Psychol Res (1998) 61: 295–307

ORIGINAL ARTICLE

Asher Koriat · Shiri Pearlman-Avnion · Hasida Ben-Zur

The subjective organization of input and output events in memory

Received: 12 November 1997 / Accepted: 2 June 1998

Abstract In order to study the organization of memory for self-performed actions, 80 participants were presented with 20 action phrases for ten consecutive study-test cycles. Enactment was manipulated both in the input phase and in the output phase by having participants say or enact the phrases during encoding and/or during testing. Enactment at input or output generally enhanced both the quantity and the accuracy of recall and also improved output monitoring. More important, subjective organization, as indexed by the tendency to recall the same two phrases successively across repeated recall tests, was significant for all conditions, even on the first pair of trials, and increased systematically with repeated study-test cycles. Enactment neither impaired nor enhanced the amount of organization, and in all conditions a positive correlation was obtained between recall and subjective organization. Some commonalities in the nature of memory organization were found across all conditions. The results suggest that enactment may lead to more differentiated memory traces, resulting in more accurate recall. Although subjective organization was clearly observed when enactment was involved, its contribution to the enhancement of recall deserves further examination.

Introduction

Memory for performed tasks

The recent interest in memory for action has engendered several findings suggesting both quantitative and qualitative differences between the memory for tasks that are performed by the person (subject-performed tasks, or SPTs) and the memory for events whose source is external to the person. On the quantitative side, a great number of studies have indicated superior memory for SPTs in both free recall (e.g., Cohen, 1983; Helstrup, 1989; Nilsson & Cohen, 1988; Saltz, 1988) and recogniton (Mohr, Engelkamp, & Zimmer, 1989) over memory for verbally encoded tasks. On the qualitative side, SPT memory has been shown to exhibit a relative degree of indifference to level-of-processing manipulations (Nilsson & Cohen, 1988), primacy effect (when interitem intervals are shorter than 5 s: Cohen, 1981, 1983), generation effect (Nilsson & Cohen, 1988), rate of presentation (Cohen, 1985), and age (when short lists were presented: Bäckman & Nilsson, 1984, 1985; Cohen, Sandler, & Schroeder, 1987). These differences have led some researchers to speculate that SPT memory differs qualitatively from memory for verbal tasks (VTs). In particular, Cohen (1981) proposed that memory for SPTs is largely automatic – unlike the memory for VTs, which is considered to be generally strategic. Thus, he claimed that SPTs can be encoded without attention or intention, and this encoding is equally efficient under shallow or deep levels of processing.

A rather different view has been advanced by Helstrup (1986, 1987, 1989). According to Helstrup, memory for SPTs does not reveal strategic effects precisely because participants spontaneously utilize a variety of memory strategies in connection with SPTs. In one of Helstrup's experiments (1989), the method of loci was used during study to provide contextual cues for minitasks to be learned, the assumption being that such cues induce elaborative processing of SPTs. Consistent with Helstrup's position, the beneficial effect of context on memory was weaker under motor-encoding conditions than under nonmotor-encoding conditions. Helstrup concluded that motor memory cues are more important in poor than in rich cue situations, and whether enactment will improve memory should therefore depend on the task situation.

A. Koriat (✉) · S. Pearlman-Avnion
Department of Psychology, University of Haifa, Haifa, Israel
E-mail: akoriat@psy.haifa.ac.il; Phone: 972-4-8249432;
Fax: 972-4-8249431

H. Ben-Zur
School of Social Work, University of Haifa, Haifa, Israel

Lichty, Bressie, and Krell (1988), using relatively long interitem intervals (10 s), demonstrated a marked primacy effect for SPTs. Primacy effects are typically seen to ensue from a greater number of rehearsals accorded to the first new items in a list (see Rundus & Atkinson, 1970). Thus, the absence of strategic effects on SPTs may be confined to the situation where the interitem intervals are very short, leaving little opportunity for rehearsal.

The organization of SPT memory

The question of the automaticity of encoding is intimately linked to the question of memory organization. It is generally assumed that memory organization is a sign of strategic processing (Schneider & Bjorklund, 1998). A question of interest, then, is whether memory for SPTs exhibits organizational effects. This question has been examined in several studies using a list of items that could be grouped into a small number of predefined categories.

Bäckman and Nilsson (1984) found that young adults were better than old adults in a VT learning condition but not in an SPT condition. They claimed that older adults tend to compensate for their poor memory by taking advantage of the rich properties of SPTs to achieve better organization. Using Adjusted Ratio of Clustering (ARC) scores (Roenker, Thompson, & Brown, 1971) as a measure of organization, they concluded: "A significant superiority in organization for SPTs as opposed to sentences was obtained, suggesting that SPTs are not only organized, but organized to a greater extent than verbally presented sentences" (p. 65).

Bäckman, Nilsson, and Chalom (1986) observed that divided attention impaired recall to a greater extent for VTs than for SPTs. This was true for both non-organizable as well as organizable material. Furthermore, degree of clustering was stronger for SPTs than for VTs, as indexed by ARC scores. The results were seen to suggest that a strategic component is involved in the encoding of SPTs.

In contrast, Zimmer and Engelkamp (1989) proposed that motor encoding, as compared with standard learning instructions, improves free recall of action verbs but does not improve interitem organization. Furthermore, it was argued that in a paired-associates task, when one action phrase is cued by another unrelated action phrase, motor encoding may even impair inter-item organization (Engelkamp, 1986, 1988; Engelkamp; Zimmer, & Denis, 1989). Three experiments by Zimmer and Engelkamp (1989) which investigated the effects of enactment on memory for organized lists of action phrases confirmed the proposition that motor encoding may improve recall without enhancing organization. In one experiment, enactment failed to enhance the clustering of episodically categorized and taxonomically categorized lists, although it did improve memory performance compared to standard learning instructions. In fact, the effect of enacting on memory performance was stronger for lists composed of unrelated items than for categorized lists. Furthermore, in all lists, organization and recall were positively correlated only under verbal instructions and not under enacting instructions. In a second experiment, participants were given advance information about the categories included in the list and were instructed to make use of them in learning the items. This manipulation enhanced organization in all conditions, but improved recall performance only in the standard learning condition. This general pattern was replicated in a third experiment using a taxonomically organized list. In discussing these results, Zimmer and Engelkamp distinguished between relational encoding, which uses the association between items to be learned and is therefore pertinent to organization, and item-specific encoding, which uses information about individual items. They concluded:

> In any case, with motor encoding relational information is less important than after a standard-verbal-learning instruction… Further, enacting does not force subjects to process conceptual-relational information because acting out focuses their attention upon an individual item. It will therefore sometimes even interfere with the processing of these conceptual relations. So the additional information made available by enacting works as item-specific information (p. 165).

The effects of item-specific and relational information on recall were examined by Engelkamp, Zimmer, and Mohr (1990). Participants studied action verbs and noun lists with standard learning instructions or with the instruction to categorize the items into predefined categories. Three types of lists were used: an unrelated list, a taxonomically categorized list, and an episodically categorized list. In addition, half of the participants in each condition were given modality-specific instructions: to pantomime the actions denoted by the verb or to form an image of the referents of the nouns. Two interesting results were obtained: first, modality-specific encoding did not enhance organization, and second, the correlation between organization and recall was significant only under standard learning instructions. The authors concluded that relational encoding is independent of modality-specific encoding and that the improvement in recall performance that results from enactment is not due to improved organization.

In a subsequent study (Engelkamp & Zimmer, 1996), participants studied categorically organized lists of VTs or SPTs under focal or divided attention. Although divided attention impaired free-recall of VTs more than of SPTs, relational encoding did not differ between VTs and SPTs. These results, as well, were seen to indicate that the SPT effect is primarily based on item-specific information rather than on relational information and that VTs are more dependent on active encoding than SPTs.

How can the divergent views with respect to memory organization in VTs and SPTs be reconciled? Engelkamp (in press) has recently articulated a more refined position regarding the role of relational information in VTs and SPTs. He proposed that it is the forming of new, episodic associations between previously unrelated items that is more difficult for SPT than for VT learning (see Engelkamp, 1986). In contrast, the use of pre-experimental, categorical relations does not differ between VTs and SPTs. This position appears to explain some but not all of the discrepancies between the previously reported results. What is important for the concern of the present study, however, is that this position brings to the fore the importance of considering the type of relations that serve as the basis for organization for VTs and SPTs.

The assessment of the memory organization of SPTs

In the spirit of Engelkamp's (in press) recent position, we propose that a serious problem that arises when comparing degree of organization between VTs and SPTs is that the basis for organizing events may differ for the two types of material. For example, it might be argued that verbal material tends to be spontaneously organized in terms of semantic-taxonomic categories, whereas action events trend to be organized, perhaps, in terms of associative relations (see Koriat & Melkman, 1987). Therefore, the common method of assessing the organization of VT memory and SPT memory by using a list that is organized in terms of experimenter-defined categories may bias the results in one way or the other. Given the inherent difficulties in defining a common basis of organization that may equally apply to SPTs and VTs, a viable alternative is to rely on subjective organization, as defined by Tulving (1962). The advantage of this approach is that it allows degree of organization to be assessed without the need to specify the basis of the organization. This is the method that was used in the present study.

Underlying the measurement of subjective organization is the idea that such organization can be extracted, even for a list of "unrelated" items, by observing recurring contingencies across repeated recall tests. Thus, in Tulving's (1962) classical study, a list of 16 "unrelated" words was used. This list was presented for 16 study blocks, with a free-recall test following each presentation. Subjective organization (SO) scores were calculated by comparing the number of pairs of words that appeared in adjacent recall positions across the 16 recall protocols with the number that was expected by chance. The method yields an overall measure of sequential organization ranging from 0 (no organization) to 1 (maximum organization).

The measurement of subjective organization has been found useful in a variety of areas, including the study of the effects of drugs (Miller, McFarland, Conett, Brightwell, & Wikler, 1977) and of posthypnotic amnesia (Tkachyk, Spanos, & Bertrand, 1985; Wilson & Kihlstrom, 1986), the memory of disabled and retarded persons (Glidden & Klein, 1980; Wilson, 1977), individual differences (Earhard, 1974), developmental and age differences in memory (Glidden, 1977; Jackson & Schneider, 1982, 1985; Kokubun, 1973, 1976; Ornstein, Naus, & Stone, 1977; Rankin & Battig, 1977; Witte, Freund, & Sebby, 1990), the study of hypermnesia (Payne & Wenger, 1992), and memory organization after head injury and frontal lobe damage (e.g., Eslinger & Grattan, 1994; Gershberg & Shimamura, 1995; Levin & Goldstein, 1986).

Previous research has indicated strong correlations between organization and recall (Waters & McAlaster, 1983) in general, and more specifically between subjective organization and recall (Allen, 1968; Mayhew, 1967; Tulving, 1962, 1964). Research on memory for actions, however, yielded some dissociations between recall and organization. As noted previously, Zimmer and Engelkamp (1989) found enactment to improve recall without enhancing organization. Little correlation has also been observed between recall and clustering for SPTs, although such a correlation was obtained for VTs (Zimmer & Engelkamp, 1989; Engelkamp et al., 1990; Engelkamp & Zimmer, 1996). However, in most previous studies, organization was measured in terms of experimenter-defined categories. One exception is the study described earlier by Engelkamp et al. (1990). In Exp. 1 of that study, subjective organization was measured for lists of unrelated nouns or action verbs. The results indicated that subjective organization was not enhanced by modality-specific encoding, and, furthermore, for the action verbs, the correlation between subjective organization and recall, if anything, was lower under enactment than under standard learning. These findings were taken to suggest that relational information is less important for memory performance after enactment than after standard verbal learning.

The present study used unrelated action phrases and focused on their subjective organization in multi-trial learning. Three questions were addressed regarding the organization of action phrases: First, is SPT memory organized to the extent of yielding sequential patterning that exceeds chance level? Second, does SPT memory exhibit a lesser or a greater degree of subjective organization than VTs? Finally, how is recall related to degree of subjective organization for SPTs and VTs?

Unlike previous studies on memory organization, enactment was manipulated both during encoding (input) and during retrieval (output). The input manipulation involved having participants either read the verbal phrase during study ("say") or perform the task described ("enact"). Similarly, the output manipulation involved either having participants recall the phrases orally ("say") during test, or having them perform the recalled tasks ("enact"). All participants, however, were forewarned at study about the expected mode of testing so that they could plan for it. In a previous study by Koriat, Ben-Zur, and Nussbaum (1990), the recall of action phrases was enhanced when subjects planned to enact the phrases during testing than when they planned to only say them aloud. This result suggested that merely planning to perform an act improves its subsequent recall. While Brooks and Gardiner (1994) failed to replicate the enhanced effect of intended prospective performance, results obtained by Engelkamp (1997) suggest that the critical factor for obtaining this effect lies in the manipulation of encoding instructions *between* subjects rather than *within* subjects. This latter study, as well as that of Koriat et al. (1990), allowed assessment of the independent contribution to memory of action planning (i.e., the expectation during encoding to perform the acts at test) and of actually performing the tasks at test. The results of both studies concur in indicating that the critical factor is action planning. These results were taken by Engelkamp (1997) to suggest that both the performance-at-study effect and the performance-at-test effect are due to encoding rather than to retrieval differences. Thus, in the present study, encoding mode and expected test mode were orthogonally manipulated in a 2 × 2, between-subject design. Half of the subjects were asked to say the phrases aloud during the study phase and half were asked to enact the phrases. In addition, half of the subjects in each group were instructed that they would have to say the phrases aloud at test, and the remaining subjects were instructed that they would have to enact them at test. Only a "congruent" condition was used (see Engelkamp, 1997): Test mode was always the same as what subjects were to expect.

Method

Participants. Eighty University of Haifa students (56 females) participated in the experiment, 38 for course credit and 42 for payment. Their age averaged 23.3 years.

Stimuli. A list of 20 sentences depicting different minitasks was compiled from various sources, mostly Cohen (1981) and Koriat et al. (1990). The sentences were in Hebrew and included one to three words each (e.g., "touch your ear," "pour coffee," "smile"). Half of the sentences denoted minitasks requiring the manipulation of an external object (e.g., "smell the flower"), whereas the other half involved mainly bodily actions (e.g., "lick your lips"). Each participant was presented with the 20 minitasks for ten study-test trials, with a different order of presentation used in each trial. The presentation orders were preprogrammed so that the 20 orders used for each pair of participants conformed to a 20 × 20 balanced Latin square. That is, across these 20 orders, each minitask occupied each of the 20 ordinal positions and appeared after each of the other minitasks exactly once. Ten such Latin square arrangements were generated, and each was used with a different pair of participants in each of the four conditions. Two additional lists of four sentences each were prepared for practice. Each sentence was printed on a 13 × 10-cm card.

Apparatus. Stimuli were presented on a Visual 220 terminal connected to a Digital Micro VAX II computer. Each sentence appeared at the center of the screen for 5 s, with an interval of 2 s between sentences. Letter size was 0.5 × 0.5 cm.

Design and procedure. The experiment included ten study-test trials, in each of which all 20 minitasks were presented for learning and immediate recall. The design conformed to a two-way factorial: input condition (say vs enact) by output condition (say vs enact). Twenty participants were randomly assigned to each of the four conditions: say-say, say-enact, enact-say, and enact-enact.

The experiment was conducted individually. Participants were told that the experiment involved memory for everyday tasks. Half of the participants were instructed to enact each action upon presentation of each minitask. When the task required the manipulation of an external object, they had to imagine the appropriate object and pantomime as if it was there. The remaining participants simply memorized the minitasks. During testing, half of the participants in each of the two input conditions were asked to recall verbatim the sentences describing the minitasks, and the other half were asked to recall the tasks by enactment.

Participants were instructed in advance about the mode of recall that would be required at testing and were given practice with the two practice lists that were presented on cards. The stimuli for the experiment proper were presented on the computer terminal. At the end of each study phase, the participant was instructed to turn to the experimenter and recall the minitasks either verbally or by enacting. The experimenter recorded the minitasks that the participant said or enacted. At the end of the recall session participants were informed that they would be presented with the same list of minitasks again but in a different order, and that they should follow the same instructions.

Results

Free recall

For each participant, three memory indexes were calculated for each trial: (a) the number of items correctly recalled, (b) the number of extralist intrusions (items that did not appear on the input list), and (c) the number of repetitions (items that were repeated by the participant during recall). Before examining the results across all ten trials, we shall first focus on the results of the first trial only, in order to enable comparisons with most other SPT studies, in which only one study-test block was used.

Memory performance on the first trial. Table 1 (*upper panel*) presents mean recall, intrusions, and repetitions for the first trial. A two-way, Input × Output ANOVA applied to recall yielded a significant effect for input, $F(1, 76) = 5.06$, $p < .05$, with the enact condition producing better recall (mean = 12.45) than the say condition (mean = 11.15). Neither the output condition nor the input × output interaction was significant, $F < 1$. These results are consistent with previous findings which indicated that enactment of the items at input improves performance (e.g., Cohen, 1981, 1983; Eng-

Table 1 Mean recall, intrusions, and repetitions on trial 1 (*upper panel*) and on trials 2–10 (*lower panel*)

	Input condition	Say	Say	Enact	Enact
	Output condition	Say	Enact	Say	Enact
Trial 1					
Recall		10.8	11.5	12.6	12.4
Intrusions		1.350	0.600	0.450	0.350
Repetitions		1.00	0.150	1.450	0.300
Trials 2–10					
Recall		18.5	19.0	18.4	18.8
Intrusions		0.150	0.038	0.022	0.022
Repetitions		0.733	0.638	1.755	0.927

elkamp & Krumnacker, 1980; Engelkamp & Zimmer, 1983). The failure to observe a similar difference for the output manipulation is inconsistent with the results of Koriat et al. (1990), where expected enactment during testing was found to enhance recall regardless of input conditions. Engelkamp (1997) also found a similar pattern, when planning to enact the tasks was manipulated between subjects, as was the case in the present study.

A similar ANOVA applied to the number of intrusions indicated a significant effect for input, $F(1, 76) = 9.88, p < .01$, and for output, $F(1, 76) = 5.40, p < .05$, and a marginal effect for the interaction, $F(1, 76) = 3.16$, $p < .08$. Fewer intrusions were observed for the enact than for the say condition in the input manipulation (mean = 0.40 and 0.98, respectively), as well as in the output manipulation (mean = 0.48 and 0.90, respectively). The interaction indicates that performance was clearly worst in the say-say condition (mean = 1.35). This is the typical condition in most previous studies: Input items are verbally encoded and recall is also verbal. The best performance was found for the enact-enact condition (mean = 0.35).

These results suggest that enactment not only increases the quantity of information recalled but also improves its accuracy. In terms of the conceptual framework proposed by Koriat and Goldsmith (1994, 1996), memory quantity and memory accuracy can be distinguished in terms of the contrast between input-bound and output-bound performance. Input-bound performance is indexed by percent recall, which reflects the proportion of items that are recalled out of those presented. The output-bound measure, in contrast, reflects the accuracy of the information reported and is indexed by the proportion of correct items out of those reported. Using this index, memory accuracy averaged 0.87, 0.95, 0.97, and 0.97, for the say-say, say-enact, enact-say, and enact-enact conditions. A two-way ANOVA on these means yielded $F(1, 76) = 10.84$, $p < .005$ for the input manipulation, $F(1, 76) = 4.99, p < .05$ for the output manipulation, and $F(1, 76) = 4.35$, $p < .05$ for the interaction. Post-hoc comparisons confirmed that memory accuracy was significantly lower in the say-say condition than in the other conditions combined, $F(3, 76) = 6.73$, $p < .0005$, which did not differ among themselves. These results suggest that enactment at input and/or output helps to protect against false memories.

The number of repetitions on the first trial yielded a significant effect for output enactment only, $F(1, 76) = 15.56, p < .001$, with no effect for the input, $F(1, 76) = 1.40$, n.s., or for the interaction, $F < 1$. For the output manipulation, the number of repetitions was about five times as large for the say than for the enact condition (1.23 and 0.23, respectively). This result suggests that output monitoring (See Koriat, Ben-Zur, & Sheffer, 1988) is more deficient when testing is verbal than through enactment.

Memory performance across all ten trials. We shall next examine the results across all ten trials (see Fig. 1). It should be stressed that from trial 2 on, the condition of testing may also be expected to affect the encoding of the list for subsequent tests. For example, in the say-enact condition, enactment at testing in trial 1 might act as enactment at study, as far as memory performance on the subsequent tests is concerned. Hence, the results to be reported next, particularly those pertaining to the say-enact and enact-say conditions, must be interpreted with caution. Indeed, a preliminary three-way ANOVA – Input condition × Output condition × Trial on recall, including all ten trials – yielded significant effects only for trial, $F(9, 684) = 300.78$, $p < .0001$, and for the input × trial interaction, $F(9, 684) = 4.41$, $p < .0001$. Taken together with the results reported previously for the first trial, these results suggest that some changes in the effects of enactment occur after the first trial. Therefore, the analyses reported below were based on the results for trials 2–10 only.

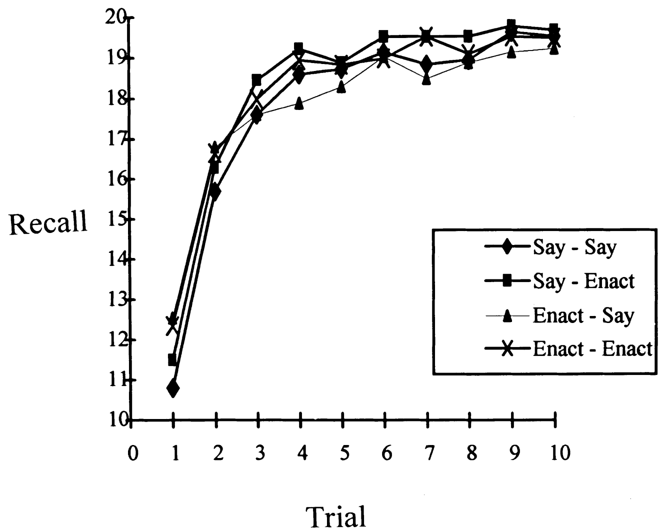

Fig. 1 Percent recall as a function of trial for each of the four conditions

Table 1 (*lower panel*) presents mean recall, intrusions, and repetitions across trials 2–10. A three-way ANOVA on recall yielded a significant effect for trial, $F(8, 608) = 72.48$, $p < .001$, as well as for the output manipulation, $F(1, 608) = 4.27, p < .05$, with a general advantage for the enact condition over the say condition (the means across the nine trials were 18.90 and 18.45, respectively). In addition, the input × trial interaction was also significant, $F(8, 608) = 2.26$, $p < .05$. A detailed examination of the results, however, did not indicate any systematic change underlying this interaction.

A similar two-way ANOVA applied to the number of intrusions indicated significant effects for input, $F(1, 76) = 6.72$, $p < .01$, for output, $F(1, 76) = 3.98$, $p < .05$, and for the interaction, $F(1, 76) = 3.98$, $p < .05$. The results replicate those observed in trial 1: More intrusions were made in the say-input than in the enact-input condition (0.094 and 0.022, respectively), and also in the say-output than in the enact-output condition (0.086 and 0.030, respectively). The interaction indicates that intrusions are particularly frequent in the say-say condition, whereas they were equally rare both in the enact-enact condition and in the enact-say condition. As noted earlier, these results suggest that enactment not only increases the quantity of information recalled but also improves its accuracy. However, in general, output-bound accuracy for trials 2–10 was almost perfect, averaging 0.991, 0.998, 0.999, and 0.999, for the say-say, say-enact, enact-say and enact-enact conditions, respectively. Once again, the say-say condition yielded significantly less accurate recall than the remaining conditions combined, $F(1, 76) = 16.17$, $p < .0001$.

It is tempting to speculate that the effects of enactment on memory accuracy occur at the encoding stage only. Because enactment at test can be assumed to affect encoding for trials 2–10, enactment encoding should then be expected to occur in these trials for all conditions except the say-say condition, and this is indeed the condition that yielded the lowest accuracy. However, the results for trial 1 (Table 1, *upper panel*) suggest that enactment during testing may also contribute independently to memory accuracy.

Number of repetitions in trials 2–10 also yielded significant effects for output, $F(1, 76) = 4.04$, $p < .05$ (number of repetitions averaging 1.24 for the say and 0.78 for the enact conditions), and for input $F(1, 76) = 8.17$, $p < .05$ (number of repetitions averaging 1.34 for the enact and 0.69 for the say conditions), but not for the interaction, $F(1, 76) = 2.56$, n.s. As in trial 1, enactment during test improves output monitoring. However, here it also seems that enactment during encoding impairs output monitoring.

Subjective organization

Subjective organization for individual pairs of trials. We turn now to the results for subjective organization. Although there are various methods of quantifying subjective organization (see Sternberg & Tulving, 1977), they all assess the extent to which arbitrary pairs of items (e.g., A and B) that were recalled in adjacent positions on trial *i* are also recalled in adjacent positions on trial $i + 1$. In the present study, the calculation followed the one proposed by Tulving (1962): We calculated, for each participant, the frequency of sequential occurrence of the same two items in successive trials, irrespective of order within a pair of items. The measure of subjective organization, following Tulving (1962), was expressed as the ratio of actual organization to maximum possible organization. Therefore, the subjective organization (SO) scores could range from 0 (no organization) to 1 (maximum organization).

The computation of the amount of organization that would be expected by chance was carried out as follows: A random ordering of all the items that were recalled by each participant in each trial was generated, and the same procedure used in computing observed SO scores was now applied to derive a measure of expected SO scores. This procedure was repeated 100 times for each subject's recall protocols, and the expected SO score was the average over the 100 times.

Figure 2 presents the results for the three main measures of the present study for each of the input-output combinations: recall (already presented in Fig. 1), observed subjective organization (for successive pairs of trials: SO2) and expected subjective organization (also for successive pairs of trials: ESO2).

The results presented in Fig. 2 suggest that subjective organization occurs from the first pair of trials on for each of the experimental conditions. It then progresses in an almost linear manner, reaching an asymptote only on the last trial, but never attaining perfect organization (i.e., after ten trials the scores are only in the 0.30–0.50 range). Figure 2 also depicts the results of the expected SO score, and, as may be seen, this measure exhibits no improvement over trials and is clearly much lower than the observed SO scores.

Figure 2 also presents recall data. Recall exhibits the strongest improvement from the first to the second trial, but the improvement continues until about the fourth or sixth trials, where an asymptote-like level is reached. This pattern of results is similar to that reported by Tulving (1962) for the first ten trials.

Two questions are of interest regarding subjective organization: First, are SPTs organized? Second, is there a difference between the four conditions in terms of the amount of subjective organization exhibited? In addressing these questions, we shall first focus on the first pair of trials, which discloses organization during initial encoding, and then examine subjective organization across all trials.

Table 2 (*upper panel*) presents mean observed and expected SO scores for the first pair of trials for the four conditions. It can be seen that the observed SO scores exceed those expected by chance for all four conditions. Separate ANOVAs comparing observed and expected SO2 scores for each condition yielded $F(1, 19) = 12.01$, $p < .005$ for the say-say condition, $F(1, 19) = 4.70$, $p < .05$ for the say-enact condition, $F(1, 19) = 3.74$, $p < .07$ for the enact-say condition, and $F(1, 19) = 8.76$, $p < .05$ for the enact-enact condition. Thus, it appears that subjective organization is evident for all conditions, even on the first pair of trials.

To examine the second question, a two-way Input enactment × Output enactment ANOVA was conducted on the observed SO scores. This analysis yielded $F < 1$ for both main effects and for the interaction. Thus, amount of subjective organization does not seem to vary as a function of enactment either at input or at output.

To investigate the increase in SO over trials, a three-way ANOVA, Input enactment × Output enactment × Trial, yielded a significant effect for trial, $F(9,684) = 759.40$, $p < .0001$. The only other significant effect was the input enactment × trial interaction,

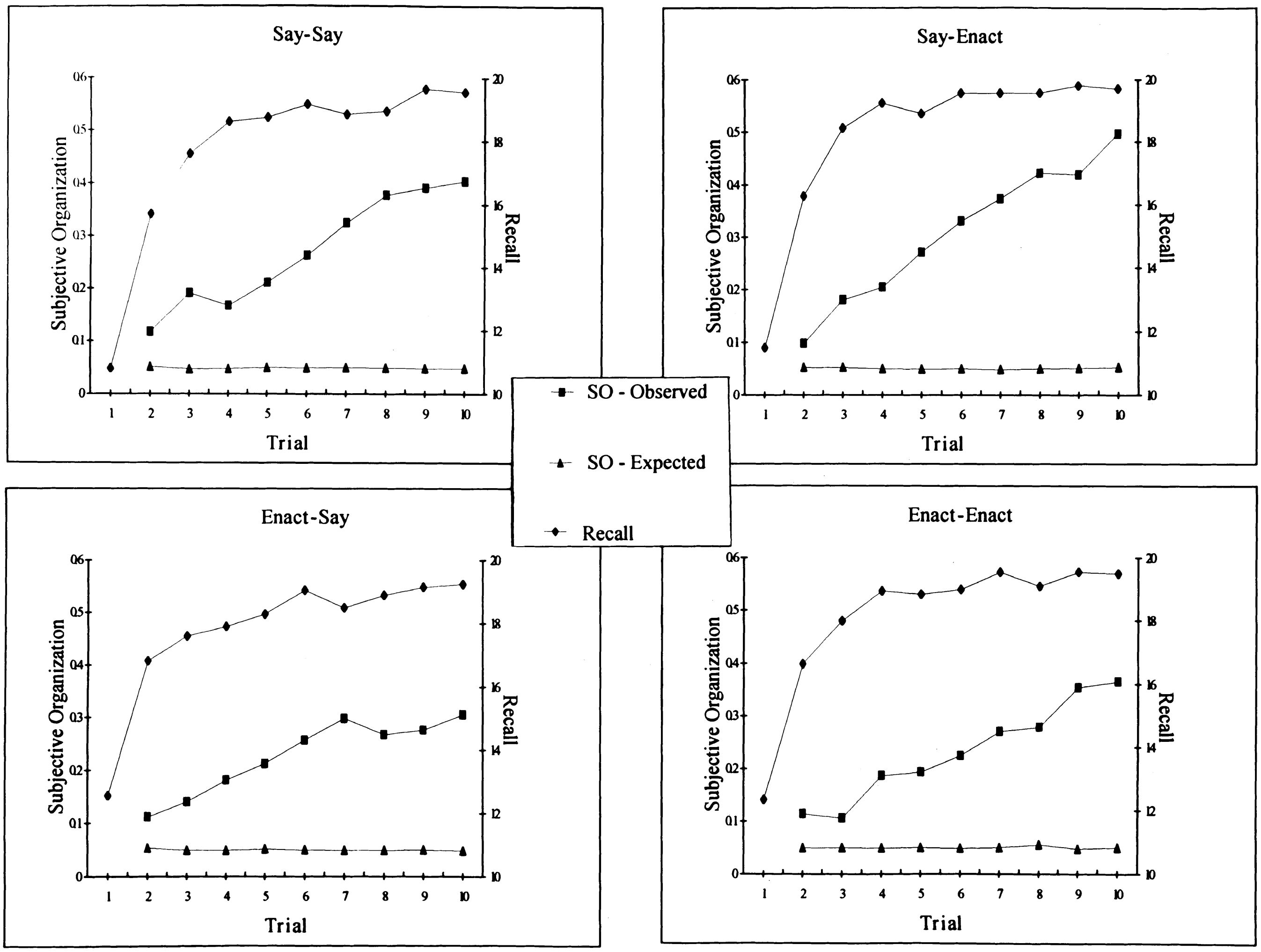

Fig. 2 Recall and expected and observed subjective organization scores as a function of trial for each of the four conditions

$F(9,684) = 2.47$, $p < .01$, which apparently stems from a nonsystematic variation. Thus, it seems that neither enactment during input nor enactment during output affects the rate at which subjective organization develops during learning.

Subjective organization across all ten trials (SO10). We also examined subjective organization across all ten trials. An overall SO score was calculated across all ten trials (SO10) using the same method for calculating SO2 scores, except that all repetitions of the same pair were counted whether or not they appeared on consecutive trials. Table 2 (*upper panel*) presents mean SO10 for the four conditions. In addition, the table presents the means expected by chance, across the ten trials.

Table 2 Mean observed and expected SO2 in the first pair of trials (*upper panel*) and across all 10 trials (*lower panel*)

	Input condition	Say	Say	Enact	Enact
	Output condition	Say	Enact	Say	Enact
First pair of trials					
Observed		0.117	0.098	0.112	0.115
Expected		0.051	0.053	0.054	0.050
Across all 10 trials					
Observed		0.346	0.382	0.312	0.326
Expected		0.120	0.122	0.126	0.121

It can be seen that the observed SO10 scores also exceed those expected by chance for all four conditions. Separate ANOVAs comparing observed and expected SO10 scores for each condition yielded: $F(1,19) = 39.98$, $p < .0001$ for the say-say condition, $F(1,19) = 102.53$, $p < .0001$ for the say-enact condition, $F(1,19) = 36.16$, $p < .0001$ for the enact-say condition, and $F(1,19) = 120.53$, $p < .0001$ for the enact-enact condition. To compare the overall amount of subjective organization for the four conditions, a two-way Input enactment × Output enactment ANOVA was conducted on the observed SO10 scores. This analysis yielded $F(1,76) = 2.55$, n.s., for input enactment, $F < 1$ for output enactment, and $F < 1$ for the interaction.

In summary, then, it seems that the amount of subjective organization is neither impaired (cf. Engelkamp et al., 1990, Exp. 4) nor enhanced (cf. Bäckman & Nilsson, 1984; Bäckman et al., 1986) by enactment, whether enactment occurs during encoding or during testing. It should be noted that Engelkamp et al. (1990, Exp. 1) observed that the subjective organization of a list of unrelated verbs was not affected by enactment.

The relationship between subjective organization and free recall

As noted earlier, Zimmer and Engelkamp (1989; see also Engelkamp et al., 1990), using categorized lists, observed that organization, as indexed by degree of clustering, was positively correlated with recall only under verbal instructions but not under enacting instructions. It is therefore important to see whether this is also true for subjective organization.

To evaluate the relationship between subjective organization and recall, two scores were calculated for each participant. The first represented the SO score across all ten trials (SO10), and the second was the average recall across all ten trials. The correlations between the two scores across participants were .48 ($p < .05$), .63 ($p < .05$), .34 (n.s.), and .29 (n.s.) for the enact-enact, enact-say, say-enact and say-say conditions, respectively. Thus, the highest correlations were observed when the input condition is *enact*, and, in fact, the correlation for the say-say condition was the lowest observed. These results do not accord with those reported by Zimmer and Engelkamp (1989) for the clustering of categorized lists, neither are they consistent with the trend reported by Engelkamp et al. (1990; Exp. 1) of lower subjective organization after enactment than after verbal encoding of a list of unrelated verbs. Thus, our results, if anything, suggest that organization may have a greater beneficial effect on recall under enactment instructions than under verbal instructions.

Are there qualitative differences in subjective organization as a result of enactment?

In the present study we chose to rely on Tulving's (1962) subjective organization measure because of the possibility that the basis for organizing events may differ between tasks that require symbolic or actual enactment and those that do not. However, it is now important to ask whether indeed the type of organization imposed on action events differs as a function of enactment (see also Bäckman & Nilsson, 1984; Bäckman et al., 1986). To examine this question, for each condition we calculated a 20 × 20 matrix that depicts the number of times each task appeared after another task across the recall protocols of all participants and trials. Each value in this matrix may be seen to reflect the relative psychological "proximity" between each pair of tasks. The 380 values in each matrix (with the diagonal excluded) were then used as one vector, and the correlation between the four vectors were then calculated. It can be seen that these correlations, presented in Table 3, are quite high, suggesting that there is a considerable commonality among the four experimental conditions in the sequential organization of action events. Of course, these commonalities also imply that there is some consensus among participants in the "subjective" organization of action events.

In order to examine the nature of organization that transpires across the four experimental conditions, we first evaluated the issue of directionality, that is, whether the frequency of occurrence of task A after task B resembles that of task B after task A. For each condition, we treated the two symmetric halves of each of the 20 × 20 matrices (with the diagonal excluded) as two separate vectors, one (labeled *Half A*) representing the frequencies of each pair when its members appeared in one order, whereas the other (labeled *Half B*) represented the frequencies when the members appeared in the reverse order. The intercorrelations among the eight vectors are presented in Table 4. Two features are notable. First, the correlations between the two vectors of each condition are high, suggesting that the common memory organization evident in each condition is relatively indifferent to the order in which the members of each pair are recalled. The lowest correlation was obtained for the say-say condition, suggesting, perhaps, that in this condition pairs of actions tend to be ordered in one way more than in another.

Second, however, the within-condition correlations are not consistently higher than the between-condition correlations, as might have been expected if the different experimental conditions were to induce qualitatively different memory organizations. It would appear that the commonality between the conditions exceeds the difference between them by a substantial degree.

Table 5 provides some insight into the common memory organization that transpires across the four experimental conditions. It lists the five pairs that appeared most often and those that appeared least often in succession, regardless of the order between the members of each pair. The frequencies of occurrence that are shown in these tables were calculated across all participants, conditions, and orders.

The results presented in Table 5 may offer some clues regarding the principles that govern the spontaneous organization of action events in general. We may offer some conjectures about these principles. Although these

Table 3 The inter-correlations between the four vectors of 380 values representing the frequency with which each minitask followed another minitask in the recall protocols

	Say-say	Say-enact	Enact-say
Say-say	–		
Say-enact	.62	–	
Enact-say	.65	.72	–
Enact-enact	.60	.78	.77

Table 4 Intercorrelations among the vectors (Half A and Half B) representing the order-dependent frequencies with which each task was recalled after another in each of the four experimental conditions

	Half A				Half B			
	SS	SE	ES	EE	SS	SE	ES	EE
Half A								
SS	–							
SE	.61	–						
ES	.65	.75	–					
EE	.58	.75	.75	–				
Half B								
SS	**.55**	.48	.53	.41	–			
SE	.55	**.67**	.69	.62	.64	–		
ES	.58	.75	**.76**	.70	.66	.69	–	
EE	.55	.75	.77	**.67**	.63	.81	.78	–

Table 5 The five pairs that appeared most often in consecutive recall positions and those that appeared least often across all conditions, participants, and orders

Pairs	Frequency
Pairs that appeared most often in consecutive recall positions	
To spin a top – To throw dice	426
To stretch your legs – To take off your shoe	370
To smile – To lick your lips	295
To paint a wall – To knock on the door	273
To stretch your legs – To stand still	244
Pairs that appeared least often in consecutive recall positions	
To stretch your legs – To blink	12
To throw dice – To lick your lips	14
To throw dice – To move your shoulders	14
To blink – To throw dice	17
To smile – To paint a wall	17

are admittedly speculative, we mention them here because they can provide a lead for more controlled experiments. It appears that action events tend to be organized in terms of the similarity between the motor activity involved and, in particular, in terms of the bodily movement and the body parts implicated. Thus, spinning a top or throwing dice involve similar hand movements; stretching one's legs, taking off one's shoes, and standing still all involve some leg movements; smiling and licking one's lips involve facial movements around the mouth; and painting a wall and knocking on a door involve repetitive hand movements. In contrast, all of the pairs with the lowest frequencies of co-occurrences involved different kinds of motor movements implicating different parts of the body. It is important to stress that this trend appears to hold with regard to the memory for action events in general, regardless of whether or not they are enacted.

The kind of organization that emerges from Table 5 is best revealed when contrasted with the organizing principles used in previous clustering studies that examined the effects of enactment on memory organization. Thus, for example, in the study of Bäckman et al. (1986), the categories were defined primarily in terms of the object involved (e.g., actions with articles of clothing or with paper and pencil). However, our results suggest that the nature of the object is less critical than the bodily action involved. Also, in the study of Engelkamp et al. (1990; see also Zimmer & Engelkamp, 1989), the taxonomically categorized verbs included such categories as actions involving cleaning (e.g., wipe or sweep). The episodically organized verbs included categories such as action sequences involving driving a car (e.g., get in or buckle up). None of these two types of organization necessarily involved the same type of bodily action or body part. If, indeed, action events tend to be organized in terms of the bodily movement and body part implicated, then previous clustering studies evaluating the effects of enactment on memory organization may have missed the mark. These observations underscore the dangers, pointed out by Tulving (1962), of measuring memory organization in terms of experimenter-defined rather than participant-defined categories.

Finally, although, as noted earlier, the correlations in Table 3 are relatively high, they still leave room for possible systematic differences between the organization of action events in the four conditions. To obtain some information about this, we used the vectors of 380 values representing the number of times each task appeared after another for each condition. To eliminate differences between the four conditions in overall recall and subjective organization, the frequency values in each vector were transformed into standard scores (with mean = 0 and $SD = 1$). Two difference scores were then calculated. The first, reflecting the effects of input enactment, was the difference between the enact and say instructions at input, regardless of output condition. To calculate this difference, the standard scores for the say-say and say-enact conditions were averaged and were then subtracted from the average of the scores for the enact-say and enact-enact conditions. In the left column of Table 6 are listed the five pairs with the highest differences (*top panel*) and the five pairs with the lowest differences (*bottom panel*). In a similar manner, a second difference, reflecting the effects of output enactment, was calculated between the enact and say instructions at the output, regardless of the input condition, and the five pairs with the highest and lowest differences are listed in the right column of Table 6.

Table 6 Differences (in standard scores) between saying and enacting, in input and output

Input		Output	
Pairs of tasks that appeared in higher frequency in enactment			
To knock on the door – To paint the wall	3.1824	To lick your lips – To Smile	3.0625
To stretch your legs – To stand still	2.7865	To throw dice – To pour coffee	2.4294
To pour coffee – To spin a top	1.9969	To stretch your legs – To stand still	2.3208
To saw a board – To pour coffee	1.9719	To smile – To blink	2.1160
To talk on the phone – To touch your ear	1.8106	To paint the wall – To knock on the door	1.9847
Pairs of tasks that appeared in higher frequency in saying			
To knock on the door – To talk on the phone	−1.4597	To smell a flower – To blink	−1.8231
To move your shoulders – To lick your lips	−1.4942	To lick your lips – To smell a flower	−1.8562
To move your shoulders – To blink	−1.5452	To saw a board – To paint the wall	−2.1295
To look at the ceiling – To paint the wall	−1.7665	To paint the wall – To look at the ceiling	−2.3293
To saw a board – To paint the wall	−2.3333	To stretch your legs – To take off your shoe	−2.5071

The results presented in Table 6 do not lend themselves to a simple interpretation. Nevertheless, we may venture the following generalization: It would seem that the organization of action events that is disclosed in Table 5 is more clearly observed under enactment than under saying. Thus, enactment at input or output tends to induce organization in terms of the bodily movement involved, and particularly the part of the body implicated. In contrast, verbal encoding and verbal reporting tend to reveal, to a greater extent, semantic aspects of relatedness, either taxonomic or episodic. Thus, both "to paint the wall" and "to saw a board" are professional chores; "to stretch your legs" and "to take off your shoe" are part of the same episode; "to lick your lips" and "to smell the flower" imply a happy, romantic mood; and "to knock on the door" and "to talk on the phone" are both associated with sound, and perhaps with an office.

The results presented in Table 6 are consistent with findings reported by Engelkamp and Zimmer (1995) on false-alarm responses in a yes-no recognition memory test for action phrases. In their study, distractors that were motorically similar to a studied item were more likely to be falsely classified as old than dissimilar distractors, and this effect was stronger for participants who enacted the actions during learning and during testing. Engelkamp and Zimmer (1994) also found that recognition performance was impaired more after SPT than after VT learning when the distractors were motorically similar. Thus, enactment may bring to the fore the motor aspects of the action and the similarity between the movement patterns implicated in each minitask.

This conclusion must, of course, be qualified. As Engelkamp (in press) has emphasized, the contribution of sensory or motor similarity to the organization of action events and to their differentiation must also depend on the strength of alternative dimensions of relatedness. Engelkamp and Zimmer (1989), for example, found little tendency to organize actions along movement patterns, and they note that this might have resulted from the use of alternative structures of organization. Thus, the spontaneous use of movement similarity as a dimension of organization may be evidenced only for lists that are truly "unrelated," either conceptually or episodically.

Discussion

There has been some disagreement about the effects of task enactment on memory organization. Some researchers (e.g., Engelkamp et al., 1990; Zimmer & Engelkamp, 1989) argued that enactment does not enhance interitem organization. Others (e.g., Helstrup, 1989), in contrast, claimed that SPTs are organized by virtue of the fact that participants spontaneously use memory strategies in connection with SPTs, and Bäckman and Nilsson (1984) and Bäckman et al. (1986) even went as far as arguing that SPTs are better organized than VTs.

Most previous work on the organization of SPTs, however, used lists of catagorized items (but see Engelkamp et al., 1990). As Tulving (1962) noted, as a measure of the underlying semantic organization, category clustering suffers from the weakness that it is grounded in externally defined categories that have been selected by the experimenter, not by the participant. Consequently, this measure must presuppose that the participant's memory organization is isomorphic with the taxonomic categories chosen by the experimenter. We should add that this weakness is all the more serious when degree of memory organization must be compared between different conditions that are suspect of inducing different types of organization (see Koriat & Melkman, 1981, 1987). This might be the case for the comparison between VTs and SPTs. Such a comparison must presume a common basis of organization, one that is captured by the experimenter-defined categories. Engelkamp et al. (1990), for example, obtained results in support of their hypothesis that different types of organization are beneficial for recalling action verbs in comparison with concrete nouns.

The present study differed in two respects from most previous work comparing memory organization for VTs and SPTs. First, the effects of enactment on degree of memory organization were assessed using subject-defined rather than experimenter-defined categories. This approach has the advantage that it does not presuppose that enactment leaves the underlying organizational basis unchanged. Second, enactment, was manipulated orthogonally during both encoding (input) and recall (output). Studies contrasting SPTs and VTs have generally focused on the effects of variation at the encoding stage. However, differences at the recall stage may be important, because planning to enact action phrases in a future test may also affect their encoding (see Engelkamp, 1997; Koriat et al., 1990).

The results of the present study clearly indicate that SPT memory is organized to the extent of yielding sequential patterning that exceeds chance level, and that this organization improves with practice in studying the same list of action phrases. These findings are consistent with the well-replicated tendency of subjective organization to increase systematically across study-test cycles. Furthermore, the amount of subjective organization was no smaller under enactment instructions, whether enactment occurred during encoding or during testing. In fact, subjective organization was equally pronounced for all conditions, both on the first pair of trials and over all ten trials combined. Thus, we found no support for a claim, emerging from the study of paired-associates learning, that interitem organization is impaired by enactment (cf. Engelkamp, 1986, 1988; Engelkamp et al., 1989), nor did we observe enhanced organization following enactment (cf. Bäckman & Nilsson, 1984; Bäckman et al., 1986). The results, however, would appear to be consistent with Engelkamp's (in press) recent position, if we assume that (a) the subjective organization observed in the present study primarily reflects the utilization of pre-experimentally established relations, and (b) the increase in subjective organization derives from the gradual discovery and utilization of such associations, rather than from the formation of new ones.

The discrepancy between the results obtained here and most of those reported previously by others may stem from the different methodologies used in assessing memory organization. Two possibilities exist. First, perhaps the basis for organizing events differs systematically between VTs and SPTs, and thus measures of the degree of organization that are based on the same experimenter-defined categories may be misleading. Indeed, this idea may underlie Zimmer and Engelkamp's (1989) decision to use both episodically categorized and taxonomically categorized lists, but their results failed to yield differential effects of enactment for the two lists.

However, our post-hoc analysis of the pairs that appeared most often and least often in succession (Table 5) suggested that neither of the two types of categorized lists used by Zimmer and Engelkamp are specifically geared to capture the relations that might be critical in the organization of action events. These relations have to do with the nature of the bodily movements involved and with the part of the body implicated – hand, legs, mouth, etc. Thus, Tulving's (1962) criticism of the common practice of measuring memory organization in terms of experimenter-defined rather than participant-defined categories clearly applies to the study of memory for action events.

Furthermore, even though there was some commonality in the nature of the memory organization exhibited under the four different conditions, our post-hoc analysis suggested possible systematic differences. Specifically, whereas enactment at input or output tends to induce an organization that centers around the bodily movement involved, verbal encoding and verbal recall would seem to make room for the effects of semantic factors that extend beyond the specific motor activity involved. Thus, perhaps enactment does induce a qualitative change in the nature of the organization imposed, but this change is not revealed by the kind of experimenter-defined categories that have been used in previous clustering studies (but see Engelkamp & Zimmer, 1995).

A second possibility is that the subjective organization measure for "unrelated" action phrases captures subtle idiosyncratic relations between items that are not revealed by category clustering measures based on well-defined, experimenter-determined categories. Such subtle relations would also be considered, of course, by the search for inter-subject, inter-condition commonalities. This does not deny the possibility of some qualitative differences in the organization of action events under enactment and under verbal encoding, but it only raises the possibility that such differences should not be easy to detect in a cross-subject analysis.

In any case, our results do not seem to concur with Zimmer and Engelkamp's (1989) claim that relational information is less important following motor encoding than following verbal encoding. Clearly, the recurring sequential contingencies that serve as the basis for Tulving's (1962) subjective organization measure are no less valid as an indication of the processing of relational information than is category clustering.

Zimmer and Engelkamp (1989; see also Engelkamp et al., 1990) also claimed that the improved recall performance associated with enactment does not stem from enhanced organization. This conclusion appears to be consistent with our results. In the present study, the effects of enactment on recall performance were not unequivocal, because the effects of enactment at input were found only for the first trial, and those of enactment at output were found only for trials 2–10. Nevertheless, it should be noted that consistent with Zimmer and Engelkamp's findings, the improved recall performance associated with enactment was not paralleled by a similar increase in subjective organization. This observation may be taken to support Zimmer and Engelkamp's claim that the recall advantage of SPTs is not due to enhanced relational processing, but to enhanced processing of item-specific information. Possibly, the multimodal, contextually rich properties of SPTs result in richer memorial representations than those formed in standard verbal learning conditions (see Bäckman et al., 1986). The imaginal, tactile, and motor codes that are activated either in actually performing the acts during encoding, or in expecting to perform them during testing, may contribute to enhanced item-specific information. This information can improve recall without affecting subjective organization.

Note that in the present study there was a small but positive correlation between recall and subjective organization in each of the four experimental conditions. This pattern is also inconsistent with that reported by Zimmer and Engelkamp (1989) and Engelkamp et al. (1990) for the clustering of categorized lists. They found organization and recall to be positively correlated only under verbal instructions and not under enacting instructions. Here in contrast, the lowest correlation was in fact obtained in the say-say condition.

Several additional results obtained in the present study deserve mention. First, we found that enactment improves not only the quantity of information recalled, but also its accuracy. Following Koriat and Goldsmith's proposal (1994, 1996), accuracy was defined in terms of output-bound memory performance, that is, in terms of the likelihood that a recalled item is correct. Our results indicate that enactment at input and/or output reduces the number of intrusions and thus improves the accuracy of the information reported. This finding has important implications because it suggests that enactment can protect against false memories. Thus, the results imply that an eyewitness reporting on self-performed actions can be trusted to be correct more than one who reports on verbally encoded actions. It is as if enactment helps the participant know what has *not* happened. What is surprising is that this is true even when enactment occurs only at the time of testing.

Another finding concerns repetitions. The results suggest that output monitoring (see Gardiner & Klee, 1976; Koriat et al., 1988) is deficient when testing is verbal rather than through enactment. It would seem that when testing requires enactment of the action phrases, participants have more cues available for determining which items they have already reported and which they have not. This parallels a finding of Gardiner, Passmore, Herriot, and Klee (1977): When participants were deprived of the auditory feedback from their oral responses in a free-recall task, they later exhibited poorer recognition of the words they had recalled compared to an unimpaired condition. In that study, participants' knowledge of their previous recall was best following oral plus written recall.

In sum, the present study provided data that are pertinent to the current controversy regarding the memory organization of self-performed actions. By employing a subjective organization approach that does not require the use of experimenter-defined categories, we obtained results indicating that enactment during input and/or output yields results similar to those obtained without enactment. This was true with regard to both the amount of organization evident in the first pair of trials, as well as with regard to the increase in the amount of organization during learning. Additional results pertaining to the effects of enactment on the nature of memory organization and on the accuracy of the reported information are worth pursuing in future work.

Acknowledgements The work reported in this paper was supported by the Max-Wertheimer Minerva Center for Cognitive Processes and Human Performance, and the paper was prepared while the first author was a visiting professor at the Max Planck Institute for Psychological Research, Munich, Germany. We wish to thank Limor Sheffer for the analyses of the data. We are very grateful to Johannes Engelkamp, Hubert Zimmer, and two anonymous reviewers for their many helpful comments on an earlier draft of the paper.

References

Allen, M.M. (1968). Rehearsal strategies and response cueing as determinants of organization in free recall. *Journal of Verbal Learning & Verbal Behavior*, *7*, 58–63.

Bäckman, L., & Nilsson, L.-G.(1984). Aging effects in free recall: An exception to the rule. *Human Learning*, *3*, 53–69.

Bäckman, L., & Nilsson, L.-G.(1985). Prerequisites for the lack of age differences in memory performance. *Experimental Aging Research*, *11*, 67–73.

Bäckman, L., & Nilsson, L.-G., & Chalom, D. (1986). New evidence on the nature of the encoding of action events. *Memory & Cognition*, *14*, 339–346.

Brooks, B.M., & Gardiner, J.M. (1994). Age-differences in memory for prospective compared with retrospective subject-performed tasks. *Memory & Cognition*, *22*, 27–33.

Cohen, R.L. (1981). On the generality of some memory laws. *Scandinavian Journal of Psychology*, *22*, 267-281.

Cohen, R.L. (1983). The effect of encoding variables on the free recall of words and action events. *Memory & Cognition*, *11*, 575–582.

Cohen, R.L. (1985). On the generality of the laws of memory. In L.-G. Nilsson & T. Archer (Eds.), *Perspectives on learning and memory* (pp. 247–277). Hillsdale, NJ: Erlbaum.

Cohen, R.L., Sandler, S.P., & Schroeder, K. (1987). Aging and memory for words and action events: Effects of item repetition and list length. *Psychology and Aging*, *2*, 280–285.

Earhard, M. (1974). Free-recall transfer and individual differences in subjective organization. *Journal of Experimental Psychology*, *103*, 1169–1174.

Engelkamp, J. (1986). Nouns and verbs in paired-associate learning: Instructional effects. *Psychological Research*, *48*, 153–159.

Engelkamp, J. (1988). Modality-specific encoding and word class in verbal learning. In M.M. Gruneberg, P.E. Morris, & R.N. Sykes (Eds.), *Practical aspects of memory: Current research and issues* (Vol. 1,pp. 415–420). New York, NY: John Wiley & Sons.

Engelkamp, J. (1997). Memory for to-be-performed tasks versus memory for performed tasks. *Memory & Cognition*, *25*, 117–124.

Engelkamp, J. (in press). *Memory for actions*. Hove, UK: Psychology Press.

Engelkamp, J., & Krumnacker, H. (1980). Imaginale und motorische Prozesse beim Behalten verbalen Materials [Imagery and motor processes in memory, of verbal material]. *Zeitschrift für Experimentelle und Angewandte Psychologie*, *27*, 511–533.

Engelkamp, J., & Zimmer, H.D. (1983). Zum Einfluß von Wahrenhmen und Tun auf das Behalten von Verb-Objekt-Phrasen [Perception and enactment in memory of verb-object phrases]. *Sprache & Kognition*, *2*, 117–127.

Engelkamp, J., & Zimmer, H.D. (1994). Motor similarity in subject-performed tasks. *Psychological Research*, *57*, 47–53.

Engelkamp, J., & Zimmer, H.D. (1995). Similarity of movement in recognition of self-performed tasks and of verbal tasks. *British Journal of Psychology*, *86*, 241–252.

Engelkamp, J., & Zimmer, H.D. (1996). Organisation and recall in verbal tasks and in subject-performed tasks. *European Journal of Cognitive Psychology*, *8*,257–273.

Engelkamp, J., Zimmer, H.D., & Denis, M. (1989). Paired associate learning of action verbs with visual or motor-imaginal encoding instructions. *Psychological Research*, *50*, 257–263.

Engelkamp, J., Zimmer, H.D., & Mohr, G. (1990). Differential memory effects of concrete nouns and action verbs. *Zeitschrift für Psychologie*, *198*, 189–216.

Eslinger, P.J., & Grattan, L.M. (1994). Altered serial learning after frontal lobe lesion. *Neuropsychologia*, *32*, 729–739.

Gardiner, J.M., & Klee, H. (1976). Memory for remembered events: An assessment of output monitoring in free recall. *Journal of Verbal Learning & Verbal Behavior*, *15*, 227–233.

Gardiner, J.M., Passmore, C., Herriot, P., & Klee, H. (1977). Memory for remembered events: Effects of response mode and response-produced feedback. *Journal of Verbal Learning & Verbal Behavior*, *16*, 45–54.

Gershberg, F.B., & Shimamura, A.P. (1995). Impaired use of organizational strategies in free recall following frontal lobe damage. *Neuropsychologia*, *33*, 1305–1333.

Glidden, L.M. (1977). Developmental effects in free recall learning. *Child Development*, *48*, 9–12.

Glidden, L.M., & Klein, J.S. (1980). Improving recall in retarded persons: Consistency of ordering and simultaneity of presentation. *Journal of Mental Deficiency Research*, *24*, 299-306.

Helstrup, T.(1986). Separate memory laws for recall of performed acts? *Scandinavian Journal of Psychology*, *27*, 1–29.

Helstrup, T. (1987). One, two, or three memories? A problem-solving approach to memory for performed acts. *Acta Psychologica*, *66*, 37–68.

Helstrup, T. (1989). Loci for act recall: Contextual influence on the processing of action events. *Psychological Research*, *51*, 168–175.

Jackson, D.K., & Schneider, H.G. (1982). Age differences in organization and recall: An analysis of rehearsal processes. *Psychological Report*, *50*, 919–924.

Jackson, D.K., & Schneider, H.G. (1985). Age, organization, and memory: Effects of presentation rate and rehearsal strategy. *Psychological Report*, *56*, 471–479.

Kokubun, O. (1973). The subjective organization in free recall learning by school children. *Tohoku Psychologica Folia*, *32*, 12–16.

Kokubun, O. (1976). Subjective organization in free recall of sentences presented in context-disorganized order. *Tohoku Psychologica Folia*, *35*, 12–16.

Koriat, A., & Goldsmith, M. (1994). Memory in naturalistic and laboratory contexts: Distinguishing the accuracy-oriented and quantity-oriented approaches to memory assessment. *Journal of Experimental Psychology*: *General*, *123*, 297–315.

Koriat, A., & Goldsmith, M. (1996). Monitoring and control processes in the strategic regulation of memory accuracy. *Psychological Review*, *103*, 490–517.

Koriat, A., & Melkman, R. (1981). Individual differences in memory organization as related to word-association, object-sorting, and word-matching styles. *The British Journal of Psychology*, *72*, 1–18.

Koriat, A., & Melkman, R. (1987). Depth of processing and memory organisation *Psychological Research*, *49*, 173–181.

Koriat, A., Ben-Zur, H., & Nussbaum, A. (1990). Encoding information for future action: Memory for to-be-performed versus memory for to-be-recalled tasks. *Memory & Cognition*, *18*, 568–578.

Koriat, A., Ben-Zur H., & Sheffer, D. (1988). Telling the same story twice: Output monitorign and age. *Journal of Memory & Language*, *27*, 23–39.

Levin, H.S., & Goldstein, F.C. (1986). Organization of verbal memory after severe closed-head injury. *Journal of Clinical and Experimental Neuropsychology*, *8*, 643–656.

Lichty, W., Bressie, S., & Krell, R. (1988). When a fork is not a fork: Recall of performed activities as a function of age, generation, and bizarreness. In M.M. Gruneberg, P.E. Morris, & R.N. Sykes (Eds.), *Practical aspects of memory: Current research and issues* (Vol. 2, pp. 506–511). New York, NY: John Wiley & Sons.

Mayhew, A.J. (1967). Interlist changes in subjective organization during free-recall learning. *Journal of Experimental Psychology*, *74*, 425–430.

Miller, L.L., McFarland, D.J., Conett, T.L., Brightwell, D.R., & Wikler, A.(1977). Marijuana: Effects on free recall and subjective organization of pictures and words. *Psychopharmacology*, *55*, 257–262.

Mohr, G., Engelkamp, J., & Zimmer, H.D. (1989). Recall and recognition of self-performed acts. *Psychological Research*, *51*, 181–187.

Nilsson, L.-G., & Cohen, R.L. (1988). Enrichment and generation in the recall of enacted and non-enacted instructions. In M.M. Gruneberg, P.E. Morris, & R.N. Sykes (Eds.), *Practical aspects of memory: Current research and issues* (Vol. 1, pp. 427–432). New York, NY: John Wiley & Sons.

Ornstein, P.A., Naus, M.J., & Stone, B.P. (1977). Rehearsal training and developmental differences in memory. *Developmental Psychology*, *13*, 15–24.

Payne, D.G., & Wenger, M.J. (1992). Repeated recall of pictures, words, and riddles: Increasing subjective organization is not sufficient for producing hypermnesia. *Bulletin of The Psychonomic Society*, *30*, 407–410.

Rankin, J.L., & Battig, W.F. (1977). Developmental differences in the organization and recall of strongly and weakly associated verbal items. *Bulletin of The Psychonomic Society*, *10*, 371–374.

Roenker, D.L., Thompson, C.P., & Brown, S.C. (1971). Comparisons of measures for the estimation of clustering in free recall. *Psychological Bulletin*, *76*, 45–48.

Rundus, D., & Atkinson, R.C. (1970). Rehearsal processes in free recall: A procedure for direct observation. *Journal of Verbal Learning and Verbal Behavior*, *9*, 99–105.

Saltz, E. (1988). The role of motoric enactment (m-processing) in memory for words and sentences. In M.M. Gruneberg, P.E. Morris & R.N. Sykes (Eds.), *Practical aspects of memory: Current research and issues* (Vol. 1, pp. 408–414). New York, NY: John Wiley & Sons.

Schneider, W., & Bjorklund, D.F. (1988). Memory. In W. Damon (Series Ed.), D. Kuhn & R.S. Siegler (Vol. Eds.). *Handbook of child psychology: Cognition, perception and language* (Vol. 2, pp. 467–521). New York, NY: John Wiley & Sons.

Sternberg, R.J., & Tulving, E. (1977). The measurement of subjective organization in recall. *Psychological Bulletin*, *84*, 539–556.

Tkachyk, M.E., Spanos, N.P., & Bertrand, L.D. (1985). Variables affecting subjective organization during posthypnotic amnesia. *Journal of Research in Personality*, *19*, 95–108.

Tulving, E. (1962). Subjective organisation in free recall of "unrelated" words. *Psychological Review*, *69*, 344–354.

Tulving, E. (1964). Intertrial and intertrial retention: Notes towards a theory of free recall verbal learning. *Psychological Review*, *71*, 219–237.

Waters, H.S., & McAlaster, R. (1983). Encoding variability and organization in free recall. *Journal of Experimental Child Psychology*, *36*, 380–395.

Wilson, B.J. (1977). Free recall and subjective organization in performance of learning disabled children. *Psychological Report*, *40*, 117–118.

Wilson, L., & Kihlstrom, J.F. (1986). Subjective and categorical organization of recall during posthypnotic amnesia. *Journal of Abnormal Psychology*, *95*, 264–273.

Write, K.L., Freund, J.S., & Sebby, R.A. (1990) Age differences in free recall and subjective organization. *Psychology and Aging*, *5*, 307–309.

Zimmer, H.D., & Engelkamp, J. (1989). Does motor encoding enhance relational information? *Psychological Research*, *51*, 158–167.