GENERAL INTRODUCTION

Did you turn off the stove before leaving home today? Did you remember to lock the door? When you last entered a room, did you push or pull the door open? These are examples of actions that you may need to remember that you have performed. They are examples of self-performed actions. The present thesis is about the memory for self-performed actions and how it differs from some other types of memory. Admittedly, my research, like most other research in this field, is not as concretely linked to everyday situations as the examples above. In the laboratory, the traditional approach has been to have subjects enact very simple actions in order to support the verbal retention of them. This thesis will allow you to gain a certain insight into the factors that affect this type of recall, and you may find them as interesting as I have. But before introducing you to the fascinating field of self-performed actions, this general introduction will guide you through some basic concepts within memory research. I will briefly describe how these concepts relate to each other and to self-performed actions. Finally, in order to clear up any confusion that may still remain, there will be a few short words on what this thesis does not encompass.

In your everyday life, you most likely talk about remembering and forgetting quite frequently. Such reflections can refer to a wide variety of experiential phenomena. The goal of scientific research is to describe all the varied memory-related phenomena and their relations in an organized and comprehensive way. This goal is not yet reached. A basic query is whether memory should be considered as a unitary concept or if different subjective experiences also reflect fundamentally different memory systems. Personally, I find the conceptualization of separate systems very useful. Several accounts of the systems underlying memory have been proposed throughout the history of memory research. I will use the approach offered by Tulving (1972), which is also the most dominant view amongst contemporary researchers.

The original theory by Tulving (1972) has undergone several stages of further development. Schacter and Tulving (1994) proposed that human memory should be divided into a set of hierarchical systems. Within long-term memory, they propose a procedural system, a perceptual representation system (PRS), a semantic system, and an episodic system. Before briefly describing each of these, I want to stress that these systems are to be regarded as functionally separate from each other but interacting. Each of these is specified with regard to the type of information it processes, its principles of operation, and the neural mechanisms subserving it. Types of processes, forms of information, and types of expression can be shared amongst systems, however.
The procedural system is the one least explored, although it is considered to be the oldest phylogenetically and autogenetically. It is not yet as well defined nor divided into subsystems as the other systems are. The types of information that most generally are considered procedural are motor skills and simple associative learning. It is also the only memory system with a non-cognitive output, although this system has output on the cognitive level as well, in the form of cognitive skills. The PRS works with very simple pre-semantic types of information. The output of PRS consists basically of the identification of words and objects through the automatic and unconscious processing of sensory input. The output from this system is typically involved in unconscious cognition such as priming. The subsystem of face identification (not face recognition) can serve as an example of PRS memory. Semantic memory is concerned with the general facts of the surrounding world. The semantic memory system is relatively advanced, and is involved in the acquisition and retention of knowledge. Such knowledge is registered without the context of time and space. Recognizing a famous person you have never met, or knowing that dogs and cats are animals, can serve as simple examples. In daily living it is used for navigating in the environment. The system is general in the sense that it does not include the specificity of time and space for the content. Finally, the episodic memory system is the masterpiece of human memory. It has developed from semantic memory (Schacter & Tulving, 1994), but has the unique ability to embed personal space and time into the memory content. It enables us to remember what we have experienced, whether it be related to one’s childhood or a particular aspect of waking up this morning. In binding together an experienced event, the episodic memory uses many types of information, including contextual, spatial, and temporal. The fact that it is the most advanced memory system also makes it the most prone to disruption.

These four long-term systems developed hierarchically from being less advanced to more advanced in the order that they were described—both within a child’s development as well as within the development of the human species. As mentioned, the systems are interactive and each higher system is supported by the lower system or systems. Each system can additionally be divided into subsystems. Subsystems within a major system share the same principal rules as the major system but can process different kinds of information.

In addition to these four long-term memory systems, a working memory system has also been conceptualized. The working memory system is unique in that it is employed in the temporary holding and processing of information. It can store various kinds of information and utilize it in performing cognitive tasks. It, however, does not retain information over a longer period of time if the information is not kept active. The working memory is the only system, besides the episodic system, that enables the conscious recollection of personal experiences.
It is important to mention that the number and nature of memory systems is not fully established, and will still be revised. This is even more the case when it comes to our knowledge of the interactions between the systems. However, the systems as proposed by Schacter and Tulving (1994) are differentiated by their operating within specific domains, having unique properties, and showing dissociations in varied memory tasks or brain injuries.

In addition to the different memory systems, there are a few more good-to-know concepts within memory research. Two separate types of memory expressions are frequently referred to; they are known as implicit and explicit expressions (Graf & Schacter, 1985; Schacter, 1987). Implicit memory refers to the effects of a lower level of unintentional and unconscious processing. It is unconscious in that the processes cannot be consciously monitored or verbally described by subjects. In contrast, explicit memory refers to one’s conscious and intentional memory. The terms mainly reflect a behavioral distinction and not a distinction between systems. However, the accounts above reveal that the lower memory systems are more frequently expressed through implicit processes and the higher through explicit.

Moreover, it is good to keep in mind that the process of remembering can be divided into separate phases. The memory systems function by encoding, storing, and retrieving information. These phases are independent in the sense that they can be affected independently. However, overlap between encoding and retrieval processes is considered important for memory performance. Tulving and Thomson have delineated the interaction between encoding and retrieval processes in their encoding specificity hypothesis (Tulving & Thomson, 1973). An important realization is that a failure on a memory test can be caused by any or all of these phases.

The studies included in the present thesis examine memory for self-enacted action sentences. Memory is hence tested for what action was performed at encoding, rather than how they were enacted. At retrieval, subjects typically retrieve the action sentences verbally. These processes belong to the episodic memory system insofar as they concern the personal experience of what action was done. This indicates that subjects are able to utilize explicit processes in recalling what actions they have performed. But it also means that the most sensitive system is being employed, which may leave the memory susceptible to influence. As with other episodic memories, self-performed action should be supported by information from the semantic system. The tendency to use previously known knowledge when acquiring new memories is an inherent quality of episodic and semantic memory. When the same behavior is applied more deliberately (explicitly) it is called elaborating or using a strategy.

Much of our basic knowledge of human memory is derived from the study of verbal learning. Before the postulation of memory systems, the main scientific distinction stood between verbal and non-verbal memory. This has
largely influenced the methodology and theories of memory research in a historical perspective. The majority of episodic memory research has therefore been based on the retrieval of word lists. One direction that modern cognitive science has taken is to study memory in regard to more lifelike episodes. Results from such studies are often compared to findings from traditional verbal learning in order to better understand the similarities and differences. There are, however, many limitations to experimental memory studies when it comes to their ability to mimic real life memory and learning. Real life experiences take place in a complex setting of internal and external contexts. These additional factors usually can serve as support for better memory encoding or as cues for better memory retrieval. To be able to draw conclusions on cause and effect in such a complicated context, scientists often study one or perhaps two factors at a time. This is a trade-off that is made to preserve the replicability and controllability that are landmarks of so called positivistic science. Self-performed actions can, in this way, be regarded as a way of adding a new dimension to the traditional verbal learning domain. Self-performing action sentences at encoding add, at least, the aspects of motor activity and being the actor to the learning process. Other extensions of verbal learning theory have been studied within a paradigm of visual imagery (e.g., Paivio, 1971), for example.

Lastly, a few words on what is, and what is not, studied in the present thesis are due. The statement that “action is action is action” may possibly be true in the video rental store, but not in human behavior. In cognitive psychology it is important to distinguish between types of action, such as activity (cognitive action), motor skills, specific action episodes, and actions to be performed in the future. Each of these is a separate phenomenon in regard to memory, but they are also related to each other. The kind of memory studied within this thesis does not concern motor skills, as in learning to ride a bike, or cognitive action. The actions at issue in the present thesis are previously self-performed specific actions. Performing such actions is dependent on several different types of information and activates several memory systems. Procedural knowledge of how the overt movements are done and coordinated, semantic knowledge about the action in general, and episodic knowledge of previously having performed the action are activated in parallel. All these types of information may come into play when subjects are later trying to remember what actions they had previously performed. In the present thesis, the focus is on the memory for “what action was done” and comparing self-performing to verbal learning. A general question in this research paradigm is whether the interaction between procedural, semantic, and episodic information is different in self-performed actions than in verbally studied actions. The specific questions to be addressed in the present thesis concern the contribution of motor modality and the effects on associative information.
INTRODUCTION TO THE PARADIGM OF SUBJECT-PERFORMED TASKS

Early findings

The experimental study of memory for self-performed action was initiated in the early 1980s. Independent of each other, two groups of researchers with different purposes conducted similar experiments (Cohen, 1981; Engelkamp & Krumnacker, 1980). Engelkamp and Krumnacker were interested in exploring what possible role motor modality played in episodic memory performance, whereas Cohen wanted to test whether verbal memory laws could be generalized to a situation that involved subjects interacting with the environment. In order to do this, participants were instructed to learn short sentences that described mini-actions. Essentially, the actions to be learned were verb-noun pairs as 'break the match' and 'lift the book', for example. Some of these action sentences were to be performed (i.e., enacted) by the subjects at the study session (subject-performed tasks, SPT), whereas others were only presented as verbal materials (verbal tasks, VT). Subsequently, the participants were asked to free recall as many of the studied sentences as they could. The results were very interesting. Both research groups reported a marked difference in the number of sentences retained, depending on whether they were enacted at encoding or not. In Engelkamp and Krumnacker’s experiment, for example, an average of 62 percent of the enacted sentences were recalled, whereas the percentage was 45 for non-enacted sentences.

These results, naturally, motivated other research groups to invest time into SPT research. SPT did not seem to be affected by whether the to-be-remembered materials were changed to bizarre phrases (e.g., Knopf, 1991), or whether only imaginary objects were used (e.g., Engelkamp & Krumnacker, 1980; Engelkamp & Zimmer, 1983), or whether memory was tested for single verbs, nouns, or whole sentences (e.g., Engelkamp, 1986). The SPT advantage over VT was nearly always considerable. The test conditions were also varied with regard to subjects’ intention to learn (Bäckman, Nilsson, & Kormi-Nouri, 1993; Kausler & Hakami, 1983) and support during testing (free recall, cued-recall, recognition) (e.g., Kormi-Nouri, 1995), but the results always favored SPT over VT. Not even switching the test subjects, from students to children (Cohen & Stewart, 1982), elderly (e.g., Bäckman & Nilsson, 1984), mentally retarded subjects (Cohen & Bean, 1983), or memory impaired subjects (Karlsson, Bäckman, Herlitz, Nilsson, & et al., 1989), seemed to negate the SPT effect. These results were extraordinary since nearly all previously studied episodic memory functions were commonly accepted as being susceptible to such changes in conditions. Moreover, it was
found that self-initiated rehearsal of the first item in a list normally lead to better retention of this item. This primacy-effect did not surface in SPT encoding (Cohen, 1981; Helstrup, 1986). This led several researchers to believe that performing actions automatically constituted an almost perfect encoding situation, leaving little room for additional improvement from individual advantages or strategies. In light of the results that had been demonstrated, the notion of an automatic activation of non-strategic encoding was postulated for SPT learning (Cohen, 1981; 1983). In this non-strategic approach, it is held that subjects do not need intentional encoding strategies in order to improve their memory when actions are performed. Further support for the non-strategic view came from several studies that involved manipulating the subjects’ strategic processing of to-be-remembered items. For example, the amount of elaboration of items was increased (e.g., Helstrup, 1987), the time of study was increased (Cohen, 1985), and subjects were made to generate the to-be-remembered items themselves at encoding (Nilsson & Cohen, 1988). All these modifications had been known to improve traditional verbal memory, but in SPT they produced only minor supportive effects, if any.

In order to understand the SPT effect, it was important to identify the procedural conditions and memory functions that would not give rise to an SPT advantage. Most reports of unimproved or diminished memory for SPTs concerned aspects of associative information. When tasks were constructed to be more dependent on associations between unrelated concepts, or measuring associative information, SPTs were not better than VTs in the initial studies. Engelkamp showed that this was the case with pair-associated learning, in which one verb is associated with another verb at encoding and then later used as a cue for recall (Engelkamp, 1986). Another type of association, serial order association, is assessed by asking subjects to order the to-be-remembered items in the same order as at encoding (i.e., serial recall). Performance on this task was found to be equal for SPTs and VTs (Olofsson, 1996). Similarly, the association between item and context was not improved in SPT experiments. This was determined by comparing the memory for self-positioned objects in space to the visual memory for objects in space (Zimmer, 1994; 1996), and by observing the recollection of the context in which items were studied (i.e., source memory) (Koriat, Ben-Zur, & Druch, 1991).

**Theoretical explanations**

The mechanism working in SPT can be one of several, or a combination of many. A closer look at real life action reveals some of the factors that appear as candidates. Real life actions are done motorically; they
interact with the environment; they are goal directed, self-motivated and self-generated, and there is feedback on the outcome. Some of these factors are also prominent in the laboratory setting of action studies, whereas others are dominant only in a real life setting. Many researchers have contributed to the body of SPT results and theories. The following brief review focuses only on some of the most influential theories that are well related to the empiric studies that will be presented later in the present thesis. Considering the multitude of possible contributors to the SPT effect, it is not surprising that several other theoretical approaches were developed (e.g., Kausler, Lichty, Hakami, & Freund, 1986; Knopf & Neidhardt, 1989; Nyberg & Nilsson, 1995)—and still are being developed (e.g., Koriat & Pearlman-Avnion, 2003; Steffens, 1999).

Engelkamp and Krumnacker (1980) attributed the SPT effect to the physical enactment by subjects and named it the enactment effect. They found support for this in a comparison between SPT and a mental imagery condition. A group of participants had been instructed to imagine themselves performing the actions denoted in the test sentences. This group had a recall percentage that was greater than for the VT condition but poorer than for the SPT condition. They also had included a comparison condition in which subjects watched actions performed by others, on videotape. This condition, named experimenter-performed task (EPT), likewise produced a result that was poorer than for the SPT condition. Hence, Engelkamp and Krumnacker concluded that something other than mental imagery or perception of action was causing the SPT advantage.

Cohen, too, asserted that a motor component in the memory trace was part of the SPT effect, but only in his later explanations (Cohen, 1989). Cohen’s initial interpretation of his own results (Cohen, 1981; 1983) did not specify an actual mechanism for the results. He did, however, stress that, in his view, SPT automatically resulted in an optimal encoding, thus rendering the use of additional memory strategies relatively unimportant. Cohen chose to call the phenomenon a subject-performed task effect (SPT effect), which is a more neutral term with regard to possible mechanisms.

Another research group that was interested in the SPT effect and its causes was Bäckman and Nilsson (1984; 1985). They, however, chose to focus primarily on other factors in the SPT experimental setting. Bäckman and Nilsson noted that when physical objects were presented at enactment, the subjects received input from additional sensory modalities, as compared with only reading or hearing the sentences. Subjects could see, feel, and sometimes even smell and taste the objects that were used for performing the denoted action. Bäckman and Nilsson argued that the SPT advantage was mainly due to the enriched encoding that occurred via the parallel use of multiple sensory modalities. It was proposed that the physical properties of objects were encoded non-strategically (Bäckman, Nilsson, & Chalom, 1986) and retrieved
implicitly (Nilsson & Bäckman, 1989). This group believed that verbal information was also processed and encoded in SPT, along with the sensory attributes; however, the encoding of verbal information, they claimed, was strategic and its retrieval explicit (Bäckman et al., 1986; Nilsson & Bäckman, 1989). This qualitative separation of two different processes working in SPT was named the dual code hypothesis.

Some of the differences between the motorical enactment of sentences and the verbal study of sentences are not visible to the human eye. Goal-directed activities are often more internally motivated and activated compared to the study of word lists. This can make activities more relevant for the actor as a person. To put it in other words, performing an action can constitute a mental context that is qualitatively different from the context of reading verbal material. Kormi-Nouri (1994; 1995) formulated an explanation for the SPT effect that rested on such a distinction. His position was that performing actions leads to greater self-reference and greater self-involvement, thus causing the SPT effect. In Kormi-Nouri’s opinion, motor activation per se is not necessary and motor modality does not contribute to the SPT advantage. Instead, Kormi-Nouri found two types of associative effects from SPT encoding. One was an increased association between the verb and the noun in a sentence. The verb and noun were integrated into one memory unit during the encoding of SPTs, making the sentences easier to remember, Kormi-Nouri claimed. The other SPT effect, according to Kormi-Nouri, was an enhancement of the association between separate to-be-remembered items in a list. Kormi-Nouri argued that SPT increases the association between items, which leads to better organization at encoding and consequently facilitates retention by making items trigger each other. Kormi-Nouri used the term episodic integration to describe these effects of greater self-involvement.

**Further data and developing controversies**

Whereas some of the theoretical positions described above mainly seem complementary to each other, there are a few differences to point out. The most studied and controversial issues concern the significance of overt motor activation in SPT, the associative effects of enactment, the non-strategic nature of SPT learning, the relation between SPT and ageing, and the contribution of real objects to the SPT effect. These controversies have been emphasized in earlier reviews as well (e.g., Engelkamp, 1998; Nilsson, 2000). Although all of these issues are more or less unresolved, the new empirical findings included in the present thesis specifically address two of them, namely a) Is the motor component a crucial and necessary factor in causing the SPT effect? b) How is associative information affected by enactment?
In order for this thesis not to exceed a practical scope, certain limitations were necessary. The decision to focus on these specific issues was, in part, swayed by personal interest; however, it was also motivated by my intention to argue that these two issues are more central than the others. An understanding of the motor component is of particular importance since it represents a qualitative addition to the traditional verbal learning paradigm. In proposing that the physical enactment per se affects sentence recall, Engelkamp (1980) raised the possibility of there being a motor code, separable from verbal and visual codes, for cognitive processing. Establishing the contribution of such processes, and their characteristics, is of principal importance for cognitive functions. The associative effects of SPT constitute an important link to the verbal learning paradigm. Associationism has been a movement all throughout the history of memory research. In an associative doctrine, all expressions of memory are seen as attributable to associative mechanisms. Even today, there are general theories about memory that build heavily on associationism (e.g., Klimesch, 1994; Naveh-Benjamin, 2000). Associative effects are well integrated within the traditional verbal learning approach and can provide alternative explanations to the motor code view.

The following theoretical summaries are done with these two main issues in mind. The other controversies in SPT research, which were mentioned above, are related to these two main issues, however. To provide a better understanding of the SPT phenomenon, important clarifications of all of these controversies will be briefly presented later in this chapter, which will also emphasize how these controversies relate to the main issues.

Is the motor component a crucial and necessary factor in causing the SPT effect? Evidence regarding the significance of physical movement for the SPT effect is obtained mainly from three types of research. First, SPT performance has been compared to experimenter-performed task (EPT). In EPT, subjects watch another person performing actions rather than performing actions themselves. The idea is that if physical movement by the subject is crucial for the SPT effect, then watching someone else performing the action should not lead to similar memory performance. If, however, other factors are of more importance, then EPT may share many of those factors with SPT. This would lead to EPT producing similar results as SPT. Results from such a comparison were published early by Cohen (1981), and by Engelkamp and Krumnacker (1980). Cohen reported similar magnitudes for the SPT effect and the EPT effect. In contrast, the results demonstrated by Engelkamp and Krumnacker indicated that SPT was superior to EPT. The results of Cohen have been replicated (e.g., Cohen, 1983; Cohen & Bean, 1983; Ratner & Hill, 1991) as well as those from Engelkamp and Krumnacker (e.g., Engelkamp & Zimmer, 1983), so the controversy could not be easily resolved. In an attempt to explain the inconsistencies, Engelkamp and Zimmer (1997) have argued that SPT is superior to EPT when SPT and EPT are
varied within the same list. When SPT and EPT are varied between lists (i.e., blocked presentation), they give rise to similar memory effects, Engelkamp and Zimmer claim. However, the question regarding to what extent the mechanism working in SPT and EPT are identical or unique is still up for debate.

The second line of evidence comes from applying the encoding specificity hypothesis proposed by Tulving and Thompson (1973). The encoding specificity hypothesis states that if motor code is used for encoding, then using motor cues at recall should lead to better memory performance compared to verbal cues. In a similar vein, motor distracters should disrupt an efficient encoding of motor code. Engelkamp and Zimmer have determined that the rate of false alarms at recognition is increased when motorically similar distracters are applied at recall (Engelkamp & Zimmer, 1994b; 1995). Engelkamp and colleagues, moreover, were able to demonstrate that performing studied actions at recognition magnifies the SPT advantage (Engelkamp, Zimmer, Mohr, & Sellen, 1994). The fact that motor distracters and cues influence recognition performance indicates that motor information is processed at recognition. Kormi-Nouri, Nyberg and Nilsson (1994) were, however, not able to demonstrate similarly supportive results from performing the to-be-remembered actions at recall (see also Norris & West, 1993). Furthermore, it has been shown that retention of the motor component can be hindered by visual and verbal distracters in SPT (Bäckman et al., 1993; Kormi-Nouri, Nilsson, & Bäckman, 1994). The question regarding the possible processing of motor information has thus not been fully clarified from these approaches.

Lastly, there are also important indications that motor systems in the brain are crucial for SPT memory. Nyberg, Persson and Nilsson (2002) studied those subjects in the large-scale Betula project (Nilsson, Bäckman, Erngrund, Nyberg, & et al., 1997) who did not benefit from SPT encoding (roughly 5% of all subjects). The tentative conclusion from their work was that the failure to benefit from SPT encoding reflected a dysfunctional motor system in the brain. In addition to this, the modern brain imaging techniques that we have available today (PET and fMRI) have provided a similar line of evidence. Nilsson et al. (2000) compared SPT retrieval to motor imagery retrieval and to VT retrieval while measuring brain activity by PET scan. They demonstrated that activation in the motor cortex parallels the memory performance for the task, therefore indicating the highest level of recall and motor cortex activity in SPT, an intermediate level in motor imagery, and the lowest in VT. Similarly, Nyberg et al. (2001) demonstrated that a number of the motor regions that showed an increased activity in SPT encoding, in comparison to VT encoding, were also activated during SPT recall. These results do indeed indicate that these types of motor neurons are directly involved in SPT encoding and retrieval. However, the relevant motor areas were activated in the recall of action sentences even when no overt movement was applied, as with motor imagery. There is also a possibility that the relevant motor areas are likewise activated in the purely verbal processing
(VT) of action sentences. To rule out this possibility, the brain activation in verbal action sentence encoding and recall would have to be compared to that in the verbal encoding and recall of other verbal material (besides action sentences). This has yet to be done.

How is associative information affected by enactment?

The second major controversy in SPT research concerns the possible effect on associative information. As was mentioned, Engelkamp has proposed that associative information in general is not enhanced for SPT (Engelkamp, 1986; Engelkamp & Zimmer, 1994a). Results confirming this proposition have been demonstrated in regard to pair-associate learning (Engelkamp, 1986), serial recall, (Olofsson, 1996) and the association between item and context (Koriat et al., 1991; Zimmer, 1994; 1996). The contradicting results and theories have mainly been related to two kinds of associative information that need to be explained before the results are reviewed.

For describing memory encoding, Hunt and Einstein (1981) proposed making a distinction between two types of basic processes that can be activated independently of each other. For processing of the qualities and characteristics of individual words, they suggested the term item-specific processing. As a parallel process, they proposed the term relational processing, which describes the processing of information that is shared by several (or all) items of study (see also Marschark, Richman, Yuille, & Hunt, 1987; McDaniel, Einstein, & Lollis, 1988). The association between nouns that are members within the same superordinate category can serve as an example of relational information. To be more concrete, the nouns “dog,” “bird,” and “shark” share so-called categorical-relational information because they are members of the superior category “animals.” In SPT, however, there is yet another type of processing to consider—the processing of the association between individual words within a sentence. In the case of most SPT studies, this is the association between verb and noun. On one hand, this relation could be seen as being related to item-specific information. When the to-be-remembered item is a meaningful sentence, the features and properties of the sentence, as a meaningful whole, can be processed in a similar way as with the item-specific processing of individual words. On the other hand, the information that is processed is associative by nature, which makes it more related to relational information. Within SPT research, this observation has previously been made by Engelkamp and Cohen (1991) as well as Kormi-Nouri (1995). Engelkamp and Cohen preferred to treat the association between verb and noun within a command as a special case of relational information, whereas Kormi-Nouri interpreted it more as an item-specific effect. I will use the term item-specific association to refer to this connection within a to-be-remembered item.

Considerable support for the notion of SPT being neutral in regard to conceptually relational information has been found. One approach has been to vary the presentation at encoding (e.g., categorically clustered or not) and/or the
cues at recall (e.g., category-cued or not) in a way that will activate referential rather than item-specific information. These manipulations have often not affected SPT retention positively, as compared to VT retention (Engelkamp, 1988; Engelkamp & Zimmer, 1996; Engelkamp, Zimmer, & Mohr, 1990; Zimmer & Engelkamp, 1989). The measuring of relational processing by examining hypermnesia in a multiple-test free recall paradigm has yielded the same interpretation of relational insignificance (Engelkamp & Seiler, 2003; Engelkamp, Seiler, & Zimmer, 2004; Koriat, Pearlman-Avnion, & Ben-Zur, 1998; Olofsson, 1997). The multiple-test recall paradigm is based on the assumption that item-specific processing increases the probability of additional recollection at retest and that relational processing protects against forgetting at retest (e.g., Burns, 1993; Klein, Loftus, Kihlstrom, & Aseron, 1989). Yet another way of addressing relational information is by estimating clustering scores that measure the extent to which the retained items are organized according to categories embedded in the study list (e.g., Bousfield, 1953; Gollin & Sharps, 1988; Sternberg & Tulving, 1977). Some results from this approach to SPT likewise seem to indicate that conceptually relational information is as effective in VT as in SPT (Engelkamp et al., 2004; Engelkamp & Zimmer, 2002).

The estimation of clustering scores for SPT and VT is, however, a method that has yielded contradictory results. Higher clustering in SPT compared to VT has been found on more than one occasion (Bäckman & Nilsson, 1984; 1985; Bäckman et al., 1986; Kormi-Nouri & Nilsson, 1999). In these studies, however, real objects have been used in the enactment condition, which may account for the differences found (Nilsson, 2000). There are other results also indicating intensified relational processing in SPT, however. Kormi-Nouri has, since postulating the episodic integration theory (Kormi-Nouri, 1994, 1995), defended the contention that SPT enhances relational information. He has shown that the magnitude of the SPT effect is affected by informing the subjects of the categorical structure of the study lists (Kormi-Nouri & Nilsson, 1999). Likewise, Steffens (1999) has proposed that relational information is increased in SPT as measured by organization score. However, Steffens points out that the whole–list relation has to be congruent with the noun–verb relation in order for this effect to occur. As examples, Steffens gives “pick the cherry” and “pick the plum,” which should, when enacted, draw participants’ attention to the attributes that these objects share and thus to the category to which they both belong. If these relations are incongruent, as in “kick the cherry” and “hide the plum” (my examples), then carrying out the actions should draw attention away from the whole–list categorical relation and cause a negative organizational effect. In my opinion, this is exactly in line with the reasoning by Kormi-Nouri (1995), except that Kormi-Nouri uses the terms “poorly integrated” and “well integrated” instead of incongruent and congruent (see below for more details on Kormi-Nouri’s theory).

In a similar vein, Koriat and Pearlman-Avnion (2003) have made a recent attempt to clarify what type of relational information is improved by enactment and what
type is not. Koriat and Pearlman-Avnion propose that bodily relations (enactive clustering) are enhanced by SPT, whereas conceptual relations are not.

The support for improved item-specific association comes mainly from two research groups. Kormi-Nouri (1995; Kormi-Nouri & Nilsson, 1998) showed that verb–noun pairs were better integrated after SPT compared to VT. This was concluded based on the finding that one of the words could be more successfully cued by the other at recall. Furthermore, Kormi-Nouri was able to demonstrate that the SPT effect was dependent on the a priori semantic integration between verb and noun, thus supporting the idea that verb–noun integration was increased. Helstrup (1993) has similarly demonstrated that the SPT effect is greater for verb–noun pairs with high connectivity (i.e., high semantic integration) (see also Steffens, 1999).

Engelkamp, Zimmer, and Biegelmann (1993) also examined the effect of enactment on the integration between verb and noun, by using cued recall in a similar fashion to Kormi-Nouri (1995). Engelkamp et al. found that the pre-experimental connections between verb and noun did not interact with recall conditions, as had been the case for Kormi-Nouri. This indicated that verb–noun association is not processed more in enactment than in non-enactment. Furthermore, Engelkamp found that enactment hindered pair association between verb–verb pairs, as indicated by hampered cued recall in SPTs but not in VTs (Engelkamp, 1986; 1995). When Helstrup (1989) tried to replicate these findings, he instead got insignificantly higher cued recall performance in SPT compared to VT. Engelkamp argued (1989) that this effect only occurs when subjects specifically are instructed to integrate verbs or nouns, as had been done by Helstrup (1989). This hypothesis was supported in the findings of Engelkamp, Mohr and Zimmer, (1991) as well as of Helstrup (1991). On the other hand, no such instructions were given in the series of studies by Kormi-Nouri (1995; Kormi-Nouri & Nilsson, 1998). It has been suggested, however, that even Kormi-Nouri’s results are due to the same instructive mechanism, albeit through implicit instructions (Nilsson, 2000). Nilsson (2000) proposes that good semantic integration can implicitly function similarly to an explicit instruction to integrate. In Kormi-Nouri’s studies, the SPT effect is greater for sentences that are semantically well integrated prior to study, as compared to poorly semantically integrated items. Kormi-Nouri (1995) has proposed another reason for the inconsistencies. In those cases where an item-specific associative effect was not found, the encoded word pairs were either noun–noun or verb–verb pairs. A verb–noun association is more plausible, Komri-Nouri argues, and can be more easily encoded as a single memory unit.

SPT as non-strategic and automatic encoding

The notion that motor processes and codes are of importance in SPT encoding implies that SPT encoding should be implicit and non-strategic. Accordingly, Engelkamp has identified non-strategic and automatic functions as
being central characteristics of motor modality processing (Engelkamp, 1998; Engelkamp & Zimmer, 1994a). From this perspective, it is crucial to be able to demonstrate the non-strategic and automatic functions in memory for SPT. Such functions are indirect support for there being a motor component in SPT processing. A lack of non-strategic functions would, likewise, contradict Engelkamp’s description of the motor processes.

Memory strategies can be helpful for most of our explicit memory functions. Strategic encoding, in this context, entails that subjects are engaging in some degree of additional, mostly deliberate, processing of items in order to better remember them. Silent repetition, semantic association, and visualization, are examples of common mnemonic strategies. The first indications from SPT research were that such strategies were either not employed by subjects, or, at least, not helpful for them, to the same extent as in verbal or visual learning. This was determined for such strategic effects as the generation effect, the level of processing effect, the primacy effect, and rate of presentation effects. The generation effect refers to the increased memory for items that are generated by the subject themselves instead of by the experimenter (Slamecka & Graf, 1978). Such generation has not resulted in improved retention for SPTs (Nilsson & Cohen, 1988; see however Oesterreicher & Köddig, 1995). Level of processing refers to the enhancement achieved when subjects are forced to mentally elaborate on the items at encoding (Craik & Lockhart, 1972). Typically, subjects are asked questions about the physical, phonemic, or semantic characteristics of the to-be-remembered items, for example. The basic idea is that the longer it takes for subjects to answer such questions, the deeper their elaboration of the concepts will be. In verbal learning, such processing is commonly associated with a higher retention of the encoded words (e.g., Craik & Tulving, 1975). In SPT studies, the effects of deeper processing were repeatedly not found (Cohen, 1981; Cohen & Bryant, 1991; Nilsson & Cohen, 1988; Nilsson & Craik, 1990). A similar lack of a well-established strategic effect has been evidenced in regard to the primacy effect (Bäckman & Nilsson, 1984; Cohen, 1981). The primacy effect is when the first items of a list tend to be well memorized, and it results from subjects using rehearsal as a strategy. The to-be-remembered items are silently repeated in the working memory until the point is reached where the number of items are too many for further repetition. The first items are hence repeated more times than the later items. In a similar vein, the time for item study can be manipulated for all items by altering the rate of presentation. The effect of allowing more time for strategic memorizing typically heightens verbal and visual memory. Again, this effect was not found for SPTs (Cohen, 1985). More recently, Zimmer (2000) determined that an automatic pop-up mechanism for retrieval is relatively more important in SPT recall compared to VT recall. This finding is significant because it identifies a specific mechanism for the non-strategic effect in SPT.

The notion of automatic and non-strategic encoding occurring in SPT has also been challenged. Although subjects, by default, did not seem prone to
using memory strategies in SPT encoding, they could be instructed to do this in order to change their memory performance. For example, Helstrup (1987) could alter primacy effects by asking subjects to imagine that they were in a familiar room while performing the action. SPT encoding has, moreover, been improved by strategic support, such as list structure, for example, without applying explicit strategic instructions (e.g., Cohen, 1989; Helstrup, 1986; Nilsson & Craik, 1990). In addition, SPT encoding was shown to suffer from the effects of divided attention at encoding (e.g., Bäckman et al., 1986), which suggests that SPT encoding requires effort on the part of the subjects and is therefore not automatic. Furthermore, Kormi-Nouri (1995) argued that SPT is a strategic encoding since subjects can utilize a sentence’s semantic information for improving SPT recall performance. In Kormi-Nouri’s studies, the verb–noun pairs that had strong semantic connections benefited more from SPT encoding than verb–noun pairs with weak semantic connections. From this perspective, the associative effects of SPT are linked to the controversy of non-strategic processing.

The ability to use strategic encoding varies based on individual factors such as intelligence and age. Given these individual effects on SPT, there would appear to be support for the view that SPT is attention demanding. However, the results are mixed once again. As was mentioned earlier, when intelligence levels were varied amongst the subjects (e.g., mentally retarded vs. normal controls; young children vs. older children), enactment at encoding negated the differences that these group showed in VT (Cohen & Bean, 1983; Cohen & Stewart, 1982). Ratner and Hill (1991), on the other hand, have found developmental differences amongst the SPT recollections of children. Similarly, studies of the effects of ageing on SPT performance have shown inconsistent results. This empirical issue has attracted much more interest, however, and is therefore covered in a separate passage of this chapter.

In trying to understand the controversial results regarding the use of strategies in SPT research, it may be useful to interpret the words/actions distinction as a quantitative rather than a qualitative difference. In an idea developed by Nilsson (2000), words are held to be highly sensitive to encoding variables (i.e., strategies), while performed actions are considered moderately sensitive (cf., Cohen, 1983). In all episodic memory conditions, the automatic memory functions are supported by memory strategies to a varied degree depending on the difficulty of the task, Nilsson argues. Because words are more sensitive, VTs are more likely to call on strategic support compared to SPT. Under the right conditions (e.g., a very difficult task), SPT encoding will also be strategic, according to Nilsson. It should be mentioned, however, that advocates of the non-strategic view do not claim that SPTs completely exclude the possible use of intentional strategies.

**SPT and ageing**

The debate surrounding age-related effects in SPT is interesting,
partly due to the fact that the interest in age-related research in general is growing as an increasingly larger portion of the human population reaches old age. The possible beneficial effects from SPT on age-related memory decline is also interesting since it has been used as evidence for the non-strategic view of SPT. This assumption is derived from the theory that age-related memory decline, in general, is due to deficits in the use of memory strategies. Aging has similarly been seen as related to associative effects, since a number of theories propose that memory decline in general is due to deficiencies in the creating and retrieving of associations.

As mentioned in the introduction, studies describing the SPT effect as a function of age have come up with fairly varied results. While many have replicated the earlier finding of reduced age dependency for SPT (e.g., Brooks & Gardiner, 1994; Bäckman & Nilsson, 1984; 1985), an even greater amount of research has indicated that SPT suffers from an age-related decline similar to VT's (e.g., Cohen, Sandler, & Schroeder, 1987; Earles, 1996; Knopf, 1995a; Nilsson & Craik, 1990). Rönnlund, Nyberg, Bäckman, and Nilsson (2003) have summarized the results of 29 studies previously conducted on SPT and ageing, in an attempt to explain these incompatibilities. Rönnlund et al. conclude that the results in these studies typically indicate that age deficits in SPT parallel those in VT when the memory task is difficult (e.g., long list, free recall). The difference in age dependency is seen mainly in easier tasks (e.g., short lists, recognition test, cued recall) and may be due to the effectiveness of the self-generated memory strategies (Craik, 1986) employed by young subjects (but not by old subjects), which leave little room for additional improvement through SPT (Knopf, 1995b; Nilsson, 2000). Other possible explanations have also been suggested, but thus far no consensus has been reached.

The importance of possible interactions between age and SPT for interpreting the SPT mechanisms varies depending on which theoretical interpretation one has about ageing deficits in general. Age-related memory deficits can be dependent on both memory-specific factors, such as the poor use of encoding strategies and retrieval cues, as well as on more general cognitive factors, such as poor processing speed, poor inhibitory functions, and poor sensory functioning (see Dixon, Bäckman, & Nilsson, 2004 for review and contemporary issues). Within SPT research, the position has commonly been that age-related decline is an effect of poorer memory strategies. Either the elderly are seen as lacking the ability to use memory strategies as efficiently as younger subjects, or it is thought that they do not use their abilities, in memory tests, to the same degree, even though they can if instructed to do so. These views on ageing deficits naturally lead to interpreting SPT effects on ageing (or the lack thereof) as strategic effects. Considering the pluralistic nature of cognitive ageing in general, and the inconsistent findings with regard to SPT, these studies do not provide conclusive arguments for the strategic versus non-strategic discussion on SPT.
**Real and imaginary objects in SPT**

Within SPT research, two different traditions have emerged in regard to using actual objects or not in encoding SPTs. Early on, it was proposed that the use of real objects rather than imaginary objects would be important for understanding the SPT effect. That object features had an influence on the SPT effect was put forth in support for the dual code hypothesis (Bäckman & Nilsson, 1984) and used as evidence against the motor modality hypothesis (Engelkamp & Krumnacker, 1980). More recently, it has been claimed that real objects are important for item-specific association (Kormi-Nouri & Nilsson, 1998; 1999) and for interpreting results on relational organization (Nilsson, 2000).

Whereas Bäckman and Nilsson (1984) originally attributed a large part of the SPT effect to the features of weight, color, and size etc., others demonstrated SPT effects that were independent of object effects (e.g., Engelkamp & Krumnacker, 1980). When comparing SPT using real objects at recall to SPT using or imaginary objects, it is often concluded that the inclusion of objects increases the magnitude of the SPT effect, but that they are not necessary for the emergence of an SPT effect. Many SPT studies have been conducted with imaginary objects in order to separate these two effects from each other. In nearly all cases, an impressively large SPT effect has been found nonetheless. Recently, however, Steffens (2003) has reasserted the claim that the SPT effect is mainly caused by the intentional or unintentional presentation of physical objects at encoding. When carefully controlling all objects present in the context of encoding and recalling SPTs, Steffens was able to demonstrate that there was no SPT effect superior to VT.

It is not controversial to claim that the presentation or use of real objects will make a difference for the SPT effect, as it would in many other memory tests. The controversy surrounding the use of objects has mainly centered on whether the subject–object interaction can explain the difference between SPT and experimenter performed tasks (EPT) (Nilsson, 2000). If the case were that the results for SPT with imaginary objects paralleled the EPT results, then SPT could be similar to perception of actions (EPT) with regard to effective mechanisms. The SPT effect would then be due to the perceptual input and not the output of motor activity. When SPT is performed with only imaginary objects, it is most common that an SPT effect will result. However, when it has been compared to EPT with imaginary objects, the results have not been unequivocal. In studies by Engelkamp (Engelkamp & Krumnacker, 1980; Engelkamp & Zimmer, 1983), SPT recollection has been superior to EPT recollection, whereas Ratner and Hill (1991) reported finding the same levels of retention for both conditions. Although there is not much debate on the non-necessity of real objects for achieving an SPT effect, since an SPT effect is nearly always obtained with imaginary objects (see however, Steffens et al., 2003), it can be argued that the SPT effect is simply a perceptual effect (like EPT), as long
as the inconsistencies described above remain unresolved.

Even from a theoretical position that assumes the SPT effect is qualitatively different from the EPT effect, it is still important to understand how using or perceiving real objects will interact with the SPT effect. When SPT using real objects is compared to SPT using imaginary objects, an elevated SPT effect in the real object condition is commonly found. This, in itself, is not surprising. However, what needs to be clarified is if the use of real objects interacts with SPT encoding differently than it does with other conditions (e.g., EPT and VT).

Engelkamp and Zimmer (1983) tested such an interaction effect between the objects used in the SPT and the EPT conditions, without finding an interaction. The SPT effect was superior to the EPT effect, and memory was equally improved by the inclusion of real objects in both conditions, Engelkamp and Zimmer reported. This indicates that objects have no special importance in the SPT phenomenon. Kormi-Nouri and Nilsson, on the other hand, argued that real objects at enactment are critical for achieving an SPT effect with item-specific association (Kormi-Nouri & Nilsson, 1998; 1999). They further believe, in accordance with Engelkamp and Zimmer, that the effect on relational and item-specific information (not item-specific association) is independent of real objects. This suggestion has not been explicitly tested in any following studies.

**A dichotomy in the theoretic directions of today**

Today we have several theoretical approaches that are of significance in SPT research, as was mentioned earlier. Two well-developed theoretical frameworks for the SPT phenomenon stand in clear contrast to each other. Between them, they basically comprehend all of the above-described controversies. Therefore, I shall summarize the presented findings and controversies within these theories before focusing on the questions at issue for the present thesis.

As a result of the extensive SPT research that has been conducted, opinion on the original theoretical positions of Cohen (1981; 1983), Bäckman and Nilsson (1984; 1985), and Engelkamp and Krumbacker (1980) has approached a consensus. The notions of non-strategic encoding and significant contributions of motor activity in SPT encoding were the unifying similarities. Engelkamp has taken on the task of developing a detailed theory based on these assumptions (e.g., Engelkamp, 1998). Today, Engelkamp is the primary advocate of the multimodal memory theory for SPTs. The multimodal memory theory states that memory encoding can be governed by three independent programs. The programs are specified as modality-specific with regard to codes, properties, and representation. Prior to the SPT paradigm, Paivio (1971) had postulated that there were two modality-specific codes, the verbal and the visual code. Paivio’s dual-code theory on encoding has received wide acknowledgment in cognitive theory.
research. Engelkamp and Zimmer (1984; 1985) proposed a motor modality program as the third to have an influence on the memory for SPTs. Besides the advantage of having a third modality in SPTs, the SPT effect is due to the fact that motor encoding is more efficient than verbal or visual encoding, Engelkamp and Zimmer claim. The multimodal memory theory, moreover, states that in SPT subjects do not need to employ intentional strategic encoding processes or active rehearsal in order to remember actions. Item-specific information is the main type of information improved by the motor modality, according to Engelkamp (1998). Relational information is uninfluenced by SPT, whereas the association of previously unrelated words (i.e., item-specific association) is hindered in SPT (Engelkamp & Cohen, 1991; Engelkamp & Zimmer, 1994a). In recent discussion, Engelkamp has modified this view by adding that enactment should integrate the components of a sentence that are relevant for the meaning of the action. To put it in Engelkamp’s (1998) own words:

A further differentiation arises with regard to verb-object associations to be established for the first time during the learning episode. In analogy with learning new associations between unrelated actions, it is a matter of episodic-relational encoding processes. In enactment, this episodic relational encoding between action and their object is exactly the opposite of that between actions. While focusing on information relevant to the action through enactment impedes the establishment of associations between unrelated actions, it promotes it between actions and their objects because both are relevant to the respective action. … To summarise, then, when considering episodic-relational encoding within phrases it is essential to check whether or not part of the information to be associated is relevant to the action. (p.127-128)

The theory that can be seen as representing the opposite contention to Engelkamp’s is the episodic integration view of Kormi-Nouri (1994; 1995). As I mentioned above, Kormi-Nouri sees SPT encoding as entirely strategic. He is of the opinion that every aspect of SPT learning is intentional and involves effort. There is no motor memory trace contributing to the SPT effect, in Kormi-Nouri’s view. Instead, the SPT effect is caused by greater self-involvement and self-reference in the context of enactment. This can be thought of as an altered mental context, which is brought about by performing actions. The increased self-involvement results in a better registration of the experience, thus making the action and the concepts in it (verb and noun) more specific. In other words, it facilitates the integrating of the experience into a comprehensive whole. The mechanisms involved are two types of integrative processes, according to Kormi-Nouri. The noun and the verb in a sentence are more closely bound to each other.
(item-specific association) and encoded as one memory unit. In addition, the associations between separate items presented in the same situation are also made easier (relational integration). These two types of intensified associations are together referred to as episodic integration. The effectiveness of episodic integration is furthermore dependent on the level of semantic integration between the verb and the noun in an action sentence. Semantic integration refers to the knowledge-based associations that we have acquired about words. As an example, the verb “read” is semantically well connected to the noun “book,” whereas it is poorly semantically integrated to the noun “bottle.” Still, “read on the bottle” denotes a sensible and possibly occurring action, even if it is not an everyday action. Kormi-Nouri uses the dichotomy “poorly integrated” (PI) and “well integrated” (WI) items when he refers to the level of semantic integration. In reality, the level of semantic integration is continuous. Semantic integration interacts with episodic integration so that WI items benefit more from episodic integration (i.e., SPT) compared to PI items.

These two theories are at odds with respect to their acknowledgement of the presence of specific motor memory traces in SPT. However, Kormi-Nouri does admit that physical movement contributes to the SPT effect (Kormi-Nouri, 2000). Although it does not result in motor memory traces, it does affect self-involvement, according to Kormi-Nouri. But, in his further opinion, movement is not necessary for achieving a qualitatively genuine SPT effect. Because of their relatedness, there is a difficulty in comparing the mechanisms in the SPT effect regarding these two theories. Take the comparison of SPT to EPT, for example. Movement is not the only difference between SPT and EPT conditions from Kormi-Nouri’s theoretic viewpoint. Even if SPT is shown to be superior to EPT with regard to memory performance, Kormi-Nouri can easily argue that SPT leads to greater self-involvement compared to EPT, thus explaining the difference. It would help clarify the significance of motor activation if this internal state could be controlled, i.e., if motor activation comparable to SPT could be achieved without performing actions.

The positions on strategic encoding are not diametrically different either, in regard to these theories. In Kormi-Nouri’s view, all aspects of SPTs are strategic. Engelkamp believes that strategies can be beneficial for SPTs, but that they are, for the most part, unnecessary. The processing in the motor modality is automatically more efficient compared to the verbal and visual modalities, Engelkamp argues. He adds, however, that the parallel processing in the verbal and visual modalities can be subject to memory strategies.

The most clear cut difference between these theories, in my view, is in the area of associative processing (i.e., item-specific association and relational association). Engelkamp has produced several studies indicating that relational processing is not improved in SPT, and some indicating that associative processing can even be hindered by SPT (especially the item-specific association). He has stated the position that the encoding in the motor modality is...
only item-specific, whereas relational processing takes place in the conceptual system. However, if the noun is relevant for modifying the meaning of the action, then Engelkamp, as well, acknowledges the integration of verb and noun to be an effect of enactment. Encoding in the motor modality is what separates SPT from VT in Engelkamp’s contention. This is not a view shared by Kormi-Nouri, who, in contrast, bases large parts of his theoretical explanations for the SPT effect on the enhancement of associative information. The enhancement applies to both relational and item-specific associations, in Kormi-Nouri’s view.
OBJECTIVES AND SUMMARY OF THE EMPIRICAL
STUDIES

Objectives

The possible contribution of a motor component was in the previous chapter argued to be one of the most significant issues. It is essential to take a position either accepting or rejecting the role of the motor component, in my view, since it has a broader bearing on memory research. The existing theories about episodic memory are mainly based on auditory (verbal) and visual materials as well as the processing thereof. If motor programs are to be established as support for episodic sentence memory, then these theories would need to be revised or expanded.

In order to establish that movement is an important aspect of the SPT effect, it must be separated from alternative aspects that could explain the phenomenon. The most crucial one is increased self-involvement, since it has explicitly been suggested as an alternative explanation. As was argued in the introduction, most of the current findings in which enactment supports sentence memory can just as easily be attributed to greater self-involvement as to a motor component. These two alternative central mechanisms in SPT are also associated with very different consequences for the understanding of the episodic memory system. A methodological separation of these factors is necessary for advancing the discussion. One purpose of this thesis has, hence, been to test and discuss the necessity of motor movement.

The other issue of considerable importance mentioned in the previous chapter was that of determining the associative effects in SPT. Associative effects are interesting in themselves because there exist numerous results and theories on associative effects in human memory that can be applied to SPT research. Moreover, the associative effects of SPT are, for the most part, not compatible with the motor code processing view proposed by Engelkamp. Accordingly, the other aim of this work has been to test the assumption that a limited processing of associative information occurs in SPT encoding.

This dissertation reports on three empirical studies that were conducted in order to clarify (a) if motor movement can cause the SPT effect independently of higher self-involvement, and (b) if the associations within and between action sentences are affected by enactment.
Study A

Study A was designed in order to address the question of whether item-specific associations and relational associations contribute to the SPT effect. As was described in the introduction to the SPT paradigm, these issues have been studied using several methods and by several research groups without any consensus being reached. The methodological approach in Study A was to vary recall conditions in order to activate the use of item-specific associations and relational associations respectively, and to compare how they contribute to performance. Performance on verb-cued recall, it was argued, is dependent on the item-specific association between verb and noun. The verb-cued recall condition was compared to the free recall of sentences (i.e., verb-noun pairs). Category-cued recall of nouns, it was argued, is dependent on the relational association between nouns, and was compared to the free recall of nouns. Kormi-Nouri’s theory (1995) predicts that verb-cued and category-cued recall will both be more effective in SPTs as compared to VTs, because SPTs enhance the processing of item-specific association and relational association. This reasoning is, moreover, in line with the transfer appropriate processing framework (Morris, Bransford, & Franks, 1977) in assuming that retention will be greater when the encoding processes and the retrieval processes are overlapping (cf. Tulving & Thomson, 1973).

Two experiments were conducted with this approach. Experiment 1 was conducted on three large population-based samples from the Betula prospective cohort study (Nilsson et al., 1997). The subjects were healthy persons between 35 and 60 years old. The experiment was conducted as a within-subject design, meaning that all subjects were included in all compared conditions. Each study list consisted of 16 short action sentences with poor semantic integration between verb and noun (e.g., roll the pineapple). The main result was an interaction showing that the SPT effect was larger in the verb-cued recall condition compared to free recall and category-cued recall. In other words, it was found that verb-cued recall was much more effective for remembering SPTs compared to remembering VTs, while category-cued recall was equally effective after both types of encoding. The results clearly supported the notion that item-specific association is enhanced in SPT encoding as compared to VT encoding. Improved relational processing could not be demonstrated, however.

Experiment 2 was conducted with the additional aim of controlling for the use of real objects, the contributions from working memory, and some potential carry over effects of the Betula procedure, which could all have affected the results in Experiment 1. The participants were 40 students. Each study list consisted of 36 items. Half of the items were category-cued at recall and the other half were verb-cued. The results on item-specific association and relational association were all replicated in
Experiment 2. The SPT effect was again greater in verb-cued recall than in free recall and category-cued recall.

The findings were discussed in relation to an experiment reported by Kormi-Nouri and Nilsson (1999), which was similar in its comparing of free recall to category-cued recall and verb-cue recall. Kormi-Nouri and Nilsson had not obtained the crucial interaction that was the main result in Study A. The three major methodological differences in the experiment by Kormi-Nouri and Nilsson in comparison to Experiment 2 in Study A were that (a) the categorical nature of nouns was revealed before encoding, (b) the type of recall was varied between subjects, and (c) the verb-cued recall of sentences was compared to the free recall of nouns instead of the free recall of sentences. Because Kormi-Nouri and Nilsson only compared the verb-cued recall of sentences to the free recall of nouns, and not the free recall of sentences, it is difficult to interpret the effect on verb-cued recall. In Study A, it was argued that one cannot evaluate the effect of verb-cues without a proper comparison condition in free recall (i.e., free recall of sentences). This made it difficult to compare the results of Study A with the results of the study by Kormi-Nouri and Nilsson.

The limitations of using category-cued recall for assessing relational processing were also discussed. Relational information can be of a different kind than that reflected in noun categories. The semantic categories can, for example, be based on the verbs or on scripts (e.g., preparing dinner, cleaning the house). This can affect how the relational information is affected by SPT encoding.

The conclusions of the experiments, taken together, were that item-specific association enhancement for SPTs is a reliable long-term memory effect that is not dependent on the use of real objects. That enhanced categorical relational processing may have contributed to increased memory performance was ruled out for SPTs, with high statistical certainty.

Study B

Study B used the same theoretical framework of transfer appropriate processing, as in Study A, in order to study the item-specific and relational association effects in SPT. The SPT effect in verb-cued recall was thus compared to that in category-cued recall and free recall. In Study B it is proposed that the possible associative effects of SPT can vary as a function of age, so that they are not an equally large part of the full SPT effect in all age cohorts. This can, moreover, be a contributing reason for the inconsistent results regarding age-related memory decline in SPTs. In other words, the age-related effects on SPT were suggested to vary depending on the associative demands of the test. Theoretical support for that assumption
comes from theories that view cognitive ageing effects in general as effects of associative deficits. The associative deficit hypothesis (Naveh-Benjamin, 2000), for example, states that older subjects’ memory deficits are largely due to their limitations in creating and retrieving associative information.

Study B was conducted on a sample from the Betula study (Nilsson et al., 1997) and examined age cohorts from 40 to 85 years old. The oldest cohort was excluded, and a median split was conducted on the other cohorts, in order to avoid floor effects. The results demonstrate that the difference between SPT and VT recall is reduced as a function of age, but only in verb-cued recall, not in free recall and category-cued recall. This reduction therefore does not apply to SPT encoding in general nor to the verb-cued recall tested in general. It is the ability to fully benefit from the combination of SPT encoding and verb-cued recall that is impaired in the older cohorts.

The procedure used in the Betula project was discussed as being a possible confounder. The fact that the verb-cued recall test was administered 40 minutes later than the category-cued and free recall tests were, was seen as the most important issue. The greater time difference between encoding and recall may have interacted with the age factor to produce a different decline of the SPT effect in verb-cued recall.

The results were in line with the associative deficit hypothesis and indicate that the creation of item-specific associations in SPT is limited in old age. The lack of an age-related decline for the category-cued recall condition was interpreted as indicating a lack of relational processing in SPT encoding, rather than as an indication that the elderly are unaffected in their ability to use relational association at encoding.

Study B underscores the importance of recognizing the item-specific association effect in SPT, because it can show dissociative effects when additional variables are included. In relation to the controversy of age-related decline in SPT, these results indicate that SPT is affected by ageing as is the case with other episodic memory tasks. However, earlier results have found equal or reduced age effects in SPT compared to VT—and not the enhanced age effect that was identified in Study B.

Study C

Study C addressed the issue of whether motor enactment is necessary for the SPT effect. Engelkamp has taken the position that processing in a motor code is causing the SPT effect, whereas Kormi-Nouri claims that movement is not necessary because the SPT effect is caused by a greater self-involvement in performing actions. Based on the contention that greater self-involvement and motor activation are inseparable parts of
performing action, it was proposed in Study C that other encoding conditions must be compared in order to separate these two theoretical explanations from each other. Such a separation is necessary in order to study motor activation independently of the aspect of greater self-involvement.

It was argued that sign language could serve as a condition for separating motor activation from greater self-involvement. Signed languages are today recognized as being as equally complex and systematic as spoken languages. They are more qualitatively comparable to spoken languages than to non-verbal communication. The signing of action sentences is hence essentially a verbal task (VT) that includes motor activation comparable to SPT. It was further argued that the act of signing cannot result in increased self-involvement as would occur when enacting actions, since it is qualitatively similar to speaking. In order to isolate the motor component in sign language and identify whether it was the main difference in comparison to the VT condition, the effects of translation and motor imagery were assessed in control groups.

Recall performance was found to be equal for the sign language task condition and SPT condition, and significantly lower for the VT condition and the translation comparison condition. The motor imagery condition produced intermediate retention performance, which was in line with expectations. The results indicate that motor activation contributes to the similarly enhanced performance in SPT and SLT as compared to VT. The planning of motor activation is also seen as a possible contributor to the SPT effect, due to the motor imagery effect in Study C.

In Study C, the conditions were varied between different groups of subjects. Since the signing subjects could not be randomly sampled from the same population as the other groups of the experiment were, there may have existed pre-experimental differences between the groups. Age, gender, education, and word comprehension could be statistically ruled out as significant group differences. It was acknowledged that other pre-experimental differences may have influenced the results.

The conclusion of Study C is that overt movement makes a unique contribution to the SPT effect. The results clearly support Engelkamp’s explanation of the SPT effect more than they do Kormi-Nouri’s. However, the report does express that the processing of motor memory traces is not assessed per se in Study C.
DISCUSSION

Thus far, the relevant theory and data surrounding SPT research have been reviewed and three empirical studies have been presented. At this point, it is time to relate the presented studies to previous results and theories. The discussion will start with the specific questions that were posed when describing the purposes of the thesis. This section will discuss to what extent those questions have been answered through the presented studies, and how the results relate to the theoretical aspects of the SPT paradigm. The studies included will also be related to the other controversial issues that were laid out in the introduction to SPT. Before concluding, the general limitations of the present work will be briefly discussed.

Is motor activation necessary for the SPT effect?

Study C was designed specifically for the purpose of addressing the issue of whether motor activation is a necessity for the SPT effect. Motor activation was studied under a condition that does not produce the increased self-involvement that may be found with enacting actions. Increased self-involvement is the main alternative explanation for the SPT effect, compared to motor modality processing. In Study C, it was demonstrated that the memory of the sign language task group was as good as that of the SPT group. Three comparison conditions had been included to account for alternative effects in the sign language task condition. It was argued that the SPT and the sign language task group mainly have motor activation as a shared component and that the motor component was the main difference between the sign language task group and the VT group. If these arguments stand, then the results of Study C present good evidence that there is a specific effect of motor activation per se.

The possibility of other factors in the sign language task being more decisive than motor activation is worth re-examining. For anyone not familiar with sign language production, it may be difficult to evaluate the sign language task condition. However, there is ample evidence supporting that sign language processing is qualitatively the same as that of spoken language (for reviews see, Emmorey & Lane, 2000; Messing & Cambell, 1999). According to the linguistic definitions of language, sign language is nothing less than a spoken language. Confounding factors in the procedure of Study C are not mainly caused by sign language per se, but may be due to surplus processes. The subjects in the sign language task group of Study C heard a sentence in Swedish and then reproduced the sentence in Swedish sign
language. This is also a task of translation, which could account for the effect on memory. But the control condition, in which subjects were asked, in a similar way, to translate into English, did not produce any elevated memory performance. The question then becomes whether translating in sign language can be much different from translating in a spoken language, with regard to memory effects. Again, there are no scientific studies to rely upon for an answer. In Study C it was speculated that there may be an increased level of motor imagery in translating to sign language. The subjects translating from Swedish to English were therefore given the instructions to imagine themselves self-performing the actions before translating the sentences. Motor imagery did not have an effect in this group and there was only an insignificant enhancement in the pure motor imagery condition. Given this, it can be concluded that even if the degree of motor imagery is different between the forms of translation, it does not explain the sign language task performance. In my view, there is no other obvious reason for the signing condition to cause the elevated memory effect. A deeper understanding of sign language mechanisms in verbal and non-verbal cognition is required in order to be able to know with certainty.

Alternative explanations for the signing effect can possibly be found in the fact that the subjects in the sign language task condition were not sampled from the same population as the other subjects. Some important differences in the experimental conditions did thereby exist prior to the experiment. The differences most likely to affect memory (age, gender, education, word comprehension) were controlled for statistically and thus do not account for the recall differences. However, the fact that one group was sampled from a minority population (hearing signers) who had no familiarity with the role of subjects in experiments, and that the others were sampled from a population of psychology students, can constitute a difference that is not easily controlled for. To assure that unforeseen factors have not contributed to the results, the experiment would need to be replicated with randomized groups or a within-subject design. There was a similar experiment on this topic conducted parallel to Study C, by Zimmer and Engelkamp (2003). Zimmer and Engelkamp used both hearing and deaf subjects in separate sign language task conditions, and the same subjects conducted the VT conditions for comparison. The results of Zimmer and Engelkamp are exactly in line with those in Study C, showing that a signing effect, comparable to the SPT effect, does emerge.

Another important question is whether the results regarding the sign language task also constitute support for motor memory traces in SPT? This claim is difficult to make since motor memory trace per se is not assessed in Study C. Direct support for motor code processing can be presented, for example, in the effects of parallel motor tasks (at encoding or retrieval), or through functional brain imaging (PET or fMRI) that
demonstrates the differential activation of motor areas. The studies that use motor distracters or support at encoding or retrieval have yielded contradictory results, as was described earlier (e.g., Engelkamp et al., 1994; Kormi-Nouri, Nilsson et al., 1994). The brain imaging data shows a clearer picture, which is still hard to interpret. Studies by Nilsson et al. (2000) and Nyberg et al. (2001) clearly demonstrate that motor neurons are directly involved in SPT encoding and retrieval to a higher degree than in VT encoding and retrieval. However, both these studies also demonstrate large similarities in SPT, VT, and motor imagery retrieval. Furthermore, since brain-imaging results are derived from differences between conditions, rather than absolute values for conditions, they have certain limitations. The reported difference in brain activation between SPT and VT can be due to activation in SPT or deactivation in VT. More importantly, the level and pattern of brain activation at VT cannot be evaluated without an additional comparison condition. If the encoding and retrieval of nonsense words, for example, had been included in these studies, findings might have been able to show that the activation for verbally encoded action sentences was more similar to the motor encoding of action sentences than to the verbal encoding of nonsense words. Such results would have indicated that the encoding of action sentences, verbally or otherwise, activates motor areas. In my view, it is therefore difficult to come to the conclusion that the motor activation in SPT encoding and retrieval is qualitatively different to that in VT, even though it is quantitatively increased.

While the conclusions regarding the significance of motor activation for the behavioral SPT effect are pretty clear, the conclusion regarding a specific motor mechanism differentiating SPT from VT is slightly ambiguous. It seems clear that overt motor activation is necessary to achieve a full SPT effect, and that it plays a unique role in behavioral level memory. Furthermore, the effect can be related to motor systems in the brain. It is not established, however, whether motor information is processed qualitatively differently in SPT as compared to VT and especially motor imagery. The overt movement in SPT can recruit the same (motor) mechanisms as the verbal processing of action sentences, albeit more effectively. Until such results have been demonstrated, however, the motor modality theory of Engelkamp (1998) is most applicable for the results presented in Study C.

**Are there associative effects separating SPT from VT?**

The results in Study A and Study B are relatively clear in determining that the SPT enhancement is not limited to item-specific information (i.e., verb-specific or noun specific). Furthermore, it seems that SPT encoding affects item-specific association differently than relational
association. This was established by the interaction between type of encoding and type of recall. Verb-cues at retrieval result in much better memory performance when combined with enactment at encoding compared to VT at encoding. The elevated memory performance in this interaction is, according to the transfer appropriate processing framework, the expected effect of overlapping processes at encoding and recall. It was, hence, concluded that SPT processing overlaps with verb-cued processing more than VT does. The verb-cued paradigm is based on verbs activating the recollection of the appropriate noun through existing integration, indicating that the overlapping processes are based on item-specific association. Similarly, the success in category-cued recall is dependent on the processing of categorical relational information at encoding. But, combining enactment at encoding with category cues at recall does not increase performance compared to non-enactment. It can thus be concluded that enactment does not activate categorical relational processing more than non-enactment.

The body of evidence indicating there is an enhancement of item-specific association in SPT is considerable. Previous findings (e.g., Helstrup, 1993; Kormi-Nouri, 1995; Kormi-Nouri & Nilsson, 1998) are in agreement with the results of Study A and B. Since his early opposition, Engelkamp (e.g., Engelkamp & Zimmer, 1994a) has switched to a more consistent view (Engelkamp, 1998) in which item-specific association can be considered a consistent SPT effect. The controversy on item-specific association is now over whether it is modified by factors such as pre-experimental association and the inclusion of objects. For future research, it would be worthwhile to investigate the limitations of using verb-cued recall for assessing integration. The dependence on associative information in verb-cued recall is confounded by there being a degree of dependency on item information. Verb-cued recall requires the retention of the correct noun in addition to a recollection of the correct association between verb and noun. A purer measure of integration would be a test in which all verbs and nouns from the study session are presented together and the task is to associate the nouns and verbs with each other. Such a task would assess the retention of the association without demanding verb or noun recall.

In Study B, the encoding/retrieval interaction is studied amongst different age cohorts. The two-way interaction between encoding, retrieval, and age, demonstrated in Study B, supports the notion that there is a common mechanism at work in these three variables. Whichever factor is the cause of the encoding/retrieval interaction in Study A, must also be connected to age-related deficits. Since the conclusion of the present thesis is that item-specific association causes the overlap between SPT and verb-cued recall, the results demonstrated in Study B imply that old age can limit the processing of item-specific association. Many theories assert that associative deficits are the main age-related deficits (e.g., Chalfonte & Johnson, 1996; Gilbert, 1941; Light,
These theories are hence in line with the results of Study B. There are, however, several different theories on age-related memory deficits. Difficulties in remembering verbs, difficulties in utilizing supportive conditions, limitations in the use of strategies, limitations in processing speed, and poor inhibitory functions are a few of the competing (or complementary) explanations. The purpose here is not to clarify which is most in line with the findings on SPT and ageing. That would require a separate thesis. Given that the effect is found only in the combination of SPT and verb-cued recall, but not in the combination of SPT and category-cued recall, the association deficit hypothesis seems to be the most plausible candidate. In any case, Study B shows that the item-specific associative properties of the to-be-remembered items should be acknowledged when SPT is applied to ageing populations.

Conceptual relational processing, in contrast, seems unaffected by SPT encoding. At least it does not result in an enhancement of the SPT effect. In Study A as well as Study B, category-cued recall yielded results similar to free recall. The retention processes in free recall and category-cued recall overlapped with the processes in enactment at encoding to the same extent. All in all, the associative effects in the included studies are much in line with Engelkamp’s theoretical explanations for the SPT effect. Engelkamp claims that categorical-relational information is not enhanced by enactment and that item-specific association can be enhanced between units that are relevant for the meaning of the action. Kormi-Nouri, on the other hand, argues that both item-specific and relational association is enhanced. I believe that it is entirely possible for an encoding condition as SPT to have differential effects on item-specific association compared to the association assessed in category cued-recall and compared to other assessments of relational information. Compared to the earlier studies on item-specific association, the earlier studies on relational association have been more numerous and more varied with regard to assessing relational information (e.g., organizational clustering, body-related association). The neutral effect of SPT on relational information, presented in Studies A and B, should probably only be generalized to the conceptual relations reflected in noun categories. Furthermore, according to Steffens (1999), this type of conceptual relation should be activated in SPT only when attention to this feature in the nouns is assisted by verb congruence (cf., PI and WI items in Kormi-Nouri, 1995). In Study A and Study B, in all items, verb and noun are poorly integrated semantically. This implies that the connection between verb and noun is incongruent with regard to the noun category (see page 12 for a more detailed description). The lack of a relational effect in Study A and Study B is hence in line with Steffens’ contention, when it comes to this type of to-be-remembered items.

The studies by Steffens (1999), Helstrup (1993), and Kormi-Nouri (e.g., 1995) all seek to draw attention to the semantic integration between
verb and noun as a modulator for the SPT effect. In principal, semantic association can influence episodic associative effects since the semantic system is known to support episodic memories. According to these researchers, the associative effects of enactment are enhanced if a good semantic association exists between verb and noun. For the results in Studies A and B, this suggests that the associative effects could have been stronger if the pre-experimental semantic associations between verbs and nouns had been greater. Engelkamp (1998), however, argues that such semantic effects are effective on the conceptual level and should not interact with SPT encoding since SPT encoding is done in motor code. His view is supported by two studies which show that the SPT effect is not dependent on pre-experimental integration (Engelkamp et al., 1993; Mohr, 1992). This specific controversy is not addressed in any of the studies included in the present thesis, as all items are poorly integrated semantically. More generally, all of the studies mentioned above (Engelkamp et al., 1993; Helstrup, 1993; Kormi-Nouri, 1995; Mohr, 1992; Steffens, 1999) indicate that enactment does not create new associations as much as it enhances existing associations. A similar conclusion regarding the creation of new associations can be drawn from the pair associate studies on SPT (e.g., Engelkamp, 1986; Helstrup, 1991), which have found SPT to be ineffective for creating associations between previously unrelated verb–verb pairs and noun–noun pairs. Studies A and B do not contradict this proposition. Even in a sentence with poor semantic integration between verb and noun, as in “knock on the pan,” for example, I would argue that some semantic integration exists for everyone who knows that a pan is concrete enough to make a knocking sound when you knock on it. Hence, an enhancement of association can be caused by enactment.

To summarize, it has been concluded that it is the overlap between the encoding and retrieval processes which causes an enhanced SPT effect in verb-cued recall. Item-specific association is believed to account for this overlap. A similar overlap has not been found between SPT and category-cued recall. It has therefore also been concluded that categorical-relational processing is not enhanced by enactment. This latter conclusion may not be generalizable to other forms of relational processing, however. The associative findings in the studies included are in line with Engelkamp’s theoretical view, but also in line with Steffens’ view.

Other controversies in SPT research

The main purpose of the present thesis is not to address issues in SPT research other than those discussed above. Nevertheless, the studies included may have implications on some of these issues. In the following, I will briefly relate the included studies to the other main controversies,
including age-related SPT effects, the non-strategic nature of SPT encoding, and the significance of objects.

**Age-related SPT effects**

Study B concerns the interaction between age and item-specific association in SPT. The aim was to shed some light on the inconsistencies in age-related SPT findings. The controversy concerned whether SPT suffers from similar ageing deficits as VT does or whether such deficits are reduced by enactment. Study B demonstrated one condition in which SPT suffers more than VT from age-related decline, and two conditions in which SPT and VT were similarly affected. A number of previous studies have found there is no age-related memory decline in SPTs. These findings are not supported by any of the recall conditions of Study B. It is thus concluded that the including of enactment at the encoding of verbal episodic material does not change the age-related decline of episodic memory performance. As can be expected in other episodic memory tests (Naveh-Benjamin, 2000), the decline is most pronounced when the associative demands are higher.

It was mentioned earlier that the interpretation of age-related SPT effects depends much on the particular view one has of ageing in general. One approach to ageing deficits deserves particular mentioning because it relates to the controversy regarding the strategic processing of SPTs. Age-related memory decline can be dependent on the inability or unwillingness of older subjects to use memory strategies to the same extent as younger subjects. This explanation could be applied to the results in Study B—if it can explain why the deficit surfaces only in the combination of SPT and verb-cued recall. One explanation could be that SPT only enhances an explicit integration strategy (cf., the following section). The overlap of an integrative strategy at encoding and integrative cues at recall (i.e., verb-cued recall) could be problematic for the older subjects to fully cope with.

**SPT as non-strategic encoding**

None of the studies included have manipulated instructions or conditions to reflect differential strategic processing in SPT compared to VT. Accordingly, any remarks on the topic will have to remain theoretical or speculative for now. Regarding Study C, the topic of strategy can be raised in relation to the sign language task condition. Is there any evidence of strategic or non-strategic processing in the sign language task? Since all tasks were performed under deliberate learning conditions, the subjects are likely to have mobilized strategies for handling the task at hand. The question is then whether signing has made the use of strategies more effective compared to the VT condition, or whether signing has activated different explicit strategies. The explicit use of motor imagery at encoding and the explicit retrieval of motions at recall are possible additional strategies used in the signing
condition. The effects of motor imagery were controlled for in two of the comparison conditions. Motor imagery did not account for more than a small part of the total enhancement. A series of simple feedback questions were administered after the experiment in Study C in order to tentatively assess some possibly important factors. Two feedback questions concerned whether subjects had explicitly tried to retrieve the words of the action sentence or the motion denoted in the sentence. Both types of explicit retrieval strategies were self-evaluated by the subjects on a Likert type scale. The absolute difference between the reported retrieval of movement compared to the reported retrieval of words was highest for the sign language task condition, intermediate for the SPT and motor imagery conditions, and lowest for the VT and translation conditions. None of the differences were significant, however. A covariance analysis, using the difference as covariate, revealed very small adjustments of the mean recall performances. The reported difference in retrieval strategy was an insignificant covariate. The conclusion is that all of the conditions in Study C used retrieval of motions as an explicit memory strategy to the same degree. This conclusion does not exclude the possibility that other strategies were differently activated in the separate condition.

Strategic explanations have been applied earlier to account for increased item-specific association in SPT. Engelkamp, Mohr and Zimmer, (1991) as well as Helstrup (1991) determined that the integration of previously unassociated verb-pairs and noun-pairs was not enhanced after enactment, unless explicit instructions to integrate were given. The explicit strategy was hence established as the cause for integrative effect. In a similar vein, Nilsson (2000) suggested that good semantic integration between verb-noun pairs would serve as an explicit instruction to integrate in SPT encoding. Good semantic integration would thus activate an explicit strategy of integrating the verbs and nouns of action sentences. In the studies included, no explicit instruction to integrate had been given. The semantic association between verbs and nouns in the to-be-remembered items was relatively poor. Based on these facts, it seems probable that the item-specific association effect in the studies is not an explicit strategic effect. Although strategic processing has not been directly examined in any of the studies included, there are some indications that it is non-strategic processing in the SPT and the sign language task that is causing the advantage. But, the issue of to what extent the item-specific effect in SPT should be regarded as strategic or not is still open for discussion and should be further explored in the future.

The significance of real objects for the SPT effect

Experiments using real objects as well as imaginary objects have been presented in the studies included. The main result to emphasize is that a substantial SPT effect has been demonstrated in all of these experiments. The mere occurrence of an SPT effect does not, therefore, appear to depend on
real objects. Steffens (2003) claims that this is not the case, and that experiments using imaginary objects, in fact, have many real objects in the experimental setting that can serve as retrieval cues. Moreover, Steffens asserts that enactment demands focusing on objects in the context more than VT does. This explanation is unlikely to account for the demonstrated SPT effects in the studies included. In both of the studies where imaginary objects were used (Study C and Experiment 2 of Study A), special care was taken to avoid the use of to-be-remembered items which included nouns that were likely to have their references present in the experimental setting. Moreover, the experimental setting was controlled with respect to objects, except for the occasional objects that subjects brought with them to the experiment. In Experiment 2 of Study A, the control of to-be-remembered items could not be fully applied since the action sentences were partly adopted from the Betula study, which had been done in order to provide a greater consistency between the experiments of Study A. Out of 72 to-be-remembered items in Experiment 2 of Study A, five objects (e.g., socks) were assumed to be present for all subjects, and three additional objects (e.g., tie) could be brought in by some of the subjects. The SPT advantage in free recall was, on average, 7.42 items. Considering that the objects, if present, could serve as cues in VT as well, and that the subjects were not allowed to actually interact with objects in SPT, I find it unlikely that such objects would account for a large part of the advantage.

Kormi-Nouri and Nilsson (1999) put forth the contention that real objects are important for item-specific association. The assignment of such a role to objects in SPT is not supported by the studies included. Only Study A examines item-specific association with and without the use of real objects. Although the absolute numbers are difficult to compare between the different experiments in Study A, item-specific association can be described by the statistical effect size (partial $\eta^2$) of the encoding/retrieval interaction. In Experiment 1, with real objects, the effect size for the integration was 0.25. In Experiment 2, with imaginary objects, the effect size was 0.22. Admittedly, the comparison of these experiments is not straightforward. Although the encoding procedures and the to-be-remembered items are largely comparable, there are big differences in the retention procedure and the delay between encoding and verb-cued recall. My tentative conclusion, based on the similar effect sizes, is that the exclusion of real objects has not made a difference for item-specific association.

**General limitations**

A general difficulty in studying memory is that a specific task is rarely dependent on only one of the memory systems. In studying episodic
memory, the semantic system, for example, nearly always has an influence on test performance. This becomes a problem when specific functions are to be studied. In non-applied psychology the fundamental functions are often what researchers want to understand. To get around this problem, a variety of tasks and methodological approaches should be utilized. Through this, possible confounders and modulators can be identified. The studies included could, for example, be followed up by studies that add different relational measures, compare noun cued recall to verb-cued recall, and apply recognition tests. The reasons behind inconsistent results can sometimes be found through such variations.

Cross-sectional data is used for assessing age-related differences in Study B. This is important to keep in mind when interpreting the age-related effects. The results of Study B reflect differences between age cohorts at a given point in time. They do not reflect the development of age deficits in individuals. All age cohorts have unique backgrounds with respect to education, health facilities, traveling, war experience, etc. Many such factors will affect memory capacities in addition to the factor of age. For assessing age-related decline as it develops within individuals, it would be necessary to longitudinally follow the same cohort of subjects over their adult lifespans. In the Betula project, from which the data in Study B is derived, there have been four waves of data collection for the first sample. The Betula project thus provides the opportunity to conduct longitudinal analyses of age-related decline as well as cross-sectional analyses. Rönnlund, Nyberg, Bäckman and Nilsson (in press) have recently given a detailed account of how the cross-sectional data compares with the longitudinal data in the Betula project, in regard to both episodic and semantic memory. While cohort membership and maturational change are the main problems of the cross sectional design, the longitudinal design needs to particularly consider the practice effects and dropout effects. In their analyses, Rönnlund et al. corrected for the longitudinal design in Betula, including practice effects and dropout effects. For the episodic memory measure (different than the SPT and VT measures in the present thesis), the cross-sectional and longitudinal estimations of change (decline) were similar in the oldest cohorts (60-85 years old). However, for the younger age cohorts (35-60 years old), cross-sectional data indicated decline whereas longitudinal data indicated stability over this age range. The episodic memory conditions included in Study B are likely to be subject to similar variations. This does not necessarily affect the results presented in Study B, however, because they are based on comparisons of these episodic memory conditions. Above all, the cross-sectional approach will affect the slopes of all conditions in Studie B. In my view, there is no reason to believe that the relations between different conditions in Study B would be very different in a longitudinal analysis.
The early SPT results were surprisingly generalizable over different groups of subjects, as was described in the introduction to the SPT paradigm. This was surprising because the episodic memory system is believed to be relatively sensitive to a variety of influences. The output of other memory systems, especially the procedural system, is much more stable and even globally generalizable. The subjects in Study C and Experiment 2 of Study B were sampled from students at universities and are therefore relatively particular samples in regard to their possible influences. The subjects in the Betula study were randomly sampled from the target population of a medium sized Swedish city (Umeå), which renders the sample unusually representative of a larger population.

Conclusions and final comments

One main point of contention in the present thesis concerns whether motor processes or conceptual processes are at the root of the SPT effect. The contribution of conceptual processing in the SPT effect, however, has never really been questioned. It is the possible contribution of motor processes that is more at issue. Based on the studies in the present thesis, the conclusion has been reached that conceptual explanations are inadequate without the effects of the overt motor output being included. Overt motor activation is crucial in order to achieve a full SPT effect.

The integration of concepts within an action sentence can, moreover, be concluded to be one of the more powerful effects in performing SPT. This has been the other main point of contention in the present thesis. The relational information shared by members of a noun category is, by contrast, an associative effect that is not enhanced in SPTs compared to VTs.

Considering the theoretical directions within SPT research, it is concluded that most of the assumptions in Engelkamp’s theoretical framework are supported. A direct effect of a motor modality was not assessed, however. According to my interpretation of Engelkamp’s conclusions, he does not assign as central of a role to item-specific association as the present thesis does. This effect has primarily been stressed by Kormi-Nouri.

Can the finding of a significant role for overt movement also be a direct cause for the increased item-specific association in SPT? To test such a hypothesis, one could combine the approaches of the studies included and test the verb-cued recall for signed action sentences. Since this was not done, I am left with speculations. Seeing that an essentially full “SPT effect” was demonstrated in the sign language task condition of Study C, and that the difference in SPT effect size is dependent on whether item-specific association is retrieved or not, the proposed relation does not seem unlikely.
One of the forthcoming tasks of SPT research should be to identify the crucial factors that influence the significance of overt movement, on the one hand, and conceptual effects, on the other. Furthermore, it would be interesting to explore the relations between the memory for enacted action sentences and self-performed real life actions, including such aspects as emotions, goal, evaluation of result, and social context. The door is open for the future of behavioral cognitive science to consider motor processes and their relation to verbal processes to a higher degree.
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