment door. However, she interrupts the action midway and instead starts performing a two-hand search by first putting her left hand in the left pocket, and reaching for the right pocket with her right hand. This seems to be the logic she would like to use to search all of the jackets, though it does not always work due to minor incidents and material aspects of the jackets. For instance, for every jacket except one she needs the support of her left hand when initially reaching with her right hand for the pocket towards the wall. Also, when searching the first jacket a shoehorn, which is in her way, falls down from the rack. She picks up the shoehorn and continues on her search of the other pocket with her right hand, and also puts her left hand back into the first pocket. For one of the jackets she seems to find a piece of paper, which she puts back into the jacket. One jacket is searched faster than the other jackets. This seems to be the thinnest jacket on the rack. Finally, she quickly pauses at the last two jackets on the rack (as seen from the entrance) and does not search them at all. These are the two thickest jackets on the rack.

Just as for the bag above she seems to make decisions as she goes along regarding which spaces to search and which to skip. After searching the jackets she walks at a relatively rapid pace back to the kitchen area, specifically toward the handbag located on the right chair next to the kitchen table.

C. The handbag

The handbag seems to consist of two pockets: one main and one side pocket. These pockets are quickly searched, while the bag is moved stepwise across several spots around the kitchen table: from the right chair next to the kitchen table, to the kitchen table, and hanging on the other kitchen chair next to the shoulder bag, which she then immediately starts to search again.

D. Shoulder bag: second occasion

When she searches the shoulder bag a second time the pace has increased. It is probably a stressful situation for Moa. Also, several action turns is, in contrast to the first search, completely without interims between the occasions Moa has hands in pockets. This means that she starts to use both of her hands. Putting her left hand in one pocket at the moment she takes her right hand out of another – preparing a third pocket with her right hand before putting her left hand into this pocket.

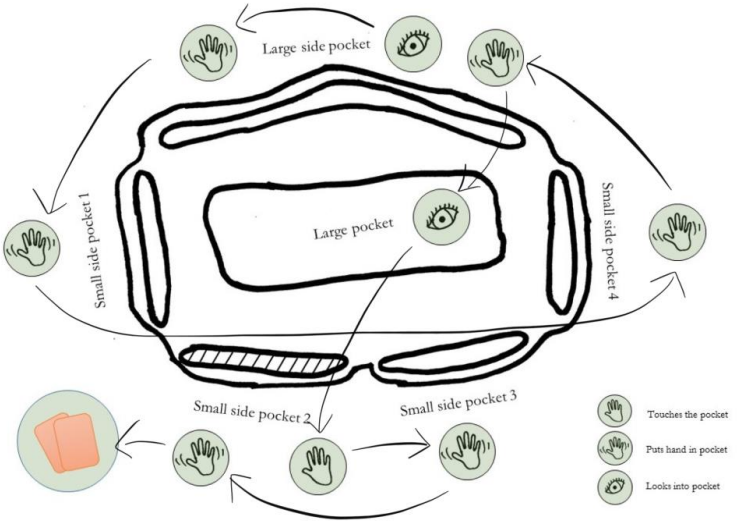


Figure 17: Moa's second search of the shoulder bag

As Moa searches the bag she again focuses on the same pockets as the previous search (see figure 17). She thoroughly searches small side pockets 1 and 4 which suggests that she sticks to her previous ideas of where the target might be. She also searches the large side pocket one time with her eyes and thoroughly two times with her hands, suggesting that she has not neglected the possibility of the cards being located there. Also, Moa does not search the large pocket thoroughly, she just puts her hand in quickly and takes it out. Given that this is a large pocket this is an insufficient action to search the whole pocket. One possibility is that at this moment she has already decided to open small side pocket 2, because quickly after action 6 she again touches the opening of small side pocket 2. Compared to her actions during the first search it is a quicker touch this time, suggesting that she did not give much thought to whether to actually open it this time. Quickly after the touch she non-thoroughly searches small side pocket 3 and quickly returns to small side pocket 2, which she opens and takes out what seems to be a pair of glasses, followed by the cards. She immediately walks to the walk-in closet and takes out a jacket. Before buttoning the jacket she puts the cards in one of the pockets on the jacket.

Insights from the case

The primary observation in this case is the wealth of knowledge that Moa seems to use to find the cards. The mixture of resources she uses are what makes the search far more sophisticated than a random one would be, though it is also possible that this is why the search takes longer than might have been necessary.

Naturally, the first question to ask is, why did she not search the small side pocket 2 earlier? We do not completely know, but a number of conditions provide clues. The first condition is that Moa seems to have ideas about where the cards could be. The large pocket is unlikely because it is where she puts bulky objects such as a hairbrush and a calendar. That Moa seems to have an idea of where the cards might be located is clear from her search of the jackets, specifically when she decides to skip searching the two thickest jackets. It is currently spring, therefore it is unlikely that the cards will be found in jackets that are intended for winter. The result is what could be seen as a trade-off between the ongoing action sequences of searching jackets and the ongoing guiding thoughts of when to stop the search.

This also relates to Greta. Recall that Greta says that her keys always end up in the jacket she used the last time she came home. To find the keys she says that she "sometimes remembers which jacket she used", but as in Moa's case, Greta can also use this deliberate remembering processes in combination with a physical search. In the case of Moa's search of the jackets, this combination of resources appears to be an efficient search heuristic for this occasion. But if we look at the search of the shoulder bag from a similar perspective, we instead see something that seems inefficient from an outside perspective.

Narrow small side pockets are shaped to hold flat objects, therefore they are likely to hold cards. Moa appears to support this idea, since she makes thorough searches of all side pockets except for the target pocket. In fact, her belief in this idea seems strong enough to make her distrust her past searches of these pockets, and as a result she searches each at least two times. She also seems to distrust her initial search of the large side pocket, and compensates during the second search by physically searching it twice.

A review of all of the spaces that she searches also makes it clear that Moa is guided by thoughts of her previous activities. From a deliberate perspective, it is likely that she searches the bags and jackets because, like the objects she is searching for, they are associated with non-domestic activities. The fact that she decides to search the exercise shoulder bag two times suggests that this is a primary search target. The cards are also objects that are needed when Moa leaves home to exercise. Moa has knowledge of her habits and the ways that she uses certain personal objects, therefore other spots in the home seem less relevant for the search. As mentioned in a previous chapter, Greta talks about something similar in an interview when she describes her search strategies for finding her glasses in this way: "First to the computer in the bedroom, then to the living room and finally to the kitchen." Interestingly, she says, "I only have a two-room apartment and therefore there is not much space to search". If one counted the number of possible spaces in a two-room apartment, the answer would be a large number. However, Greta also adds that she "only reads in specific places" and therefore the spaces are limited based on her knowledge of her own practices. Charles also describes a search strategy that is similar to Greta's for locating his keys when they are not on the hallway bureau, although in Charles' case he also has problems seeing, which makes the search harder even when the keys are located in open spaces.

Residents' understanding of their past activities gives structure to the way they search for objects in their home environments. What Moa's search demonstrates is that her knowledge about herself creates a hierarchy of spaces to search. In this hierarchy, the handbag holds spaces that are one of the least likely spaces, but still a set of spaces that are worth considering. If the handbag had been more likely it would have been more efficient to search it before walking to the hallway to search the jackets.

All of the spaces that are searched are special for a number of reasons. First, without physical intervention they are hidden from visual observation. They are therefore more likely to tax internal memory and problem-solving resources than the spaces that are more easily observable. Partly because the spaces are hidden, during the search episode they are searched through a combination of tactile and visual means, together with what seems to be a combination of opportunistic perceptual and more deliberate internal cognitive resources. These internal resources need not necessarily be directly related to remembering where she put the cards the last time she used them, e.g. using episodic memory abilities. Rather, the hierarchical search practices used by Moa and other participants suggest that it is driven by a broader knowledge base of oneself and the physical circumstances of activities where the objects are used, that is, the kind of knowledge that is formed by continuous interaction with a relatively stable environment. It therefore seems that the participants use a combination of episodic memories of their own activities and fixed knowledge (semantic memories) about their home environment to find objects.

A part of the cognitive process of locating the objects is related to how residents usually act when coming home. For instance, Moa usually puts her keys on the bureau in the hallway, but for the two cards it could be that she just leaves them where they happen to "land" at the end of each activity in which she uses them. In that case, the shoulder bag she uses when she goes to exercise would be a good place to search. As noted in the previous chapter, Felicia described something similar for her cycle keys. When viewed in this way, episodic memory is replaced by a set of heuristics for finding specific objects or kinds of objects. What Moa needs to remember is where and when she usually uses the cards, and she appears to do this, since there are obvious reasons for the places she searches.

The spaces Moa searches are also special because they hold objects that tend to move around among a set of spaces, and are therefore more taxing on internal resources. These are also spaces that can be part of two different search trees when they are within the home environment compared to when they are part of a non-domestic activity. Specifically, when Moa goes to exercise she brings her shoulder bag and jacket, etcetera. These objects contain the spaces where she puts her cards during the activity. This is a smaller search tree than the one that is created when Moa comes home again with the spaces, and where the spaces again become part of all other jackets and all other bags. What seems to be a smaller problem when Moa is out of the house becomes a larger problem the next time she is leaving home.

Based on previous observations I can imagine a strategy where the cards would always end up in the same spot after being used, just like the keys when Greta comes home, but based on the way that Moa searches the spaces this does not seem to be the case. In relation to this it is important to realize that the situation of using, for instance, a bus card is different from the situation of unlocking the door to the apartment. The normal situation when unlocking the door is non-stressful. In contrast, when Alice mentions stressful situations for herself and older adults in general, interacting with the machine on the bus is one thing she mentions. Alice thinks that older

adults travel by bus too little to become efficient users of the machines, but using the machine on the bus is also physically and interactively taxing. For instance, the bus often starts moving before the person is able to find a seat. It is also sometimes a queuing situation with performative aspects, which Alice also mentions is a factor for stress in many circumstances, for instance, checking out in grocery stores. Therefore, deciding where the bus card ends up after such an experience is probably not always the primary priority, nor is it an ideal encoding situation.

Going back to the question of why Moa does not search the small side pocket earlier in the process, even though her actions of touching and grabbing suggest that she considers the pocket: this question lacks answers from interviews, but one possible reason for her not to search this pocket earlier is that it also contains another item. Just before taking out the two cards she takes out what seems to be a pair of glasses. When the glasses are in a closed pocket, on the surface, then the pocket looks like one that does not primarily contain flat objects. One hypothesis, then, is that she is captured by the perceptual appearance of the pocket and makes a quick decision that there are more likely spaces than a pocket which seems to contain a bulky object. It could also be that she knows what this bulky object is.

Given the number of possible pockets in the bag across which to distribute objects, the act of placing the cards in the same pocket as a pair of glasses seems unlikely. This suggests that the reason for Moa skipping small side pocket 2 could have little or nothing to do with remembering. It could instead be, just as it was for the jackets, about a perceptual cycle in which decisions to search spaces are made by interacting with a physical environment (c.f. Neisser, 1976) which displays certain affordances or signifiers (c.f. Gibson, 1986; Norman, 2011) that can be mapped onto a current knowledge base.

The idea of the perceptual cycle, in which the residents sample information from the environment and modify their current knowledge of states, has also been in the background for several previous observations in my analysis. The fact that the cycle often relies on a combination of visual and tactile sources is also a recurring feature of many situations. For instance, consider Charles, who has severe problems with his vision in one eye. His impairment has consequences for several aspects of his everyday life. One example is figuring out how he should turn and push his prescribed inhaler when he experiences problems with breathing. Charles cannot easily see how the inhaler is supposed to be used and also finds it hard to interact with from a tactile point of view. When Charles shows me how it supposed to be used I get the impression that he manages to use it after some trial and error, but the situation when he needs to use it is, from Charles' point of view, not a situation in which trial and error is preferred.

In the example above Charles cannot completely rely on sight to understand how the inhaler works. Reliance on tactile and motor abilities is, in fact, a common aspect of interacting with new technology. Recall, for instance, the issues regarding Alice's new iPad. When interacting with the iPad Alice cannot easily see what she is doing wrong or what she should do to make it right. There is simply a lack of salient feedback. Charles also mentions issues with new technology when, the third time I visit him, I find that his apartment building has a new door phone. I type in the apartment number, whereupon he answers and says to me through the speaker on the phone, "we will have to see if it works" to open the door. It works, and when I enter his apartment he adds that it does not work if he holds the button too long, "You should only tap lightly." From Charles' point of view, it does not make sense why the amount of applied pressure should matter.

7.4 Types of routines: what cognitively is at stake

It has been clear that the way the participants describe their practices does not always account for the cognitive mechanisms, or it simply suggests that they are using very different cognitive mechanisms that more adhere to the principles described in the above passages of leaving home.

Recall, for instance, how Beatrice says that most mornings, after her regular 9 o'clock phone communication with a friend, she checks the status of aspects of her home environment. If Beatrice does not have any early non-domestic activity she says that she dawdles around in her apartment. In other words, according to my interpretation, she tends to various aspects of her home environment in a way that is similar to what Moa was observed doing when killing time before leaving home. Based on the observations described above, turning to the environment for information about what to do seem to be fundamental to much of the management of everyday activities.

To illustrate what is cognitively at stake from the individual's perspective when contrasting types of routines, recall Beatrice's description of how she waters her plants. As previously described, she says that she waters the plants every second day. But the hesitance of her approximation suggests that it was just an approximation rather than a routine, or mechanism, that accounts for the cognitive accomplishment. In fact, tasks that are initially described as time-driven or top-down are actually often better described as event-driven or bottom-up. In Beatrice's case, it seems that she uses a combination of resources when she dawdles around in her apartment in the morning after nine.

From an individual-centered perspective her description of her watering procedures signify different cognitive tasks. Watering plants every second day is, by the nature of its description, a time-cued prospective memory task, while using the weather and soil as sources can be viewed as an event-cued habitual prospective memory task. The time-cued task requires Beatrice to keep track each day of whether she watered yesterday, while the event-cued task demands that when Beatrice is dawdling in her apartment most mornings (habitually), she recognizes the plants (event-cued) as entities that need attendance. It is likely that Beatrice accomplishes the task of watering flowers by using a mixture of abilities that recall the past and sense the present, but regardless of this, the event-cued watering task probably taxes Beatrice's internal cognitive resources less than if she were required to remember by herself that she should remember to water, and whether or not she watered yesterday.

Also, the practices Beatrice refers to are not only practices of remembering. From the point that Beatrice decides or remembers to feel the soil the task is no longer about remembering. The tactile feedback from the soil now drives the decision of whether to water or not based on Beatrice's knowledge about the specific plants and environmental circumstances. Which, however, should not be regarded the simplest of decisions since the task requires knowledge.

A similar interpretation of routines can be used to understand her description of updating her account notebook every week. After saying that she does this roughly once a week she says she updates it "when the wallet is full [of receipts]". The number of receipts in the wallet is a physical cue for when to update the notebook, which she has the opportunity to notice when she uses her wallet, which is not necessarily every day but is likely to be relatively often. Recall also Greta's spaces for incoming mail, which have natural constraints, a microwave and a wall, that work as cues for the initiation of activities. Home environments seems to be full of such constraints that establish cues that residents can exploit when they move about in the environment.

According to Beatrice, although her use of tools has increased over time, her use of routines has not. She says that when they had a family to manage, routines were more important: "Monday: laundry-day. Tuesday: ironing. Wednesday: shopping. Thursday: baking. Friday: cleaning." Now that she lives alone, she says that routines are not as important. What Beatrice means by routines in this case are time-driven events, in the example above based on days of the week. However, on a number of occasions she describes ways of doing things that are also routines, but unlike the above examples they are primarily event-driven routines or day-based routines. Recall, for instance, that she talks to a friend every morning at nine. Also, when she is going to have guests for dinner she plans to do the shopping two days before. Previously I also described how she writes things on the to-do list when making plans over the phone.

Therefore, altogether, although Beatrice in fact says that she has decreased the number of routines over time in her life, my interpretation is that the above descriptions mean that she has increased or kept to the same number of event-driven routines. Routines are no longer driven by the uniqueness of single days of the week. Instead, they are driven by the physical circumstances of the environment and morning (and evening) routines.

One interpretation of the above passage is that the routine of remembering to water the flowers every second day is a retrospective account of the outcomes of Beatrice's practices, and not necessarily an account of the practices, or cognitive mechanisms, that establish a positive outcome of keeping plants alive. Her description of the sources of information instead suggests that the mechanism is of an interactive kind, wherein she browses certain sources for information. Of course, the account of watering flowers every second day and browsing the plants and weather for information do not exclude each other. Beatrice can concurrently browse soil, perceive the warmth of the day, and also have an idea that she should water the plants roughly every second day. The combination of resources can then create a rather robust cognitive activity.

7.5 Chapter discussion

A recurring topic of all of the previous chapters has been how the residents rely on, and exploit, their environments for cognitive means such as prospective memory situations. In this chapter it has become clear that the practices of turning to spaces are more abundantly used than what could be seen in previous chapters.

All participants have been observed to have habits of turning to the physical environment to browse for information about their present circumstances. These habits are important because they can decrease the individuals' cognitive burden. The fact that participants turn to spaces for cues and information, and that they seem to have a number of different resources for any given situation, also means that spaces can compete to be the primary source of information. This in turn can place a higher demand on the person's retrieving practices - how they turn to the environment - because the retrieving practices can determine which source of information is the most pronounced in a given situation. For many of the situations described above, the competiveness of information in the environment has been important. Occasionally, participants have also been captured by their environment and hence cued to initiate a cognitive activity that was inefficient or negative.

Overall, there seem to be important practices of shaping the environment but also, as seen in the recent examples, practices of extracting information from the environment that range from perceptual interpretive processes to moving the body in congenial ways. To borrow concepts that are usually used within cognitive psychology for intra-cranial processes, it is therefore possible to understand the use of the physical environment in terms of both encoding and retrieval practices.

Both kinds of practices exist on different levels of routines. If summarizing the interactive practices used by the participants to manage many of the activities I have observed they could, for the case of leaving home, functionally be described as in figure 18 below. In the figure I have stripped the descriptions from a number of potential individual abilities that the participants utilize to manage tasks involving prospective memory in real life. It is not that some individual abilities are less important; in contrast, a number of the above examples demonstrate the individual cognitive resources that the participants have. However, the figure highlights what seem, based on my cognitive ethnography, to be important components of cognitive mechanisms in real life settings; and not just for the case of leaving home.

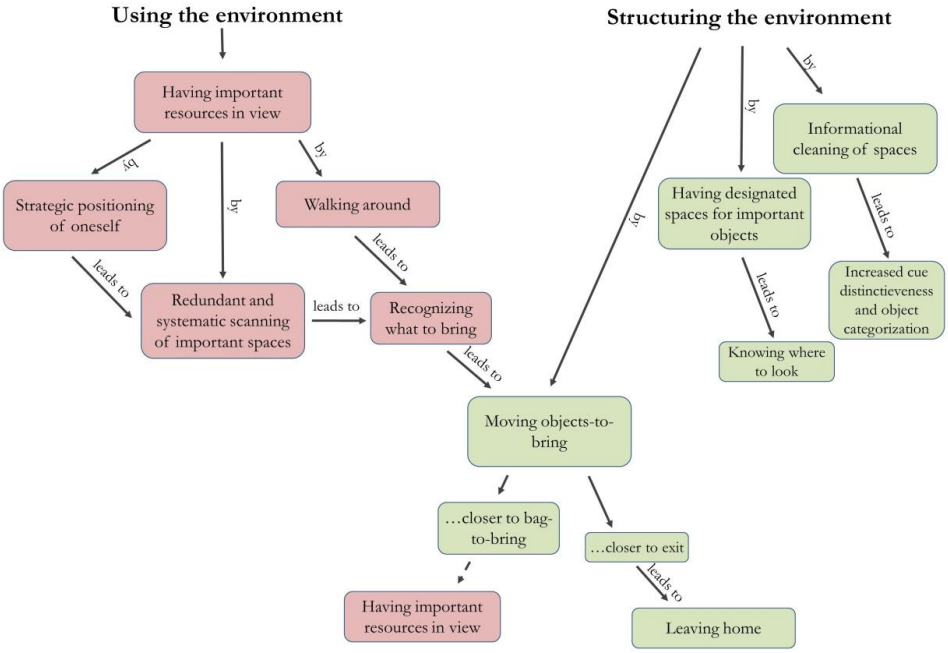


Figure 18: Basics of leaving home

Finally, compared to professional settings it seems that home environments are in greater need of maintenance practices that stabilize the environment, as well as retrieval practices that account for a multipurpose environment in which objects and resources are often not exactly where, ideally, they should be.

Chapter 8. Prospective memory in real life

As I argued in Chapter 2, with few exceptions previous research on memory strategies relating to the physical environment and prospective memory has mainly been based on self-reporting studies, which has brought a number of insights to the field, but with only minor descriptions of the underlying mechanisms in real-life situations. It seems clear that, within cognitive psychology, cognitive strategies *unaided* by the physical environment are empirically studied and theoretically modeled in more detail than are the ways in which people are functionally connected with their surroundings. Below I first present a summary of the findings of previous chapters, and then I view them in relationship to previous research on prospective memory.

8.1 Summary of empirical findings

Chapter 5 deals with cognitive resources and includes descriptions of variations in how participants shape common cultural tools such as calendars and notes, and also describes how some participants invent new tools that are not uniformly used by all of the participants, and are probably not common across larger populations. Most of the *shaping practices* that I have observed create a cognitive ecology that decreases the cognitive burden for the individuals. In practice, this means that for the situations I have observed, almost every time participants move objects, information, or themselves, they end up in a better cognitive situation. Of course, this does not mean that everything individuals do, in both encoding and retrieval situations, decreases the individual's cognitive burden. I also saw examples when tools or resources, such as calendars, were not formed in a way that decreased persons' cognitive burden. Furthermore, in Chapter 6 I noticed that, depending on the circumstances, people occasionally also placed resources in less congenial places in relation to later situations. In those cases, the individuals needed to involve themselves in deliberate *repair practices*.

To further understand the cognitive ecology, how the environment is shaped, and what is demanded of individuals in home and nearby environments, I used the perspective of *position properties of resources* in the home environment. I have observed that many resources in home environments assist individuals in remembering and forming relevant intentions, and many resources of this type have static and visible positions. For example, a calendar is typically placed

on the wall or on a frequently passed top of some piece of furniture. Resources that have visible positions are inclined to work well with the *scanning and browsing practices* participants display.

Visibility is however not the case for most resources in home environments. If all of the resources that were relevant for all of the activities that people conduct in their home environments had visible positions, the environment would be informationally dense and would cause an attentional challenge (I return to this in 9.1). Therefore, objects are tucked away from the top surfaces and are ideally (but not always) brought to the surfaces when needed. Some objects are hidden from visual perception as a consequence of previous uses and can also have dynamic positions, which means that their positions change from occasion to occasion. These properties have consequences for prospective memory because they set the premises for cue availability**.**

Furthermore, many of the objects that participants initially describe as having an intended, fixed position, seldom do. Instead, most commonly used objects such as keys, shopping lists, glasses, letters to post, etcetera. have a number of locations that are more likely than other locations. These intended positions seem to represent an ideal of the arrangement of the home. It is not necessarily a negative thing that objects do not have fixed positions if they are located on top surfaces that individuals often walk past, but as is seen in the analysis, it becomes more of a problem if the resources are relatively hidden.

Nor is it necessarily a negative thing that the residents do not stick to their ideals, because the participants also display and describe a high level of knowledge about the spaces their resources inhabit, as a consequence of their own everyday practices. In my analysis, this knowledge seemed crucial for their management of several situations and incidents, such as finding misplaced objects. Resources with different position properties are more or less cognitively taxing. Finding and using a resource that has a hidden and dynamic location taxes individuals more than, for instance, finding and using a resource that has a static and visible position. All of the more significant memory slips I observed, or which the participants themselves described, that had to do with keeping track of something in the near-future or the recent past, were related to resources being located in poorly visible locations, relative to the common movements of the individuals.

Altogether the empirical findings display inter- and intra-individual variations, in terms of the practices participants deploy in both their shaping practices and exploit of space.

8.2 Generalizability of findings

The eight people, with respective environments, I have studied have a number of characteristics that have shaped the empirical grounds for my findings and possibly have consequences for the generalizability of the conclusions. For instance, all participants are over 70 years; they are all, except from one, women; they all, except from one, live alone; they are all relatively healthy and active outside their homes.

Their age, for instance, can suggest that the practices I have observed are based on long life experience of managing their everyday lives, and therefore the practices can be expected to be finely tuned to the circumstances of their everyday lives. A consequence of this is that the same practices might not be as common within a younger population. Furthermore, they do not have a working life to tend to, but they, however, seem to have compensated the lack of a working life with engagements in associations and similar. Therefore, what intentions they needed to remember during working life have been exchanged for new intentions. This might, in turn, be a consequence of that I have studied a particular group of older adults (i.e. previously active working women).

Moreover, the fact that they live alone has consequences for the orderings of space. For instance, the orderings in space is to a large extent a consequence of their own actions and they can therefore to a greater degree rely on their own memory abilities to find objects. By the same principle, the deliberate or incidental use of space, that has consequences for prospective memory processing, is normally a consequence of their own actions only. Therefore, the same conclusions might not be generalized to for instance couples or families: Other practices might be necessary for managing similar types of activities within couples and families. I, however, have unpublished video-material of two families before they leave home; for which initial analysis suggests, at least, there is nothing that stands in direct opposition to the principles described in this thesis.

Finally, I have not in the thesis included any measurements of participants' memory abilities. Therefore, I cannot say anything on the relationship between their individual abilities and the practices they display. However, most of what I observed has, for instance, often seemed to involve unproblematic abilities of connecting cues in the environment to their plans and objectives. A population with, for instance, Alzheimer's disease would have likely involved more situations where the coupling between individuals and environments would have been more problematic. Despite that distributed cognition does not foremost take an individualistic perspective it also acknowledges that distribution beyond individuals is a feature and ability of human cognition that can display variations across sub-populations.

That said, I however do not think that the features of the environments and the practices the participants employ are as phenomena unique to them. They are more general principles of distributed cognition in homes and everyday life, that have consequences for prospective memory processing in home environments.

8.3 Consequences for the understanding of prospective memory

The above described findings have both theoretical and methodological consequences for the research field of prospective memory. I see my overall contribution to prospective memory research as a description of the cognitive task world of prospective memory in real life situations. Description of cognitive task worlds can yield specification of what people in a system do to accomplish goals, but also what the sections of environments do.

In Chapter 2 I described how prospective memory is a process (see Uttl, 2008) that span from a planning phase to a cue notice to a plan accomplishment. Graf (2005) specifies parts of the process description further by noting that for prospective memory process to be successful the following conditions must be met: (a) Prospective memory cue(s) must be noticed, that can either be done through more automatic processes or more deliberate search processes. (b) Prospective memory cues must be singularized, that is being recognized as important for some previously formed goal. (c) Previous plans must be recollected (the retrospective component). I have also viewed prospective memory as a process across situations which to some extent corresponds to the functional specifications made by Uttl and Graf.

I have described rich variations in how participants are functionally connected with their environments, where they make use of cognitive tools, functional spaces, and other physical features in both planning phases and cue noticing situations of prospective remembering. In the analysis I was inspired by theoretical models for cognitive experiments and more environmentally uncoupled memory processes (c.f. Jenkins, 1979). In specific, I did not only consider encoding and

retrieval situations, I also described the practices the participants employed in their interaction with their environment from an encoding perspective, that is, how they shaped their environments, and from a retrieval perspective, that is, how they use their environments.

Some of my findings are in line with, and specifications of, past research in the field of prospective memory. For instance, regarding planning phases, past research has shown that planning for future intentions by making them more concrete through, for instance, external tool use is beneficial for the remembering process (see, for instance, Brom & Kliegel, 2014). In line with this I have presented several examples of how participants plan their futures and remember intentions in correspondence with information in their physical environments. Furthermore, in an experimental study Kliegel, Martin, McDaniel, Einstein, and Moor (2007) found that the use of planning strategies, through planning tools, had positive effects for later performance when tasks are relatively complex. The employment of planning tools in the case of complexity is in fact what I see. Participants employ complex planning and memory tools for parts of everyday life that are relatively more complex, that are beyond the perceptual reach of their senses, and for which they do not have routinized practices for managing. By doing so they anchor their planning thought processes and make their internal intentions more concrete.

Also, what the description of the task world presented in previous chapters suggests is that the practices the participants employ and the orderings of space have consequences for whether the residents are allowed to rely on cued recall, or if they need to use free recall for remembering intentions and plans. This is within the field of prospective memory research named as a cue-focality issue; which is a concept that suggests that cues for intentions are harder to notice if they are conceptually or physically separate from the ongoing task (see, for instance, Ihle, Hering, Mahy, Bisiacchi, & Kliegel, 2013). My observations, and a perspective of distributed cognition, expand on this concept by suggesting that the problem is potentially greater in home environments than in laboratory settings, because in home environments there is a greater risk of not encountering a cue at all. Overall, the home environment has larger degrees of freedom, in terms of both how to shape the environment and how to move in the environment, than the types of situations that are usually studied in resource-stripped environments.

Another part of using cognitive resources in home environments specifically deals with retrieval practices. In my observations, the participants almost always succeeded in retrieving the information they needed from resources that they encountered in the environment. This is not strange given that the residents are knowledgeable about the objects and information in their homes, which, to a large extent, they themselves have put there and have experience of using. This runs contrary to many common measurements of prospective memory in real-life settings where the setup often involves introducing new props that the participants should work with for the sake of performing.

Familiarity is a concept within memory research that is frequently addressed in theory but is, to my knowledge, never really addressed empirically within prospective memory research. In my analysis, people can be described as experts at retrieving information from important segments of their home environments. There is, in most of the situations I have studied, no interpretive gap between cue and intention. This is to some extent a consequence of that I have observed activities that the participants are very familiar with, therefore they have their ways of interpreting features of their environments in relation to these activities. In other (but fewer) situations that I have observed, the participants are less knowledgeable about what environmental features mean in relation to their ongoing activities. In those situations a single cue does not necessarily lead to the same amount of

information extraction for establishing relevant intentions and plans for managing upcoming activities. In the case of the activities and settings where they are more knowledgeable, a single cue will often suffice.

Another cognitive challenge for individuals in everyday activities at home is the size of the environment that holds resources, and the previously-noted large degrees of freedom that resources can have in relation to the spaces that contain them. One method for managing this complexity from a retrieval perspective is the technique of using scanning and browsing practices, which the participants frequently display. Participants both overtly express, and in practice demonstrate, how they consult spaces for information. There is structure in these practices because the participants cannot and do not consult all spaces equally. Instead, there seem to be hierarchies that define which spaces are more relevant than others in relation to a particular ongoing activity, and also in general across everyday chores, independent of a current ongoing activity. These reasoning about hierarchies of important spaces is a continuation of what the research field prospective memory names "prominent places" (de Frias, Dixon, & Bäckman, 2003). I have also shown that what can be regarded as a prominent place is a function of both the shaping and using processes of space; processes which are not always easily reported on.

This structure of consulting the environment is something that is compatible with the participants' ways of reasoning about and shaping spaces, which I described previously. Therefore, one could hypothesize that these practices are a strategy for coping with the large number of spaces, and with the multi-space aspect of certain resources. They are redundant, frequent and repetitive; something that Wu et al. (2008) observed within families and that I have now observed in individuals. All of these aspects are close to what is usually regarded as important in professional settings. These types of retrieval practices have also been previously described within prospective memory research, in most detail in relation to clock-checking (see, for instance, Mäntylä, Missier, & Nilsson, 2009). My observations suggest that similar practices exist for the management of space in general, for many types of cognitive activities in real life.

Another, related and ongoing, debate within prospective memory research is on the retrieval mechanisms for prospective memories. Specifically the debate is about whether retrieval mechanisms of noticing a cue rely on automatic or deliberate mental processes (see, for instance, McDaniel & Einstein, 2007; Smith & Bayen, 2006). I have made no measurements of these mechanisms and therefore I cannot say whether the practices I have observed rely on either automatic or deliberate processes. However, I have found that when considering prospective memory in real life, and specifically the mechanisms that allow prospective memories to be retrieved, it seems important to consider the movements of individuals in relation to the spaces involved.

In experimental studies in prospective memory research, all aspects of encoding and retrieval situations are typically decided a priori by the researchers. Complementary to this, I find that situations are a function of shaping and retrieval *practices*, and that these practices are cognitive skills in their own right. Therefore, these practices should probably be accounted for if peoples' performances in home environments, and the age-prospective memory paradox, are to be better understood. The practices I have observed provide insights into which inter- and intra-individual variations might exist across a larger population than what has been studied in this thesis.

Furthermore, it is methodologically noteworthy that several of the above findings follow from the discrepancies between what participants initially say they do and what they later actually do, or what they say they do after follow-up questions. My analysis is therefore an argument against single

occurrence self-reports. This is for several reasons. Most individuals cannot specifically review the prevalence and consistency of their own practices. This is not strange, because reviewing one's own practices is complicated and not what people normally do. This is likely because what is demanded of them is to verbalize processes which are to some extent automatic. I have used observations and follow-up questions in relation to the actual environments being addressed to arrive at more specifically described mechanisms. I opted for using what Geertz (1973) call *thick descriptions* to establish the existence of these mechanisms and their relevance for prospective remembering. However, I have not used any experimental setup to review *how* important these mechanisms are in relation to prospective memory performance. This is something for future research.

Also, many of the practices described above would not have been as easily observed without the use of video observations, which in future research could be used more. Whether the micro-management of everyday life can really be grasped through self-reports at all is an open question. In Chapter 2 I discussed how research on external memory aids and real-life situations has been conducted through peoples self-reported reflections on their own uses. These self-reports do not include practices of both encoding and retrieval in relationship to an environment. There are probably ways to design and employ self-reports that shift the focus from the previously used quantitative metrics, and instead combine both quantitative metrics with more qualitative aspects of the kind I have reported on. However, for now, the theoretical development of agents' cognitive connections with everyday environments will also need more detailed descriptions and analyses. Future research that pursues these questions will almost certainly require methodologies other than self-reports.

Chapter 9. Distributed cognition in home environments

This chapter is a discussion of the more general cognitive principles of distributed cognitive systems in everyday life, most notably in home environments, that to some extent lean against a comparison with cognition in professional settings. These principles are not principles of prospective memory only, but instead of orderings in homes, that have consequences for, and become part of, various cognitive processes in homes.

9.1 Features of the environment

The conclusions from the empirical chapters suggest a number of similarities between home environments and the more commonly studied complex socio-technical environments[21]. Parts of the home environments are designed or have been modified to serve one or more cognitive tasks, in many cases retrospectively but more commonly to support future intentions and scenarios. Similarly to the aforementioned socio-technical environments, this is often done through particular routines where the place, tool, and the routine combine to serve a cognitive function. As previously mentioned, it should be noted that there is a large variation in the specific implementation of these functions in the eight environments studied. For instance, one participant (Beatrice) has developed a large number of specialized tools to support several cognitive tasks, for instance dinner planning tools, that cannot be observed in the other participants. This large variation is not necessarily a difference to professional environments, but can nevertheless be an indication of that each cognitive system generally develops tools, functional spaces, and routines to reach a reasonable level of performance.

In relation to the use of cognitive tools there is a prominent difference between the home environments I have studied and many of the professional environments that have been studied previously. Home environments do not have many tools that contain representational content. The calendar, reminder notes, some recipes, and Beatrice's tools are exceptions. Apart from these, most of the other resources that the residents have shaped are largely non-representational. Occasionally the resources I have described contain representational content, such as letters. When they are

[21] Parts of the discussions presented in this section have also been presented in Dahlbäck and Kristiansson (2016)

grouped in some way that creates a functional space, it can be argued that they become a cognitive tool because they both hold representational content and serve a representational function. These could be temporary elements in the environment, such as a letter on a hallway table, or permanent installations in the environment, like having different spaces for more important and less important mail. Here, I also find that the cognitive couplings individuals have with features of their environments do not necessarily display representational content on both ends. To clarify, let me return to the definition of cognition, and Hutchins' version of distributed cognition, which I also described in Chapter 3.

The traditional definition of cognition, which Hutchins endorses, holds that cognition is "...computation realized through the creation, transformation, and propagation of representational states." (Hutchins, 1995a, p.49). As noted in Chapter 3 he explicitly relaxes his definitions of computation and representational media by treating general structures in the world as representational media. My description of the cognitive couplings between agents and environments is close to the way that Hutchins interprets representational media.

My observations of the participants' approach to their non-representational environment show that they also have a cognitive coupling with non-representational features of their environment. I contend that these connections still count as interaction that establishes new cognitive states. This is part of the individuals' expertise in their own everyday environments and is not necessarily unique to home environments.

In chapter 3 I noted that, in Hutchins' listing of observable representational media for mapping the relationship of the ship to its environment and the position plotted on the chart, Hutchins (1995a p.119) lists "the world" as a representational medium. Hutchins specifies that the relationship between the ship and every object in the surrounding world is specifiable as a direction and a distance, and hence (my wording) is a representational medium. I borrow the same kind of reasoning and argue that, for instance, plants in relationship to windowsills in home environments in the cultural settings that I have studied is specifiable as the intention of that they should remain alive. Just as with the ship, the plants in relation to other physical features signify certain information.

A counterargument to my reasoning could be that the relationships between objects in the world exist independently of an interpreter. It is a cultural phenomenon that plants in windowsills signify certain intentions, therefore an interpreter is necessary. But representations are always stand-ins for something else in relation to an interpreter (c.f. Peirce, 1932). Therefore, even spatial relationships between objects in the world become meaningful in relation to an interpreter. In Hutchins' case, the interpreters were the navigators of a large vessel at sea. The navigators' professional vision (c.f. Goodwin, 1994) is in fact often referred to in Hutchins' book, and meaningful vision of the world also works with Hutchins' definition of cognition as primarily a cultural process.

Despite my use of what a cognitive coupling is, representational and non-representational information in the world can still serve different functions. A likely reason for the difference between professional and home environments in terms of tools is that activities of daily life in home environments, for my participants, do not require tools that contain representational content to the same extent as in professional settings. In many professional settings there is a process that has to be monitored, which is both complex and not directly perceivable from the position of operators. Therefore, the operators need particular tools that represent the process. The processes that must be monitored in everyday life are often less complex and more easily perceived than in professional settings, where distributed cognition has been applied.

But this does not mean that everyday life cannot be complex and demand the creation of tools with specific functionalities, or that individuals simply prefer externalizing thoughts into their environment. After all, externalizing thinking processes is a fundamental aspect of human cognition (c.f. Hutchins, 1995a). When, for instance, viewing Beatrice's to-do list, it became clear that since she has so many intentions she needed something that could stand in for the quantity and complexity of these intentions. Everyday life and home environments must, like many professional settings, deal with distances from monitored processes. Interestingly, the most common representational tools used in everyday life, such as calendars, and in fact almost all of Beatrice's self-invented tools, deal with the world outside the home – a world that cannot be directly perceived from the home environment in present time.

It must also be noted that there are instances of cognition in home environments, such as home healthcare situations, that create a combination of professional and non-professional environments. This has not been addressed in this thesis but has been addressed elsewhere (see Dahlbäck, Kristiansson, & Stjernberg, 2013; Kristiansson, 2013; Palen & Aaløkke, 2006). Also, as mentioned above, the environments studied with distributed cognition are often a special type of professional environment, namely environments with technologically advanced tools and with objectives that demand the deployment of teams. Therefore, the contrast that is made here between the two kinds should not be seen as two discrete cases, but rather as two endpoints on a continuum. In fact, there are likely several continua.

As with professional environments, there are examples in the material of cultural knowledge accumulation about the cognitive elements in home environments, where participants describe how some of their routines and tool designs are learned from or influenced by older generations. It is also interesting to note that some of these practices may have been developed when a person was adjusting to living alone after their partner passed away. One participant, Beatrice, decided to develop a complex memory tool for remembering social events after her husband passed away, which can be interpreted as a transformation of a distributed memory system initially comprised of two persons to a one-person system that yields a similar result. So the details of a distributed memory system can change with changing circumstance while keeping its basic functionality.

In contrast to past studies using distributed cognition in home environments (Crabtree & Rodden, 2004; de Léon, 2003; Palen & Aaløkke, 2006; Rajkomar, Blandford, & Mayer, 2013) I have taken a broader perspective on the environment and included more activities. I have, for instance, studied the preparations before leaving home in the midst of managing other domestic activities. To some extent I think it is necessary to do so to characterize cognitive systems in homes because the home environment is a multipurpose environment. To have claims on efficiency or cognitive performance in everyday life, all primary and secondary objectives, cognitive or not, must considered together. This has had consequences for my analysis. For instance, some actions that might be considered inefficient when viewed in the context of one activity are not necessarily inefficient when viewed as part of pursuing several objectives simultaneously.

In multipurpose environments, many functional spaces and cues are necessarily hidden because of space limitations. This causes errors because individuals cannot rely on their ability to easily react to what they perceive. Instead they need to tap into their knowledge base and direct their thoughts to the correct hidden spaces, and occasionally use search or repair strategies when their initial idea is wrong. For a clear comparison with professional environments consider the kitchen, which in the homes I visited is used for many aspects of managing and planning everyday life. If one room were to be called a control room in the home environments studied, it would be the kitchen, and

in some cases, specifically, the kitchen table. This is probably not true for all home environments, but for almost all the homes I have visited the kitchen is also used as the primary place for coordinating everyday life. There is no space in these kitchens to keep utensils, etcetera., in open areas. To some extent these kitchens were designed from the start to keep such things hidden, but the fact that people use kitchen spaces for functional and aesthetic purposes other than preparing food is also a factor. Consequently, cooking in a home environment taxes individuals more than the environment in an ideal professional restaurant would.

Multifunctional spaces and space limitations also have an impact on an individual's *maintenance practices*. Sometimes objects end up in locations where they were used previously rather than where they will be needed later. Together with the fact that objects can have, and also often need to have, dynamic positions properties, order in home environments occasionally decreases and individuals therefore need to engage in maintenance practices to restore order. I cannot, based on my observations, say how these disorder/order cycles work, but at least some participants engage in on-the-go maintenance practices when they encounter a displaced object and have nothing else urgent to pursue. They therefore seem to be reactive. A likely hypothesis is that each home has its own cultural particulars for maintaining order, and that some cultural maintenance practices are more reactive while others are more proactive in their mechanism.

Consider Moa's search process. The reason why she had to engage in such a process was that there are items which have multiple likely locations and that these locations do not always map to needs of current ongoing activities. Despite that she clearly displayed enough knowledge about her environment to find the items the search process also suggested that she did not have a proactive routine for decreasing her burden of remembering bringing the items. Something similar was seen in one situation with Yvonne. This is also a difference between everyday environments and professional environments: people do not generally have a bus card in every bag or jacket they might bring when leaving home, because that would be too expensive. In a professional setting an expense related to having duplicate copies of some object which is crucial for managing some activity would, in more cases than in everyday environments, be an expense worth its cost.

Maintaining some order and consistency in home environments leads to less cognitive taxing to residents because they do not have to rely on the process of remembering the activities they have engaged in recently to work out where a particular object has ended up. Charles, for instance, described a case where his keys ended up someplace other than his normal spots. This situation taxed his episodic abilities to a larger extent than if they had ended up in one of the places where he usually keeps them, which would have allowed him to rely to a greater extent on his knowledge about the normal circumstances in his home.

Allowing for momentary disorder in home environments is acceptable because performance demands are not usually as great as in professional settings. But importantly, I have primarily studied people living alone, where there is no team that shares resources and coordinates efforts. Therefore, when objects occasionally end up astray or have dynamic position properties it does not affect anyone else. However, the participants' consistent efforts to establish order suggests that they are aware of cognitive benefits of a relatively consistent and predictable environment.

Another related notable difference between many professional settings and the environments I have studied is that in all environments described, except one, it is the same person that shapes the spaces that also uses them. Possible consequences of this are that each homes relatively unique processes are not a problem and that order/disorder-cycles do not need to be as consistent as in team-based professional settings.

9.2 Individual's practices and the expert resident

I have considered the participants' practices and what the environments demand from the participants previously. Here I want to continue the discussion about the practices of the agent, and distributed cognition as a perspective that primarily been used for professional settings, and consider the agent living in the home environment as an expert.

Throughout my analysis I have referred to participants' experience-based seeing of their environment. This seeing has been viewed both from the perspective that features signify intentions and that individuals project thoughts onto the structures in the environment. Projection has been used by Kirsh (2009) to explain cognitive mechanisms when there is a more or less clear mapping between the structures in the world and the mental processes. Specifically, the primary cases considered are tic-tac-toe and dancing. In the case of tic-tac-toe, the physical structure is a grid for playing tic-tac-toe and in the case of dancing, i.e., learning a choreographed routine, the physical structure is the body of a dancer. These are good examples because they make the theoretical point clear: physical structures can anchor mental thought processes (and decrease memory and imaginative demands). I have also observed clear examples of this, for instance, Beatrice's still incomplete plans for future dinner invitations, which she projects thoughts onto. But I have also observed less successful cases when, for instance, a calendar structure is not suitable for anchoring certain mental planning processes, whereupon the demands on mental processes increase.

I think the phenomenon of projecting thoughts onto physical aspects of the environment is related, or perhaps even similar, to a process of exploiting structures in the environment that is clearly not representational and that has not been designed to easily map to a task at hand. One such example was when Moa used the structures of the jackets on the coat rack to decide which jacket to search. In this case it seemed that Moa combined her ideas of that the cards could be in a jacket and the approximation of when she used them the last time, and mapped those ideas with the structures the jackets displayed. This is not an argument against Kirsh's claim. This only shows that individuals are inclined to anchor thoughts in the structures that are present in order to achieve their current ongoing objectives. I therefore agree with Kirsh (2009) that projection and anchoring are fundamental processes of thought.

To a large extent, the participants make all resources more useful, whether they are representational or not, through what Kirsh calls "the intelligent use of space", wherein resources are grouped and placed in congenial ways. I have used his concepts abundantly throughout my analysis. However, although Kirsh has explored the theoretical domains of using space, he has presented few in-depth empirical descriptions of everyday life. I have added to this field of study by analytically validating his observations. I have also expanded on Kirsh's use of intelligent *use* of space. Kirsh focuses his theoretical descriptions on how the shape of a space can assist individual cognition and how individuals can then be functionally connected with their environment. In my analysis it became meaningful to talk about two ways of using space: shaping space, and using the shaped spaces. What Kirsh describes as the intelligent use of space is what I have described under the heading of shaping a space. The actual use of space, which my analysis suggests is important for the functionality of space, has been about the practices that individuals use to monitor the features of their environments, independent of if the spaces are intelligently shaped or not. My using space partially overlaps with what Kirsh refers to as projection, which has been described previously.

Based on my observations, I also see an opportunity to talk about the intelligent use of space as a skill. Using a combination of perception and projecting processes is part of the skill of using the

environment, as is the way we use our bodies to consult the environment. To some extent, Kirsh has already discussed some of these aspects as cognitive skills, but he has mainly done this by first establishing a raison d'etre for humans' use of space as a fundamental part of human intelligence (c.f. Kirsh, 1995), and second mapping the number of ways that arrangements of space can benefit human cognitive processes, and finally discussing the nature of the benefit (Kirsh, 2010a). Also, the main empirical basis for Kirsh is based on individuals who are outspoken professionals in their fields, so there is no question of whether they are skillful or not. In another article, Kirsh (2008) further makes the assumption that we (especially older adults) are all experts in our everyday lives:

> "Because most people become experts or near experts in dealing with their everyday environments – shopping, driving, socially conversing, preparing their meals, coping with familiar technology – they probably know enough about these domains to have effective problem-solving methods for handling the majority of problems they confront. For the few problems they cannot handle, they usually have work-arounds, such as calling friends for advice or knowing how to halt or abort a process, that let them prevent catastrophic failure." (Kirsh, 2008, pp. 289-290).

As described, all of the participants indeed display levels of expertise in how they manage their daily chores, both in how they prepare their environments and how they read their environments in relation to their own goals and intentions. All of this is based on their expert knowledge of their own practices and their environments.

Of course, such mechanisms establish a cognitive connectivity between the agent and parts of the environment that adds up to some sort of expertise. Also, despite the fact that most participants have not received professional training for most daily chores, there are cases when participants have education and experience (in cooking, financial management, healthcare, etcetera) from their previous (working) lives that feeds expertise into their management of daily life. This lends support to Kirsh's (2008) claim that most people become experts or near experts in dealing with their everyday environments. Note, however, that for the generations I have studied, the expertise that comes from their previous working life is, to some extent, gender-based. Traditional working life and education for women, compared to traditional working life for men, mirrors to a larger extent what has been demanded of women in their private lives.

I have not observed anything that stands in direct contrast to Kirsh's relatively open assumptions regarding everyone's expertise, but his assumptions do raise questions. My observations suggest that the participants display proficiency in shaping and using their environments in relation to a number of activities, but their proficiency does not extend to all activities or all situations that exist in everyday life. This is something that the participants are aware of and that they discuss, just as they display and discuss their proficiency in other activities (in fact, in most of the activities to which I have been granted access). This duality of everyday life was, for instance, clear in Alice's expressions of parts of cooking activities versus activities of using her iPad.

The participants definitely have and display workarounds for avoiding catastrophic failures in most situations, but as has been reported in the analysis, certainly not for avoiding all incidents. The consequences for slips are usually not grave because activities within the home, especially, often allow for repairs. Perfect performance is furthermore seldom the top priority, even though all participants have their priorities. What makes a failure catastrophic can only be understood from the perspective of the individuals. In all situations where there was some incident, the participants used workarounds at some point to avoid an undesirable outcome, but it also became obvious that

some of these situations caused emotional discomfort, and could therefore be understood as a negative incident.

Finally, since by definition everyday life involves multiple activities wherein both the individuals and the world they are coping with change over time, people do not necessarily become experts in all aspects of our everyday environments. That said, experiences in life probably do lead people toward more expertise overall.

Chapter 10. Concluding remarks

In this thesis I have started to build a bridge between the research fields distributed cognition and prospective memory in the older population. I set out arguing that distributed cognition as a theoretical perspective and research approach would likely bring complementary insights to the current understanding of how people manage prospective memory in real-life situations, particularly for the understanding of the general older population. Another goal was to empirically describe and theoretically characterize the home from the perspective of distributed cognition; a perspective that has traditionally been used as a perspective to understand cognition in complex socio-technical environments. Below is a short summary of my conclusion and a few remarks to these conclusions.

First, despite that there are differences between the cases of professional and non-professional environments, the pattern that emerges is one of a continuum, or more likely several continua, of cognitive function between the everyday environment and the complex socio-technical environments. Although the home environment is different from professional settings, the expert residents are in almost constant connection with features in their environments. The cognitive practices described in this thesis seem paramount for allowing the individuals to stay connected in functional ways from which they benefit in many activities in daily life. This supports Hutchins' formulation of distributed cognition as a perspective on all cognition. Distributed cognition is not only applicable to work practices, instead it is a formulation of the general features of human cognition. The home environment and everyday life is no exception to this formulation.

Despite that I have started to empirically and theoretically characterize the home environments from a distributed systems perspective I have not made a specific theoretical description, in any length, of features of the cognitive environments which makes it possible to talk about types of cognitive systems. Descriptions of types of cognitive systems from a distributed cognitive perspective has been discussed before – see, for instance, Kaptelinin and Nardi (2006), Schwartz and Martin (2008, presented in sections 3.4), and Sutton (2006) – but I have not contrasted my descriptions with this ongoing discussion. However, my plotting of resources on hidden/visible- and static/dynamic-dimension, and the descriptions of features of multipurpose environments, can be seen as attempts at formalizing distributed cognitive properties of environments in general.

Second, I have contributed to prospective memory research and other forms of memory research by describing the cognitive task world of everyday life, i.e. rich variations in how participants are

functionally connected with their environments, where they make use of cognitive tools, functional spaces, and other physical features. Inspired by theoretical models for environmentally uncoupled memory processes I have analytically observed the practices the participants employ in their interaction with their environment from an encoding perspective, that is, how they deliberately and incidentally shape their environments, and from a retrieval perspective, that is, how they use their environments.

I have followed up on what prominent researchers in the field of prospective memory research suggested in the 80's: interactions with the environment should be understood as inherent aspects of the prospective memory process (Craik, 1983, p.118). My contribution can be understood as an observation-informed specification of aspects of this process in real life. A specification that suggests that the deliberate and incidental shaping and using space are inherent properties of the prospective memory process.

I have provided descriptions of new properties of prospective memory processing in real life. However, these observations should be viewed as suggestive, rather than predictions, of what account for cognitive performance in real life situations in the general older population. They can be viewed as suggestive of what can be made part of measuring of prospective memory processes and strategies. Perhaps the practices and expertise of everyday life displayed by the participants can also be used for the development of strategy packages for other populations, to assist in their pursuits of plans and intentions in everyday life. This is however, as noted previously, also a question of how generalizable my observations are.

Finally, distributed prospective memory in everyday life can certainly be understood as an ability persons have: brains have the ability to keep track of future intentions. Past research has shown this, and so do also several examples from my empirical material. However, distributed prospective memory is more generally how a cognitive system keeps track of future intentions through interactions between components of the system. Accordingly, I have in this thesis shown that prospective remembering can be understood as a process that takes place between persons, arrangements of space, and tools; as a consequence of past events. All this are consequences of the basic feature of human cognition as a distributed process.

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