Prospective Memory

From intention to action

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Chapter 1 GENERAL INTRODUCTION

The goal of this thesis is to provide insight into the psychological processes that subserve remembering and acting on behavioural intentions. People have many plans but often do not carry out these intended activities: they change their minds, or they are physically unable to carry out the planned activity, but often they simply forget. Behavioural intentions may be forgotten due to distractions: we may intend to prepare dinner in a few minutes time but when the doorbell suddenly rings and a neighbour starts discussing the latest gossip, we may forget all about dinner. Alternatively, we may forget an intended activity because we have not specified well enough how, where and when the activity will take place. Planning is an important step between the formation of an intention and acting on it. An intention to buy fuses is more likely to result in action if the intention is accompanied by a specific plan to do it next Thursday when we go shopping. In addition, some intended activities are carried out frequently, perhaps on a habitual basis. For example we may add sugar every time we pour ourselves a cup of coffee. The general observation is that habitual intended activities are almost never forgotten.

Before discussing the specific research questions, some general background of the concept of *intention* will be given, as well as a demarcation of the kind of intention that is addressed in this thesis. This is followed by an overview of psychological research on *prospective memory*, a topic that concerns precisely those mechanisms which underlie remembering and acting on behavioural intentions.

Intention

The term intention, derived from the Latin verb *intendere* (‘to direct attention’), is used in many different ways. In Scholastic logic, for example, intention is a concept used to describe a relation between a mind and an object. Knowing something, believing something, desiring something; these are all examples of intending. However, this is not the kind of intention that we are dealing with in this research.

In action theory, intention is taken in a different but related sense, as in acting with the intention of accomplishing a specific purpose. With the intention of killing Snow White, the evil stepmother tempted her to eat a poisoned apple. In this case we are talking about a *goal intention* (Heckhausen & Beckmann, 1990): a commitment to attain a particular goal.

Instead of referring to a reason for an action, an intention can also refer to an action in the future. The evil stepmother intends to achieve Snow White’s death (goal intention), and after some deliberation she lays plans to poison her. The evil stepmother intends to give Snow White a poisoned apple next time they meet. In this case we are talking about a *behavioural intention:* performing the action is the desired state of the world. It is this type of intention that we are concerned with here. Every time the word intention is used in this thesis, behavioural intention is meant.

We now turn to the nature of an intention. Is it simply a *decision* to act in a certain way? To get a feeling of what is intention, let us start with Oblomov, the main character in the Russian novel of the same name by Ivan Goncharov (1859/1954). In the first chapter he is introduced as follows:

> […] on awakening, he resolved to rise, to perform his ablutions, and, his tea consumed, to consider matters, to jot down a few notes, and, in general, to tackle the affair properly. Yet for another half-hour he lay prone under the torture of this resolve; until eventually he decided that such tackling could best be done after tea, and that, as usual, he would drink that tea in bed - the more so since a recumbent position could not prove a hindrance to thought.
>
> Therefore he did as he had decided; and when the tea had been consumed he raised himself upon his elbow and arrived within an ace of getting out of bed. In fact, glancing at his slippers, he even began to extend a foot in their direction, but presently withdrew it.
>
> Half-past ten struck, and Oblomov gave himself a shake. 'What is the matter?' he said vexedly. 'In all conscience it is time that I were doing something! Would I could make up my mind to – to – ' […]

Not surprisingly, after the publication of *Oblomov*, the term oblomovism entered the Russian language as a synonym for inertia, lassitude, inactivity, weak will, and indolence. In the excerpt, Oblomov seems to have the intention to get out of bed, but something is stopping him. Also in the remainder of the story, Oblomov never acts on his intentions. His intentions obviously lack one or more ingredients, but which?

Many action philosophers have tried to define intention (for an overview see Mele, 1997, for example). Where we now use the word intention, Aristotle (384-322 B.C./1955) used the word 'proaireton', meaning 'that which has been chosen beforehand'[1]. In the more recent past, philosophers have tried to show that intention is not different from other forms of intending (like knowing), and have tried to analyse intention into a compound of *desire* and *belief*.

First of all, an intention has a motivational element: to intend to swim implies to *desire* to swim. Of course, there are some problems here: one part of me wants to finish this thesis, and another part of me just wants to go to the island of Samoa and read the stories by W. Somerset Maugham all day. Desire is a rather ambiguous concept. Davis (1984) therefore makes a distinction between *volitive desire* and

[1] The Dutch 'voornemen' is a literal translation of the Greek term.

appetitive desire. The first kind of desire is synonymous with *want* and *wish* and appears as a transitive verb. The latter kind appears as a noun and has the near synonyms *appetite*, *craving*, *urge* and *longing*. According to Davis, these two kinds of desires are logically independent; we can wish to do something without that something having any intrinsic appeal (e.g. doing the laundry), and we can view an act as very appealing but at the same time not wish to do it (eating unhealthy food). At the same time, however, an appetitive desire generates and motivates a volitive desire. Davis subsequently argues that intention entails only *volitive* desire.

But merely having a volitive desire to do something does not make me intend to do it. I also need to *believe* that I will do it. I can have a volitive desire to finish writing a symphony today, but I lack the belief that I will. This implies that I do not intend to finish it. Belief is called the cognitive element of intention.

So, are desire and belief all we need to define intention? Unfortunately not. I may wish the government to fall, I may even believe that it will fall, but I definitely cannot intend it to fall. A behavioural intention needs to be about *action*, not a mere event. As already stressed by Aristotle, the object of intention needs to be under the agent's *control*. Note that the control only needs to be *perceived* control. Consider the case of a student who intends to study at home tonight. Whether or not his books are actually at home or have been taken by somebody else, psychologically speaking the intention remains the same, as long as he believes that his books are there.

In conclusion, the term *intention* as it is used here involves a volitive desire to perform an action in the near or distant future; we believe that we are able to do it and that we will do it. Thus, an intention is more than a simple decision; the aspect of *decision* is incorporated in the volitive desire. Perhaps it was precisely this aspect that Oblomov lacked: he wanted to get out of bed, perhaps he even believed he was able to get out of bed, but somehow the wish to get out of bed was not strong enough (cf. ineffective intentions, Velleman, 1989, p. 137 ff.). Alternatively or additionally, Oblomov may have lacked the belief that he would get out of bed, based on his previous record of how often he had acted on his resolutions (cf. Velleman, 1989).

Antecedents of intention

Aristotle noted that intentions are deliberated on and formed with reason or thought. Actions are chosen on the basis of available knowledge; specific knowledge can therefore alter people's intentions. In present day theorising, knowledge and deliberation are still regarded as important antecedents of intention.

Intentions can be motivated by different kinds of reasons. In the Theory of Reasoned Action (Fishbein & Ajzen, 1975) an intention to engage in a certain behaviour, which is defined as a decision, is the proximal cause of that behaviour.

Such an intention can be formed on the basis of an attitude. For example, I can have a positive or a negative attitude towards going on vacation to France with a caravan. Such an attitude influences the decision to opt for such a vacation. Attitude in turn depends on beliefs about the effects of the behaviour and an evaluation of these expected effects. If I evaluate an expected outcome as positive, I am likely to have a positive attitude towards the behaviour, increasing the chance that I will decide to engage in the behaviour.

In addition to attitudes, intentions are also influenced by beliefs about what important people think that one should and should not do (*subjective norm*). If I believed that my colleagues would snigger behind my back if I went to France with a caravan, I would think twice before deciding to do it, but only if I valued their approval. Sometimes, intentions are based solely on the basis of subjective norm. An intention can be the direct result of a request by another person; we often comply with the wishes of someone else without much deliberation.

In the preceding section it was argued that intentions also involve a belief of having control over what we desire to do. Accordingly, Ajzen (1985, 1991), in his Theory of Planned Behaviour, added *perceived behavioural control* as a direct predictor of intention. In summary, similar to philosophical ideas about the dependence of intention on belief, desire, and control, the Theory of Planned Behaviour assumes that intentions are formed on the basis of belief (behavioural and normative beliefs), desire (hidden in the evaluations of behavioural outcomes and in ignoring or complying to the wishes of significant others), and control.

Thus, intentions can be self-generated, resulting from a positive attitude towards the behaviour, or can be imposed by someone else without any strong positive or negative attitude, or result from a combination of these two factors. Whatever the case, intentions are comparable as long as they involve 1) a volitive desire 2) the belief to be able to perform the action and 3) the belief that you will perform the intended activity.

From intention to action: Prospective memory

Actions often follow intentions immediately, but a delay between intention and action is not unusual; we are frequently unable to immediately act on an intention. When someone asks us to pass a message to person so-and-so, we cannot do this before we actually meet this person. At other times we are able to carry out an intended action immediately, but may have other priorities so that we put it off. But when intention and action are separated in time, how can they be causally related?

The psychologist’s answer to the question of how intention results in future behaviour is *memory*: an intention is stored in memory and at a later point is retrieved and acted on. This type of memory is referred to as memory for intentions (Loftus, 1971) or *prospective memory* (Meacham & Leiman, 1982). Others prefer to talk about realising delayed intentions (Ellis, 1996; Ellis & Milne, 1996), stressing the point that intentions need not only be remembered but also acted upon. Prospective memory has to be distinguished from retrospective memory: remembering *that* I called my mother yesterday is a form of retrospective memory, remembering *to* call my mother tomorrow is a form of prospective memory.

After the formation of an intention to act in the future, people usually engage in other activities. Whereas in regular memory tasks participants are explicitly asked to recall or recognise information, in prospective memory tasks there is no direct prompt for recall: people need to identify a suitable moment without the help of others or of an external aid like an alarm clock. It is very much like waking up on time. The major difficulty in prospective remembering is that people need to remember *that* something needs to be done.

The use of cues

The chance that we remember our intentions can be greatly enhanced through planning, which can involve specifying or creating cues. Harris (1978) mentioned three conditions to make a cue maximally effective. A cue should 1) be given as close as possible before the time when the action is required, 2) be active, by which Harris meant that we can be sure that it is noticed, and 3) provide a hint as to what has to be done. For example, a pile of library books at the front door provides a direct hint that they need to be returned. But a cue like a knot in a handkerchief can also greatly improve prospective remembering (see e.g. Meacham & Colombo, 1980).

A cue can be *created* by noting the intended action in a diary, for instance. Relatively simple technologies can help in creating active cues (e.g. a kitchen timer) or can even force us to quit whatever we are doing (e.g. a message suddenly appearing on our computer screen indicating that we need to save the active file). Instead of creating cues we can also *specify* the cues that need to trigger the intended behaviour. We can form elaborate associations between the intended activity and other activities we will engage in later. We can also link the activity to a certain time or a specific event.

This thesis focuses on this type of specified event cues, which have proven to be very useful. Gollwitzer and his colleagues, and also other researchers, have shown that intentions in which the *when*, *where* and *how* of a postponed action are fully specified, have a high chance of fulfilment (Gollwitzer, 1999; Brandstätter, Lengfelder, & Gollwitzer, 2001; Chasteen, Park, & Schwarz, 2001; Verplanken & Faes, 1999). Such intentions, termed *implementation intentions*, have the format *if X* *happens then I will do Y*, where X typically denotes an event that is described in very concrete terms. They maintain that the positive effect of the formation of implementation intentions is due to automatic action initiation: the specified cue is capable of triggering the postponed action automatically. Bargh and Gollwitzer (1994) claim that acting on implementation intentions is similar to acting out of habit: with a good plan, the only thing needed in order to perform the action at the required moment is the perception of the specified cue.

Models of prospective remembering

There are several models that can explain how event-based intentions result in actions. The Norman and Shallice theory of action control is a very general theory of how action is controlled (Norman & Shallice, 1986). According to the theory, action is controlled by both contention-scheduling and a Supervisory Attentional System. The theory proposes that tasks require cognitive resources only when they are new, require planning, or are technically difficult. These resources are provided by the Supervisory Attentional System (SAS). In contrast, routine and habitual actions can be controlled by contention scheduling alone, without intervention from the SAS. If deviation from routine is deemed necessary, the SAS influences behaviour by biasing the contention scheduling processes.

The theory states that when a new action has to be carried out and one needs to deviate from normal routine, the SAS is needed. This model zooms in on a required task-switch: you have to stop doing what you are doing and initiate the required action. This model concurs with layman intuitions about action control. People report that they usually make errors when they are distracted or absent-minded (Reason, 1983).

There are also more specific models for how intentions result in actions. Some of these focus on the storage of intentions in memory and potential dynamic properties of their memory representations, whereas other models put more emphasis on how such a representation is activated by environmental cues and how they ultimately result in action.

Memory-based models

The general idea in the memory-based prospective memory models is that when an intention is formulated, it is stored in memory as declarative knowledge and plays a causal role in action. Because an intention is merely a memory content, the probability that it will be retrieved depends on the level of activation of the representation and the presence of adequate retrieval cues. A fully activated intention representation is accompanied by recall of the intention and subsequent action. There is usually no further deliberation on alternative courses of action.

According to Reason (1983), an intention, or plan, as he calls it, exists as a collection of critically active cognitive schemata. Their activation is refreshed by periodic reviews of the intention. Reason assumes that in the absence of this review procedure, the activation of these schemata will decay spontaneously. Forgetting planned actions can also be caused by interference from earlier or later planning. “Unless we repeatedly remind ourselves to divert from our normal route home to buy the fish, we are liable to return fishless” (p. 126).

In contrast, Goschke and Kuhl (1993, 1996) argue that mental representations of intended actions have a special dynamic status in memory, and they discuss evidence that supports this claim. The *intention-superiority effect* is the observation that words denoting an intended action are recognised faster and more accurately than neutral words. This effect suggests that an intention is represented at a higher level of activation. Goschke and Kuhl report experiments that provide evidence that the effect reflects an unwitting enhancement of the activation level of intention-related concepts. They also provide some evidence that the activation level is high after intention formation, then diminishes, but rises again prior to the appropriate time of action. As soon as the intended action is carried out, the dynamic properties disappear (see also Marsh, Hicks, & Bink, 1998).

Reason’s model could explain the intention-superiority effect: because an intention is usually periodically reviewed, the representation of the intention will be kept at a higher level of activation. However, Goschke and Kuhl (1993) showed that specific strategies could not explain the intention superiority effect. Alternatively, a higher level of activation can explain why an intention springs to mind from time to time, so that it *seems* as if we actively remind ourselves.

From cue to action

Other models focus more on what happens when an intention-related event takes place. Given an intention represented in memory, how does it result in behaviour at the right time? These models focus on the link between the intended action and the cues that were specified during intention formation.

The Noticing+Search model, proposed by Einstein and McDaniel (1996), identifies two separate stages in prospective remembering. First of all, an event should be noticed: it should not only be perceived but it should also create some internal response. This can be a general feeling of familiarity, for example; such a feeling of familiarity is more likely when the actual event was used specifically during intention formation, instead of described only in categorical terms. For example, when there is a new play on, you are more likely to remember your intention to buy tickets if you had intended to see this particular play than if you had intended to see *any* play; this is true because the name of this play can cause an internal response when it is displayed in the local newspaper.

After an event is noticed, a memory search for the meaning of the event is instigated. It is like seeing somebody jogging in the park. At first you do not recognise her, but somehow she looks familiar. Then, after searching your mind, you recognise her as the woman who cleans your desk at the office twice a week. It is argued that this search in memory also applies to the retrieval of an intention. It is assumed that the noticing stage is relatively automatic, but the memory search is controlled and requires cognitive resources.

In contrast, according to the associative memory system model (McDaniel, Robinson-Riegler, & Einstein, 1998), no controlled memory search is necessary. Prospective memory is supported by the medial-temporal/hippocampal module - a reflexive associative memory system - as described by Moscovitch (1994). This module supports the retrieval of an intended action when a target event is attended to, by automatically producing interactions between the cues and memory traces previously associated with these cues. Only if there is sufficient interaction between the target event and the memory trace of the intended action will the intention spring to mind: rapidly, obligatorily, and with few cognitive resources. Whether there is sufficient interaction depends on the number of associations the cue has and on the strength of the associative link. For example, Guynn, McDaniel, and Einstein (1998) found that reminding people of the intended action facilitates prospective remembering, whereas reminding people of the target event does not, but that the use of reminders referring both to the intended action and the target event facilitates performance even more. In addition, it can be expected that the strength of the link increases when an intention is practiced. Successful prospective memory is also dependent on the degree of processing of the cue, and whether or not the retrieved intention is put into action, which is the responsibility of other processes (see Guynn, McDaniel, & Einstein, 2001).

Availability of cognitive resources

All of the above models of prospective memory make different predictions regarding the need for and the role of cognitive resources. Can prospective memory be supported by automatic processes alone or is high-level action control imperative?

The Norman and Shallice (1986) model explicitly states the necessity of cognitive resources; these are always needed when departing from normal routine (Reason, 1990). Cognitive resources are needed at the time of departure from normal routine when the action needs to be carried out. In contrast, Reason's (1983) model implies the necessity of resources between the time of intention formation and the appropriate time of execution, in order to remind oneself of the intention from time to time.

The Noticing+Search model states that a controlled memory search is always needed, requiring cognitive resources. In contrast, the automatic associative memory system model predicts that once a cue is processed well enough, no resources are needed for memory retrieval given a strong association. However, once retrieved, the intention needs to be held in working memory and the ongoing task needs to be interrupted, and these processes are resource-dependent (Guynn et al., 2001). Finally, Gollwitzer and his colleagues (e.g. Brandstätter et al., 2001) claim when using implementation intentions, an intended action is initiated automatically, requiring no cognitive resources.

Let us now look at the evidence regarding the need for cognitive resources in the case of event-based intentions. It has been shown for example that if participants are carrying out an ongoing task, performance is negatively affected by having an additional event-based prospective memory task to perform (Smith, 2001), suggesting that a prospective memory task usurps cognitive resources. Smith argues that cognitive resources are necessary to monitor for cues that indicate that the intended task has to be carried out. Other experiments have shown that dividing attention leads to worse prospective remembering: if participants, in addition to some ongoing task and a prospective memory task, are given a third task, prospective memory suffers (McDaniel et al., 1998; Stone, Dismukes, & Remington, 2001). Prospective memory also suffers if the difficulty of an ongoing task is increased (Kidder, Park, Hertzog, & Morrell, 1997; Stone et al., 2001; Marsh & Hicks, 1998). Even if the total number of tasks and the difficulty level of the ongoing task(s) remain unchanged, but participants are required to switch between different ongoing tasks at unpredictable times, prospective memory is worse than when no switches are required (Marsh, Hancock, & Hicks, in press).

However, manipulating the availability of cognitive resources does not always affect prospective memory. D'Ydewalle, Luwel, and Brunfaut (1999) found that the addition of an extra ongoing task did not affect prospective memory performance. Otani cum sui (1997) varied the cognitive demands of some ongoing activity but found no effect. In summary, the evidence regarding the need for cognitive resources is mixed. This is probably due to the fact that experimental procedures vary widely regarding the nature of the ongoing tasks, the way that cognitive load is manipulated, and the kind of prospective memory task.

In an attempt to explain the discrepancies in the findings, Marsh and Hicks (1998) focused on the kind of demands that are made on the cognitive system.

Making use of the Working Memory framework (Baddeley, 1986), they tested whether an effect of a manipulation depends on the part of working memory that the ongoing task makes use of. Working memory consists of three systems: the Central Executive, responsible for executive functions like planning, monitoring, and inhibition; the Phonological Loop for retaining verbal information; and the Visuo-Spatial Sketchpad for retaining visual and spatial information. It could well be that only one component of working memory plays a role in the carrying out of delayed intentions.

Marsh and Hicks manipulated the use of these three components in order to discover which manipulation affects prospective memory. Participants had to perform three concurrent tasks. Firstly, in each separate trial, participants were presented with three words that had to be reproduced at the end of the trial. Secondly, whenever one of these words signified a fruit, they had to respond by pressing the f-key on the keyboard (the prospective memory task). Thirdly, an extra task was added that differed only in its degree of difficulty. This was the task that either required the use of the Central Executive, the Phonological Loop, or the Visuo-Spatial Sketchpad. They manipulated the availability of one of these components in separate experiments. When the third task required only the Phonological Loop or only the Visuo-spatial Sketchpad, increasing the difficulty of this task did not result in worse performance in the prospective memory task. However, when the third task demanded the use of the Central Executive, increasing its difficulty did affect performance. This suggests that it is the Central Executive that needs to be available in order to comply with a prospective memory instruction. However, it is not yet clear what its exact role is.

Research questions and outline

Instead of asking whether or not prospective remembering depends on the availability of cognitive resources and is therefore fully automatic or dependent on controlled processing, this thesis takes a different approach. Following the multi-process view of McDaniel and Einstein (2000), it is acknowledged that prospective memory can be supported by many different kinds of processes, some controlled, some automatic. This thesis challenges the view that the Central Executive always needs to be available for successful prospective remembering.

Prospective memory tasks can be dealt with in many ways. Which strategy is adopted depends on personality characteristics (Goschke & Kuhl, 1996), expectations (Brandimonte, Ferrante, Feresin, & Delbello, 2001), and the extent to which people trust their memory and attentional capabilities (Marsh, Hicks, & Landau, 1998). The strategy that people employ determines whether they deploy executive processes such as monitoring. If people expect a task to be difficult but very important, it is likely that they will engage in monitoring for cues. Such monitoring is one example of an executive process.

In certain situations prospective remembering can also benefit from bottom-up processes. As practice makes perfect, we can expect that in situations in which the same intention has been acted on many times before, it will become easier to remember to act on that same intention. Repeatedly acting on an intention ultimately results in habitual behaviour, so that the intended activities are never forgotten and initiation is automatised, no longer requiring cognitive resources provided by the Central Executive. Due to a strong link between the prospective memory cue and the intended action, the cue can directly trigger the response, so that performance can rely more on bottom-up processes and becomes independent of the availability of executive processes.

There are also other bottom-up processes that may support prospective memory: some cues are so obvious that they immediately indicate *what* needs to be done (e.g. a rubbish bin full to the brim). But very often there are no cues and you need to remember the intention without any help from the environment. Craik (1986) has stressed the point that some memory tasks require more self-initiated operations than other memory tasks. For example, recognition tasks are easier than free recall tests, because there is more environmental support. Craik argues that self-initiated operations are even more important for prospective memory tasks. But there are also differences between prospective memory tasks in their need for self-initiated operations. It is therefore better to ask in what types of situations bottom-up processes no longer support performance and executive processes are necessary.

The research in this thesis is based on two general questions. Both have in common that they relate to the way in which prospective remembering can benefit from specific processes in different situations.

Question 1 *Does frequent and consistent practice of an intention lead to habitual prospective remembering, rendering executive processes superfluous?*

What effect does practice have on the way in which an intention is remembered and acted upon? Two situations will be compared: one in which the intention has been practiced in the recent past both frequently and consistently, and one situation in which the intention is wholly new, and has never been acted on before. Assuming that prospective remembering depends on an associative link between an event and the action that needs to take place as soon as this event occurs (see e.g. Guynn et al., 1998), one would expect that a strengthening of that link through extensive practice (repeated use of the same cue) will lead to habitual prospective remembering

(Ouellette & Wood, 1998). It is hypothesised that practice of a cue-action combination (i.e. an intention) leads to automatised initiation of the action, rendering performance more reliable, faster, and less susceptible to manipulations of cognitive resources; in other words, premeditated behaviour becomes habitual behaviour. It is also hypothesised that the automaticity acquired through practice is goal-dependent.

Question 2 *What role do executive processes play in prospective remembering?*

Marsh and Hicks (1998) have argued that the Central Executive plays an important role in prospective remembering. Since they only used a specific type of prospective memory task, it should be established to what extent this claim can be generalised. Marsh and Hicks used categorical instructions: "Respond to words designating a type of fruit". It has already been shown that categorisation processes are affected by cognitive load (Baddeley, Lewis, Eldridge, & Thomson, 1984). It is therefore hypothesised that the need for executive processes is to some extent dependent on whether a target word is described categorically (respond to types of fruit) or specifically (respond to *apple*).

More generally, the question is what the exact role of the Central Executive is: is it mostly required for categorisation, or is it responsible for more general aspects of prospective memory? For instance, it may be responsible for 1) reviewing and updating the intention in memory, 2) the level of processing of target events, 3) retrieving the intention from memory, or 4) making a switch from the ongoing task to the prospective memory task once the intention is retrieved. Only 2) and 3) will be addressed here.

The theoretical background of these questions will be discussed more thoroughly in the following chapters. They will be further developed, leading to specific hypotheses that will be tested in a total of seven experiments. The research question regarding previous enactment of the intention will be addressed in Chapter 2. Next, the question of whether executive processes are needed in order to categorise target events will be dealt with in Chapter 3 and in Chapter 4. Finally, Chapter 5 contains a general discussion of the findings, providing answers to the above-mentioned questions, together with the conclusions that can be drawn from them.

Chapter 2 HABITUAL PROSPECTIVE MEMORY*

ABSTRACT

This chapter addresses the question of whether and how repeated practice of intentions facilitates prospective memory. The influence of practice on the execution of postponed actions was examined in three experiments. In Experiment 1, a detection task was used. Practice led to faster responses and fewer omissions. After practice, performance was also no longer influenced by manipulations of attentional resources, suggesting automation. A discrimination task was used in Experiment 2. Speed acquired through practice was dependent on goal activation, suggesting that any automaticity acquired through practice is still goal-dependent. In Experiment 3, an event-based prospective memory task was used. Here, a negative *practice effect was observed. Seemingly, mere practice of an action given an event does not necessarily lead to habitual prospective remembering with automatic properties. It is argued that automaticity in habitual prospective remembering is dependent on goals.*

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* This chapter is a slightly altered version of Van den Berg, Aarts, Midden, and Verplanken (2002a). Part of this research was presented at the Second Meeting of the European Social Cognition Network, Heidelberg, Germany, August 31 - September 3, 2000.

Introduction

The term prospective memory was introduced by Meacham and Leiman (1982). It refers to remembering to carry out intended actions that are postponed for some reason. Meacham and Leiman made a distinction between two kinds of prospective remembering: episodic and habitual. In habitual prospective remembering the intended action is engaged in frequently and consistently. Episodic prospective remembering, on the other hand, involves intended actions performed infrequently or in different contexts. Meacham and Leiman argued that habitual prospective remembering is more successful than episodic remembering, because it is facilitated by extra environmental cues or events that are linked to the intended actions, like brushing ones teeth upon entering the bathroom.

In the past two decades, the number of papers on prospective memory has grown rapidly, most of these studies involving episodic prospective memory tasks (Brandimonte, Einstein, & McDaniel, 1996). However, despite the fact that many intended actions are habitually performed in everyday life, and that habitual aspects therefore play an important role in prospective memory performance, the number of prospective memory studies focusing on habitual aspects has remained limited. The experiments described here were conducted to explore habitual prospective remembering. Specifically, the main question addressed here is whether and how repeated and consistent execution of an intention in the past influences performance in later event-based prospective memory tasks.

In an experiment on habitual prospective memory, Meacham and Singer (1977) provided participants with a set of eight stamped postcards and the instruction to post one card every week. Participants also received a list of specific dates on which they had to send these cards. Half of the participants had to send one every Wednesday, the others had to send one every week but on variable days. They reasoned that if an intended action is completed frequently under the same circumstances, remembering to perform that action becomes easier, i.e. becomes habitual. The number of cards actually posted did not differ for these two groups, however.

Whether or not this study dealt with habitual prospective remembering can be disputed. It is important to make a distinction between two kinds of intentions: *repeated* and *habitual* intentions (Kvavilashvili, 1992). Repeated intentions involve actions that have to be carried out every time a particular event takes place, while habitual intentions relate to intended actions that have been repeatedly performed in the past. According to Kvavilashvili and Ellis (1996) “a repeated intention seems to be a necessary intermediate stage in transforming a single episodic intention into a habitual one” (p. 38). This statement implies that with more practice, a repeated intention becomes habitual: easier to remember and less likely forgotten (Meacham & Leiman, 1982). One could measure such ease by testing people's prospective memory performance after practice. Repeated execution of an intention might lead to higher response rates later on: the more often the intention has been performed in the past, the more successful prospective remembering becomes. Applying this logic it becomes apparent that the Meacham and Singer study did not involve habitual intentions but involved repeated intentions, just like many other laboratory studies on prospective memory (e.g. Einstein, McDaniel, Smith, & Shaw, 1998; Marsh & Hicks, 1998); Meacham and Singer's study did not address the effect of prior repeated execution of an intention on subsequent prospective memory performance.

The analysis above makes it clear that using paradigms with repeated intentions is not a fruitful approach in tackling habitual prospective memory. Habitual prospective remembering cannot be distinguished from episodic prospective remembering by merely observing response rates of repeated intentions. A different approach is therefore taken here, based on the proposition that habitual prospective remembering can only be distinguished from episodic prospective remembering on the basis of underlying mechanisms that are the result of prior practice.

Automaticity in habitual prospective remembering

An important distinction between episodic prospective remembering and habitual prospective remembering is the extent to which postponed actions are initiated automatically. That is, an intention that is repeatedly performed in response to similar conditions becomes a habitual one that acquires properties of automaticity. The automatic aspects of habitual intended behaviour have received quite some attention in recent social cognition literature. It is often argued that habitual intended behaviour is mentally represented as direct links between environmental cues and the action, and is therefore capable of being controlled by the environment (James, 1890; Ouellette & Wood, 1998). This environmental "control of behaviour originates in intended, consciously chosen behavioural responses that only become habitual after frequent and consistent employment" (Bargh & Gollwitzer, 1994, p. 73; cf. Kvavilashvili & Ellis, 1996). Habitual behaviour is characterised by automaticity: a habitual action is initiated immediately, reflexively, and efficiently as soon as the relevant environmental cues are present, without the mediation of a conscious decision (Ach, 1935).

The idea that the environment controls habitual behaviour directly is also central to the Norman and Shallice (1986) theory of action control. This theory proposes that tasks require attentional resources only when they are new, require planning, or are technically difficult. These resources are provided by a Supervisory Attentional System (SAS). In contrast, routine and habitual actions can be controlled by *contention scheduling* without intervention from the SAS. If deviation from routine is deemed necessary, the SAS influences behaviour by biasing the contention scheduling processes. Thus, according to this theory, the environment can directly control habitual behaviour, but the influence of the environment is overruled when the system encounters new situations or has new goals.

In proposing a different view, Schwartz and her colleagues (1991) contend that "even routine activities, smoothly executed, are planned and regulated, and verified through continuous monitoring of outcomes" (p. 382). They argue that successful contention scheduling in the service of routine task performance is dependent on sufficient activation of goals. When goals are not sufficiently activated, even highly routine behaviour, such as drinking coffee and brushing teeth, can become disorganised, and irrelevant objects and their affordances may exert great influence leading to utilisation behaviour, behaviour that is characterised by picking up and using objects when this is not appropriate to the task at hand (Lhermitte, 1983). Whereas Norman and Shallice (1986) contended that habitual behaviour is preserved in patients with prefrontal lesions, Schwartz and her colleagues argue that routine actions rely heavily on executive control systems. Ouellette and Wood (1998) also doubt whether well-practiced sequences in routine behaviour are truly automatic and independent of attention (cf. Logan & Cowan, 1984; Logan, 1989). Given these different views in the literature, the main question that has motivated our research concerns the extent to which automaticity in habitual prospective memory depends on goal activation.

Goal-dependent automaticity

There is mounting evidence suggesting that many processes that seem automatic – whether relating to action or judgement – are actually dependent on goals. Bargh (1997, 1989) refers to this type of automaticity as *goal-dependent automaticity*: only given a goal, behaviour can be triggered automatically by the mere presence of environmental objects or events. Thus, walking past the local supermarket, you will only enter if you have the goal of buying groceries. Without this goal, the habitual response will not be triggered by the environmental cues. In terms of habitual prospective remembering, then, a repeatedly performed intended action in a stable context will show automatic properties like reflexiveness and efficiency, if the goal to perform that action is sufficiently activated.

There is some evidence supporting this idea. In a study on travel behaviour, Aarts and Dijksterhuis (2000) subjected habitual and non-habitual bicycle users to an initial task where one half were given the instruction to travel to a specific destination later on, and the other half were not. Participants subsequently took part in a decision task assessing their readiness to take the bike after briefly being presented with a destination. Consistent with the idea that habits are goal-dependent, habitual participants showed significantly faster responses than non-habitual participants, but only when they had previously been instructed to travel later on. Without such a travel goal, there was no difference between the response latencies for habitual and non-habitual participants. These findings indicate that the automatic activation of habitual actions through environmental cues requires a relevant goal.

Goal-dependent automaticity is also observed in studies on stimulus-response (S-R) translation, that is, the transformation of a stimulus code into an action code. Automatic S-R translation depends, for example, on the subject's goals or on the degree of preparation. According to Hommel (2000a, 2000b), intentional processes seem to implement a task set enabling and configuring automatic translation processes. They set the stage for automatic processing to occur, rendering responses to stimuli faster and more reliable (cf. Logan & Gordon, 2001). Hommel argues that this goal-dependent automaticity also applies to automaticity as the result of extensive practice. However, since this idea has not been directly tested so far, it remains to be seen whether the automaticity acquired through practice is conditional on intentional processes.

Allport and Wylie (2000) also suggested that automatic behaviour resulting from practice is goal-dependent. They put forward a tentative model of goal setting and 'selection for action', distinguishing between *goal activation* and *performance readiness*. Performance readiness refers to the time needed for the system to settle to a unique response (cf. Fagot, 1994), which is largely conditional on the association strength between the stimulus and the respective response and possible conflicting responses acquired through extensive learning. Allport and Wylie believe that these S-R bindings and their strengths are not susceptible to control processes like goal activation, but can only be altered through overt practice. In this model, *goal activation* determines *what* task is performed. Response times for that task then largely depend on performance readiness, that is, the amount of conflict in the cognitive system: if the stimulus activates cognitive subsystems that are irrelevant to the task or primes a different response as a result of prior practice with a different task, response times can increase dramatically (such as in the Stroop task, for example). Accordingly, a highly activated goal to respond in a specific way to a specified stimulus eases the selection of that response and renders interference from other associated responses less likely (cf. Aarts & Dijksterhuis, 2000).

Based on the literature discussed above, we propose the following model for event-based habitual prospective remembering. Through extensive prior practice of an intention, strong links are formed in memory between the event and the intended response (S-R bindings) that influence S-R translation processes automatically (i.e. are beyond control and require no attentional resources, cf. Hommel & Eglau, 2002).

However, these bindings only facilitate response selection if there is sufficient activation of the goal associated with that event-response pair (cf. Schwartz et al., 1991). Response selection is ultimately determined by goal activation. Stimulus-response translation is thus not identical to response selection (Hommel & Eglau, 2002); mere translation does not need to result in overt corresponding behaviour. Thus, habitual prospective memory is characterised by goal-dependent automaticity (Bargh & Gollwitzer, 1994): a postponed action that has been repeatedly executed in the past in response to the same event will be automatically initiated given an activated goal to perform that action.

The experiments

Three experiments were carried out, focusing on the influence of practice of a repeated intention on the later performance of that same intention. All experiments consisted of two phases: a practice phase and a test phase. In the practice phase, participants either practiced to perform an intention (pressing two keys) in response to a target event (a word presented on the computer screen) or did not practice. In the second phase, all participants were tested for omissions and swiftness of initiating the postponed action in response to the target event under different conditions. In Experiment 1, we first tested the hypothesis that practice of an intention results in automatic (habitual) prospective remembering in terms of efficiency (fewer omissions, higher speed, requiring only few resources). In Experiment 2 we tested whether these effects of practice can be modulated by task instruction and are thus goal-dependent. In Experiment 3, the effects of prior practice of an intention were tested using a prospective memory task that is more embedded in an ongoing activity.

Experiment 1

This experiment focused on efficiency as an indicator of automaticity in carrying out a postponed action. Efficient behaviour is typically not influenced by the difficulty of a concurrent task (Logan, 1979). Participants performed the random number generation (RNG) task (Evans, 1978), and were instructed to respond as soon as they saw a target stimulus present on the computer screen. The RNG task requires executive control processes. Marsh and Hicks (1998, Exp. II) have shown that increasing the pace of this task results in more omissions on a prospective memory task. In our experiment, we hypothesised that, without prior practice, increasing the RNG pace would affect performance negatively, showing more omissions. However, if practice of a repeated intention results in automatic and thus efficient behaviour, increasing the pace of the RNG task in such a case should not show such an effect.

Method

Participants. Sixty-six undergraduate students were paid for their participation. The mean age was 21 years (*SD* = 2.4). Thirty-three of the participants were male.

Materials. The target stimulus that functioned as the cue for performing the postponed action during the test phase of the experiment was the word *fame* ('roem' in Dutch). During the test phase, the distractor stimuli were twelve different existing four-letter words, orthographically rather similar to 'roem'. This was done to ensure that the target word did not have any special signalling qualities that would capture attention (Yantis, 1993).

Before the test trials, there were 48 practice trials. In the relevant practice condition the same words (target and distractors) were used as in the test trials. In the irrelevant practice condition, the target stimulus was the letter *w* and the distractors consisted of 12 other consonants displayed in random order in the middle of the screen.

The presentation of the visual stimuli was continuous and quasi-random, using stimulus onset asynchronies (SOAs) of 700, 1800, and 2500 ms. In this way, there was always a stimulus on screen, avoiding attentional capture by sudden on-sets (Yantis, 1993). Expectancy effects were avoided by new stimuli appearing unpredictably.

Design. We used a 2 (practice: relevant, irrelevant) × 3 (cognitive load: low, medium, high) factorial between-subjects design. The experiment consisted of a practice phase with either relevant or irrelevant practice and a test phase. During the test phase the cognitive load was manipulated by varying the pace with which participants had to generate numbers randomly (RNG task). The RNG pace during the practice phase was 0.8 Hz.

Procedure. On arrival at the laboratory, participants were told that the investigation concerned the allocation of attention and peoples' ability to perform two tasks at the same time. Participants worked in separate cubicles. The two tasks were explained verbally. In the irrelevant practice condition, letters were presented on a computer screen and participants had to respond as quickly as possible when they saw the letter *w*. In the relevant practice condition, words were presented and participants had to respond as quickly as possible when they saw the word *fame*. The response consisted of pressing two marked keys on a computer keyboard ('/' and 'z') rapidly after each other: first right, then left. While they performed this task, they also had to perform the RNG task. Participants heard beeps and after each beep they had to call out a number between 1 and 10 (inclusive). Participants had to call out numbers as randomly as possible; the order had to be entirely unpredictable. They had to give both tasks the same amount of attention: both were equally important. A 15 seconds practice trial was given and the experimenter provided feedback on the speed of the response and the randomness.

After these instructions, the experimenter started the practice phase, consisting of 48 trials in total, and sat down behind the participant, writing down the generated numbers. Short breaks occurred every 12 trials, when participants were given feedback by the experimenter in case they did not perform the RNG task correctly. The target word or letter was presented randomly 10, 15, 20, or 25 seconds after the beginning of the trial, and remained on screen for 3 seconds. If participants responded in time, another letter appeared and beeps were presented until the end of the three seconds. One trial therefore took either 13, 18, 23 or 28 seconds in total. Participants were required to keep calling out numbers until the end of the trial. The next trial started 5.5 seconds later. If participants had not responded in time or gave an incorrect response, the software provided the participant with feedback during this inter-trial interval.

At the end of the 48 trials of the practice phase, participants were told that they had to do one final short test. In the irrelevant practice condition, participants now would see words. Their task was to respond when the word *fame* appeared by pressing the right and left key as quickly as possible. For participants in the relevant practice condition, the instruction to respond to *fame* by pressing the right and left key as quickly as possible was merely repeated. Thus, all participants were given the same instruction: an action had to be postponed until the right word appeared on the screen. Furthermore, all participants were told that there would be two minor changes in the procedure. Firstly, the pace of the RNG task would be slightly increased; secondly, the word *fame* was going to appear later in the trial. After this instruction, five additional trials started. Participants did not know how many trials there would be. The actual pace of the RNG task depended on the experimental condition. Only in the medium and high load conditions was the pace actually faster than during the earlier trials: in the medium load condition the pace was increased to 1.0 Hz, and in the high load condition, the pace was increased to 1.2 Hz. The target word appeared randomly after 35, 40, 45, or 50 seconds, and participants were given three seconds to respond. A pre-test had shown that in a low cognitive load situation this is a sufficiently large time window for a response to occur. Participants were subsequently debriefed, paid, and dismissed. The whole procedure took about 30 minutes.

Results and discussion

Accuracy. The main dependent variable of interest was the number of responses made by each participant (with a possible maximum of five). Subjecting this measure to a factorial ANOVA testing a main effect of practice, a linear effect of cognitive load, and an interaction effect, yielded a significant main effect of practice, $F(1, 62) = 7.87$, $MSE = 0.16$, $p = .01$. The main linear effect of cognitive load was also reliable, $F(1, 62) = 9.33$, $p = .003$. However, these effects were qualified by a significant interaction effect, $F(1, 62) = 5.25$, $p = .03$. Planned comparisons revealed a significant linear relationship between cognitive load and the mean number of responses in the irrelevant practice condition, $F(1, 60) = 13.87$, $MSE = 0.16$, $p < .001$, showing that an increase in cognitive load resulted in fewer timely responses. No such effect was observed in the relevant practice condition, $F = 0.28$ (see Table 1).

Table 1. Mean number of responses as a function of practice and cognitive load.

	Low load	Medium load	High load
Irrelevant practice	5.00	4.73	4.36
Relevant practice	5.00	5.00	4.91

Response times. A factorial ANOVA was performed to test the effect of training, a linear effect of cognitive load, and their interaction on response times during the final test trials, treating the omissions as missing data. Training had a significant effect on response times, $F(1, 62) = 8.78$, $MSE = 18849$, $p = .004$; those in the relevant practice condition responded significantly faster ($M = 662$ ms, $SD = 113$) than those in the irrelevant practice condition ($M = 762$ ms, $SD = 155$). The linear main effect of cognitive load, $F = 0.30$, and the interaction effect, $F = 0.20$, were not significant.

To summarise, the results show that performance on prospective memory of participants who had frequently and consistently acted on the intention earlier was not affected by an increase of the difficulty of a secondary task, neither in terms of accuracy nor in terms of speed. In contrast, performance of participants who had practiced the same task but with a different target stimulus suffered from an increase in cognitive load. Increasing the difficulty of the concurrent task resulted in more omissions. This finding is in line with Marsh and Hicks (1998, Exp. II) who found that increasing the pace of the RNG task from 0.8 Hz to 1.0 Hz to decrease monitoring abilities resulted in significantly more omission errors on a prospective memory task (episodic repeated intention).

Experiment 2

So far, the findings are consistent with the proposed model: given the intention to respond to a stimulus with a certain action (goal activation), behaviour is facilitated by stimulus-response bindings acquired in the past, showing automaticity in terms of speed, reliability, and not being dependent on the availability of attentional resources. Importantly, all participants in Experiment 1 had the same intention, and thus the goal-dependent nature of automatic prospective remembering was not tested. A second experiment was therefore conducted in which goal activation was manipulated by providing participants with different task instructions to test the effects on speed and reliability of acting on an intention.

In order to manipulate goal activation for an event-response combination, a four-alternatives discrimination task was used in Experiment 2. Four different responses (i.e. four alternative ways of using two response keys) were associated with four different targets. Practice for one of the combinations (pressing right and then left in response to the word *horse*) was varied; this was either practiced or not. After practicing, participants received either the explicit instruction to respond with right and then left on seeing the word *horse* or not. We hypothesised that facilitating effects of practice on response times for a target stimulus would depend on goal activation for that subtask: practice effects would particularly emerge when the goal to perform that subtask task was highly activated. The more salient a particular goal (goal activation), the faster the response selection process.

Awareness – or rather unawareness – is often mentioned as an indicator of automaticity (Bargh, 1989). One reason that people feel that they do things on automatic pilot is that they are often unaware of having performed some routine action, such as whether they locked the front door this morning. Many people report having driven home and, on arrival, to have no recollection of the way home; they must have been fully conscious while driving as no accident occurred, but there is no recollection of the act of driving. Therefore, for exploratory purposes, we tested whether practice of an action leads to worse recollection of having performed that action, which can be regarded as an indication of automaticity.

Method

Participants. Ninety-seven paid undergraduates participated in the experiment. The mean age was 21 years (*SD* = 2.5). Forty-two of the participants were male.

Design. Participants were randomly assigned to one of four conditions, differing in the kind of practice and the kind of explicit instruction they received after practice and before the final test trials. These explicit instructions were used to influence goal activation for one particular target word-response combination, namely pressing the right key and then the left key upon seeing the target word *horse*. The design was not factorial. Table 2 gives short descriptions of the four conditions.

Two conditions, the Relevant practice/Relevant instruction and the Irrelevant practice/Relevant instruction conditions, are comparable to the relevant and irrelevant practice conditions of Experiment 1, respectively: after relevant or irrelevant practice, participants received an instruction to respond by pressing right and then left upon the presentation of the target word *horse* as quickly as possible.

The other two conditions were for control purposes. In order to establish the effect of the explicit instruction, participants in the Relevant practice/No instruction condition did not receive the instruction after practice, but were merely told to continue the task they were working on. Participants in the Relevant practice/Irrelevant instruction condition received the explicit instruction to respond to one of the other target word as quickly as possible. In this way, the effect of an instruction per se – given relevant practice – could be more accurately established.

Procedure. On arrival at the laboratory, participants were told that they were going to take part in research on speed and accuracy of responding to different stimuli appearing on the computer-screen. Participants worked in separate cubicles and the experimenter gave the instructions verbally. Participants had to look at the middle of the screen where words and numbers were going to be presented. If they saw a number smaller than five, they had to press a marked button on the left of the keyboard ('z') twice and if they saw a number larger than five, they had to press a marked button on the right of the keyboard ('/') twice. If they saw the word *bludgeon* ('knots' in Dutch), they had to press the left button first and then the right button. Practice was manipulated by having participants in the Relevant practice conditions respond to *horse* ('paard' in Dutch) by pressing the right button first and then the left button; participants in the Irrelevant practice condition had to perform the same action but in response to *stone* ('steen' in Dutch). Thus, the only difference between the two kinds of practice conditions was that either *horse* or *stone* was used in combination with the right-left response. Participants were told that speed and accuracy were of equal importance.

After the explanation of the procedure, the experimenter left a note with a summary of the four target-response combinations, started the program, and left the cubicle. The stimuli were presented randomly in such a way that each word was presented in 25 percent of the trials. In 25 percent of the trials a number smaller than five was presented, and in 25 percent of the trials a number greater than five was presented. There were a total of 400 trials, so that each combination was practiced 100 times.

After the 400^{th} trial a message appeared on-screen, stating that there would be a short break. Fifteen seconds later, a new message appeared stating that the task would continue. Nothing else happened in the Relevant practice/No instruction condition. In contrast, participants in the other conditions were then given the explicit instruction that was presented for seven seconds. Participants in the relevant instruction conditions now had to respond to the word *horse* as quickly as possible by pressing the right key first and the left key. Participants in the Irrelevant instruction condition were instructed to respond to the word *bludgeon* as quickly as possible by pressing the left and then the right key. For the participants in the No instruction condition, the message that the experiment would start again was visible for an extra seven seconds.

After this goal manipulation, the 25 test trials started. The order of the stimuli was no longer randomised. The target word *horse* was presented five times: on the 3^{rd}, 7^{th}, 12^{th}, 18^{th}, and 25^{th} trial. Response times were measured, taking only the first key hit of a correct response into account. After the last trial, participants were asked about the explicit instruction (if there had been one), and had to give an estimate of how often they had responded to *horse* correctly after the last short break. Finally, they were thanked, paid and dismissed.

In summary: some participants practiced responding to *horse* (relevant practice) whereas others to *stone* (irrelevant practice), and some participants received an extra instruction: the extra instruction was either to respond to *horse* (relevant instruction), or to *bludgeon* (irrelevant instruction), or there was no extra instruction.

Results

During debriefing, two participants did not recall the extra instruction correctly and these were excluded from the analyses.

Accuracy. The number of times participants had responded correctly to the target word *horse* was computed (see Table 2). Mean numbers did differ across the groups, $F(3, 91) = 3.78$, $MSE = 0.341$, $p = .01$. Tukey HSD tests revealed that in the Relevant practice/Irrelevant instruction condition significantly fewer correct responses were made than in the Relevant practice/Relevant instruction condition, $p = .02$, also fewer than in the Relevant practice/No instruction condition, $p = .02$, and marginally significantly fewer than in the Irrelevant practice/Relevant instruction condition, $p < .10$. These last three conditions did not differ significantly, *p*s > .83.

Response times. Incorrect responses to *horse* in the test trials were excluded from the analyses. For each participant we averaged the correct response times for *horse*, disregarding response times larger than 1500 ms. Means and standard deviations are displayed in Table 2.

Table 2. Mean response times in ms for the target word *horse* and the mean estimated and actual number of correct responses to *horse* (standard deviations in parentheses).

Experimental condition	Mean RT	Mean estimated number	Mean actual number
Relevant practice/relevant instruction	534 (89)	3.57 (1.14)	4.86 (0.36)
Irrelevant practice/relevant instruction	617 (91)	4.79 (1.97)	4.75 (0.44)
Relevant practice/no instruction	595 (96)	2.42 (1.17)	4.89 (0.32)
Relevant practice/irrelevant instruction	655 (102)	3.50 (1.36)	4.35 (1.04)

An ANOVA showed that groups differed on response times to the target word, $F(3, 91) = 7.14$, $MSE = 8839$, $p < .001$. The hypothesised effects of instruction and practice were tested separately. Given relevant practice, instruction had a significant effect on response times, $F(2, 64) = 9.52$, $MSE = 9061$, $p < .001$; a relevant instruction led to faster response times than no instruction, $p = .04$ or an irrelevant instruction, $p < .001$. In addition, given a relevant instruction, practice had a significant effect on response times, $F(1, 54) = 1.75$, $MSE = 8137$, $p = .001$.

Awareness. At the end of the experiment, participants had to estimate the number of times they had responded to *horse* by pressing right/left (see Table 2). An ANOVA on differences between the actual and the reported number (difference scores), with the experimental condition as a between-subjects variable, revealed an intercept significantly different from zero, $F(1, 91) = 51.60$, $MSE = 2.33$, $p < .001$, indicating that participants on average underestimated the number of times they had actually responded. A significant effect of the experimental condition, $F(3, 91) = 10.57$, $p < .001$, showed that the degree of underestimation differed per condition. Post-hoc Tukey tests revealed that the underestimation in the Relevant practice/No instruction condition was significantly larger than in all other conditions (ps $\leq .05$). Furthermore, the Relevant practice/Relevant instruction condition showed significantly more underestimation than the Irrelevant practice/Relevant instruction condition, $p = .01$, but not significantly more than the Relevant practice/Irrelevant instruction condition, $p = .76$.

Discussion

Goal activation determined what was done. Whether participants responded correctly to the target word *horse* depended on what goal was salient: when an irrelevant goal was salient, participants made more errors than when the relevant goal was salient. This suggests that goal activation affects the response selection process.

As expected, practice had a positive effect on response times. When the explicit instruction was to respond to a target word with a certain response (i.e. high goal activation), participants who had practiced this stimulus-response combination responded faster than participants who had not practiced this combination (but had practiced the same response in combination with a different target word). These findings are in line with those from Experiment 1 which showed the same general benefit from practice on response times, and suggest automation in responding.

More importantly, given relevant practice, response times were influenced by goal activation. Participants with high goal activation responded significantly faster than participants with normal goal activation (no explicit instruction). The effect of goal activation cannot be explained by a general increase in arousal: with high activation of an irrelevant goal (one related to a different stimulus-response pair) response times were slower than with a highly activated relevant goal.

Participants with relevant practice also underestimated how often they had responded correctly to the target word *horse*. This can be regarded as an indication of a decrease in the awareness level often associated with automatised behaviour (Bargh, 1989). Estimations were however better for those participants who, in addition to having had relevant practice, were again explicitly instructed to perform the specific practiced response. This suggests that when a particular highly practiced action becomes very important and people pay more attention to it, for example locking the front door before going on a long trip, they are afterwards more likely to remember whether the action was carried out or not than when it is less important.

To summarise, practice resulted in habitual prospective remembering as far as immediacy and recollection of having performed an action are concerned. The automatised behaviour is not ‘unintentional’, however: the speed and accuracy of responding after practice were affected by goal activation.

Experiment 3

In Experiment 2 participants were engaged in only one ongoing task: the intention to respond to a target word was embedded in a four-alternatives choice reaction time task. In Experiment 3, an intention was embedded in a very different ongoing task. Participants performed a short-term memory task: they were presented with a set of words in several trials and were asked to recall these words after each trial. At the start of this short-term memory test, they were told that if they happened to see a particular word (*horse*) they had to press two keys on the keyboard. Whether or not participants responded to the target word was used as a measure of prospective memory. The target word appeared twice, once after 8 minutes and once after 16 minutes.

This procedure was used to investigate prospective memory under conditions in which people do not rehearse their intentions continuously, as they have to focus on the ongoing task. In this way, everyday prospective memory tasks, in which intentions are not rehearsed continuously, can be mimicked.

In a similar way as for Experiment 1, the effects of practice on prospective memory were studied while manipulating cognitive load, to test the hypothesis that habitual prospective memory is characterised by automatic features like reflexiveness and efficiency. A slightly altered version of the Marsh and Hicks method (1998, Exp II) was used, where a target word was embedded in a short-term memory task. Marsh and Hicks used the RNG task to manipulate cognitive load. Indeed, they found a significant effect of RNG pace. In this experiment, we hypothesised that Marsh and Hicks' result would be replicated, but only when the repeated intention had not been practiced. If it had been practiced, it was expected that, in a similar way as for Experiment 1, cognitive load would not affect prospective remembering. This would show that, after extensive practice of the intention, prospective remembering becomes habitual, characterised by efficiency.

Method

Participants and design. One hundred paid undergraduates were randomly assigned to four experimental conditions, resulting from a 2 (practice: relevant, irrelevant) $\times$ 2 (cognitive load: high, low) factorial between-subjects design. The mean age was 22 years ($SD = 3.0$).

Materials. A total of 58 five-letter words were used for the short-term memory task. These were randomly selected from a Dutch word list (Martin, 1971) with the restriction that none of the words semantically or orthographically resembled the target cue word *horse* ('paard' in Dutch). Nine additional words were used for the practice trials.

Procedure. On arrival at the laboratory, participants were told that they were taking part in research on the speed and accuracy of responding to different stimuli appearing on the computer-screen, and that the experiment consisted of two parts. Participants worked in separate cubicles, and the instructions were given verbally. The first part was about learning and the second part about memory. The learning part was identical to the practice manipulation in Experiment 2: half of the participants practiced the four-alternatives discrimination task with the target word *horse* (relevant practice), and the other half practiced with *stone* (irrelevant practice). There were 400 trials in total, with *horse* and *stone* appearing 100 times.

When participants had finished the learning task, the experimenter explained the part of the experiment about short and long-term memory. In order to test short-term memory, participants would be presented with three consecutive words in one trial. After a while, they would get a signal to say these three words aloud. There would be several such trials. To make this task a bit harder, people would have to do something else at the same time. They were to call out numbers from 1 to 10 in a random fashion (RNG task). Randomness was first explained to them, after which participants were allowed to practice the RNG task for about 30 seconds.

Participants were subsequently told that, along with their short-term memory, their long-term memory performance would also be tested: if one of the presented words was the word *horse*, they had to press the right and left key consecutively as fast as possible (prospective memory instruction). They were instructed to keep their hands on the keyboard during this test. The experimenter said that all three tasks, short-term memory, long-term memory and RNG, were equally important. Participants practiced the whole procedure, that is, the short-term memory task together with the RNG task. The target word did not appear during these practice trials. The experimenter then started the experimental sequence. The long-term memory task was not repeated. The experimenter sat down behind the participant and wrote down all numbers and words that were called out by the participant.

There were 30 trials. Except for the words, these were identical to the trials in the Marsh and Hicks (1998) study. A trial started with on-screen instructions to start calling out numbers. Short beeps indicated the required pace. Depending on the experimental condition, the beeps occurred every 1000 ms (1 Hz, high load) or 1250 ms (0.8 Hz, low load). Eleven seconds after the start of a trial, the first word appeared at the centre of the screen for a 1.5-second duration. Delays of 1.5 seconds separated the disappearance of the first word and the appearance of the second word, and similarly for the second and third word. All words were presented for a duration of 1.5 seconds. After the disappearance of the third word, the beeps continued for another 6.5 seconds, after which a distinctive sound was generated by the computer and a prompt on the screen requested participants to recall the three presented words. Participants were given 5 seconds for recall and the next trial started after another 2 seconds. Participants had been informed that the order of recalling words was not important, and that they should stop generating random numbers as soon as they had to call out the words.

The target word *horse* appeared during the 15th and the 30th trial. On both occasions it appeared as the second word. The computer registered the responses and the response times. Responses were registered until the end of the trial, before the recall phase.

Results and discussion

During debriefing, all participants were able to repeat the prospective memory instruction correctly.

RNG task. Measures for randomness were computed as described by Evans (1978; see also Marsh and Hicks, 1998). A factorial ANOVA revealed a significant effect of cognitive load: participants in the low load condition were more random (M = 0.39, SD = 0.04) than the participants in the high load condition (M = 0.42, SD = 0.03), $F(1, 96) = 21.14$, $MSE = 0.001$, $p < .001$. This indicates that generating random numbers becomes more difficult when speed is increased. The effect of practice, F = 0.31, and the interaction, F = 1.08, were not significant.

Short-term memory performance. The number of words correctly recalled in the short-term memory task were computed for each participant, and were submitted to a factorial ANOVA with practice and cognitive load as independent variables. Participants under high load conditions did not perform significantly worse than the participants under low load conditions (64% and 66%, respectively; $F(1, 96) = 0.27$, $MSE = 0.023$). Participants with relevant practice performed on average slightly better than the participants in the irrelevant practice condition (67% and 63%, respectively) but this effect was also not statistically reliable, F = 1.54, p = .22, nor was there a significant interaction effect, F = 0.19.[1] Short-term memory performance did not correlate with RNG performance, r = .08, p = .42.

Prospective memory performance. The number of prospective memory responses did not correlate with RNG performance or short-term memory performance, multiple R = .09, p = .68. A logit analysis of the proportions of responses on the first and second trial was performed with trial as a within-subjects variable and cognitive load and practice as between-subjects variables, as well as all two and three-way interactions. Proportions are displayed in Table 3. Proportions were generally higher on the second trial; proportions were lower for relevant practice, and were negatively affected by cognitive load. However, the analysis only revealed a

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[1] A factorial ANOVA showed a marginally significant effect of cognitive load on how often participants recalled the target word for the short-term memory task: under low load on average 1.96 times (SD = 0.20), under high load on average 1.86 times (SD = 0.35), $F(1, 96) = 2.80$, $MSE = 0.08$, $p < .10$. The effect of practice was not significant, F = 1.00, nor was the interaction effect, F = 0.94. See Chapter 5 for a discussion of these results.

significant effect for trial, *B* = 0.42 (effect coding, in this case -1 vs 1), $p < .01$; no other effects were significant. Thus, performance on the first and second occasion differed significantly. We therefore analysed performance on the two trials separately. A logit analysis showed that practice had a negative effect on performance on the first trial, *B* = -.43, *p* = .05. The main effect of cognitive load, *B* = -.30, *p* = .17, and the practice by load interaction effect, *B* = -.20, *p* = .37, were not significant. On the second trial, all effects were not significant, *p*s > .71. To summarise, practice had a negative effect on performance on the first target trial, and performance generally improved on the second target trial and was the same in all experimental conditions.

Inspection of the proportions in Table 3 suggests that the trial effect is mainly at work in the relevant practice, high cognitive load condition. Although the two and three-way effects were not significant in the analysis, the trial effect was further scrutinised using the McNemar change test (Siegel & Castellan, 1988) for each experimental condition. Indeed, it turned out that the trial effect was only significant in the relevant practice, high cognitive load condition, $p < .01$ (all other *p*s > .50).

Table 3. Proportion of participants who responded to the target word on its first and second occurrence.

Practice	Low Load	High Load
	First target trial	
Irrelevant	.76	.72
Relevant	.67	.42
	Second target trial	
Irrelevant	.84	.80
Relevant	.79	.81

A factorial MANOVA was carried out with response times on the first and second target trials. Omissions were treated as missing data. The main effects of cognitive load, $F(2, 52) = 0.79$, practice, $F = 0.73$, and their interaction, $F = 0.33$, were not significant. The general mean was 1205 ms (*SD* = 523).

The results of Experiment 3, then, are inconsistent with our predictions. First, contrary to Marsh and Hicks' (1998) study, cognitive load did not affect prospective memory performance when the intention was not practiced. Furthermore, practice did not lead to beneficial effects in prospective memory performance. Thus, although the results of Experiments 1 and 2 suggested automation in prospective memory as a result of practice, it did not occur when the prospective memory cue was embedded in a different unrelated ongoing task and appeared infrequently.

General discussion

Three experiments were conducted to test the effects of practice on the fulfilment of intentions. We hypothesised that prior practice of a repeated intention facilitates prospective remembering, that is, prospective remembering becomes habitual, characterised by so-called automatic qualities like speed, reliability, efficiency, and reduced awareness.

In the first experiment, the effect of practice on prospective memory was tested under dual-task conditions in a detection task. Results showed that responses were faster, fewer omissions occurred, and performance was not influenced by increased cognitive load when the intention was practiced. In the second experiment, in which a four-alternatives discrimination paradigm was used to test the emergence of habitual prospective memory in a more complex task, the speed-up effects were replicated. Furthermore, practiced participants seemed less aware of having performed the actions, indicating another important property of automaticity. More importantly, however, this experiment confirmed the hypothesis that the speed-up effects of practice are conditional on goals. Participants who practiced the intention, and were again explicitly given the instruction to perform that response later on, were significantly faster in their responses to the target event than participants who practiced the intention but were given an irrelevant instruction or no instruction at all (see also Aarts & Dijksterhuis, 2000).

Taken together, then, Experiments 1 and 2 suggest that a mere association between stimulus and response (S-R binding) acquired through practice does not suffice for habitual (automatic) prospective memory to occur. What matters is the enhanced activation of the goal to perform the response as soon as the target stimulus appears. This suggests that automaticity acquired through practice – at least in the domain of repeated event-based intentions – is highly dependent on goals. In terms of Allport and Wylie (2000): performance readiness only provides the ability to respond quickly and reliably to stimuli with a response: it relates to the speed of S-R translation given an intention. However, the intention or goal determines what is actually done, and thus goal activation is responsible for response selection.

In the third experiment, we tested practice effects under dual-task conditions, when participants were busily engaged in ongoing tasks for some time and the target stimulus was embedded in one of those ongoing tasks. We hypothesised that load would affect prospective remembering in the case of an episodic intention, replicating Marsh and Hicks (1998, Exp II), but not in the case of an intention that had been practiced frequently and consistently. Firstly, no significant effect of cognitive load was found; secondly, practice did not have a positive effect on prospective remembering.

Observing no effect of cognitive load while Marsh and Hicks (1998) reported such an effect may be due to the fact that we mentioned the specific target word in the instruction, whereas Marsh and Hicks had asked participants to respond to words from a category (fruits). One study by Van den Berg, Aarts, Midden, & Verplanken (2002b), reported in Chapters 3 and 4, tested the hypothesis that cognitive load effects are more probable when using categorical instructions than with specific instructions, but found no evidence for this. In other words, the fact that in Experiment 3 a specific target word was used instead of a categorically defined target word does not seem to be able to explain the discrepant findings.

Another explanation could be related to different ways of coping with all three tasks. This is suggested when comparing results on the short-term memory task and the Random Number Generation (RNG) task: participants in our study performed better on the RNG task compared to participants in Marsh and Hicks' experiment, but worse on the short-term memory task. This suggests that, compared to Marsh and Hicks' study, participants in this study paid more attention to the RNG task and less to the words that were displayed on the screen, leading to worse recall and less compliance with the prospective memory instruction. Focusing more on the RNG task, participants in this study may have engaged less in monitoring for the target word. As the RNG task interferes with monitoring, but participants are not monitoring for the target word anyway, no effect of cognitive load on prospective memory can be expected. Perhaps participants in the Marsh and Hicks study paid more attention to the prospective memory task. Under low load conditions this led to relatively high response rates. However, an increase of load on executive functions hindered continuous monitoring for the target event and resulted in lower response rates.

The finding that practice did not facilitate prospective remembering, and even had a negative effect when only taking the first occurrence of the target event into account, resembles the negative enactment effect observed by Schaefer, Kozak, and Sagness (1998). In their study, participants were asked to carry out a number of tasks after they had finished the experiment but before leaving the room. This was supposedly needed to get everything ready for the next participant. In one condition, the experimenter showed them how to perform the tasks (the demonstration condition). In another condition, participants in addition had to carry out these tasks themselves in preparation for their own upcoming session (the performed condition), and in a third condition, participants were merely asked to perform the tasks so that everything was prepared as it had been for their own session (informed condition).

After the experiment had finished, the researchers checked whether participants performed the tasks, that is, if they had prepared everything for the next participant. It was found that more tasks were completed in the informed condition than in the performed condition. Performance in the demonstration condition did not differ from the other two conditions. Twenty-nine percent of all participants performed none of the tasks, and most of these were in the performed condition. This negative enactment effect could not be explained by worse recall of the instructions. Schaefer and colleagues argued that it might be due to the participants' expectations about the task's difficulty (cf. Marsh, Hicks & Landau, 1998), affecting beliefs about their own ability in dealing with it. Such a meta-cognitive effect may also have been at work in Experiment 3. Participants with relevant practice may have been more inclined to rely on their acquired 'automaticity' and delegate control to the environment, no longer thinking about the instruction.

The finding of a general improvement on the second trial, especially as this occurred mainly in the relevant practice group, provides a clue to what might have caused the negative practice effect on the first trial. The improvement over time resembles the results of Brandimonte, Ferrante, Feresin, and Delbello (2001). These researchers found that participants with a prospective memory instruction performed better at the end of the test than at the beginning. In their experiments there was also a second group of participants (the vigilance condition) who had had different practice trials, before the experimental trials started. Participants in the prospective memory condition only practiced the ongoing task and no target appeared. Participants in the vigilance condition also practiced the ongoing task, but target words also appeared several times. It is likely that this manipulation during practice affected the expectation regarding the frequency of target words in the test phase. Participants in the vigilance condition were much better at responding to the target words (fewer omissions) than in the prospective memory condition. As they also showed slower responses to the ongoing task, this suggests that they were actively monitoring for target words (cf. Smith, 2001). They responded to the target words and performance did not change over time. On the other hand, participants in the prospective memory condition performed generally worse, but they improved over time, suggesting that they became better 'tuned' for this task.

Although in the study by Brandimonte et al. (2001) the effects of the number of targets during practice were confounded with effects of instruction (the instructions were varied slightly between conditions), their results seem to suggest that expectations regarding the frequency of target words and their actual frequency affect the way in which participants deal with a prospective memory task. Performance over time is stable when expectations match the encountered situation to a sufficient degree, but changes when they do not match. With this in mind, the results from Experiment 3 suggest that participants in the relevant practice group had incorrect expectations regarding the frequency of target words. Perhaps because the target words had appeared so often during practice, they initially expected them to occur with the same frequency in the new test, and that they would be responding in the same semi-automatic way as they had before. But when target words did not appear for several minutes, the prospective memory instruction was forgotten. Only when naming the target word for the short-term memory task did participants realise their omission and correct their expectations and strategy. They were then more alert when the target word appeared the second time.

RNG and short-term memory performance were not significantly better in the relevant practice condition, so that there is no support for the idea that participants allocated fewer resources to the prospective memory instruction in favour of the other two tasks. In other words, there was no indication that a certain underestimation of the task’s difficulty or expectations regarding target frequency led to a different way of handling the ongoing tasks. This leads us to suspect that, whatever difference there was in dealing with the prospective memory task, it can only be attributed to processes going on in-between trials, when participants had recalled the words and prepared themselves for the upcoming trial. Many participants later indicated that they had thought about the prospective memory instruction in-between trials, but not while engaged in RNG and memorisation. There was, unfortunately, no systematic observation of these self-reports, and it is therefore unknown whether this happened more often in the irrelevant practice group than in the relevant practice group. None of the participants with relevant practice indicated afterwards that (s)he had been confused when the target word appeared. The target word simply did not remind them of the instruction at all, or not in time. Some of the participants indicated that they had expected the target word to appear more often, but these remarks were also not systematically recorded.

Based on the above line of reasoning, we suggest the following interpretation of the results from Experiment 3, in keeping with the proposed model of habitual prospective memory presented in the introduction. Participants in the irrelevant practice condition received an episodic intention to respond as soon as they saw the target word, while being engaged in a short-term memory task and generating random numbers at the same time. The reason why no load effect was observed was probably that participants were not monitoring for the target word while engaged in number generation and word memorisation, but only thought about the prospective memory task in-between trials. The instruction was remembered and there was no reason to think that it was no longer important.

In contrast, the same intention was not new for the participants with relevant practice. They had performed this task many times before and probably anticipated that it would be very easy to do it again in a slightly different context (cf. Schaefer et al., 1998). They probably delegated its control entirely to the environment, as had been possible during the preceding task, when they were responding in a semi-automatic way. Consequently, the goal to perform the task was not updated in between trials and was no longer active in working memory by the time the target word appeared. Alternatively, the instruction *was* remembered now and then in between trials, but the goal no longer seemed important. Perhaps participants suspected that they had misunderstood the instruction and did not update the goal to respond to the target word.

Whatever the case, since stimulus-response links acquired through practice do not determine behaviour (Allport & Wylie, 2000; see also the effect of goal after practice in Experiment 2), in absence of a relevant goal the target word did not trigger the related response automatically. The stimulus evoked a response more in line with the currently active goal: memorisation in service of the short-term memory task.

In conclusion, our research shows that extensive practice of an intention does not necessarily lead to habitual prospective remembering. The results suggest that after frequent and consistent repetition, automatic responding to target events only occurs given sufficient activation of a relevant goal at the time of the event. The combination of perceiving a cue, remembering the intention and subsequently acting on it, appears not to be automatised through repeated cue-action practice. Future research on prospective memory should pay more attention to strategy and should apply a systematic recording of self-reports. Disentangling the effects of expectancy and effects of instruction (Brandimonte, et al., 2001; see also Duncan Emslie & Williams, 1996) would be a good start.

Chapter 3 Categorisation and the Role of Executive Processes[*]

ABSTRACT

This chapter explores the generality of the claim that executive processes play an important role in event-based prospective memory tasks. It was hypothesised that they are less important if a prospective memory task requires no categorisation of cues. In addition to effects of executive load on categorisation processes it was explored whether executive functions are involved in noticing the cues or in other processes after the target is noticed. Results showed no significant effect of manipulating executive resources on general prospective memory performance. This can be explained by the strategy applied by the participants.

[*] This chapter is partly based on Van den Berg, Aarts, Midden, & Verplanken (2002b).

Introduction

Prospective memory research deals with actions that are intended to take place in the future. It studies the mechanisms underlying the execution of postponed actions, and tries to determine the variables that might facilitate or hinder the execution of postponed actions. An important obstacle in acting on behavioural intentions is that we are often so involved in other matters that we forget all about the things that need to be done. We may intend to buy fish on the way home, but when driving home, we are so lost in thought that we arrive home fishless. Many have argued that an attentional check is always necessary when behaviour is supposed to depart from the ordinary course of action (e.g. Jastrow, 1905; Norman & Shallice, 1986; Reason, 1990).

This attentional factor received quite some attention during the 1990s in the literature on prospective memory. It is generally argued that prospective memory tasks that require more self-initiated processing (Craik, 1986) are more susceptible to effects of manipulations of cognitive load. For example, it has been argued that time-based tasks require more self-initiated monitoring than event-based tasks, which can rely more on automatic processes (Einstein & McDaniel, 1990). However, evidence on the effects of load on event-based prospective memory is rather mixed (see Chapter 1).

In an attempt to clear up these contradicting results, Marsh and Hicks (1998) carried out a series of experiments, showing that increasing the difficulty of an ongoing task only affects prospective memory if that ongoing task requires executive functions. For example, in one experiment the ongoing task consisted of the Random Number Generation task, which requires the use of the Central Executive in working memory (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). Increasing the pace in which participants had to call out numbers randomly had a dramatic effect on performance on a concurrent prospective memory task. In contrast, in other experiments in which an ongoing task did not require the Central Executive but only the Phonological Loop or the Visuo-Spatial Sketchpad, increasing its difficulty level did not affect prospective memory. Marsh and Hicks explained their results by supposing that successful prospective memory requires monitoring and planning, which are the responsibility of the Central Executive.

This chapter and the following we will explore the generality of the claim that Central Executive functions are crucial for successful event-based prospective memory. As McDaniel and Einstein (2000) suggested, the extent to which event-based prospective remembering is supported by relatively automatic processes or requires more resource-demanding monitoring depends on the characteristics of the task and the properties of the target cue, amongst other things. The experiments were set up to test whether effects from manipulations of executive resources depend on the way in which the cue for an event-based prospective memory task is specified. It will also be explored exactly what processes in prospective remembering are affected when executive functions are taxed.

Specification of the prospective memory cue

Fully specifying the conditions in which an intended action needs to take place increases the chance that the intention will be acted upon (Gollwitzer, 1999). The way in which a target event is specified has a significant impact on prospective memory success. For example, in a lab study by Einstein and McDaniel and their co-workers (Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995), participants had to press a key whenever they came across particular words during an unrelated ongoing task. Some were told that they would have to respond to animal words (general or categorical instruction), others had to respond to 'tiger', 'lion' and 'leopard' (specific instruction). Each target word was presented during the ongoing task. Participants with a specific instruction responded significantly more often than participants with a categorical instruction. Ellis and Milne (1996) and Cherry et al. (2001) found similar results.

There are several prospective memory studies reported in the literature in which categorical instructions were used (e.g. Marsh & Hicks, 1998; Hicks, Marsh, & Russell, 2000; Brunfaut, Vanoverberghe, & D'Ydewalle, 2000; Marsh, Hicks, & Hancock, 2000). Using such instructions might be an attempt at making the prospective memory task in a laboratory setting harder in order to avoid ceiling effects. However, the more theoretical consequences of using such instructions have been neglected. If a prospective memory task is linked to a category of events, performance is more difficult because some target event first needs to be identified as a member of the specified category before the intended action can be associated with it. This extra categorisation step is not needed if the target event is fully specified and the target event can immediately remind someone of the intended action. This extra step might have unintended effects on how people handle the prospective memory task or what experimental manipulations have an effect on performance.

People might use different strategies in dealing with a prospective memory task with a highly specified target event compared to one that is not. The type of instruction may influence the perceived difficulty of the task (Marsh, Hicks & Landau, 1998) or expected salience of the cue (McDaniel & Einstein, 2000). In addition, other processes can support prospective remembering in cases where the event is fully specified (recognition processes, a sense of familiarity, see Whittlesea & Williams, 2000; see also McDaniel & Einstein, 2000). In other words, the specification of a target event might influence the need for executive resources, for all sorts of reasons.

In the Marsh and Hicks (1998) study, the target event that needed to trigger the postponed action was defined in terms of a category: participants had to press a key as soon as they saw a word designating a type of fruit during an ongoing short-term memory task. Increasing the difficulty of an additional task requiring executive resources resulted in fewer prospective memory responses. This could be interpreted as showing that event-based prospective memory in general is dependent on executive processes, but an alternative explanation is possible.

Baddeley and his colleagues have shown that categorisation is affected by cognitive load (Baddeley et al., 1984). In one experiment, they first presented a category name and then a word, and participants had to indicate whether the word was an instance of the category. When memory was loaded with a sequence of six random numbers (e.g. “435162”) that participants had to call out repeatedly, the time to verify category membership was increased relative to a no load and an articulatory suppression condition (calling out “123456” repeatedly). In another experiment, they found that with the same load manipulation, the number of category exemplars that participants could generate dropped significantly. We may therefore hypothesise that when a prospective memory task requires categorisation, performance suffers more from cognitive load compared to a prospective memory task that does not require categorisation. This hypothesis is supported by the results of an earlier study (Chapter 1, Exp. 3), in which no effect of executive load was found on a prospective memory task that did not require categorisation, but was highly similar to one of the experiments reported by Marsh and Hicks (1998, Exp II).

Note that we are not suggesting that executive load only has an effect on prospective memory when categorisation is involved. Indeed, McDaniel et al. (1998, Exp. 4) found an effect of dividing attention on an event-based prospective memory task that did not require categorisation. We are merely hypothesising that the effect of load is larger with tasks that require categorisation than with tasks that do not.

Taxing the Central Executive might also affect processes other than categorisation that are needed for successful prospective memory. It might affect searching for the intention once a target event is noticed (the Noticing+Search model, Einstein and McDaniel, 1996); it is assumed that this memory search is controlled and might therefore be influenced by manipulations of cognitive load. It is also possible that Central Executive functions are responsible for noticing the target event for an event-based prospective memory task as suggested by Marsh and Hicks (1998), or that they in general affect the level of processing of the target event

(McDaniel & Einstein, 2000). These alternatives will be put to the test in this chapter and the next.

In summary, based on the above analysis we predicted that when cognitive load is manipulated in a way that taxes executive functions, a general effect would be found on prospective memory. However, based on the finding that categorisation is affected by cognitive load (Baddeley et al., 1984), the effect of taxing executive functions was expected to be larger with a categorical description of the target event. This hypothesis was tested in Experiment 5, using the paradigm of Marsh and Hicks' (1998) second experiment and varying the type of instruction. First, however, the process of categorisation itself was explored in Experiment 4.

Experiment 4

The object of this experiment was to test the assumption that carrying out postponed actions in a simple two-choice speeded response time task requires more time with a categorical instruction than with a specific instruction. As Wilkins (1971) and (Baddeley et al., 1984) already showed that categorising typical exemplars is faster than categorising atypical exemplars, two different exemplars were used: one highly typical, one less typical. It was hypothesised that mentioning only the category of the target words should lead to longer response latencies compared to mentioning the exact target word, particularly when the target word is atypical in relation to the specified category.

Method

Participants and design. Sixty-six undergraduates served as paid participants. They were randomly assigned to the cells of a 2 (instruction: specific, categorical) × 2 (target word: apple, grape) factorial between-subjects design.

Materials. The words *apple* and *grape* were chosen as exemplars from the category of fruits. This was based on a small study in which 25 students were asked to name the first types of fruits that came to mind. *Apple* was the most frequently mentioned exemplar. Hence, *apple* was chosen as the typical exemplar for the category of fruits. The first three or four exemplars were named relatively quickly. After that, naming exemplars took more effort. *Grape* was mentioned less often than *apple* and, if mentioned, never came among the first four. We therefore chose *grape* as the non-typical exemplar, particularly since in Dutch it also has the same number of letters as *apple*.

Procedure. On arrival at the lab, participants were placed in separate cubicles equipped with computers. Instructions were presented on the computer screen.

Participants were told that they were taking part in an experiment dealing with key responses to words appearing on the screen. Accordingly, words would appear on screen and participants had to respond as quickly as possible by pressing one of two designated keys. In the categorical instruction condition, people had to press the right key when they saw a word designating a type of fruit. For other words, they had to press the left key. Half of the participants in this condition were presented with the target word *apple*, the remaining half were presented with *grape*. In the specific instruction condition, half of the participants had to press the right key only in response to the word *apple*, and in all other cases they had to press the left key. The remaining participants had to respond to *grape* by pressing the right key, and the left key in all other cases. Nothing was said about the number of words that would appear. They just had to respond as quickly and as accurately as possible.

Participants pressed keys on the PC's keyboard marked “left” or “right”. All words appeared at the same location on the screen, preceded by a fixation point for 500 ms. Response latencies were measured in milliseconds from the onset of the words to the time participants pressed a key. The time interval between word-trials was 2 seconds. The words were presented in random order and were preceded by four practice trials. The target word (*apple* or *grape*) appeared as the eighth word. The other words denoted five-letter string items that were presumed not to be associated with fruits (e.g. *chair*, *table*, and *spoon*).

Results and discussion

The dependent measure of interest was the response latency on the fruit exemplars. Two participants did not give the correct response when the fruit exemplar appeared (that is, they pressed left instead of right), and were excluded from the analyses. We subjected the response times to a factorial ANOVA with instruction and target word as independent variables (means are displayed in Table 4). The main effect for instruction was only marginally significant, $F(1, 62) = 3.20$, $MSE = 0.01$, $p = .08$. The main effect of the target word was not reliable, $F = 2.25$, $p = .14$, however, there was a significant interaction effect, $F = 4.52$, $p = .04$. Contrast analyses revealed that with a categorical instruction, responses were faster to *apple* than to *grape*, $F(1, 64) = 8.46$, $MSE = 0.01$, $p = .005$, a typicality effect. With a specific instruction, response times were not different for the two words, $F = 0.38$, showing that the typicality effect is not the result of irrelevant word characteristics. In addition, response times to *grape* were faster with a specific instruction than with a categorical instruction, $F(1, 64) = 9.47$, $MSE = 0.01$, $p < .01$. However, this effect did not occur for *apple*, $F = 0.40$. Thus, instruction had a significant effect only with an atypical target word.

Baddeley et al. (1984) and Wilkins (1971) already showed that atypical exemplars are categorised more slowly than typical exemplars. Here, we see that the categorisation process *itself* takes a significant amount of time only when dealing with less typical exemplars. This finding may be related to the effects of typicality found in prospective memory studies (e.g. Mäntylä, 1994).

We next tested the effect of instruction in a prospective memory task.

Table 4. Mean response times in ms as a function of type of instruction and target word (standard deviations in parentheses).

	Instruction	
Target word	Categorical	Specific
Apple	483 (70)	492 (160)
Grape	581 (110)	476 (100)

Experiment 5

The objective of this experiment was to test whether the availability of executive resources is more important when a target event in a prospective memory task is defined categorically than when it is fully specified. Marsh and Hicks (1998) showed effects of cognitive load on prospective memory when using the random number generation (RNG) task (Exp. II). In this experiment the same paradigm was used, now including a condition with a specific instruction. We expected to replicate the results of Marsh and Hicks in that, with a categorical instruction, performance rates would be affected by executive load. Based on the results of Einstein et al. (1995), Ellis and Milne (1996), and Cherry et al. (2001), we expected higher performance rates with a specific instruction than with a categorical instruction. However, since Baddeley et al. (1984) have shown that categorisation is sensitive to manipulations of cognitive load, we expected that the load effect would be larger with a categorical instruction than with a specific instruction.

Method

Participants and design. A total of 91 paid undergraduates, with a mean age of 21 years (SD = 2.1), were randomly assigned to four experimental conditions, of a 2 (instruction: specific, categorical) × 2 (cognitive load: low, high) factorial between-subjects design.

Materials. We randomly selected 68 five-letter words from a word frequency list (Martin, 1971), avoiding words that are semantically related or orthographically similar to 'apple' but with a similar frequency. Nine words were used for the three practice trials; the remaining words were presented in the experimental trials, together with the target word *apple*. The practice trials and the target trial were identical for each participant. Word presentation for the remaining trials was randomised.

Procedure. The procedure was almost identical to that of Marsh and Hicks' (1998) Experiment II. Participants were engaged in a short-term memory task. Each trial took 25 seconds. During each trial, three words were visually displayed in succession on a computer screen. Each word was visible for 1500 ms. At the end of each trial, participants had to report as many of these three words as possible, for which they had five seconds. The next trial started immediately after these five seconds. During each trial, participants also had to perform the RNG task. Those in the high load condition had to call out a number every 1000 ms, those in the low load condition had to call out a number only every 1250 ms. The pace was indicated by short beeps that were presented throughout each trial.

At the beginning of the experiment, participants were told they would have to perform a short-term memory task, while also performing the RNG task. Participants then practiced the RNG task without the short-term memory task. They then received the prospective memory instruction: those participants in the categorical instruction condition had to press the enter-key as soon as they saw a word presented on the screen that was a type of fruit; those in the specific instruction condition had to press the enter-key as soon as they saw the word *apple*. The three tasks, short-term memory, prospective memory and RNG, were equally important. All participants were subsequently given three practice trials during which no fruit exemplar was presented. After these practice trials, twenty experimental trials started. The number of experimental trials was not mentioned, nor were the participants reminded of the prospective memory task at this point. The target word *apple* appeared as the second word on the last trial.

The software recorded whether the participants responded to the target word and if so, how long after the onset of the target word. We counted all responses that occurred between the onset of the target word and the moment that the beeps stopped and the message appeared to recall the three words, which was fourteen seconds later. Some participants gave the response after they had stopped generating random numbers and started recalling the words they had seen, but these were regarded as omissions.

The experimenter was seated behind the participant and recorded the generated numbers and the words that were recalled. After the last trial, participants were debriefed, paid, and dismissed.

Results and discussion

Random number generation. Regarding the performance on the RNG task, we computed a score for randomness based on Evans (1978; see also Marsh and Hicks, 1998). We computed this score for each participant based on the five trials preceding and including the target trial. A low score denotes a high degree of randomness. A factorial ANOVA revealed that participants in the low load condition were significantly more random ($M = 0.34$, $SD = 0.05$) than participants in the high load condition ($M = 0.37$, $SD = 0.06$), $F(1, 87) = 8.26$, $MSE = 0.003$, $p = .005$. There was no main effect of instruction, $F = 0.23$, nor an interaction, $F = 2.08$, $p = .15$. The significant load effect indicates that the high load condition was more demanding than the low load condition.

Short-term memory. We next counted the number of words that participants recalled correctly during the short-term memory (STM) task, and performed a factorial ANOVA with load and instruction as independent variables. Participants in the low load condition recalled more words (65%) than participants in the high load condition (62%), but this difference was not significant, $F(1, 87) = 1.10$, $MSE = 86.43$, $p = .30$. However there was a significant main effect of instruction: participants with a categorical instruction recalled on average fewer words correctly (60%) than those with a specific instruction (67%), $F(1, 87) = 4.60$, $p = .04$. The load by instruction interaction effect was not significant, $F = 0.12$. These results suggest that participants with a categorical instruction paid less attention to the short-term memory task than participants with a specific instruction.

Eighty-five percent of the participants successfully recalled the target word *apple*. A logit analysis of this percentage was performed with effect codings (-1, 1) for the main effects of cognitive load, instruction and their interaction. Eighty-nine percent of the participants in the low load condition recalled the target word versus 80 percent in the high load condition, but this main effect of cognitive load was not statistically reliable, $B = -0.26$, $p = .42$. There was also no significant main effect of instruction specificity, $B = 0.51$, $p = .12$, and no significant interaction, $B = 0.31$, $p = .34$.

Prospective memory. When asked during debriefing, all participants could reproduce the content of the prospective memory instruction. The proportions of participants that responded to the target word are displayed in Table 5. The proportions were analysed in a logit analysis with instruction, load and their interaction as predictors (effect coding). A significant main effect of instruction was found: response rates were higher in the specific instruction condition than in the categorical instruction condition, $B = 0.45$, $p = .04$. The main effect of load was not reliable, $B = -0.13$, $p = .54$, nor was the interaction effect, $B = -0.36$, $p = .10$.

Table 5. Response rates for the prospective memory task as a function of cognitive load and type of instruction (group sizes in parentheses).

Instruction	Low load	High load
Categorical	.35 (23)	.45 (22)
Specific	.73 (22)	.50 (24)

In summary, responding to the target word in accordance with the prospective memory instruction was more likely with a specific instruction than with a categorical instruction. Results did not confirm the hypothesis that load effects are larger with categorical instructions than with specific instructions.

General discussion

Experiment 5 tested whether effects of cognitive load on prospective memory depend on the level of specificity of the prospective memory instruction. The hypothesis that effects of a manipulation of available executive resources would be larger with a categorical instruction than with a specific instruction was not confirmed by the results.

Our results showed that it is important to be specific when describing the exact target event that needs to trigger some behaviour. Acting on behavioural intentions becomes much easier when specifying the exact circumstances in which the action needs to take place. This replicates the findings of earlier studies (Ellis & Milne, 1996; Einstein et al, 1995; Cherry et al., 2001; see also Gollwitzer, 1999).

This instruction effect can be explained either by the fact that, with a categorical instruction, an extra step is needed in order to identify a perceived target word as the prospective memory cue, or by the fact that, with a specific instruction, the target word was actually mentioned, so that it could attract more attention based on feelings of familiarity. In terms of the Noticing+Search model of prospective memory (Einstein and McDaniel, 1996), this would mean that a specific instruction helps in noticing the prospective memory cue. Results showed that the target word was better recalled with a specific instruction than with a categorical instruction in the short-term memory task, suggesting that it attracted more attention. However, this effect was not statistically significant and not as large as the instruction effect on prospective memory (though quite possibly because performance was already at ceiling). Moreover, instruction had a general effect on short-term memory performance that cannot be attributed to familiarity. Thus, it seems unlikely that the effect can be explained by familiarity. The extra categorisation step is probably responsible for the instruction effect.

This instruction effect was not observed in Experiment 4. There, responding to *apple* was not different with a categorical instruction than with a specific instruction. In Experiment 4, participants were already categorising words, waiting for a target to appear. In contrast, participants in Experiment 5 were heavily engaged in some other ongoing task, so that categorisation of the word now had to occur spontaneously. We conclude that prospective memory tasks with categorical instructions are more difficult because an extra categorisation step needs to occur spontaneously.

Even with a categorical instruction, no negative effect of executive load was found. This contradicts the results of Marsh and Hicks (1998, Exp. II), although the procedures were similar. Both experiments used the same category (i.e. fruits) and highly typical exemplars. The only differences, as far as we can tell, concern first the language and second the fact that we only had one target trial instead of two. We do not think that language is an important issue here. One may argue, though, that using only one target trial instead of two leads to a less powerful measure. However, since the proportions are in the opposite direction to our expectations, a power problem cannot be held responsible, more particularly since more participants were used than in the Marsh and Hicks experiment. Furthermore, Marsh and Hicks (1998) reported that they did not find significantly different response patterns in the first and second trial.

The discrepancy between Marsh and Hicks' effect of load with categorical instructions and the present null-finding with categorical instructions may be explained by differences in the strategy applied by the participants. In Experiment 5, participants with a categorical instruction recalled on average 60 percent of the words presented, whereas Marsh and Hicks reported a percentage of 78. In contrast, our participants performed better on the RNG task (i.e. were more random) compared to those in the Marsh and Hicks study. It is quite possible that participants in this study paid more attention to the RNG task, therefore paying less attention to the words, which led to worse performance on both the STM and the prospective memory task. If no attention is paid to the words on the screen, and thus to the prospective memory task, it is unlikely that participants are monitoring for a target word. It may then not be that strange that we did not find an effect of taxing executive functions responsible for monitoring.

Load did not have any significant effect on prospective memory, neither on the perception of the prospective memory cue nor on any other process. This study did not confirm the hypothesis that taxing executive processes has a larger impact with categorical instructions than with specific instructions. Note that in Experiment 5, a typical category instance was used as the target word. Results from Experiment 4 suggest that categorisation itself is not such a difficult task when dealing with typical target events. With atypical target events, however, categorisation becomes more difficult as revealed by increased response times, perhaps because it requires more self-initiated processing (cf. Mäntylä, 1994). Hence, an effect of cognitive load on prospective memory may be more likely when using categorical instructions and with target events that are atypical in relation to the category mentioned in the instruction. The hypothesis regarding such an interaction between load and instruction with atypical target words will be tested in the next chapter.

Chapter 4 CATEGORISATION AND CUE TYPICALITY*

ABSTRACT

The Central Executive is assumed to play a key role in prospective memory. The hypothesis is tested that the need for its availability is to some extent dependent on the need for self-initiated categorisation of intention-related events. The effect of a manipulation of executive resources was expected to be larger for prospective memory tasks with categorical instructions than with specific instructions. Since categorising atypical instances is more difficult than categorising typical instances, typicality of the target event was also manipulated. Results showed no significant effect of load on the prospective memory performance measure. However, taxing executive functions did affect performance on the ongoing short-term memory task. This is interpreted as showing that load effects found in other studies can be partly explained by an effect on the processing of target events.

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* This chapter is based on Van den Berg, Aarts, Midden, & Verplanken (2002b). The research was presented at the XII Conference of the European Society for Cognitive Psychology, Edinburgh, Scotland, September 5-8, 2001 and at the annual meeting of the Dutch Association of Social-Psychological Researchers (ASPO), Tilburg University, December 6-7, 2001.

Introduction

In the previous chapter, the hypothesis was tested that effects of a manipulation of executive resources on prospective remembering partly depend on the type of instruction. A more pronounced effect was expected if categorisation is needed than when it is not needed. The data did not confirm this because the load manipulation had no general effect on prospective memory whatsoever. The way in which participants distribute their attention over the different concurrent tasks might have contributed to the counterintuitive results. In this chapter, the same hypothesis will be tested again, using a different experimental procedure.

In a similar way as in Experiment 5, participants were engaged in a verbal short-term memory task. The prospective memory task was to press a key as soon as one of the words that needed to be memorised was a particular word (i.e. the target word). In addition, while participants were engaged in the short-term memory task they had to perform an extra task that was used to manipulate the load that is placed on the Central Executive in working memory (Baddeley, 1986).

One important alteration is that now both typical and less typical target words were used. Remember that in Experiment 5 a typical exemplar from the category of fruits was used (*apple*). Results from Experiment 4 suggest that the categorisation of atypical exemplars is a bigger problem than the categorisation of typical exemplars. Mäntylä (1994) argued that responding to atypical target words in a prospective memory task requires more self-initiated processing than responding to typical exemplars. We therefore hypothesised that an increase in load on executive resources interferes mostly with the categorisation of atypical exemplars. Hence we expected that the effect of executive load would be largest in prospective memory situations in which a cue that is specified only categorically, is itself an atypical instance of that specified category.

A second alteration concerns the way in which executive processes were taxed. In Experiment 5, a procedure was used in which cognitive load was manipulated by using the RNG task, a procedure which had already demonstrated significant effects on prospective memory performance (Marsh & Hicks, 1998, Exp. II). Marsh and Hicks related this to the fact that the RNG taxes the Central Executive, which is responsible for monitoring and planning that are needed for successful prospective remembering. However, as noted by Vandierendonck, De Vooght, and Van der Goten (1998), the RNG task not only taxes the Central Executive but also the Phonological Loop system. A load manipulation that only taxes the Central Executive was therefore used in the new experiments. In this way, it could be established whether it is only the Central Executive system that is responsible for prospective memory performance, and not any of the other systems or a combination of systems.

There was also a second reason for choosing a different manipulation of executive load. In the previous chapter it was argued that strategic influences could be one possible reason why no effect of cognitive load was observed. A comparison of performance on the short-term memory task and the RNG task between Experiment 5 and the experiment reported by Marsh and Hicks, revealed that our participants performed better on the RNG task but worse on the short-term memory task. This suggests that participants paid too much attention to the RNG task, so that they did not have enough resources left to monitor the words on the screen, resulting in worse recall and rather bad prospective memory performance, even in the low load condition. In order to make participants more attentive to the words on the screen, a manipulation of the Central Executive task was chosen that is less demanding than the RNG task. At the same time, the difficulty of the short-term memory was increased to keep the whole procedure as demanding as in the previous experiment.

Two experiments are described here that are highly similar and were carried out at the same time. Participants were randomly assigned to the experiments and their conditions. The executive load was manipulated in both experiments, with an extra manipulation of target word typicality. Experiment 6 used categorical instructions and Experiment 7 used specific instructions. After the experiments have been reported and discussed separately, a complete three-way design will be analysed, and the implications for the general hypothesis regarding categorisation and cognitive load will be discussed. In a similar way as in the previous chapter it will also be assessed what other process (or processes) subserving prospective memory might be the responsibility of the Central Executive: taxing the Central Executive might possibly affect the level of processing of the cue, or hinder a controlled memory search.

Experiment 6: Categorical instructions

In this experiment a categorical prospective memory instruction was used with both typical and less typical target words. As categorising atypical exemplars is more difficult than categorising typical exemplars (Exp. 4; Wilkins, 1971; Baddeley et al., 1984), a main effect of typicality was expected. Mäntylä (1994) argues that responding to atypical exemplars in a prospective memory task is more difficult than responding to typical exemplars, because it requires more self-initiated processing. The availability of executive resources was manipulated using the Random Interval Generation (RIG) task, which does not involve functions of the Phonological Loop or the Visuo-spatial Sketchpad, but taxes only the Central Executive. This task, that requires tapping irregular sequences, has been developed and tested by Vandierendonck (Vandierendonck et al., 1998; Vandierendonck, 2000). It has been shown that tapping random intervals is less demanding than random number generation at a pace of 1 Hz (Vandierendonck et al., 1998, Exp III). It was expected that by using the RIG task, participants would be more inclined to monitor for the target event than by using the RNG task as in Experiment 5.

Furthermore, cognitive load was manipulated while controlling for mental fatigue. In the paradigm of Experiment 5, as well as in many other paradigms, load is manipulated by increasing the difficulty of the ongoing task that people are performing between the time of instruction and the occurrence of the target event. This means that at the time of occurrence of the target event, participants in the high load condition have, for a certain period, been working harder than those in the low load condition. It is therefore not clear whether any difference in performance should be attributed to general fatigue or specifically to the *availability* of the Central Executive. In order to test the hypothesis that prospective remembering critically depends on the executive functions available during the time that the intention needs to be retrieved, we should take care to keep the degree of exertion equal across experimental conditions. Cognitive load was therefore manipulated in such a way that groups differed only to the extent that the Central Executive was taxed during the time that the target event occurred and the response needed to be made.

We hypothesised that a manipulation of executive resources has an effect on a prospective memory task with categorical instructions, but more so when the target event is a less typical instance of the specified category, since atypical target events are thought to require more self-initiated processing.

Method

Participants. Eighty paid undergraduates participated in the experiment. The mean age was 22 years (*SD* = 5.3).

Materials. We used 91 three, four, and five-letter words. Two of them, *owl* and *sparrow*, were used as target words in the experiment. In Dutch both words consist of three letters. The target words were chosen based on a small study, in which 30 people named the first five birds that came to mind. Twenty-seven people named *sparrow* and this was the most frequently named bird, whereas only one person named o*wl*. We chose to use these words since they are identical in word length and varied in typicality. The remaining 89 distracter words were randomly selected from a frequency list (Martin, 1971). Half of them came from the list of frequently-used words, in which *sparrow* was listed, and the other words were taken from the list of less frequently-used words, of which *owl* was a member. Care was taken to ensure that none of the words was semantically related or orthographically similar to the target words. No other bird names were used. Fourteen words were used for the practice trials, whereas the remaining words were quasi-randomly assigned to the experimental trials, ensuring that words of different word-lengths were present in any given trial.

Design. Participants were randomly assigned to either the low load or high load condition. There were eleven experimental trials. The target words appeared in the fifth and eleventh trial. In one target trial the typical target word (*sparrow*) appeared and in the other the less typical target word (*owl*) appeared, so that typicality was a within-subjects variable. Thus we had a 2 (cognitive load: high, low) × 2 (target word: sparrow, owl) design with a repeated measure on the second variable. The order in which the target words appeared was balanced.

Procedure. Participants were tested individually. When they entered the lab, the experimenter told them that the experiment was about testing peoples' memory and their creativity. Participants sat down in a cubicle in front of a computer screen, a keyboard, a pen and a piece of paper. The experimenter briefly summarised the experimental procedure. There were several trials. Seven words appeared in succession on the screen during each trial. Participants had to try to memorise them, and at the end of the trial had to write down as many of these words as possible and construct one grammatically correct sentence with as many of these words as possible. In order to increase the difficulty of memorisation, the participants had to tap the *b*-key on the keyboard during the presentation of the words. The experimenter then demonstrated how to tap fixed intervals and how to tap randomly. Fixed interval tapping required tapping an isochronous rhythm: all intervals between two taps had to be equal in length (about half a second). Tapping random intervals required tapping a completely unpredictable rhythm. The prospective memory task and the number of trials were not mentioned at this point.

After the verbal instructions, the experimenter left the cubicle and participants read the complete set of instructions on the computer screen. This was self-paced, except for the part where the prospective memory task was mentioned. This task was presented as an extra task in order to test long-term memory and it was on screen for 7 seconds. Participants had to hit the enter-key as quickly as possible as soon as the name of a bird appeared among the words to be memorised during the experiment.

In the instructions random and fixed tapping were explained in further detail. Participants had to alternate between fixed tapping and random tapping; a switch had to be made after each trial. Whether participants had to tap regularly or randomly was indicated at the top-right part of the screen. For both tasks, participants had to tap at an average rate of two taps per second. The three tasks, RIG, short-term memory, and long-term memory were equally important.

There were two practice trials, one with random tapping and one with fixed tapping. The software provided feedback that was identical for all participants. In order to ensure a maximum difference between the low and high load conditions, positive feedback was given on the way they tapped fixed intervals, and it was indicated that randomness could be improved. The experimental trials then started, without further feedback.

Before each trial it was indicated whether participants had to tap fixed or random intervals; participants then started tapping. The first word appeared after five seconds and remained on screen for 1.5 seconds. The next word appeared 1.5 seconds after the removal of the first word. The same applied to the remaining five words. After the removal of the last word, the trial continued for another five seconds. A beep then sounded and a message appeared telling the participant to now write down as many words as possible and to construct a sentence. The next trial started 40 seconds later

The target words appeared as the fourth word in the fifth and eleventh (the last) trial. Half of the participants started with random tapping and half started with regular tapping. In this way, those who started with random tapping were also tapping randomly when the first target word appeared on the fifth trial, and when the second target word appeared in the eleventh trial. The opposite applies to those who started with regular tapping. Thus, every participant tapped both random and fixed intervals; only the kind of tapping during the target trials was manipulated.

The software registered how participants tapped and whether and when participants responded to *owl* and *sparrow*. Only those responses were counted that occurred before the end of the trial when the words had to be written down. After the last trial, the participants were debriefed, paid, and dismissed. The whole procedure took between 20 and 25 minutes.

Results

Random and fixed interval generation. Participants had to alternate between tapping random and regular intervals. The average deviation was used as a measure for regularity. For each trial of each participant, we computed the average deviation from the mean length of the intervals in the sequence. However, we did not compute the measure for the trials during which the target words appeared, since many participants interrupted the tapping task in order to give the prospective memory response. The average deviation in a sequence was subsequently turned into a proportional measure by dividing it by the mean interval length of that sequence. A value of 0.10 for a given trial thus means that each interval deviated on average by ten percent from the mean interval length during that trial. A proportional measure was chosen as participants varied in their mean interval length (although participants had to tap, on average, in a rhythm of 2 Hz). Here we are only interested in regularity.

For each participant we averaged the measures for the random tapping trials and the measures for the fixed tapping trials separately. A paired-samples *t*-test on the regularity scores showed that participants were significantly more regular during the fixed tapping trials (M = 0.11, SD = 0.06) than during the random tapping trials (M = 0.41, SD = 0.14), $t(79) = 18.01$, $p < .001$.

Short-term memory. We counted the number of words that participants recalled correctly during the eleven experimental trials. Two mean scores were computed for each participant, one based on the random interval tapping trials and another based on the fixed interval tapping trials, and these were subjected to a paired-samples *t*-test. When tapping random intervals, the mean number of words recalled was significantly lower than when tapping fixed intervals (65% and 69%, respectively), $t(79) = 4.20$, $p < .001$.

Table 6. Prospective memory response rates as a function of cognitive load and target word. Each proportion is based on twenty participants.

Target word	Low load	High load
Sparrow	.40	.28
Owl	.23	.15

Prospective memory. During debriefing, all participants could recall the contents of the prospective memory instruction. Response rates are displayed in Table 6. A McNemar change test (Siegel & Castellan, 1988) showed that response rates on the first and second trial were not statistically different, $p = .35$. Next, a logit analysis was performed on the response rates with effects of a within-subjects variable for target word and a between-subjects variable for cognitive load, and their interaction (effect coding). Results showed a significant main effect of typicality, $B = 0.40$, $p = .005$. The main effect of load ($B = -0.27$; $p = .25$) and the interaction effect ($B = -0.02$; $p = .92$) were not significant.

Discussion

As the prospective memory task required categorisation, we expected a main effect of cognitive load, that should also be larger for the less typical target word *owl*. The results did not confirm this hypothesis: the effect of the load manipulation was not different for the typical and the less typical target word, although there was a significant main effect of target word. Response rates were higher for the typical target word than for the less typical target word, which replicates the findings of Mäntylä (1994; see also Cherry et al., 2001). The data therefore do not support Mäntylä's notion that typicality effects are attributable to self-initiated processing. However, we should be careful with this interpretation since there was no general effect of the cognitive load manipulation.

Though not on prospective memory, the load manipulation had a significant effect on general short-term memory performance: participants could recall fewer words with little executive resources available than with more resources available. This is in accordance with studies showing that memory encoding processes are affected by cognitive load (Naveh-Benjamin, Craik, Gavrilescu, & Anderson, 2000; Naveh-Benjamin & Guez, 2000; Craik, Govoni, Naveh-Benjamin, & Anderson, 1996).

Experiment 7: Specific instructions

Experiment 6 revealed a significant effect of the target word on prospective memory performance, and this effect was ascribed to differences in typicality. In order to ascertain that it was not merely an effect of other word characteristics like familiarity or distinctiveness (McDaniel & Einstein, 1993), for example, two control conditions were run with other participants using the same target words but instructions that specifically mentioned the target words. If word characteristics other than typicality caused the difference in proportions in Experiment 6, we should find a similar effect with a specific instruction. However, if the difference in response rates were due to typicality in relation to the specified category, then we would not expect to find a difference in response rates when using a specific instruction.

As with specific instructions, no categorisation of target event needs to take place, a smaller effect of the cognitive load manipulation was expected than the one observed in Experiment 6, assuming that categorisation is indeed affected by cognitive load (Baddeley et al., 1984).

Method

Participants and design. Eighty undergraduates served as paid participants. The mean age was 21 years (SD = 2.2). They were randomly assigned to four conditions, determined by a 2 (target word: sparrow, owl) $\times$ 2 (cognitive load: low, high) factorial between-subjects design. Participants in the sparrow condition only saw *sparrow* and those in the owl condition only saw *owl*.

Procedure. Exactly the same procedure was used as in Experiment 6, except that now the prospective memory instruction was specific: “hit the enter-key as soon as you see the word *sparrow*” (or *owl*). The target word appeared both on the fifth and on the eleventh trial.

Results

Random and fixed interval generation. The regularity measures for the trials were computed as described in Experiment 6. A paired-samples *t*-test showed that participants’ tapping was significantly more regular during the fixed trials ($M = 0.11$, $SD = 0.05$) than during the random trials ($M = 0.40$, $SD = 0.15$), $t(79) = 18.73$, $p < .001$, demonstrating that participants were tapping fixed intervals and random intervals correctly.

Short-term memory. In a similar way as in Experiment 6, we computed two STM scores for each participant - one based on random tapping trials and one based on fixed tapping trials - and subjected these to a paired-samples *t*-test. Short-term memory recall was significantly worse for the random trials than for the fixed trials (68 and 72%, respectively), $t(79) = 3.90$, $p < .001$.

Prospective memory. All participants could repeat the prospective memory instruction during debriefing. The proportions displayed in Table 7 show that response rates for *owl* were higher than for *sparrow*. Indeed, an ANOVA on the number of responses (minimum 0, maximum 2) with target word and cognitive load as independent variables revealed a significant main effect of the target word, $F(1, 76) = 5.82$, $MSE = 52.90$, $p = .02$. The main effect of load, $F = 0.07$, and the load by target word interaction effect, $F = 0.29$, were not significant.

Table 7. Prospective memory responses rates as a function of cognitive load and target word.

Target word	Low load	High load
Sparrow	.60	.58
Owl	.78	.85

Discussion

As soon as typicality was no longer an issue (i.e. with specific instructions), the finding from Experiment 6 that *sparrow* was easier to respond to than *owl* disappeared. Under specific instructions *owl* was even easier to respond to than *sparrow*. We therefore may conclude that it was typicality itself that was responsible for the different response rates for the two target words in Experiment 6.

In a similar way as with the results from Experiment 6, we found no significant main effect of the executive load on prospective memory. As expected the effect was even smaller than with a categorical instruction. Also similar to Experiment 6 was that the taxing of the Central Executive had a significant effect on short-term memory performance: when participants had to tap random sequences they afterwards recalled fewer words than when they had to tap regular sequences.

Combined analysis of Experiments 6 and 7

Since this study addresses the role of the Central Executive in prospective memory and its central aim is to test whether an effect of taxing its availability depends on the type of prospective memory instruction, the results from Experiment 7 (specific instructions) were compared with the results from Experiment 6 (categorical instructions).

Except for the type of instruction, the materials and procedures of Experiments 6 and 7 were identical. In addition, the experiments were run concurrently with a random assignment of participants to experiments and conditions. The response rates under high and low load can therefore be analysed with the type of instruction as an additional independent variable. Note however that in Experiment 7 the same target word appeared on both trials, whereas in Experiment 6 a different word appeared on the second trial. For this reason only the response rates for the first target word were compared (see Table 8).

Table 8. Prospective memory response rates (for first target word only) as a function of cognitive load and type of instruction.

	All participants (N = 160)		Given first target word recalled (N = 133)	
Instruction	Low load	High load	Low load	High load
Categorical	.35	.20	.40	.28
Specific	.65	.65	.72	.79

Note: Columns 3 and 4 show the proportions when only analysing those participants who reported the target word on the short-term memory task.

As stated in the Introduction, we expected that cognitive load would have a larger effect on prospective memory with a categorical instruction than with a specific instruction. A logit analysis was performed with instruction, cognitive load, target word and all two and three-way interactions as predictors of a prospective memory response to the first target word (effect coding). Parameters are presented in Table 9 (column 'All participants'). The analysis revealed a significant main effect of instruction and a significant instruction by target word interaction effect.

Table 9. Parameter estimates (effect coded) based on logit analyses of prospective memory rates for first target words of Experiments 6 and 7.

Effect	All participants		First target word recalled	
Specificity	0.86	*	1.00	*
Cognitive load	-0.16		0.01	
Target word	-0.30		-0.32	
Specificity*Load	0.22		0.28	
Specificity*Word	-0.41	*	-0.58	*
Load*Word	-0.19		-0.17	
Specificity*Load*Word	-0.07		-0.15	

Note: One analysis is based on all participants (*N* = 160, column 2); another is based on only those participants who recalled the first target word in the short-term memory task (*N* = 133, column 3). Asterisks indicate statistical significance ($p < .05$).

Here, we have replicated the instruction effect that others found earlier (Einstein et al., 1995; Ellis & Milne, 1996; Cherry et al., 2001): an instruction that specifically mentions the target word results in better prospective memory than a more general instruction that only mentions the category that the target word belongs to. The significant interaction effect reflects the finding that a typicality effect was found in Experiment 6, showing that 'sparrow' was responded to more often, and that in Experiment 7, with a specific instruction, this effect was reversed.

Ongoing task performance

A repeated-measures ANOVA was carried out on short-term memory performance with instruction and cognitive load as between-subjects independent variables. Cognitive load had a significant effect on short-term memory performance: when tapping random intervals, participants recalled fewer words (66%) than when tapping fixed intervals (71%), $F(1, 158) = 32.80$, $MSE = 0.23$, $p < .001$. This effect was independent of the type of instruction: the interaction effect was not significant, $F(1, 158) = 0.08$. There was also a significant main effect of instruction on the general percentage of words recalled: participants with a specific instruction recalled more words (70%) than participants with a categorical instruction (67%), $F(1, 158) = 4.21$, $MSE = 0.94$, $p = .04$.

As both cognitive load and instruction had a general effect on the number of words recalled, it might also have affected recall rates for the target words. The number of times the first target word was recalled on the short-term memory task was therefore analysed. A logit analysis with effects of cognitive load, instruction and their interaction (effect coding) revealed no main effect of instruction, $B = 0.21$, $p = .35$, but a marginally significant effect of cognitive load, $B = -0.41$, $p = .07$: in the low load condition, 89 percent of the participants recalled having seen the target word, whereas in the high load condition this percentage was only 78. The interaction effect was not significant, $B = 0.08$, $p = .71$.

As people cannot be expected to respond to a cue that they do not perceive, we analysed prospective memory performance again but only for those participants of whom we are sure that they saw the target word. The same logit analysis on the prospective memory response rates was performed but now including only those participants who reported the target word in the short-term memory task. Results are presented in Table 9 (first target word recalled). Again, there was a significant main effect of instruction and a significant word by instruction interaction effect.

Table 9 shows that the main effect of cognitive load was now smaller than in the earlier analysis. This suggests that any effect that the manipulation might have had on prospective memory can be entirely attributed to an effect on processing of the prospective memory cue, as reflected by the marginally significant effect of load on recall rates of the target word. Manipulating cognitive load had no effect on prospective memory given that participants perceived the target word and could report them at the end of the trial.

General discussion

We tested the hypothesis that effects of manipulations of executive resources are dependent on the type of instruction: they were expected to be larger with categorical than with specific instructions. The availability of executive resources and instruction specificity were manipulated in two experiments, as well as the typicality of the target word in relation to the category mentioned in the categorical instruction. Based on the assumption that in the case of a categorical instruction more self-initiated processing is required for responding to atypical exemplars than for responding to typical exemplars, the largest effect of cognitive load was expected in a situation with a categorical instruction and a less typical exemplar as the target word.

No significant effect of the executive load manipulations on prospective memory was found, not even with a categorical instruction and a less typical exemplar as the target word. This makes it hard to draw any strong inferences. The main conclusions here will be those that can be drawn from Experiments 6 and 7. Chapter 5 contains a discussion of how these conclusions relate to the results from the previous chapters.

Instruction specificity itself had a clear effect on prospective memory response rates. Prospective memory performance was significantly better with specific instructions than with categorical instructions. This replicates earlier findings by McDaniel et al. (1995), Ellis and Milne (1996), and Cherry et al. (2001).

McDaniel and his colleagues (1995) ascribe the specificity effect to a greater need for self-initiated processing: with categorical instructions, prospective memory is more dependent on continuous strategic monitoring. This view is not supported by the current results, as there was no significant interaction between instruction specificity and cognitive load. This hypothesis deserves further scrutiny, however, as there was no main effect of cognitive load.

Furthermore, the specificity effect cannot be attributed to recognition processes as a result of having seen the target word in the instructions. If this were true, the same recognition process would have increased processing of the target word resulting in better recall rates on the short-term memory task. This was not the case.

The cognitive load manipulation affected the recall rates for the target words. In the high load condition, participants recalled fewer words than in the low load condition, and this was also true for the target words. So, load seems to have an effect on the processing of events that need to cue an intended action. It seems therefore that the role of the Central Executive is to monitor the environment for cues.

Chapter 5 GENERAL DISCUSSION AND CONCLUSIONS

Overview and discussion of the results

The seven experiments reported here were aimed at answering the general question of what processes can subserve prospective memory in different situations. The first three experiments, reported in Chapter 2, focused on the distinction between habitual/practiced versus episodic intentions. The experiments described in Chapters 3 and 4 focused only on episodic intentions.

Experiment 1 showed that practice can lead to facilitated response selection: responses become faster, more reliable and no longer dependent on the availability of cognitive resources. The fact that such acquired automaticity still depends on goal activation, was shown in Experiment 2. Experiment 3 showed that practice does not always facilitate performance.

Experiment 4 showed that categorisation of events that need to cue an action takes time, especially when dealing with events that are atypical in regards to the category. Experiment 5 showed that prospective memory performance is better when an event cue is described very specifically compared to when the same cue is only described in categorical terms. A manipulation of executive load did not have an effect on prospective memory performance, suggesting that prospective memory is not dependent on the availability of executive resources. In Experiments 6 and 7, a different load manipulation was used and typicality was introduced as an additional variable. Again, an effect was found of the type of description of the cue, categorical or specific. A main effect of typicality was also found: with a categorical description of the cue, prospective memory performance was better with a cue that was typical than with a cue that was less typical. However, in a similar way as in the previous experiments, no significant effect of the load manipulation was found.

Two central research questions were presented in the introductory chapter. Here, answers to those questions will be given.

Question 1 *Does frequent and consistent practice of an intention lead to habitual prospective remembering, rendering executive processes superfluous?*

Chapter 2 showed that when an intention has been acted upon frequently in the past, behaviour can change dramatically. The usual effects of practice were observed: responses became faster, they were no longer influenced by the demands of a secondary task (Experiment 1), and participants became worse at estimating the number of times they had acted on the intention (Experiment 2), suggesting a change in awareness level. By practicing an intention, responding seems to become automatised.

However, when dealing with a more everyday prospective memory task in which people need to remember to act on an intention while engaged in some other task, practice no longer has these typical effects on behaviour (Experiment 3). Performance can even break down due to underestimating the difficulty of the task. It seems that as soon as people are performing an unrelated ongoing task, they forget all about the intention. As a result, practice no longer facilitates performance, probably because the effects of practice on behaviour are goal-dependent. When the goal to act on the intention is not maintained and gets de-activated, the 'automaticity' acquired through practice disappears. It seems that the goal has to be reinstated again at the appropriate moment (cf. Smith, 2001), and this reinstatement was not practiced in the experiment.

How do these findings relate to the common intuition that in daily life, habitual intentions seem to be carried out more automatically than newly formed intentions? It is important to note that habitual intentions are embedded in daily routine, integrated in larger streams of action. The experienced automaticity turns out to be highly dependent on goals that are active at the time of action. Remembering to put the car keys in a designated place after using the car can become a part of the routine of coming home (opening the door, wiping your feet, hanging up your coat, etc.). Environmental cues and currently active goals together make it easier to remember the habitual intention, and once the related goal is reinstated, the action can be initiated effortlessly. As put by Ouellette and Wood (1998): "Habitual responses are likely to occur with minimal thought and effort to the extent that the contextual features integral to performing the response and one's behavioural goals are similar across time and setting" (p. 55). In other words, habitual prospective memory is characterised by goal-dependent automaticity.

In conclusion, mere practice of an intention, in terms of practicing a cue-action link, does not necessarily lead to habitual prospective remembering.

Question 2 *What role do executive processes play in prospective remembering?*

Executive processes might be involved in the processing of target events, self-initiated categorisation of stimuli, or a controlled memory search. These possibilities will be discussed below.

Processing of target events

Executive processes are involved in the processing of stimuli that might serve as cues for an intended action. Results from the prospective memory experiments in which a target event was embedded in an ongoing short-term memory task (Exps. 3, 5, 6, and 7) showed that when executive functions were heavily taxed, participants could recall fewer words and recalled the word that needed to trigger the prospective memory response less frequently than when executive functions were less heavily taxed. Only in Experiments 6 and 7 was the difference in short-term memory recall rates statistically reliable (many observations and within-subjects effects), but the pattern was similar across the experiments. Similar effects were also obtained by Marsh and Hicks (1998) and Vandierendonck et al. (1998).

The effects observed in the Marsh and Hicks experiment and in Experiments 3 and 5 of this thesis could be explained by articulatory suppression (Baddeley, 1990): because the RNG task requires participants to call out numbers, it was more difficult to retain verbal information about the words that were presented in the short-term memory task. Calling out more random numbers per time unit led to more articulatory suppression, thus affecting short-term memory.

However, articulatory suppression cannot explain the similar effects observed in Experiments 6 and 7 and in the Vandierendonck et al. (1998) study, because in those experiments, participants were generating random intervals, which does not require talking. The effect on short-term memory performance can therefore only be explained by effects on the *processing* of stimuli, not on retaining the information in working memory. This conclusion is supported by other studies showing that high cognitive load conditions can lead to blindness to highly familiar and meaningful words at the visual fixation point (Rees, Russell, Frith, & Driver, 1999; Mack & Rock, 1998; see also Duncan et al., 1996).

Thus, executive processes seem to play a role in the processing of cues that might be relevant for an intended action. Under high cognitive load conditions it is possible that cues are no longer perceived. This means that prospective memory may fail, not because of a memory retrieval failure or a problem with disengaging from the ongoing activity, but because the critical environmental conditions are not detected. Note, however, that the effects on the short-term memory measures were rather small, a three to seven percent decrease in the number of words recalled, and probably therefore not detected on the less sensitive prospective memory measure.

No evidence was found for the idea that executive resources need to be available to start up and/or execute a controlled memory search for information associated with a noticed event cue (Einstein & McDaniel, 1996). Once the target cue was noticed (and could be reproduced in the short-term memory task), there was no effect of the cognitive load manipulation. For a further discussion of this conclusion, see the section 'Prospective memory models revisited'.

Categorisation

Specificity. It was hypothesised that executive processes are responsible for the categorisation of events that need to cue an intended action. Categorisation is not a mandatory process: Experiments 5, 6 and 7 showed that acting on an intention is less successful when participants have to categorise target events than when participants know the exact target event in advance. This *specificity effect* has been demonstrated experimentally previously (Ellis & Milne, 1996; Cherry et al., 2001; Einstein et al., 1995). The specificity effect resembles the effects of *implementation intentions* (Gollwitzer, 1993, 1999): intentions in which the *when*, *where*, and *how* of the postponed action are fully specified. Their positive effect on carrying out intended activities has been shown by Gollwitzer and Brandstätter (1997), Aarts, Dijksterhuis, and Midden (1999), Brandstätter et al. (2001) and Chasteen et al. (2001), for example.

Several factors could explain the specificity effect. It can be argued that highly specific intentions lead to heightened mental accessibility of the specified environmental cues that need to trigger the intended action. In this way cues are more easily noticed. Smith (2001) however reports data that do not support this explanation. One would expect that words with a heightened level of activation would also be recognised faster. Smith found that words in a lexical decision task that needed to prompt an action were not responded to faster than control words. Alternatively, target words that have been mentioned specifically may create some sense of familiarity when they are encountered during the ongoing task, and may therefore attract attention. However, results from the experiments reported here do not support this interpretation. If specified target words were indeed to attract attention, this would also lead to increased processing of the target word, in turn leading to better recall for these words in the ongoing short-term memory task. This effect was not found here.

Another explanation for the specificity effect is that categorical intentions require more self-initiated processing than specific intentions do (Einstein et al., 1995). With categorically specified cues there is little or no environmental support (Craik, 1986): categorisation needs to occur spontaneously, without being prompted by an obvious external cue, and therefore requires executive resources. This hypothesis was tested in Experiments 5, 6 and 7, but was not supported by the results. With categorical instructions, no effect of taxing the Central Executive was found. However, as Marsh and Hicks (1998) found such an effect with categorical instructions, this hypothesis deserves further scrutiny.

So, if self-initiated processing cannot explain the observed specificity effect in the studies reported here, we need an alternative explanation. The fact that no effect was found of taxing executive resources suggests that the effect is not attributable to top-down influences; seemingly, participants were not actively categorising the words that were presented to them. Therefore, bottom-up processes must have caused the specificity effect. With a specific instruction, the cue must have served as a direct reminder of the intention, not because it created a sense of familiarity or attracted attention, but simply because there was already a strong mental association between the word and the intended action, which was absent with a categorical instruction.

The specificity effect can be explained by activation spreading from an activated node representing the prospective memory cue through an associative network (e.g. Collins & Loftus, 1975; Anderson, 1983). With a categorical instruction, an associative link is created between a category of cues (e.g. birds) and an intended action (e.g. to press a key). On the other hand, with a specific instruction, an associative link is created between a specific cue (e.g. sparrow), and an intended action. When the target cue comes along, an activation model predicts that more activation spreads to the representation of the intended action when there is a direct association. In the case of a categorical instruction, activation first needs to spread to the category (or categories) associated with it, after which activation spreads to the representation of the intended action. In the case of a specific intention, the intended action is more easily activated, therefore, and more easily 'springs to mind'.

To summarise, specifying the exact situation in which an action is to be carried out has a positive influence on performance. However, there is no evidence for the claim that the right cues are more easily noticed, or that the effect is related to a lesser need for top-down processing. It is more likely that the effects observed here are due to bottom-up processes enabled by specific information about the cues.

Typicality. Not only was prospective memory worse with categorical instructions, but the performance further deteriorated when the target cue was an atypical exemplar of the specified category (Experiment 6). In a similar way as for the specificity effect, this typicality effect was not shown to be related to the availability of executive resources. The same activation model can explain the typicality effect: activation spreads more easily from an exemplar to some category if the exemplar is highly associated with it (i.e. is typical) than if the exemplar is not strongly associated with it. Such a stronger link can be the result of *conjoint frequency* (the number of times that two words co-occur) or related to the *prototypicality effect* (Rips, Shoben, & Smith, 1973; Rosch, 1973). This type of associative network model also accounts for the results of Experiment 4: given that participants are categorising words, this can occur faster with typical exemplars with a strong link than less typical exemplars with a weaker link to the category in question.

Although Mäntylä (1994) was right in supposing that typical targets provide more retrieval support than less typical target words, there is no evidence for the idea that this is related to a requirement of self-initiated processing, since typicality effects did not interact with the demands of the ongoing activity.

Mäntylä's study was aimed at testing the hypothesis that age-related decline in prospective memory performance is related to diminished self-initiated processing. Under the assumption that atypical target cues require more self-initiated processing, both typicality and age were varied in a prospective memory task with categorical instructions. An interaction effect was indeed found. However, if, as the present results suggest, typicality effects in prospective memory are not related to self-initiated processing but age effects are (Craik, 1986), this provides some clues as to why Mäntylä's (1994) results were not replicated by Cherry et al. (2001). The two studies found different age by typicality interaction patterns. Taking into account the different experimental set-ups, it can be concluded that the interaction effects are not explained by self-initiated processing.

In summary, the results suggest that participants did not deploy any executive resources to categorise stimuli. If this were true we would have seen good performance under low load conditions and worse performance under high load conditions.

Executive resources and strategy

A common notion is that people make more errors or become more forgetful when they are distracted (Reason, 1990). Attentional distraction has been shown to result in increased error rates on a number of tasks that do not involve prospective memory. But also with prospective memory tasks, people promise to do something, but the next day they may excuse themselves by saying: "Sorry I was so involved in other things that I forgot all about it."

In the research presented here, cognitive load manipulations were aimed at influencing the availability of executive resources at the time that a stimulus needed to cue an action was present. Although there is some evidence that this availability had an effect on prospective memory, by influencing the processing of stimuli, the effects on the whole were rather small. Importantly, the significant effect on general prospective memory performance reported by Marsh and Hicks (1998) could not be replicated.

Marsh and Hicks (1998, Exp. II) used the RNG task, which involves monitoring (Miyake et al., 2000). Note that monitoring is a matter of strategy: people can choose to monitor for a specific target event or choose not to and hope that when the event occurs the intention is automatically remembered. If rapidly generating numbers makes it impossible to monitor for a target event, this does not mean that people are monitoring when they are generating numbers at a slower pace. The fact that participants performed better on the two ongoing tasks (RNG and short-term memory) compared to the Marsh and Hicks experiment suggests that participants deemed performance on these to be more important than performance on the prospective memory task (relative to Marsh and Hicks' participants). It is important to note here that in this research and the experiment of Marsh and Hicks the instructions were given in a similar way: it was stressed that all three tasks were equally important. Seemingly, an experimenter has only limited influence on the way that participants handle the tasks. Participants may have their own interpretation of what is equal with regards to the use of cognitive resources.

In Experiment 6 the availability of executive resources was manipulated in a different way, using the random interval generation task. The experimental procedure was also altered in other ways, aimed at making strategic monitoring for the prospective memory target event more likely. The load manipulation was based on the assumption that this task requires executive processes supported by the Central Executive (Vandierendonck et al., 1998; Vandierendonck, 2000), and regular interval generation does not or does so to a much lesser degree. There is evidence that random interval generation negatively affects the possibility to inhibit prepotent responses such as saccadic eye movements (Stuyven, Van der Goten, Vandierendonck, Claeys, & Crevits, 2000) and disrupts monitoring for repetitiveness (Vandierendonck, 2000). Although the effect was now in the hypothesised direction, there was still no significant effect on general prospective memory performance. This might indicate that the manipulation was too subtle, perhaps because executive resources were also taxed in the low load condition due to task-uncertainty (alternating fixed and random tapping; cf. Marsh et al., 2002). But again, it might be related to strategy: if participants chose not to monitor, then no or only few executive resources would be deployed even in the low load condition. Participants may have relied more on bottom-up processes, which are not well supported in the case of a categorical instruction.

Thus, the *availability* of executive resources is only important if people *engage* in monitoring. If this interpretation is correct, one can conclude that Marsh and Hicks (1998) did not establish that prospective memory depends on executive functions, but rather that their participants tried to monitor in order to comply with the prospective memory instruction.

The findings are in line with the observation made by McDaniel and Einstein (2000), that whether prospective memory relies on executive processes depends on a lot of different factors. According to them, one should not ask whether executive load affects prospective memory but instead which types of prospective memory tasks are particularly sensitive to executive load. It is most likely that tasks that seem to be difficult and deemed very important are more likely to be affected by executive load than tasks that seem to be easy and well-supported by the environment.

Prospective memory models revisited

In Chapter 1, two models were described that focus on how an intention is retrieved from memory once the pre-specified target event takes place. The Noticing+Search model (Einstein & McDaniel, 1996) hypothesises a rather automatic stage of recognising a target event on the basis of some feeling of familiarity, after which a controlled stage is initiated in which memory is searched for the significance of this feeling of familiarity. In contrast, the automatic associative memory system model (McDaniel et al., 1998) supposes that memory retrieval is an obligatory process requiring no cognitive resources once the target event has been processed to a sufficient degree.

Apart from an effect on processing of environmental stimuli, there was no effect of the load manipulation on prospective memory. This implies that retrieval of the intention from memory does not require the availability of executive resources, which is in line with the automatic associative memory system model.

Note, however, that this does not imply that the Noticing+Search model is incorrect. The existence of a controlled memory search once a target event is noticed cannot be tested by manipulating the availability of cognitive resources. Although controlled, it may still be initiated and completed obligatorily. The same reasoning can be applied to the Norman and Shallice (1986) model of action control. It is highly likely that the claim that departing from custom always requires executive processes is true. It is possible that executive resources are needed for additional processing once the intention is retrieved from memory: the intention needs to be held in working memory while the ongoing task needs to be interrupted, after which the intended behaviour needs to be initiated (Guynn et al., 2001). The fact that no effect of an executive load manipulation was found, does not disprove this claim, as executive processes can be called upon obligatorily. Therefore, as long as no precise analysis of performance on concurrent tasks is made, the discussion about the need for cognitive resources is not advantageous when dealing with cognitive load manipulations. Making a distinction between top-down and bottom-up processes is more fruitful. The results suggest that bottom-up processes alone can support prospective memory.

The automatic associative memory system model can explain the instruction specificity effect: the target event can trigger the intended action directly in the case of a specific instruction, but only indirectly via the associated category in the case of a categorical instruction. Furthermore, it accounts for the typicality effect, as there is a weaker association between a category and an atypical exemplar than between a category and a typical exemplar. The Noticing+Search model in combination with the assumption of an obligatory search, cannot readily explain the typicality effect.

The automatic associative memory system model addresses only the retrieval of the intention from memory given a specific cue. It is insufficient as it does not incorporate strategic effects leading to top-down influences on prospective memory performance, and therefore cannot explain why some other studies have found effects of cognitive load manipulations. Strategic influences on prospective memory, such as those related to perceived difficulty, importance, and expected frequency of the target event, have received only limited attention in cognitive approaches to the problem of how intentions result in actions (Marsh, Hicks, and Landau, 1998; Brandimonte et al., 2001). If more motivational elements and issues like expectation were incorporated into the cognitive theories, we might even solve one of the more difficult problems in the field, namely how to distinguish prospective memory tasks from vigilance tasks. This issue is resolved when we realise that ultimately it is the *participant*, not the researcher, who determines whether an experiment addresses prospective memory or vigilance. More generally, a psychology aimed at discovering the mental processes that direct everyday behaviour is bound to fail when it does not acknowledge that people interpret instructions and determine their strategy, and therefore to some extent choose what mental processes they deploy.

The limits of the automatic associative memory system model are also obvious when dealing with the issue of practice. The model predicts that when cue and intended action are highly associated, the intended action will be retrieved automatically when the cue is sufficiently processed. However, Chapter 2 showed that practice does not lead to better prospective memory performance when engaged in an unrelated ongoing task. A strong association between cue and action is obviously not sufficient for acting on a previously formed intention. It seems that ‘the retrieval of an intention’ imports much more than simply the activation of the representation of an action that needs to be carried out. The data from Experiment 3 suggest that we need to assume a more complex mechanism underlying the transformation of an intention into action than the one set forth in the automatic associative memory system model.

Also the idea that representations of intentions have a special dynamic status in memory (Goschke & Kuhl, 1993) cannot account for the absence of a positive effect of practice. Even if it is true that representations of actions reside in memory at a high level of activation, as suggested by the intention superiority effect, they do not seem to control the initiation of that action given the perception of a cue. The model for habitual prospective remembering proposed in Chapter 2 might serve as a stepping stone for further research on how intention, action, and practice relate to each other, and for prospective memory research in general.

In concluding this thesis, I would like to stress the importance of a clear conceptualisation of intention when studying prospective memory. For example, what is actually meant when one says, “An intention is retrieved from memory”? Descriptions are often vague and imprecise. Numerous philosophical analyses of the intention concept already exist and it would be very interesting if psychologists could translate these ideas into empirical terms.

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Samenvatting (summary in Dutch)

Dagelijks nemen we ons voor nog iets te doen. Onderweg naar huis moeten we nog langs de winkel voor een pak melk, we willen vanavond nog even iemand bellen, en morgen op het werk moeten we een afspraak met iemand maken. Al deze gedragsintenties onthouden is lastig; het is niet voor niets dat we gebruik maken van agenda's en krabbeltjes op kladblaadjes.

Geheugen voor gedragsintenties wordt ook wel prospectief geheugen genoemd. Onderzoek naar prospectief geheugen richt zich in het algemeen op de vraag hoe men zich gedragsintenties op tijd herinnert; wat bepaalt nu of we ons een voorgenomen handeling nu wel of niet tijdig herinneren en uitvoeren? Dit proefschrift richt zich op cognitieve obstakels op de weg van intentie naar gedrag. Er worden zeven laboratorium-experimenten beschreven. Proefpersonen waren hoofdzakelijk studenten van de Technische Universiteit Eindhoven, die allen een instructie kregen om bij een bepaalde gebeurtenis een simpele handeling uit te voeren.

Hoofdstuk 1 geeft allereerst een beschrijving van het begrip intentie. In dit proefschrift wordt slechts gesproken over gedragsintenties die gekoppeld zijn aan een gebeurtenis, zoals bijvoorbeeld het voornemen om zodra wij een zeker persoon tegenkomen een boodschap door te geven. Na de begripsbepaling volgt een overzicht van de meest gangbare modellen voor prospectief geheugen. Een algemene gedachte is dat executieve processen, verantwoordelijk voor de controle van gedrag op hoog niveau, erg belangrijk zijn bij het zich op het juiste moment herinneren van een intentie en het uitvoeren van het voorgenomen gedrag. Dit proefschrift zet enkele kanttekeningen bij deze stelling; immers, mensen kunnen op verschillende manieren met voornemens omgaan. Strategie is dus een belangrijke factor. Welke processen een doorslaggevende rol spelen bij het zich tijdig herinneren van intenties kan ook sterk afhangen van eigenschappen van de intentie zelf. De experimenten die in de volgende hoofdstukken worden beschreven, richten zich op twee karakteristieken van intenties, namelijk a) of het voorgenomen gedrag al eerder frequent is uitgevoerd (Hoofdstuk 2), en b) de mate waarin de gebeurtenis waarbij het voorgenomen gedrag moet plaatsvinden van tevoren specifiek is omschreven (Hoofdstukken 3 en 4).

Hoofdstuk 2 geeft een beschrijving van drie experimenten die ingingen op de vraag of veelvuldig en consequent handelen naar een intentie leidt tot gewoontegedrag, dat wil zeggen, een bepaalde automaticiteit in het uitvoeren van handelingen. Indien dit het geval is, moet dit tot gevolg hebben dat executieve processen veel minder belangrijk worden. Experiment 1 liet zien dat het oefenen van een voornemen om bij een specifieke stimulus een respons te geven, leidt tot sneller en efficiënter gedrag: er werden minder fouten gemaakt en reactietijden werden korter. Tevens bleek dat, na oefening, mensen helemaal geen last meer hadden van het gelijktijdig uitvoeren van een andere taak waar executieve processen voor nodig waren. Dit wijst er op dat, na oefening, executieve processen inderdaad minder belangrijk worden bij het uitvoeren van voorgenomen gedrag.

Ook Experiment 2 liet positieve effecten van oefening zien. Deze effecten bleken echter wel afhankelijk te zijn van doelen die proefpersonen hadden. Oefenen had vooral snelle reacties tot gevolg wanneer mensen zeer expliciet geïnstrueerd werden om op een zekere stimulus te reageren. Er kwam ook naar voren dat oefening leidt tot het achteraf onderschatten van het aantal keer dat gehandeld is naar de intentie, wat suggereert dat na oefening mensen minder bewust zijn van het uitvoeren van het gedrag. Samengenomen suggereren de resultaten van Experimenten 1 en 2 dat het veelvuldig uitvoeren van een intentie leidt tot een zekere automatisering van het gedrag: reacties worden sneller, betrouwbaarder, en men wordt zich minder bewust van het uitvoeren ervan. Echter, er lijkt toch een zekere doelafhankelijkheid te bestaan. Experiment 3 liet daarna zien dat er eigenlijk helemaal geen automaticiteit is als gevolg van oefenen. In dit experiment moesten mensen ook met een respons op een stimulus reageren, maar gedurende langere tijd waren ze bezig met een andere taak. Toen de stimulus pas na minuten verscheen, waren er juist veel mensen die oefening hadden gehad die vergaten op de stimulus te reageren. Dit is dus een negatief effect van oefenen op prospectief geheugen en waarschijnlijk het gevolg van een onderschatting van de moeilijkheid van de taak. Maar tevens lijkt het zo te zijn dat zogauw mensen zich niet meer bewust zijn van het doel om te reageren, er ook geen automaticiteit is in het gedrag.

Uit Experiment 3 bleek niet dat executieve processen van cruciaal belang zijn bij het uitvoeren van een intentie. Het is mogelijk dat dit komt omdat de situatie waarin het gedrag moest plaatsvinden van tevoren heel specifiek was omschreven. Wellicht dat executieve processen belangrijker worden wanneer de precieze gebeurtenis waarbij een handeling moet plaatsvinden vooraf niet helemaal duidelijk is. Want waar zijn executieve processen eigenlijk voor nodig? Mogelijkerwijs zijn ze verantwoordelijk voor het in de gaten houden of een bepaald situatie of gebeurtenis zich voordoet. Dit is onderzocht in Hoofdstuk 3. Na vastgesteld te hebben in Experiment 4 dat het categoriseren van gebeurtenissen toch lastig is, vooral als de gebeurtenis waarbij een intentie ten uitvoer moet worden gebracht een niet zo typisch geval is van de categorie die is omschreven, is getoetst in Experiment 5 of executieve processen belangrijker worden bij een categorisch omschreven gebeurtenis. Denk bijvoorbeeld aan een intentie zoals het doorgeven van een boodschap als je één van je collega's ziet (categorisch omschreven situatie) of als je Frans ziet (specifiek omschreven situatie), en de kans dat je je de boodschap herinnert op het moment dat je Frans, die een collega van je is, werkelijk tegenkomt. Uit de resultaten bleek dat de intentie vaker tot gedrag leidde bij een specifiek omschreven gebeurtenis dan bij een categorisch omschreven gebeurtenis, maar er was geen ondersteuning voor de gedachte dat het categoriseren van een situatie als een situatie waarin gehandeld moet worden afhankelijk is van de beschikbaarheid van executieve processen, noch dat deze beschikbaarheid überhaupt van belang is voor prospectief geheugen taken.

Zoals gezegd had Experiment 4 laten zien dat categorisatie vooral een probleem is bij atypische voorbeelden van een categorie. Daarom gaat Hoofdstuk 4 nogmaals in op de vraag of executieve processen van belang zijn voor het categoriseren van gebeurtenissen, nu echter in het geval van atypische gebeurtenissen. In Experiment 6 werd een kritieke gebeurtenis categorisch omschreven en werd nagegaan of mensen de intentie uitvoerden als een typische gebeurtenis zich voordeed en als een atypische gebeurtenis zich voordeed. Het bleek dat mensen vaker de intentie vergaten bij de atypische dan bij de typische gebeurtenis, maar er was geen bewijs voor de hypothese dat de beschikbaarheid van executieve processen van cruciaal belang is voor het prospectief geheugen. Experiment 7 liet zien dat mensen bij een specifiek omschreven gebeurtenis veel minder vaak de intentie vergeten dan bij een categorisch omschreven gebeurtenis, maar er was geen bewijs voor de hypothese dat dit te maken had met executieve processen.

Hoofdstuk 5 resumeert de resultaten en geeft antwoord op de centrale vragen van het proefschrift. Oefening baart kunst, luidt het adagium, maar kennelijk is dit niet het geval wanneer we te maken hebben met gedrag dat we voornemens zijn in de toekomst uit te voeren. Oefening kan leiden tot onderschatting van de moeilijkheid van het zich op tijd herinneren van een intentie en daarmee tot een kleinere kans dat voorgenomen gedrag wordt uitgevoerd. Er is geen sprake van automaticiteit als gevolg van oefening zodra men, in afwachting van het juiste moment, langere tijd met ongerelateerde taken bezig is.

Uit de experimenten is niet gebleken dat executieve processen noodzakelijk zijn voor het categoriseren van gebeurtenissen die mogelijk cruciaal zijn voor de uitvoering van voorgenomen gedrag. Bovendien was er geen bewijs voor het idee dat executieve processen nodig zijn voor het uitvoeren van voorgenomen gedrag. Hier moet wel de kanttekening gemaakt worden dat in de experimenten slechts de beschikbaarheid van executieve processen is gemanipuleerd; zeer waarschijnlijk zijn executieve processen wel nodig voor het onderbreken van de huidige taak en het initiëren van het voorgenomen gedrag, maar worden ze automatisch ingezet. In ieder geval zou men op basis van de huidige experimenten wel voorzichtig de conclusie kunnen trekken dat bij het optreden van een intentie-gerelateerde gebeurtenis het niet uitmaakt of de aandacht nu weinig of veel is afgeleid: bij veel afleiding wordt de kans niet kleiner dat voorgenomen gedrag uitgevoerd wordt.

Deze conclusie is echter in strijd met eerder onderzoek waaruit bleek dat een manipulatie van de beschikbaarheid van executieve processen wel invloed heeft op prospectief geheugen. Een nadere vergelijking wijst uit dat deze discrepantie mogelijkerwijs te maken heeft met strategieën die mensen toepassen: wanneer het onmogelijk wordt executieve processen in te zetten voor een prospectief geheugen taak, leidt dit alleen tot slechtere prestaties wanneer überhaupt gepoogd wordt ze in te zetten. Als mensen al onder 'normale' omstandigheden geen executieve processen inzetten in afwachting van een intentie-gerelateerde gebeurtenis, dan heeft extra afleiding waarschijnlijk geen effect.

De manipulatie van de beschikbaarheid van executieve processen had wel een effect op het waarnemen van de specifieke gebeurtenis waarbij de handeling moest plaatsvinden. Dit effect was echter zo klein dat het niet leidde tot meetbare effecten op de kans dat de voorgenomen handeling werd uitgevoerd. Het effect doet denken aan ander onderzoek waar is aangetoond dat cognitieve belasting kan leiden tot het blind worden voor stimuli die zich midden in het gezichtsveld bevinden.

Het proefschrift eindigt met een evaluatie van de verschillende modellen voor prospectief geheugen die in Hoofdstuk 1 waren besproken en een oproep tot een betere conceptualisering van het begrip intentie.

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