THE ENACTMENT EFFECT
STUDIES OF A MEMORY PHENOMENON

by

Lars Nyberg

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The enactment effect refers to the superior memory performance of enacted events over nonenacted events. There has been considerable disagreement on how to explain this effect, and it has been claimed that the basic laws of enacted and nonenacted events are different. The present thesis addressed both of these aspects of memory for enacted events. In Study I (Nilsson, Cohen, & Nyberg, 1989), the slopes of the forgetting curves for enacted and nonenacted events were compared, and found to be similar. In Study II (Nyberg, Nilsson, & Bäckman, 1992), the effect of age on recall of enacted and nonenacted events was studied, and an aging effect was found for both types of events. In Study III (Nyberg, Nilsson, & Bäckman, 1991), it was attempted to sort out various components contributing to the enactment effect, but no single component was found to be a prerequisite for the effect. Study IV (Nyberg & Nilsson, 1992) tested the hypothesis stating that conceptual information is contributed by enacted events. No support was found for this hypothesis. Based on the results of Study I and II, and a critical review of the literature, it is concluded that there is no reason for introducing new laws of memory for enacted events. The results of Study III and IV are discussed in relation to contemporary accounts of the enactment effect, and several features of previous explanations of the effect are called into question. Finally, a tentative model is proposed in which the enactment effect is explained in terms of enactment increasing the distinctiveness of the memory traces by adding item-specific and relational information.

Key words: Memory, enactment, memory laws, memory trace, item-specific information, relational information, distinctiveness.


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Preface

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Introduction

MEMORY is the name given to the process of encoding, storage, and retrieval of information (Murdock, 1974; Tulving, 1987). Traditionally, memory has been viewed as an unitary entity, but during recent years there has been a shift in orientation. Today, a lot of research is devoted to the question of whether memory really is unitary, or consists of several interrelated brain systems. A number of different classificatory schemes have been proposed by proponents of a multiple memory systems view (for a review, see Tulving, 1985). In order to define the domain of the present thesis, I will briefly describe one influential organizational scheme suggested by Tulving and Schacter (1990). This scheme distinguishes between four long-term memory systems: Procedural memory is believed to underlie changes in skillful performance and responding to stimuli; priming is concerned with identification of perceptual objects; semantic memory is concerned with acquisition and use of factual knowledge; and episodic memory mediates memory of personally experienced events. The present thesis is concerned with a phenomenon of episodic memory.

Tulving (1979) suggested an orientation toward phenomena of episodic memory in which recollection of an event is jointly determined by the information stored in memory about the event (the trace\(^1\)) and the information that is available to the rememberer at retrieval (the cue). Successful recollection is dependent on the compatibility between trace and cue information, a dependency which is salient in the encoding specificity hypothesis (Thomson & Tulving, 1970). To this hypothesis was later added the encoding specificity principle (Tulving & Thomson, 1973). This principle states that "specific encoding operations performed on what is perceived determine what is stored, and what is stored determines what retrieval cues are effective in providing access to what is stored" (Tulving & Thomson, 1973, p. 369). The formulation of the principle made the dependence of the memory trace on the encoding operations more explicit. This inter-dependency between the characteristics of memory traces and the encoding operations performed

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\(^1\) Several different views on traces have been put forward in the literature (e.g., vectors, lists, nodes, points, see Estes, 1991). At this point, the term "trace" is used, without any commitment as to its nature, to refer to a persistent change in the memory system following perception of an episodic event (Craik, 1979).
at input has been considered in explanations of the effect of several encoding manipulations:

The concept of encoding elaboration was introduced by Craik and Tulving (1975). They showed that encoding manipulations that served to elaborate or enrich the encoded trace of a target word led to better memory performance; memory performance was seen as dependent on the elaborativeness of the final encoding. In explaining how elaboration improves performance, the concept of elaboration has been tied to the concept of distinctiveness of the memory trace (Jacoby & Craik, 1979; Lockhart & Craik, 1990; Moscovitch & Craik, 1976). Elaborative processing at encoding is believed to allow formation of a more distinctive, discriminable memory trace that stands out and is therefore more retrievable.

Degree of rehearsal has for a long time been associated with degree of memory performance (e.g., Rundus, 1971). Craik and Lockhart (1972) suggested that rehearsal can be broken down into two main types; maintenance rehearsal and elaborative rehearsal. Maintenance rehearsal involves maintained processing at the same level of analysis, whereas elaborative rehearsal leads to further elaboration of the stimulus. The original assumption was that only the latter form of rehearsal produced improved memory performance (Craik & Lockhart, 1972). This assumption, based on the hypothesis that only elaborative rehearsal causes permanent changes in the memory trace, received some experimental support (e.g., Craik & Watkins, 1973). However, it was also shown that recognition memory clearly benefits from maintenance rehearsal (Woodward, Bjork, & Jongeward, 1973), and the current view is that maintenance rehearsal produces small increases in recall, and substantial increases in recognition (Greene, 1987). Clearly, this shows that also maintenance rehearsal can produce permanent changes in the memory trace, although these changes are most obvious when memory is tested with recognition. Based on the notion that recall depends heavily on interitem elaboration, whereas recognition is increased by intratitem integration (Mandler, 1979), it has been suggested that maintenance rehearsal causes repetition of the features related to the physical aspects of items, whereas elaborative rehearsal adds relational information to the traces (Greene, 1987; Lockhart & Craik, 1990).
The way the stimulus materials is presented is known to substantially affect memory performance. One of the best known examples is the "generation effect" (Jacoby, 1978; Slamecka & Graf, 1978). This effect refers to a memory benefit for materials generated by subjects themselves compared to materials supplied by the experimenter (e.g., Bobrow & Bower, 1969; Schwartz, 1971). Generation effects have been demonstrated on free recall, suggesting that some form of relational processing is enhanced by generation (Hirshman & Bjork, 1988; McDaniel, Riegler, & Waddill, 1990). However, the effect of generation is strongest on discrimination tests such as recognition (Begg, Snider, Foley, & Goddard, 1989), and it has been proposed that the generation effect primarily is due to the encoding of item-specific information, leading to a more distinctive record of the generated items (Begg et al., 1989; Gardiner & Hampton, 1985).

Taken together, this brief discussion of current accounts of the effects of elaboration, rehearsal, and generation illustrates the strong relationship between the characteristics of memory traces and the encoding operations performed at input. It also highlights that the goodness of a particular encoding operation depends on the nature of the cues present at retrieval. Thus, given the assumption that a retrieval cue is effective only to the extent that its informational content matches those of the trace, it is possible to make inferences about the effect of an encoding operation on the memory trace by observing the effectiveness of different cues (cf., Tulving, 1979). It is the overall purpose of this thesis to present an analysis of the effect of a more recently developed encoding manipulation, enactment, given a proper account of available retrieval information.

**Memory of enacted events**

The study of memory for enacted events was initiated by Engelkamp and Krumnacker (1980), Saltz and Donnenwerth-Nolan (1981), and Cohen (1981). In its basic form, this paradigm requires subjects to perform minitasks in response to verbal instructions (e.g., roll the ball) which the subjects are instructed to try to remember. The typical control condition is to present the same verbal commands without requiring the subjects to perform the acts defined by the instructions. Following presentation,
subjects are instructed to make free recall of the verbal instructions. The principle finding within this paradigm is that memory for enacted action phrases generally is superior to memory for the same action phrases without enactment (e.g., Bäckman, Nilsson, & Chalom, 1986; Cohen, 1981; Engelkamp & Zimmer, 1985).

A slightly different procedure has also been used to study memory of enacted events. As in the standard procedure, subjects are presented verbal instructions that are encoded with or without enactment. However, instead of a free recall task, subjects are given a cued recall task. A cue-word from the verbal instructions is presented, and subjects are instructed to complete the instruction by recalling the rest of the sentence. Enactment has been found to substantially increase memory performance also with this procedure (Saltz, 1988; Saltz & Donnenwerth-Nolan, 1981).

Following Cohen (1981), enacted action phrases will here be referred to as SPTs (Subject-Performed Tasks), nonenacted action phrases will be referred to as VTs (Verbal Tasks), and the enactment effect will be referred to as the SPT-effect. In addition, a few studies have included a condition involving performance by the experimenter instead of the subjects. This manipulation will be referred to as EPT (Experimenter-Performed Task).

At this point, I would like to highlight the distinction between learning of motor skills and memory of SPTs (cf., Cohen, 1989a). This distinction relates to the distinction between procedural memory and episodic memory (e.g., Tulving, 1987). The study of acquisition of motor skills has a long history (see e.g., Adams, 1969a), and relevant examples of motor tasks are the Line-Drawing test and the Rotary Pursuit test. The object in the learning of motor skills is to achieve efficiency in reproduction of movement patterns. In contrast, the object in SPT memory is to remember as many commands as possible from a study trial. Moreover recall is in the form of verbal descriptions; not reproduction of action patterns.

It is evident from the literature that it is possible to look at the SPT manipulation in, at least, two different ways. In the early papers by Engelkamp and Krumnacker (1980) and by Saltz and Donnenwerth-Nolan (1981), enactment was seen as a way of improving memory performance. Engelkamp and Krumnacker set out to test the hypothesis that motor processes, in addition to verbal and imaginal processes, influence recall
performance, and Saltz and Donnenwerth-Nolan had the specific purpose of investigating *how* motoric enactment facilitates sentence memory. Quite opposite, Cohen (1981) used the SPT task as a specific form of memory materials rather than as a form of encoding support, and the purpose of the Cohen paper was to test the generalizability of some memory laws established for free recall of word lists by using SPTs.

I prefer to view the SPT manipulation as a form of encoding support rather than as a specific form of memory materials. Still, the papers to be presented in the empirical section of this thesis are relevant for both of these aspects of memory for enacted events. Next, findings that have led to the suggestion that memory of SPTs and VTs are based on different laws will be discussed. That section is followed by a discussion of theoretical explanations of the SPT effect.

Separate laws for memory of enacted and nonenacted events

Cohen (1981) set out to test the generality of some memory laws² by using members from two different event classes; one-way events (e.g., words) and two-way events (e.g., SPTs). The term one-way event was used to define a class of events in which subjects do not exert any observable effect on the environment, whereas the class of two-way events involves the observable manipulation of the environment by subjects. The rational for the study was that to the extent that memory laws exist, these laws have been established by using one-way events and nothing is known about their generalizability to other event classes.

The results of the Cohen (1981) study suggested lack of generality for a few of the laws tested. Specifically, whereas there was a strong positive recency effect for SPTs as well as for VTs, SPT recall did not show any effect of primacy. Also, subjects self-reports indicated that they did not use active memorisation strategies for SPT lists, but they did so for word lists. Moreover, the levels of processing manipulation did not affect SPT recall.

² The concept of law was used by Cohen (1981) in a rather liberal sense to refer to reliable memory effects such as the primacy effect and the levels-of-processing effect. Cohen (1985) has acknowledged that laws and effects are not synonymous, and a more proper term for the "laws" to be discussed in this section is therefore "effects". In this section, I will, however, use the terminology adopted by Cohen (1981). A more thorough discussion of the concept of law is given in the General discussion section.
In all, these memory-law violations were interpreted as suggesting that traditional encoding mechanisms are of little importance in SPT recall.

A couple of studies involving subject-related variables provided further support for this interpretation. Cohen and Stewart (1982) demonstrated that the typical developmental effect found in verbal recall did not significantly show up in SPT recall; 9-year-old children's performance was comparable to the performance of 13-year-old children. Since it has been claimed that developmental effects should show up in strategic tasks, Cohen and Stewart interpreted this finding as indicating that SPTs are nonstrategically encoded. Comparable levels of recall for educable mentally retarded subjects and nonretarded controls was demonstrated by Cohen and Bean (1983). The mentally retarded subjects were presumed to have general strategic deficits. For this reason, the lack of difference in memory performance can be seen as supporting the interpretation that SPT encoding is nonstrategic.

Further experimental study revealed additional differences between SPT and VT memory. Cohen (1983) showed that labeling some items as more important to remember than others had a strong effect on recall of VTs, but only a minimal effect on SPT recall. In that study it was also shown that subjects were rather good at predicting which VTs they were to recall, but not which SPTs should be easy to recall. In addition, Nilsson and Cohen (1988) found that the generation effect and encoding elaboration had no effect on SPT recall (see also Nilsson, Nyberg, & Kormi-Nouri, 1992).

Taken together, the differential effects of various experimental- and subject-related variables can be taken as suggesting that SPTs and VTs obey different memory laws. That the basic laws of SPT and VT memory are different has also been proposed by others (Nilsson & Bäckman, 1989a). Nilsson and Bäckman added two SPT-VT dissociations to those described above. First, they pointed out that intentionality to learn does not affect SPTs (e.g., Kausler, Lichty, & Freund, 1985). Second, SPTs and VTs behave differently with respect to the phenomenon of recognition failure of recallable items (Nilsson, Law, & Tulving, 1988; see also Svensson & Nilsson, 1989).

Cohen has, as stated above, offered an explanation of the different patterns of results for SPTs and VTs in terms of lack of memorisation
strategies in the case of SPTs (see e.g., Cohen, 1989a). That is, during standard instructions subjects do not appear to use memorisation strategies to improve the encoding of SPTs. This may be due to the fact that subjects do not know how to improve encoding of SPTs (Cohen, 1989a; see also Helstrup, 1987). Thus, in the sense that subjects do not use strategies when encoding SPTs, SPT learning can be said to be automatic.

The studies to be presented in the empirical section of this thesis have implications for the notion that the basic laws of SPT and VT memory are different (Study I), and for the "strategy-explanation" of these memory law violations proposed by Cohen (Study II).

Starting with the issue whether memory of enacted and nonenacted events are based on different laws, it can be questioned what criteria should be fulfilled to motivate the introduction of new laws of memory. For example, the lack of primacy effect for SPT recall has, as described above, been seen as a rather strong argument in favour of the notion that SPT recall obey different laws than VT recall. Helstrup (1986) has, however, argued that building memory laws based on differences in serial position curves is suspicious. Virtually any variant of the serial position curve has been shown possible to produce by various experimental manipulations.

A stronger criterion would be if the superior memory performance of SPTs over VTs interacts with rate of forgetting such that the magnitude of the SPT effect increases over time. This is because, so far, degree of original learning has not been demonstrated to affect rate of forgetting (Slamecka & McElree, 1983).

Slamecka and McElree (1983) pointed out that the large amount of studies of the effect of encoding operations on long-term retention stands in sharp contrast to the very few studies of the effect of encoding operations on normal forgetting (i.e., forgetting that occurs with the passage of time). In fact, based on a review of the literature, Slamecka and McElree concluded that the literature provided no firm answer to the question of how degree of learning affects forgetting. They therefore set out to test this issue empirically, and found that long-term forgetting of verbal lists is unaffected by the degree of original learning. Slamecka and McElree (1983) based this conclusion on test of vertical parallelism. Loftus (1985) has favoured a method involving analysis of horizontal parallelism, and by using this method he has found that forgetting is slower for higher
degrees of initial learning. Slamecka (1985) has, however, criticised this method, and he argued that the method suggested by Loftus (1985) involves a confounding with the ages of the lists being compared. The question of how to analyze forgetting curves remains a critical issue, but most, if not all, studies of normal forgetting have involved test of vertical parallelism. This method was also used in the empirical section of the present thesis.

Thus, the strong effect of degree of original learning on long-term retention has not been found to be reflected in the rate of forgetting. Therefore, a reflection of the initial superiority in memory performance of SPTs over VTs on the rate of forgetting could be taken as support for the view that the basic laws of enacted and nonenacted memory are different. In fact, such a finding would suggest that the underlying memory processes involved in SPT- and VT memory are different; a view previously advanced by Nilsson and Bäckman (1989b). This is because the forgetting curves for memory abilities assumed to be mediated by separate underlying memory systems are quite different. One relevant example is the slopes of the forgetting curves for episodic memories and memory for continuous motor skills. Most memory theorists agree that it is likely that memory of episodes and memory of skills are mediated by different memory systems in the brain (e.g., Squire, 1992; Tulving & Schacter, 1990), and the slopes of the forgetting curves for these different types of materials are also fundamentally different (e.g., Adams, 1969b).

Taken together, it has been argued that serial position curves are hardly constancies on which to build laws of memory (Helstrup, 1986). It appears that different rates of forgetting would be a stronger support for the notion of different laws, and one of the purposes of the present thesis was to compare the slopes of the forgetting curves for SPTs and VTs (Study I).

Turning now to the question of how to explain the apparent memory law violations, Cohen's suggestion of SPT learning being automatic rather than strategic implies that recall of SPTs should be independent of subjects' age (cf., Hasher & Zacks, 1979). In line with this expectation, Bäckman and Nilsson (1984, 1985) found an eliminated age effect when SPTs were used as the to-be-remembered materials. Bäckman and Nilsson (1984, 1985) compared free recall performance for young subjects (approximately 20 years of age) and old subjects (approximately 70 years of
age). Clearly, the finding by Bäckman and Nilsson of an eliminated age effect for SPTs supports Cohen's assumption of SPT learning being automatic.

However, although a few studies have replicated the finding of an eliminated age effect (Cohen & Faulkner, 1990; Dick, Kean, & Sands, 1989), several studies have found that age differences indeed influence SPT recall (e.g., Cohen, Sandler, & Schroeder, 1987b; Guttentag & Hunt, 1988; Knopf & Niedhardt, 1989; Nilsson & Craik, 1990). Findings of age differences cast doubts on Cohen's "strategy-explanation" of the different data patterns obtained for SPTs and VTs. It is therefore urgent to explore the reasons as to why the aging effect sometimes is eliminated, and sometimes present (or only reduced).

Differences in the experimental procedures have been put forward as a potential solution to the puzzle (see Cohen 1989a; Engelkamp & Cohen, 1991). The specific items used may be one important difference. In general, commands vary greatly in recallability (e.g., Cohen, 1989a), and recent findings suggest that item type can interact with subject age (Norris & West, 1991). Variations in list length have also been considered in this context (Cohen et al., 1987b). Cohen et al. found reliable aging effects in SPT recall for long lists (37 items), but not for short lists (14 items), suggesting that effects of aging show up when the task is more demanding (for similar conclusions, see Knopf, 1991; Norris & West, 1991). However, an interpretative difficulty with the finding by Cohen et al. (1987b) is that VT recall for short lists was only marginally more affected by age than was SPT recall. In addition, Kausler and co-workers have consistently found aging effects in memory of subject-performed activities using short lists (e.g., Kausler et al., 1985). Obviously, the picture is not clear, and the relation between age and SPT recall was therefore studied in the present thesis (Study II) using exactly the same materials (12-item lists) as in the first study reporting an eliminated age effect (Bäckman & Nilsson, 1984).

In this context it is warranted to stress that not only studies of the relation between SPT recall and age have yielded mixed results. Rather, I consider lack of replicability as a central problem in this area of research. Relevant examples of variables that have generated divergent outcomes are levels-of-processing, developmental effects, and primacy. These variables will be
discussed at some length in the General discussion section. Furthermore, it is also true that many of the dissociations demonstrated between SPT and VT-recall are based on single studies only (cf., Nyberg, Nilsson, & Bäckman, 1992). Thus, there is an obvious danger in that future research will reveal additional inconsistencies. Nevertheless, it is a general consensus on the issue of primary concern in here; the enactment effect is a highly reliable phenomenon (cf., Cohen, 1989a).

Theoretical explanations of the enactment effect

The major distinguishing feature of SPT learning is the involvement of enactment, and all SPT researchers would probably agree that an explanation of the SPT effect has to involve the motor component.

The position taken by Engelkamp and Zimmer (e.g., 1985) lends special importance to the motor component of SPTs. These authors have motivated their strong emphasis on the motor aspect by suggesting that enactment improves item-specific encoding (Hunt & Einstein, 1981), and thereby produces the SPT effect (see e.g., Engelkamp, 1990; Engelkamp & Cohen, 1991). Engelkamp and Zimmer have modified Paivio's dual-code theory in the sense that they have added a motor system and a conceptual system to the theory proposed by Paivio (Paivio, 1971). Activation of the motor memory results from performing an action (Engelkamp & Zimmer, 1985), and activating the motor system is assumed to improve item-specific encoding (i.e., encoding of information connected to the to-be-remembered information).

Cohen has also assigned particular importance to the motor component in explaining the SPT effect (see e.g., Cohen, 1989a). According to Cohen, the actual pattern of motor activity is unimportant. As long as some appropriate activity is involved, memory performance benefits from enactment. As to how enactment improves memory, Cohen has suggested that enactment facilitates retrieval by adding a dimension to the memory trace (Cohen, 1989a).

The position taken by Cohen resembles the explanation favoured by Saltz in the sense that Saltz has also suggested that enactment facilitates sentence recall by resulting in a motoric image or trace (Saltz, 1988; Saltz
Donnenwerth-Nolan, 1981). Saltz assumes that enactment helps specify the meaning of the various concepts that are a part of a sentence, thereby improving recall of the sentence. In a sentence like "the boy threw the ball", the act of throwing is an attribute of the boy. Enactment would lead to a more specific activation of the attribute (throwing) of the concept (boy) than just reading the sentence. Due to this more specific activation, the concept is assumed to be registered more precisely, leading to less overlap with other concepts and thereby increased retention (cf., Klein & Saltz, 1976).

Also Bäckman and Nilsson put strong emphasis on the motor component in explaining the SPT effect (Bäckman & Nilsson, 1984, 1985; Bäckman, 1985, Bäckman et al., 1986). In essence, this framework explains the SPT-effect by referring to the richer encoding situation in the case of SPTs. Several sensory systems are involved during encoding of SPTs, and each SPT comprises a number of different features on which the encoding can be based (e.g., motor features and features of color, texture, and shape). As a consequence of the multimodal and rich properties of SPTs, it is proposed that two kinds of information can be involved in the SPT task (the verbal commands and the motor actions), whereas only information about the verbal commands is available in the case of VTs.

It should be evident from the above discussion that the motor component holds a central position in explanations of the SPT effect. However, it must be observed that there has been considerable disagreement as to whether motor activity on the part of the subject is a prerequisite for the SPT effect. This issue relates to the question of whether motor processing has to be overt to facilitate memory performance, or if covert (i.e., imagined) actions also produce an SPT effect. Starting with the question of physical motor activity, Cohen does not assume that self performance is of particular importance for the SPT effect. In support of this view, Cohen has repeatedly shown that SPTs are not significantly better remembered than EPTs (Cohen, 1981, 1983; Cohen et al., 1987a), and Cohen considers SPTs and EPTs as memorially very similar (Cohen, 1989b). In contrast, Engelkamp and Zimmer (1983, 1985) claim that there is a qualitative difference between SPTs and VTs, and they have found that SPTs are better remembered than EPTs.
Turning to the distinction between overt and covert enactment, Engelkamp and colleagues have shown that covert enactment improve performance (cf., Engelkamp & Krumnacker, 1980; Engelkamp, Zimmer, & Denis, 1989). Similarly, Saltz has found that covert enactment actually can lead to a higher performance than overt enactment (Saltz & Donnenwerth-Nolan, 1981; see also Saltz, 1988). Interestingly, Bäckman (1985) reported results suggesting that the importance of overt enactment may be dependent on the age of the subjects. Bäckman presented subjects sentences like "roll the ball", and simultaneously the objects in the sentences were presented. Half of the subjects were allowed to act motorically, whereas the other half encoded the sentences without motor action. The results showed no difference in memory performance between the two task conditions for young subjects. In contrast, elderly subjects' performance was significantly decreased when the motor component was excluded. It was suggested that activation of the tactual modality and presence of motor aspects was a critical prerequisite for the elderly's high performance on SPTs. To explain the pattern of results for the young subjects, it was suggested that young subjects might be capable of recoding the materials so that motor aspects become a part of the stored information. Visual imagery was seen as a plausible type of recoding. Thus, the young subjects' high performance when the motor component was excluded was explained in terms of subjectively initiated covert enactment.

Helstrup has also found that imagined acts are as well remembered as performed acts, and he has argued that act recall produces similar results irrespective of whether the acts are concretely performed, symbolically performed, or imagined (Helstrup, 1986, 1987). This is consistent with the problem-solving approach favoured by Helstrup. In terms of this approach, motor attributes do not comprise a separate source of information. Rather, whether or not enactment leads to superior memory performance than nonenactment is suggested to depend on the specific encoding conditions. Thus, if the orienting responses to the task material engages subjects, and the situation involves sufficiently useful memory cues (e.g., imaging oneself performing the acts), the addition of motor cues will not make any difference (see Helstrup, 1987). Obviously, this view differs from the strong emphasis on the motor component found in most other explanations of the SPT effect.
Another distinguishing feature of SPT learning is involvement of objects. However, this feature is not a part of all experimental paradigms. That is, whereas the paradigm used by Cohen and by Bäckman and Nilsson involves real objects, the procedure followed by Engelkamp and Zimmer and by Saltz does not involve presenting subjects with real objects. Instead, the subjects symbolically perform the actions defined by the instructions, and a clear effect of enactment is still obtained (see also Helstrup, 1986). Presumably due to the lack of involvement of concrete objects in the procedure followed by the latter research groups, the object component does not hold a central position in explanations of the SPT effect. However, as noted above, the object component plays an important role in the framework proposed by Bäckman and colleagues. This framework assumes that the SPT effect is based on the multimodal, rich encoding of SPTs, and the richness of the encoding is considered to be dependent on the sensorial richness of the stimulus event. SPTs involving manipulation of real, concrete objects (e.g., "roll the marble"; "bounce the ball") should be more apt for a rich encoding than SPTs not involving such objects (e.g., "lift your arm"; "point at the door"), and therefore better recalled. This is because SPTs involving external objects should comprise a larger number of features on which the encoding can be based (cf., Bäckman et al., 1986).

Type of objects has also been considered in analyses of interitem differences in SPT recall (Cohen et al., 1987a). Cohen et al. distinguished between SPTs involving extra-environmental objects (e.g., "roll the ball") and SPTs not involving extra-environmental objects (e.g., "point at the door"). It was hypothesized that since the extra-environmental objects are removed immediately following event presentation, the environment should provide poorer retrieval cues for SPTs involving this type of objects, and the results supported this hypothesis. In the same study, it was attempted to experimentally separate the action and object components of action events in order to find out which component that primarily determines recall probabilities of action events. They found that the action component had the major role; objects played only a subsidiary role.

The importance of objects for the SPT effect as well as for interitem differences in event memory, and the significance of the motor component, was further addressed in the present thesis (Study III).
More recently, it has been hypothesized that SPTs, in addition to motoric information, also add conceptual information (Nilsson & Craik, 1990). Nilsson and Craik demonstrated what they termed additive and interactive effects between SPTs and various variables. Additive effects of variables are expected to show up for variables that induce information that is orthogonal to that induced by SPTs. Given that SPTs add motoric information, it is thus expected that SPTs act additively with variables that do not induce motoric information. Such effects have, for example, been demonstrated for list structure and retrieval cues (Nilsson & Craik, 1990).

Interactive effects should occur for variables that induce encoded information that overlaps with information added by SPTs. Curiously, a few variables that not add motoric information have been found to act interactively with SPTs. For example, the levels-of-processing manipulation has been shown to act interactively with SPT effects: Whereas memory of verbal information benefits from a deep encoding, SPT memory is only little affected by processing level (e.g., Cohen, 1981; Nilsson & Craik, 1990). A possible explanation to the interactive effect between the SPT- and the levels-of-processing manipulations is that SPTs, in addition to motoric information, add information induced by the levels-of-processing manipulation, and that their dual occurrence contributes nothing further. Interactive effects have also been reported between SPTs and the generation effect (Nilsson & Cohen, 1988). Both levels of processing and generation have been suggested to enhance recall through the addition of conceptual information (e.g., Craik & Lockhart, 1972; Graf, 1982). For this reason, Nilsson and Craik proposed that SPTs, in addition to motoric information, add conceptual information.

The proposal that SPTs add conceptual information has important implications for theories of SPT memory since it implies that one basis for the SPT effect would be inducement of a richer conceptual representation. However, as acknowledged by Nilsson and Craik (1990), the empirical evidence supporting this proposal is sparse. One of the studies reported in the empirical section of this thesis therefore tested the hypothesis that enactment leads to inducement of a richer conceptual representation (Study IV).
Overview of the empirical studies


Nilsson, Cohen and Nyberg (1989) compared the forgetting rates for SPTs and VTs. The first experiment used the procedure for measuring forgetting suggested by Slamecka and McElree (1983). That is, no attempt was made to equate initial recall levels for the encoding manipulations compared. Subjects were presented with 3 12-item lists of SPTs and 3 12-item lists of VTs. The VTs were typed on cards which were shown to the subjects, and also read by the experimenter. For SPTs, the instructions were read aloud by the experimenter. The presentation rate was approximately 5 s per item. A test of immediate free recall (IFR) was given after each list. In addition, one third of the subjects were given an unexpected final free recall (FFR) test two minutes after recalling the items from the last presented list. Another third were given the same test after 1 day (24 hours), and the last third of the subjects were given the same test after one week.

Analyses of the FFR-data showed a main effect of materials (an SPT-effect), and a main effect of retention interval (showing that forgetting occurred). The critical interaction between materials and retention interval was, however, nonsignificant. The lack of interaction indicates similar forgetting rates for SPTs and VTs.

Experiment 2 used a slightly different procedure for measuring forgetting. In this experiment, effort was investigated in trying to equate the initial recall values (i.e., to eliminate intercept differences; cf., Nelson & Vining, 1978). This was done by varying the number of presentations during acquisition (half of the items were presented once and the other half twice).

The materials and the procedure were basically the same as in Experiment 1. Only two SPT lists and two VT lists were, however, used. The results showed, once again, a nonsignificant interaction between encoding condition and retention interval. An analysis of the effect of the attempt to equate the initial recall values showed that this attempt failed; one presentation of SPTs produced a significantly higher recall.
performance than did two presentations of VTs. Analysis of the forgetting functions for these conditions only, revealed a nonsignificant interaction.

In Experiment 3 an additional attempt was made to equate the initial recall values. SPTs were presented either once or twice, whereas the VTs were presented either three or four times. The retention intervals differed from the first two experiments; subjects were tested after 2 min, after 6 hours, or after 24 hours. In all other important respects, the experimental design was similar to the design in Experiments 1 and 2.

Analyses of the IFR-data showed that this time, the attempt to equate the initial recall values was successful; the performance for four times presented VTs was not significantly different from the one or two presentations of SPTs. However, once again, no significant interaction was found, leading to the conclusion that long-term forgetting functions for SPTs and VTs do not differ. In turn, this was seen as suggesting that the mechanisms underlying SPT and VT recall are not fundamentally different.

Finally, the drop in performance between IFR and the first FFR test (given after a 2 minutes retention interval) was compared for SPTs and VTs. Visual inspection of the data suggested that this drop was somewhat more pronounced for VTs than for SPTs. This impression was given partial support by analyses of the data from each of the experiments, as well as for an analysis of data collapsed across experiments.

Taken together, although the long-term forgetting functions did not differ, the data suggested that there is a somewhat more marked forgetting rate over the first few minutes after study for VTs compared to SPTs.

**Study II (Nyberg, Nilsson, & Bäckman, 1992).**

Nyberg, Nilsson, and Bäckman (1992) tried to replicate the studies presented by Bäckman and Nilsson (e.g., 1984, 1985) showing an eliminated age effect for SPTs. In addition, the drop in performance between IFR and FFR was compared for SPTs and VTs. Following Bäckman and Nilsson (1984), both recall of sentences and recall of nouns from the sentences were used as verbal controls. These verbal conditions will collectively be referred to as VTs.
One group of elderly subjects \((M = 69.3)\) and one group of young subjects \((M = 19.1)\) were tested. Subjects were presented with six 12-item lists which were the same materials as used by Bäckman and Nilsson (1984). Items in two of the lists were presented as SPTs, in another two of the lists as sentences, and in still another two only the noun in each action phrase was presented. The lists were counterbalanced across materials, and order of list presentation was counterbalanced across subjects. The action phrases and the nouns were presented by means of a slide projector at a rate of 5 sec per item. Before presentation of each list, subjects were instructed to try to remember as many items as possible, and after presentation of each list there was an IFR test. Fifteen minutes after presentation and test of the last list, subjects were given a FFR test of all 72 items.

Aging effects were predicted to show up for VTs but not for SPTs (cf., Bäckman & Nilsson, 1984, 1985). Moreover, based on Nilsson, Cohen, and Nyberg (1989), the drop in performance between IFR and FFR was predicted to be more pronounced for VTs than for SPTs.

The results confirmed the prediction for the performance drop by showing less forgetting between IFR and FFR for SPTs compared to VTs. However, the aging data showed a superior memory performance for the young subjects over the elderly subjects for VTs as well as for SPTs. The differences in recall were, however, more pronounced for the VTs than for the SPTs.

The results were interpreted as showing that the age effect is less pronounced for SPTs than for VTs since the encoding situation involves a high degree of cognitive support. Differential sensitivity to proactive interference was suggested as explanation to the difference in forgetting rates over the initial minutes of retention between SPTs and VTs (cf., Nilsson & Bäckman, 1991).

**Study III (Nyberg, Nilsson, & Bäckman, 1991).**

Nyberg, Nilsson, and Bäckman (1991) examined the basis for the SPT-effect in two experiments, and explored the question why some SPTs are easier to recall than others in one additional experiment.
Experiment 1 focused on the importance of the object component for the SPT effect. Subjects studied a mixed list of SPTs and VTs. Half of the items involved extra-environmental objects, the other half did not. The items were counterbalanced across materials. Subjects were instructed to try to remember as many items as possible for a subsequent test of free recall. Based on the theory proposed by Bäckman and Nilsson (1984, 1985), a larger SPT effect was predicted for SPTs involving extra-environmental objects (e.g., "open the book"; "lift the spoon") than for SPTs not involving extra-environmental objects (e.g., "touch your ear"; "cross your legs") since the former type of items should make the encoding environment more supportive. Note that this prediction is in conflict with the results by Cohen et al. (1987a, Exp. 1), who found a tendency for no-object events to be recalled better than object events.

The results did not confirm the prediction. There was no difference between SPTs involving extra-environmental objects and SPTs not involving such objects. In fact, there was a nonsignificant tendency for a higher memory performance for SPTs not involving extra-environmental objects (cf., Cohen et al., 1987a, Exp. 1). This finding indicates that the object component may not be a critical factor for the advantage of SPTs over VTs.

The second experiment focused on the importance of the number of modalities activated during encoding, and the importance of the action component. A similar design and the same materials as in Experiment 1 were used. The procedure differed in one respect: When an action phrase involving an extra-environmental object was presented as a VT, the object was shown to the subjects. They were not allowed to touch the objects. It was predicted that SPTs involving extra-environmental objects would give a higher memory performance than VTs involving extra-environmental objects since the SPTs involved enactment and manipulation of the objects, thereby activating an additional modality and increasing the richness.

The results showed that SPTs not involving extra-environmental objects were best remembered, and, opposite to the prediction, there was no difference in memory performance between SPTs and VTs involving extra-environmental objects. This finding shows that the memory performance does not increase as a function of the number of activated
modalities during encoding, and suggests that the action component is not especially critical for the memory performance.

Experiment 3 examined why some SPTs are easier to recall than others. In so doing, the importance of compatibility between encoding and retrieval was studied. This was accomplished by presenting subjects a mixed list of SPTs and VTs. The items were counterbalanced across materials, and were of four different kinds: Action phrases involving (1) body parts, (2) effects in the laboratory, (3) kitchen utensils, and (4) items not belonging to specific categories. It was predicted that items involving objects present both during encoding and retrieval would be best remembered [i.e. categories (1) and (2)]. Whereas this prediction is in line with Cohen et al. (1987a), a richness of encoding view (Bäckman & Nilsson, 1984, 1985) would predict the highest performance for categories (3) and (4). The results confirmed the prediction by showing a superior memory performance for categories (1) and (2) for both SPTs and VTs.

The overall impression from Experiments 1 and 2 was that it is not possible to partial out a single component as the cause of the SPT-effect. The results showed that provision of extra-environmental objects does not enhance SPT recall. The finding that SPTs and VTs involving extra-environmental objects were remembered to the same extent indicated that multimodality does not lead to a superior memory performance than does bimodal activation. Also, that SPTs and VTs were remembered to the same extent suggested that enactment by the subjects is not of special significance for the SPT-effect.

Experiment 3 pointed to the importance of a high degree of compatibility between encoding and retrieval. This result suggested that the logic of the encoding specificity principle (e.g., Tulving, 1983) can be extended from the domain of verbal materials to the domain of action events. It was concluded that it is sufficient to consider the more supportive encoding situation in the case of SPTs in explaining the SPT-effect, but that the relation between encoding and retrieval must be taken into account in trying to explain why some SPTs are more memorable than others.


Nyberg and Nilsson (1992) set out to test the hypothesis that SPTs add conceptual information to the memory trace (Nilsson & Craik, 1990). In so
doing they studied the effect of the SPT-manipulation on implicit memory performance (Graf & Schacter, 1985). Several studies in the domain of implicit memory have shown that performance on conceptually driven implicit tests (e.g., general knowledge retrieval; category association) benefits from encoding operations involving conceptual elaboration (e.g., Blaxton, 1989; Hamann, 1990; Rappold & Hashtroudi, 1991; Srinivas & Roediger, 1990). The basic idea was therefore that if SPTs add conceptual information, SPTs would produce greater priming than VTs on a conceptually driven implicit test.

In Experiment 1, subjects were presented with 30 imperatives, including 5 buffer items. To allow evaluation of the priming effect, two different study lists were used. The target nouns in each study list were from five different semantic categories (5 nouns / category). Each imperative was typed on a separate sheet, and presented for 8 s. Half of the items in the study list were presented as SPTs, and the other half as VTs. Following presentation, subjects were given two different implicit tests (category association and stem completion), followed by a test of free recall. The items in the study lists were presented in blocks of SPTs and VTs, and the order between the blocks and the order of the implicit tests were counterbalanced across subjects.

It was predicted that if conceptual information is added by SPTs, the amount of priming on the conceptually driven implicit test, category association, would be higher for SPTs than for VTs. Performance on data-driven implicit tests, such as stem completion, has been seen as not being affected by conceptual elaboration (e.g., Roediger, Weldon, & Challis, 1989). However, recently Challis and Brodbeck (1992) showed that also this type of implicit test can be affected by conceptual encoding manipulations. A higher performance on stem completion was therefore predicted for SPTs.

The results showed the standard SPT-effect in free recall. However, opposite to the predictions, priming on the implicit tests was not significantly higher for SPTs than for VTs. Since priming on conceptually driven tests repeatedly has been found to be increased by manipulations involving conceptual elaboration, this suggests that SPTs do not add conceptual information. However, to test the possibility that the category association test is not sensitive to semantic elaboration of the kind of
materials used in the present study (verbal imperatives) an additional encoding manipulation, generation, was included in Experiment 2.

In Experiment 2, three different study manipulations were used; SPTs, VTs, and generation. The generation condition involved generation of the noun in the imperatives in which the first and the last letter of the noun was switched (e.g., "earblm" for "marble"). The items in the study list were presented in a mixed fashion, and the data-driven implicit test (stem completion) was not included. In all other respects, the experimental design was similar to the design used in Experiment 1.

Generation was predicted to produce a substantial priming effect on category association, and, given that SPTs add conceptual information, the same was predicted for SPTs (i.e., in such a case there should be a parallel effect of the SPT and Generate conditions). Otherwise, the amount of priming was predicted to be the same for SPTs and VTs.

The results showed that the only condition producing reliable priming on category association was generation. Also, the difference in priming between SPTs and VTs was nonsignificant. In free recall, the pattern of results was quite different. In this test, there was a highly significant SPT-effect, and memory performance for SPTs was higher than for generate items. There was also a significant interaction between type of test and study condition.

Taken together, the results from the two experiments did not support the hypothesis of SPTs adding conceptual information, thereby increasing memory performance on free recall. Motor enrichment was instead suggested as the primary cause of the SPT-effect.

**General discussion**

The main findings of the empirical studies were (i) similar forgetting functions for SPTs and VTs; (ii) a reduced, but statistically significant, aging effect for SPTs; (iii) lack of an SPT-effect when objects were presented in VTs; (iv) a higher memory performance for SPTs not involving extra-environmental objects than for SPTs involving such objects; and (v) a non-significant SPT effect on a conceptually driven implicit test. Next, implications of these findings for the notion of separate
laws for SPT and VT recall, and for explanations of the SPT effect, will be discussed.

**Memory laws**

In evaluating the claim that the basic laws of enacted and nonenacted memory are different (Cohen, 1981; Nilsson & Bäckman, 1989a), I will follow the outline of potential laws of memory given by Cohen (1985). Cohen suggested a definition of a memory law, saying that "a memory law should be a statement about some empirical relationship in memory, which has transsituational generality and which looks like it will be around for some time to come (1985, p. 252). Note that, according to this definition, it is not required that a memory law explains the reasons for the empirical regularity. This is consistent with the more general definition of an empirical law, which states that an empirical law "seems to summarize simply some fairly directly observed regularity, whithout attempting to provide a theoretical explanation for it" (Holton & Brush, 1973, p. 158; see also Nilsson et al., 1988). Cohen (1985) tested the transsituationality of the laws he proposed by comparing word list memory with memory for SPTs. Cohen (1985, see also Cohen, 1981) claimed that SPTs are essentially *nonverbal* events, and should thereby merit for test of transsituationality. I prefer to view the SPT task as *verbal* memory for tasks that have been carried out (cf., Helstrup, 1987). However, to be able to evaluate the proposal that SPTs and VTs obey different laws, I will leave this difference aside.

The first law discussed by Cohen (1985) is related to the *acquisition phase*, and states that the better something is learned the greater is the likelihood that it will be remembered. Seven different acquisition effects feeding in to this first law, including levels of processing and primacy, were presented. All these seven acquisition effects supported the validity of the first law by turning out to hold true for word-list memory (e.g., deep processing leads to better word recall than shallow processing). However, the levels of processing and primacy effects are of special interest since they have been found not to have any effect on SPT recall (Cohen, 1981), thereby questioning the transsituationality of the first law. Since I mainly have used the SPT task as a form of encoding support, and not as a specific form of materials, the data presented in the empirical section of this thesis are not relevant to the first law. I will, however, evaluate the
apparent lack of transsituationality for the first law by using data reported in the literature.

Starting with the primacy effect, it has been questioned whether the primacy effect really is absent in the case of SPTs. Specifically, it has been proposed that since the level of the asymptote generally is higher for SPTs than for VTs (see especially Bäckman & Nilsson, 1984), this might level out the entire prerecency portion of the serial-position curve for SPTs (Bäckman, Nilsson, Herlitz, Nyberg, & Stigsdotter, 1991). Ordinary serial position effects have also been reported for SPT recall after the induction of active processing during encoding (Helstrup, 1987, Study 3).

Turning to the levels of processing effect, the relevant literature shows a mixed picture: Although Cohen's (1981) original finding of no effect of the levels-of-processing manipulation on SPT recall has been replicated (e.g., Helstrup, 1987), depth of processing has indeed been found to affect SPT retrieval. Nilsson and Craik (1990) showed an increase in SPT recall following deep processing – the increase was smaller though than for VT retrieval. Furthermore, Zimmer (1992) has demonstrated comparable levels of processing effects on recall of SPTs and VTs. It appears, then, that it is possible to include SPT recall in the first law (cf., Cohen, 1985, p. 271).

The second law discussed by Cohen (1985) concerns forgetting. Transsituational generality of this law is provided by comparable recency effects for SPTs and VTs (e.g., Bäckman & Nilsson, 1984; Cohen, 1981). Further support is provided by the finding of comparable slopes of the forgetting functions for SPTs and VTs, reported in the empirical section of this thesis (Study I). This result adds to previous demonstrations of no effect of degree of original learning on the slope of forgetting curves (Slamecka & McElree, 1983). Similarly, manipulations of encoding levels (Craik & Lockhart, 1972) have failed to affect the slope of forgetting curves (Nelson & Vining, 1978). Thus, an important implication of the finding of similar slopes of forgetting curves for SPTs and VTs in Study I is that it suggests a strong similarity between the specific encoding operation under investigation and other encoding manipulations. In addition, this finding indicates that the mechanisms underlying SPT recall and VT recall are quite similar (cf., Cohen, 1985; Helstrup, 1987), thereby refuting
suggestions that qualitatively different memory processes are involved in SPTs and VTs (e.g., Nilsson & Bäckman, 1989b).

The third law discussed by Cohen is related to retrieval. The concept of encoding specificity (Tulving, 1983; Tulving & Thompson, 1973) was used by Cohen (1985) to formulate this law as the closer the match between the encoding and retrieval conditions the better memory performance. The results of the component analysis presented in the empirical section of this thesis (Study III, Exp. 3) showed that SPTs involving objects that were present during both presentation and test were remembered the best. This finding replicates results reported by Cohen et al. (1987a), and was interpreted as suggesting that the idea of encoding specificity can be extended from the domain of verbal materials to the domain of action events. This finding thus provides support for transsituationality of the third law.

Based on the above discussion of the memory laws proposed by Cohen (1985), it does not seem to be any need of separate laws for two-way events such as SPTs (cf., Cohen, 1981). This claim is further supported by examination of one additional possible law suggested by Cohen (1985); individual differences. Transsituationality of this additional law is provided by reliable individual differences in SPT recall (Cohen, 1984) and the emerging trend that SPT memory is affected by age (cf., Engelkamp & Cohen, 1991); a trend that was supported by the finding reported in the empirical section of this thesis of an age effect on SPT recall (Study II). Since short lists were used in this study, the finding suggests that the trend might be rather general in nature, and hold true not only when the tasks are relatively demanding (cf., Cohen et al., 1987b; Engelkamp and Cohen, 1991). In addition, recent findings show that, in opposite to the finding reported by Cohen and Stewart (1982), developmental effects can indeed be obtained for SPTs: Ratner and Hill (1991) found that recall of SPTs was higher for fourth graders (mean age = 9 years and 10 months) than for first graders (mean age = 6 years and 11 months).

The presence of aging effects and developmental effects on SPT recall has implications for Cohen's explanation of differences between SPT and VT recall in terms of involvement of strategy. It has furthermore been shown that recall of the verbal instructions in the SPT task is negatively affected by division of attention (Bäckman et al., 1986, 1991). To the extent that
impairment in recall following dual-task performance is a characteristic feature of strategic memory tasks (Hasher & Zacks, 1979), this adds to the evidence against the notion that SPTs are encoded without the use of strategy. Nevertheless, developmental effects, effects of aging, and effects of dual-task performance appear to be somewhat less pronounced for SPTs than for VTs (see e.g., Study II). Therefore, it cannot be ruled out that the SPT task, on the continuum progressing from automatic to effortful memory operations proposed by Hasher and Zacks (1979), is further towards the automatic end than are VTs. Alternatively, the diminished effects in the case of SPTs can be seen as supporting the dual-conception hypothesis suggested by Bäckman et al. (1991), stating that encoding of the verbal task component in SPTs is effortful and encoding of the physical features (e.g., color and weight) is relatively automatic.

Taken together, it is argued that the existing evidence is too meagre to warrant introduction of new laws of memory. Cohen (1981) stated that it may be advisable to use apparent memory law violations in the first instance as suggesting reappraisal rather than abandonment of existing laws (for a case of abandonment, see Nilsson & Bäckman, 1989a). At present, I believe that neither reappraisal nor abandonment is called for.

Theoretical explanations

The results presented in the empirical section of the thesis have implications for aspects of several previously proposed explanations of the SPT effect. The finding of a higher memory performance for VTs involving real objects than standard VTs, and the disappearance of the SPT effect when real objects were presented in VTs, show that objects do indeed enrich the encoding. However, according to a richness of encoding view (e.g., Bäckman et al., 1986), manipulation of objects should further enrich the encoding, but this was not found to be the case; SPTs and VTs involving real objects were remembered to the same extent. Moreover, if the multimodal aspects of objects are critical for the SPT effect, it is expected that the SPT effect should be smaller for SPTs not involving extra-environmental objects than for SPTs involving such objects. This was not found to hold true. Thus, the sensory richness of objects does not seem to be critical for the SPT-effect; a conclusion that also has been acknowledged by others (cf., Engelkamp & Cohen, 1991).
Although the object component does not seem to be critical for the SPT effect, the results from Study III strongly suggest that objects function as effective retrieval cues, and that they, particularly in the absence of the motoric component, can serve to enrich the encoding. This pattern of results can be seen as a possible explanation of the discrepant findings concerning the role of physical enactment by the subjects. The Engelkamp group has repeatedly found a superiority in memory performance of SPTs over EPTs, whereas Cohen has found non-significant differences between these conditions. Real objects are used by Cohen but not by Engelkamp, and in the absence of enactment on the part of the subject, this difference in procedure may have a strong effect on memory performance. That is, rather than assuming that a motor system is activated by SPTs but not by EPTs (cf., Engelkamp & Zimmer, 1985), I believe that the difference in memory performance following SPT vs EPT encoding is dependent on how supportive the encoding environment is. When real objects are used, the difference between SPT and EPT conditions in terms of encoding support is small; when real objects are not used, the difference is increased and physical enactment by the subject is critical for a high performance.

Furthermore, the finding that presentation of VTs along with external objects gave as high memory performance as did actual enactment of the action phrases has implications for the question of the importance of the motor component. Admittedly, it is possible that subjects imagined performing the tasks when they were presented with the objects and the action phrases, and thereby encoded motor aspects (cf., Bäckman, 1985). Given such an assumption, this finding appears to be consistent with explanations in which the motor component holds a salient position. However, it should be noted that the subjects were not instructed to imagine performing the actions. Therefore, it is also possible to interpret this lack of effect of enactment in accordance with the approach proposed by Helstrup (1987). That is, adding motor cues to the encoding was not necessary; the available memory cues (the objects) were sufficient. Such an interpretation implies that there is nothing special about motor cues, which seems to be in particular disagreement with the position of Engelkamp and Zimmer who consider the motor component to be of particular importance (e.g., Engelkamp & Zimmer, 1985; but see Zimmer & Engelkamp, 1989b).
I would like to argue in favour of a position in which the motor component can be described as "special, but not so special". Specifically, I do not think that there are qualitative differences between SPTs on one hand, and EPTs, VTs including real objects, and imagined actions on the other hand. I am of the impression that these different encoding manipulations can be explained in terms of their effect on the memory trace of an event, and I believe that they affect traces in a similar manner. However, there may be quantitative differences, in terms of memorability, between the traces resulting from these various encoding manipulations. Whether or not these differences show up should depend on the difficulty of the task (cf., Nyberg, Nilsson, & Bäckman, 1992), and on subject characteristics (cf., Bäckman, 1985; Bäckman & Nilsson, 1985). In the next section, a model is proposed in which it is described how enactment affects the memory trace of an event.

Finally, the study of the effect of the SPT manipulation on implicit memory performance (Study IV) provided no support for the hypothesis that SPTs add conceptual information, as well as motoric information, to the memory trace (see Nilsson & Craik, 1990). Quite opposite, the data suggested that the basis for the generation effect and the SPT effect in free recall is not the same. It has been shown that generation in terms of letter reversal leads to deeper semantic processing as compared to reading, and the generation effect is believed to be based on an integrated conceptual representation in semantic memory (Gardiner, Gregg, & Hampton, 1988). Activation of semantic memory representations is believed to underlie conceptual priming (Tulving & Schacter, 1990), and a generation effect on category association is therefore the to-be-expected finding. On the contrary, the lack of an SPT effect on category association implies that enactment does not lead to deeper conceptual processing, thereby indicating that the SPT manipulation does not work as a semantic orienting task. Thus, given that enactment does not increase the depth of processing, an explanation of the SPT effect has to be based on other terms. Klein and Saltz (1976) have shown that semantic enrichment can increase memory performance within the semantic domain, and in a similar vein Nyberg and Nilsson (1992) offered an explanation of the SPT effect in terms of motoric enrichment. In closing, this explanation will be further developed in a tentative model.
A distinctiveness model

Analysis of the effect of encoding operations must involve consideration of the nature of the memory test (Eysenck, 1979; Hunt & Einstein, 1981; Jacoby & Craik, 1979). The literature suggests that the SPT effect on cued-recall performance generally exceeds the enactment effect on free recall and recognition: Saltz (1988), based on examination of various data sets, provided the impression that enactment leads to much greater facilitation of memory on cued recall than on free recall. Svensson and Nilsson (1989) reported data showing a stronger SPT effect on recall of nouns using the verbs as cue, than on recognition of the nouns. Similarly, Nyberg (1992) reported a significant SPT effect on recall of verbs using the nouns as cue, but a nonsignificant SPT effect on recognition of the verbs. Finally, there is some evidence that the SPT effect is stronger on free recall than on recognition (Nilsson & Craik, 1990; but see Mohr, Engelkamp, & Zimmer, 1989). In all, this shows that enactment improves recall as much as it improves recognition memory, which in turn has implications for explanation of the SPT effect (cf., Tulving, 1979). This is because encoding operations mainly enhancing item-specific processing has the strongest effect on recognition memory, whereas encoding operations improving relational processing has the greatest effect on recall. Both types of processing combine to produce optimal recall (Hunt & Einstein, 1981), and it is proposed in this concluding section that enactment improves item-specific processing as well as relational processing, and that these forms of processing, in combination, serve to increase the distinctiveness of the memory trace (cf., Hunt & Einstein, 1981, p. 511).

Before presenting the support for the view that enactment improves both item-specific and relational processing, it is necessary to define the current conceptualization of the key terms memory trace and distinctiveness. A memory trace is here considered as consisting of a variety of attributes (e.g., Bower, 1967; Craik & Tulving, 1975; Underwood, 1979); no assumptions are made regarding the way the traces are stored (i.e., whether the traces are localized or distributed; cf., Estes, 1991). The attributes may be ones that are chosen by subjects at encoding (such as associations generated by strategical processing or visual images), but some attributes are also an unavoidable part of the encoding situation (such as modality of input and phonemic recoding during input).
Distinctiveness is used to describe the similarity of the product of encoding operations in terms of a memory trace to other traces (Craik, 1979), and a highly distinctive memory trace is a trace which shares few features with other to-be-remembered events.

The assumption that enactment increases distinctiveness by the addition of item-specific information (information highly specific to each input event) appears to be consistent with most previous explanations of the SPT effect. For example, Engelkamp and colleagues have explained the SPT effect by the fact that enactment activates motor programs which yield excellent item-specific information and become a part of the memory trace (e.g., Engelkamp, 1990; Zimmer & Engelkamp, 1989b). Bäckman and Nilsson (e.g., Bäckman et al., 1986) have argued that, in addition to verbal information, information about the motor actions (including features of color, texture, and shape) can be stored in the SPT task, and this additional information is believed to facilitate memory. Helstrup (1986) has favoured an "attribute-bundle memory conception", in which motor attributes are added to other attributes in the memory trace. Saltz (e.g., Saltz & Donnenwerth-Nolan, 1981) has proposed that enactment results in the storage of motoric images which leads to a more specific registration. Finally, Baddeley (1990) has explained the effect of enactment on memory performance in terms of the addition of motor cues which produces enhanced memory trace discriminability.

Thus, most explanations of the SPT effect are at least broadly consistent with the first assumption in the present model that enactment adds specific information to the memory trace – information that is not added in VTs. In line with many previous writers, we have suggested the motoric component as the source of the added information (Nyberg & Nilsson, 1992). Specifically, enactment during encoding of action phrases is believed to result in storage of some sort of motoric images (cf., Saltz & Donnenwerth-Nolan, 1981), and this attribute (the motoric image) is thereby an "unavoidable part" of the encoding situation (cf., Underwood, 1979). The encoding of motoric images should result in distinctive traces, and a distinctiveness interpretation is further supported by the finding in Study II of a smaller drop in performance between IFR and FFR for SPTs than for VTs. This finding was explained by SPTs being less susceptible to proactive interference than VTs, and it has been argued that more
distinct memory traces are less affected by interference (see Bradshaw & Anderson, 1982; Saltz & Donnenwerth-Nolan, 1981; Wickelgren, 1973).

To sum up so far, it has been suggested that enactment adds item-specific information to the memory traces, which makes these traces more discriminable than traces resulting from verbal encoding. However, this type of item-specific information is similar to what Underwood (1969) has called "discriminative attributes of memory", and should mainly serve to improve recognition memory (see also Eysenck, 1979). As discussed above, the SPT effect appears to be, at least, as great in recall as in recognition, and some sort of "retrieval attributes" (Underwood, 1969) seems warranted to explain the strong effect of enactment on recall performance. This brings us to the second assumption in the present model; that enactment improves relational processing.

Recall performance is believed to rely to a high extent on relational information, which is seen as having a generative function (Hunt & Einstein, 1981). Several different types of relational information can be identified in the literature. Relational processing as discussed by Hunt and Einstein (1981) refers to the encoding of similarities among a class of events. Hirshman & Bjork (1988), in discussing the role of relational processing for the generation effect, used the term relational to denote the relation between stimulus and response. Engelkamp and co-workers (for a review, see Engelkamp, 1990) have considered both of these forms of relational information in explaining the effect of enactment:

Engelkamp and Zimmer distinguish between categorical integration and integration of unrelated events. Categorical integration is believed to be independent of enactment, a finding supported by similar amounts of categorical clustering for SPTs and VTs (e.g., Zimmer, 1991; Zimmer & Engelkamp, 1989a,b). The second form of integration is assumed to be hindered by enactment. This assumption is supported by a study by Engelkamp (1986) in which cued recall of performed verb pairs was shown to be poorer than free recall of the same word pairs. Helstrup (1989, 1991) has shown that if subjects are instructed to try to integrate the verb pairs (or noun pairs), enactment helps memory performance. However, Engelkamp has argued that under standard SPT instructions, pair integration is actually hindered by enactment (e.g., Engelkamp, Mohr, & Zimmer, 1991).
The second assumption in the present model, thus, appears to contradict the assumptions in the theory proposed by Engelkamp and his co-workers. Below, I will present the empirical evidence that have led me to propose that enactment improves relational processing.

In contrary to the findings by Zimmer (Zimmer, 1991; Zimmer & Engelkamp, 1989a), Bäckman has reported that SPTs benefit more form the relational list structure than do VTs (Bäckman et al., 1986). Bäckman et al. found higher levels of clustering for SPTs than for VTs, and a high degree of clustering indicates that good relational encoding of the list structure has been achieved. It has been suggested that this discrepancy in results is due to the fact that SPTs with real objects were used in the Bäckman et al. study, whereas symbolically performed SPTs are used in the paradigm utilised by Zimmer and Engelkamp (e.g., Zimmer & Engelkamp, 1989). Support for the suggestion that the object component is the source of this form of relational information is provided by the high recall performance for VTs when the corresponding objects were shown, and also by the finding of markedly higher organizational scores on the object dimension than on the motor dimension, reported in the empirical section of this thesis (Study III). Furthermore, given that the object component improves this form of relational processing, this may provide an explanation to the conflicting data concerning the magnitude of the SPT effect on recall versus recognition: Engelkamp and his co-workers have found a greater SPT effect on recognition than on recall (Mohr et al., 1989), whereas Nilsson and associates have reported findings of a more pronounced SPT effect on recall than on recognition (Nilsson & Craik, 1990; Nyberg, 1992; Svensson & Nilsson, 1989). The Engelkamp group has used symbolically performed actions, whereas the Nilsson group has used SPTs involving real objects. Thus, a more precise formulation might be that the SPT procedure used in our laboratory and by Cohen (including the involvement of real objects) enhances encoding of information common to the input events.

Turning to the second form of relational processing (between stimulus and response), Engelkamp has, as noted above, based his conclusion that improved relational processing is not the basis for the SPT effect on studies of pair-relational encoding of unrelated actions (e.g., Engelkamp, 1986). I will not dwell on whether enactment improves or hinders
integration of this type of materials (interested readers are referred to Engelkamp et al., 1991 and Helstrup, 1991), because, in agreement with Saltz (1988), I believe that this is the wrong relation to consider if one attempts to explain the SPT effect. Saltz argues that the integration to be sought for is not between two unrelated actions, as in the paradigm used by Engelkamp, but rather integration within a sentence framework (i.e., between act and actor). If the latter type of integration is under investigation, he argues, enactment is indeed helpful.

In line with Saltz, I assume that enactment strengthens the relation between verb and noun. A strong integration between verbs and nouns following enactment should enhance cued-recall performance due to distinctive connections between cues and traces (cf., Lockhart & Craik, 1990). Similarly, a strong integration between verb and noun should reduce the search space, thereby facilitating free recall as well as cued recall. This view, that enactment strengthens the integration between verb and noun, is also supported by recent empirical findings from our own laboratory (Kormi-Nouri & Nilsson, 1993).

Thus, according to the proposed framework the enactment effect is explained in terms of distinctiveness. Enactment is seen as increasing the distinctiveness of the memory trace by improving item-specific as well as relational processing. Relational processing includes both categorical integration and event integration. The assumption that item-specific and relational information, in combination, serve to increase the distinctiveness of the memory trace is consistent with the view advanced by Hunt and Einstein (1981), and this explanation of the SPT effect embraces many empirical findings reported in the literature. In particular, by assuming that enactment improves both forms of processing it is possible to explain the strong effect of enactment on tests of recall as well as on recognition, and such consideration of the compatibility between trace and cue information is necessary in analyses of the workings of encoding manipulations (cf., Tulving, 1979). It should be pointed out, though, that a few aspects of the above proposed model have to be corroborated by further empirical work. The most critical test of the model is probably to examine the validity of the assumption that enactment improves relational processing. Until such a test has been performed, the conclusion that encoding of relational and item-specific information causes the enactment effect has to be tentative.
Concluding remarks

The studies presented have highlighted similarities rather than differences between memory for enacted and nonenacted events. Based on a discussion of possible memory laws related to acquisition, retention, and retrieval, it was concluded that the basic laws for recall of SPTs and VTs are the same. This conclusion is at odds with some previous proposals (see especially Nilsson & Bäckman, 1989a), and may reflect the author’s bias towards emphasizing regularities rather than anomalies. Future research will no doubt tell whether this conclusion holds true, or if the basic laws of enacted and nonenacted memory really are fundamentally different.

In addition, a tentative model was suggested in which the enactment effect is explained in terms of the addition of item-specific and relational information. It was hypothesized that these forms of information, in combination, serve to increase the distinctiveness of memory traces. Although the suggested distinctiveness model share some features with previously proposed explanations of the SPT effect, the model contains quite a large number of novel assumptions. An important task for future research will therefore be to put these assumptions under experimental scrutiny.

In closing, the concept of distinctiveness has held a central position in explanations of the effect of encoding operations on memory performance (cf., Jacoby & Craik, 1979), and it is believed that a distinctive trace stands out from traces of other events and is therefore more retrievable. The memory traces appear to stand out very strongly following enactment, suggesting that motoric information has high contrastive value (Jacoby & Craik, 1979), but still this memory phenomenon seems possible to explain by using traditional memory concepts. To me, such an explanation, avoiding the invention of new systems or mechanisms, is appealing.
References


