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The contextualization of input and output events in memory

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Summary. Several observations from everyday life suggest that people are deficient in monitoring their own actions, often forgetting that they have already performed a planned act, or experiencing doubt as to whether they have done so. These observations appear inconsistent with the many laboratory studies that indicate that people are quite efficient in monitoring their own actions. Towards the resolution of this discrepancy we proposed that: (a) output monitoring in real life often requires the retrieval of a specific, contextual!}' framed episode rather than mere familiarity with an event, and (b) output events are less strongly integrated with their environmental contexts than input events are. Therefore, despite the output advantage that is frequently reported in occurrence memory, context memory should be relatively less efficient for output than for input events. This hypothesis received some support in Experiment 1, in which generated verbal responses were remembered better than read responses, but the difference was significantly smaller for context than for occurrence memory. Experiment 2 employed a task simulating a two-person interaction. While occurrence memory was superior for self-performed tasks to that for other-performed tasks, context memory was in fact inferior for the former tasks. These results were seen to suggest that self-initiated actions tend to undergo a weaker contextual integration than events that originate from a source external to the person.

Introduction

There has been a growing interest in recent years in the memory processes involved in the active interaction of people with their environment. This interest has been accompanied by a gradual shift in the role of the subject in memory research, from that of a mere recipient of information, to that of a participant observer who also acts in generating this information. Thus, in a growing number of memory studies, subjects are required to interact actively with their environment and to monitor their own responses. Some of the questions addressed in these studies are whether memory of one's own actions differs from memory of externally presented stimuli (Engelkamp, 1990), how people monitor the execution of planned activities (e.g., Koriat & Ben-Zur, 1988), and how they tell whether they have actually performed an act or only planned to perform it (e.g., Anderson, 1984; Kausler & Hakami, 1983).

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Consider a typical social interaction - for example, a two-person conversation. In this interaction, each person must attend to the behavior of the other and retain a record of it, but must also keep track of his/her own responses. We shall refer to these two types of process as *input monitoring* and *output monitoring,* respectively (Koriat, Ben-Zur, & Sheffer, 1988). In general, input monitoring refers to the process of keeping a record of the stimuli generated by a source external to the subject, whereas output monitoring refers to the process involved in keeping track of one's own actions. Recent research suggests that the monitoring of output and input events may rest on different processes (e.g., Cohen, 1983; Engelkamp, 1990; Helstrup, 1987). The present project also addresses the question of possible qualitative differences between memory of input and memory of output events. It was motivated by an apparent inconsistency between two sets of observations pertaining to the relative effectiveness of input and output monitoring. On the one hand, several observations made under naturalistic conditions attest the frailty of memory of one's own activities. On the other hand, a great many laboratory studies have documented the relatively good performance evidenced by subjects in remembering their own past actions (Cohen, 1981), or the responses generated by them (Slamecka & Graf, 1978). In the present study we seek to clarify the discrepancy between the two sets of observations. We shall first review the evidence pertaining to both the advantages and the disadvantages of output monitoring, and then outline a proposal that attempts to reconcile the seemingly contradictory observations.

Evidence of deficits in output monitoring

One common behavioral manifestation of deficient output monitoring is the excessive checking behavior that is intended to ascertain that a planned act has been accomplished, e.g., going back to check that we have locked the door, turned off the oven, etc. Such forms of behavior, in their moderate form, are quite frequent among normal persons. For example, subjects estimated that after leaving their apartment, in 7.9% of the cases they returned to check whether they might have forgotten to lock the apartment door, but that in 99% of these instances it turned out that the door had in fact been locked (Koriat & Ben-Zur, 1988). Sher, Frost, and Otto (1983), who studied checking behavior among students, found that excessive checkers evidenced memory performance similar to that of non-checkers on standard tests of memory, but exhibited impaired memory of the actions they had performed; which suggested that excessive checking is due specifically to the ineffective monitoring of one's own actions.

Excessive checking is one of the central symptoms of the obsessive-compulsive disorder. This symptom was the third-most frequently reported among 70 children and adolescents diagnosed as suffering from obsession-compulsion (Rapoport, 1989). Reed (1985), who studied memory processes among obsessive-compulsive persons, concluded that excessive checking is not due to uncertainty about the factual information, but due to uncertainty about the episodic, personalized aspect of this information. Thus, the act of checking is intended to generate a personalized representation of the specific episode, which can serve later as evidence that the action has in fact been accomplished.

Another manifestation of deficient output monitoring is repetition behavior. Like checking behavior, it often derives from the insufficient monitoring of one's own actions. Thus, we may start the car when the motor is already running, or add a second sweetener to our coffee, forgetting that we have already done so. Repetition behavior of this sort is quite common in old age, as when one takes medicine twice, or repeats the same story over and over (Kausler & Hakami, 1983). Koriat et al. (1988) presented evidence suggesting that older subjects suffer from a greater deficiency in output than in input monitoring, and are therefore expected to have greater difficulty in deciding whether they have told a story than in deciding whether they have heard it.

Deficient output monitoring may also result in a variety of behavioral aberrations commonly subsumed under the rubric "slips of action" (Reason, 1983). These are instances in which action deviates from the person's intentions. According to Reason, such slips are likely to occur with highly practiced, routinized activities that can be executed without attention. With such activities, behavior may branch off into an unplanned subroutine when attention is not deployed at the critical decision points. Reason argues that slips of action occur because unattended activities tend to leave behind only faint and brief memory traces, and this may result either in the omission or in the repetition of a specific act. Indeed, Gardiner, Passmore, Herriot, and Klee (1977) obtained evidence suggesting that accuracy of output monitoring depends on the amount of feedback from one's own actions.

Recent work on reality monitoring (Johnson, 1988) suggests another possible source of impaired output monitoring. Since actions are often contemplated or imagined in advance of their execution, subjects may confuse the memory of the actual activity with the memory of the imagined activity. When this occurs, they tend to assume that the activity has been performed when it was only imagined (Anderson, 1984).

Altogether, the work reviewed above on checking behavior, repetition behavior, slips of action, and reality monitoring stresses the fallibility of memory of one's own actions and the problems encountered in everyday life as a consequence of deficient output monitoring.

Evidence of enhanced memory of output events

In contrast to the many problems reported about the monitoring of output events in everyday life, experimental studies on the generation effect and on the memory of subject-performed tasks stress the efficient memory of output events and the superiority of output monitoring over input monitoring. The generation effect refers to the phenomenon, first documented by Slamecka and Graf (1978), that items generated by the subject are remembered better than items provided by the experimenter. This phenomenon was demonstrated across a wide variety of experimental conditions,, with different types of stimulus materials (e.g., words, sentences, numbers) and different memory measures (e.g., free recall, cued recall, and recognition: Hirshman & Bjork, 1988; McDaniel, Waddill, & Einstein, 1988). Among the explanations offered for the generation effect is the possibility that generating a verbal response in itself constitutes a recall act (Slamecka & Graf, 1978), and that the generation task promotes a deeper processing of the individual target or increases its distinctiveness (Slamecka & Katsaiti, 1987).

In the study of memory of subject-performed tasks (SPTs), initiated by Cohen (1981), subjects are required to perform a series of minitasks in response to verbal instructions (e. g., clap hands, bounce a ball), and their memory of these tasks is subsequently tested. The results of a great number of studies indicated superior memory of SPTs than of the respective verbal instructions (e.g., Backman & Nilsson, 1984; Backman, Nilsson, & Chalom, 1986; Cohen, 1983; Engelkamp, 1990; Helstrup, 1986; 1987). This superiority was explained by Backman and Nilsson in terms of the multimodal, rich properties of SPTs as opposed to those of verbal material. Engelkamp and his associates (Engelkamp, 1990) specifically demonstrated that the SPT superiority cannot be solely attributed to the visual-imaginal encoding involved in performing the action, or to the planning of the action, but to processes related to the motor performance itself. Apparently, memory of output events is mediated by a motor representation distinct from that underlying visual imagery.

Nilsson and Cohen (1988) claimed that the memory of SPTs and the memory of subject-generated responses depend on similar cognitive processes, since in both, subjects presumably remember not what was presented to them as input, but rather what they did during encoding. Consistently with this proposal, they found that generation enhanced memory of verbal instructions, but not of enacted instructions. This supports the notion that similar processes underlie the beneficial effects of both the generation of a verbal response and the enactment of an instruction.

In sum, the results pertaining to the generation effect and the memory of SPTs suggest that responses produced by the subject leave more durable memorial representations than those received from an external source. These results appear to contradict the observations pertaining to the difficulties in output monitoring in everyday life.

In the present study we attempt to reconcile the apparent inconsistency between the scattered observations that emphasize the difficulties encountered in everyday life in monitoring one's own actions with the laboratory studies that demonstrate the superiority of memory of output events over memory of input events.

The criticality of episodic information for output monitoring

Examination of output monitoring in naturalistic settings may help clarify the causes of memory impairment. Everyday experience suggests that the most common difficulties are encountered with well-learned, *routinized activities* (Reason, 1983). Perhaps the impaired memory of output events is due to the fact that many activities in everyday life can be carried out with relatively little attention. This account, however, is not consistent with the finding that memory of SPTs is relatively indifferent to attentional effects (e.g., Cohen, 1983).

An alternative account stresses the role of *differentiation* or *distinctiveness* of memory events (Brewer, 1988; Begg, Snider, Foley, & Goddard, 1989). By definition, routinized activities are activities that are repeated frequently, and generally in a stereotyped form. Thus, the main problem should be to form a sufficiently distinctive trace of the particular episode. Surely, the difficulty that I have in deciding whether I have locked the apartment door stems from my uncertainty as to whether I have locked the door today. Similarly, I may recall that I have told a certain joke, and yet cannot remember whether I told it to a certain person. Thus, perhaps the problems of output monitoring in everyday life stem not from the inability to remember the mere occurrence of an event, but from the inability to delineate the specific spatio-temporal circumstances of that event.

This analysis suggests that as far as routine activities are concerned, it is useful to distinguish between *type events* and *token events.* Locking the apartment door represents a type event, whose tokens are the many individual episodes of locking the door. Memory of type events and memory of token events should be distinguished for two reasons. First, memory of a type event can rest on a relatively abstract representation, detached from the particular circumstances of the event. The memory of a particular token event, on the other hand, depends on the retrieval of the specific individualized episode, with its distinctive spatio-temporal context. In terms of Tulving's (1985) distinction, the storage and retrieval of type events may be accomplished solely by the semantic-memory system, whereas those of token events require reliance on the episodic-memory system. Second, the retrieval of a type event is sufficient to guide action in some situations, whereas other situations require retrieval of the particular token event. For example, I can interrupt a friend in the middle of telling a joke when I realize that the joke is familiar. On the other hand, when I am the one who is telling the joke, I should consider stopping in the middle only if I realize that I have already told the same joke to the same person. This realization normally requires retrieval of some aspects of the specific episode (Craik, 1989). Thus, one of the general characteristics of routine activities is that the monitoring of their performance must rest heavily on evidence pertaining to token events.

Hence, some of the difficulties in output monitoring in everyday life seem to derive from the need to differentiate between several episodes involving the same routine activity. Perhaps the same is true with regard to "routine" input events (e.g., watching a TV commercial, hearing a digital watch beep on the hour, or for that matter, hearing the same word in the context of two different lists in a memory experiment), except that these are less frequent than "routine" output events. Indeed, Mandler (1980), discussing memory of input events, has stressed the distinction between the recognition of an event, which is based on its mere familiarity, and the specific identification of that event, based on retrieving contextual cues. In a somewhat different context, Kanwisher (1987) made a similar distinction between type recognition and token individuation in connection with the phenomenon of repetition blindness.

Output monitoring depends on episodic information in nonroutine activities as well. For example, Koriat et al. (1988) explained the greater deficiency in output as opposed to input monitoring in the elderly in terms of the difficulty they have in encoding and retaining distinctive contextual tags (Kausler, Klein, & Overcast, 1975; McCormack, 1584). Mere familiarity with a story is sufficient to determine that one has heard (or read) the story, but is not sufficient to determine that one has told it. This is because the stories told usually represent a subset of the stories heard (or read). Therefore, to determine that one has already told a story, one must retrieve the context of its occurrence, i.e., whether it was encountered in the context of the output (told) or only in the context of the input (heard). The same is true in free recall, where to avoid repeating a word during recall one must judge whether that word had been encountered in the context of the output (recall list) or only in the context of the input (learning list).

The encoding of contextual information for input and output events

The previous discussion has indicated two possible factors that may contribute to the problems of output monitoring in everyday life: first, that with routine activities one must often retrieve the particular, individualized episode; and second, that output events often constitute a subset of input events. Both factors imply that output monitoring should rely more heavily on the retrieval of distinctive, contextual information than does input monitoring.

There is yet a third, more fundamental, contributory factor, which we examine in the present study: the *encoding* of contextual information. We propose not only that output monitoring often depends on the retrieval of contextual information, but also that the encoding of this information is more difficult for output than for input events. Thus, even in those cases in which input and output monitoring are equally dependent on contextual tagging, we should expect a greater impairment in output than in input monitoring.

This proposal is based on the idea that output events undergo a shallower contextualization than input events. The term *contextualization* is used here to refer to the establishment of associative links between an event and its contextual, spatiotemporal environment. Thus, we propose that events with a source external to the subject (e.g., stones heard), generally form rich associative Jinks with their environmental context. This is because the target event tends to be psychologically construed as an integral part of its environment. In contrast, subject-generated events (e.g., stories told, SPTs, etc.), are less strongly integrated into their environmental context. This might be due to the tendency of the acting person to perceive his/her own behavior as belonging more to himself/herself than to the external environment. This contrasts with common psychological theories in which "behavior" is seen as a product of the interaction between the "person" and the "situation," thus representing a conceptually separate category distinct from both of its determinants (e.g., Lewin, 1951). Alternatively, it can be posited that enactment focusses the subject's attention upon the motor programs required to carry out each specific action (Zimmer & Engelkamp, 1989), thus impairing contextual integration. Hence, we expect our own behavior to undergo a shallower contextual integration than the stimuli to which we respond. For example, in a two-person interaction, we expect the memory of our own behavior to be less contextually integrated than the memory of the other partner's behavior.

This proposition is consistent with recent work that suggests that motor encoding is relatively ineffective in integrating information between an event and its corresponding contextual cue, or across different events. Engelkamp (1986) used a paired-associate learning task comparing free and cued recall under imagery and motor encoding. For pairs of action verbs, cued recall was better than free recall under imaginal encoding, whereas under motor encoding cued recall was in fact inferior to free recall. Engelkamp, Zimmer, and Denis (1989) found that cued recall was generally superior to free recall, but that the difference was more pronounced when subjects imagined another person performing an action than when they imagined themselves performing that same action. This was seen to suggest that both visual-imaginal and motor-imaginal encoding facilitate item-specific encoding, but also that only visual-imaginal encoding promotes relational encoding. Helstrup (1989) also obtained results suggesting that recall benefits from contextual cues less under motor than under nonmotor encoding instructions. He had subjects learn action phrases in connection with specific cues (different locations), and found that the presentation of the cues improved recall under imaginal, but not under motor, learning instructions.

Taken together, these results suggest that although motor encoding tends to enhance target recall and recognition, it does not improve contextual integration, i.e., the establishment of associative links between the target and its corresponding contextual cues. Perhaps this is related to the general finding that enactment affects memory by enhancing the encoding of item-specific information, rather than by strengthening interitem relations. Indeed, relational information was found to be less important under motor-encoding instructions than under the standard, verbal-learning instructions (Zimmer & Engelkamp, 1989). Thus, if memory of output events is mediated by motor encoding (Engelkamp & Zimmer, 1984), this encoding should result in a great number of output events that are retained in a noncontextualized form.

The proposition that output events undergo a shallower contextualization than input events implies that it may sometimes be more difficult to retrieve the particular episode of an output event than the particular episode of an input event. This, despite the repeatedly supported contention that output events are remembered better than input events when contextual tagging is not required. Operationally stated, we expect the following interactive pattern: *Occurrence memory,* i.e., memory of the mere occurrence of the event, regardless of its specific context, should be superior for output than for input events. In comparison, *context memory,* i.e., the memory of the context in which that event occurred, should be inferior for output than for input events.

Two experimental paradigms were exploited in the present study to examine this hypothesis. Experiment 1 used the procedure commonly employed in the study of the generation effect, whereas Experiment 2 used the procedure connected with the memory of SPTs. In the two experiments we compared occurrence memory and context memory of input and output events that took place in two different environmental contexts. Occurrence memory was operationally defined as the ability to recognize "old" events, i.e., to distinguish "old" from "new" events, regardless of context, whereas context memory was defined as the identification of the context of occurrence of an "old" event.

Experiment 1

Experiment 1 exploited the general procedure employed in the studies of the generation effect (Slamecka & Graf, 1978). In the "generate" condition the subject was presented with a stimulus word and a companion cue (a word fragment), and asked to generate a response (output) that belonged to the same category as the stimulus word, according to the cue provided. In the "read" condition the subject saw the stimulus together with the full response and was asked merely to say the response aloud (input). Subjects were presented with the two types of item in two different rooms, and were then asked to classify responses, as well as new words, according to whether they had appeared in room I, in room 2, or in neither.

This design allows the comparison of input (read) and output (generated) words with regard to both memory of occurrence and memory of context. We expected output superiority in occurrence memory, but input superiority in context memory.

Table 1. An illustration of the items used in Experiment 1 and their arrangement.

	Stimulus term	Response term	Required response
Phase 1	TABLE GREEN	CH--R YELLOW	CHAIR YELLOW
Phase 2	TABLE GREEN	SO-A RED	SOFA RED

Method

Subjects. Twenty-four University of Haifa students (18 females and 6 males) participated in the experiment, 18 for course credit, and *6* paid. Their average age was 23.7 years.

Design and stimuli. The experiment included two learning phases, each carried out in a different room, and a testing phase conducted in a third room.

The stimulus materials for the experiment were prepared on the basis of the results of a preliminary study in which 103 Hebrew-speaking subjects were asked to list five members of each of 33 conceptual categories. Eighty Hebrew words were selected, four for each of 20 different categories. For each category the four most frequently listed instances were used, and the categories selected were such that there was as little overlap as possible between their members (e.g., since "fruit" was used, "food" was not included).

Each item consisted of a pair of words chosen from one of the quadruples and appearing in one of two versions. In the "read" version the response term was presented in full next to the stimulus word (e.g., CHAIR - TABLE), whereas in the "generate" version it appeared as a partial cue corresponding to the response term (e.g., CHAIR - TA-L-). It consisted of I -3 letters and blank spaces that were sufficient to specify the designated response uniquely (e.g., "TA-L-" for TABLE). Each stimulus pair was printed on a 13 x 10-cin card.

Each subject was presented with 40 stimulus pairs. In hall of the pairs the response term was a partial cue, whereas in the other half it was the full word. Subjects were instructed that, when presented with a partial cue, they had to generate a word corresponding to the cue, belonging to the same category as the stimulus. In contrast, when the response term was presented in full, they had simply to read it aloud. In both conditions they had first to speak silently the stimulus word before reading aloud the response word. Thus, each subject was presented with 20 items in each room, 10 with a "read" instruction and 10 with a "generate" instruction. Each stimulus term was repeated in the two rooms with different solicited responses, but always with the same (either read or generate) instruction. This design prevented subjects from relying on the memory of the context of the stimulus term in judging the context of the corresponding response term.

For each subject one of the words in each quadruple of category instances was assigned to the stimulus term; two were assigned either to the response terms to be read or to those to be generated (one for each room); and one served as a distractor in the classification test. The assignment of the words to the four types was counterbalanced across subjects. Table 1 illustrates (using English stimuli) the arrangement employed for each subject.

Procedure. The two learning phases of the experiment were conducted by two different experimenters, both trained graduate students. Two rooms were used for the learning phase, a "computer room," and an "office room." The "computer room" was a 7.5-m^2 room, without windows, illuminated by a fluorescent light. It housed a minicomputer and two monitors, air-conditioning equipment, a large table, a small table, three chairs, and one cabinet. The "office room" was a 6.0-m^2 room with a large window. It contained a monitor, two small tables, and two chairs. The assignment of phases 1 and 2 to the computer room or to the office room was counterbalanced across subjects. In phase I the subject and the experimenter sat facing each other across the table. The experimenter displayed each card for 5 s, and replaced it after 2 s by the next card. Twenty cards were thus presented, with the presentation order randomly determined for each subject. When phase 1 was completed, the subject was asked to move to the second learning room, where the second experimenter was waiting, and phase 2 began. The procedure was identical to that of phase 1, except that a new set of 20 pairs was used.

When phase 2 was completed, the subject was asked to move to a large seminar room for memory testing. Two paper-and-pencil tests were administered. In the first, the classification test, subjects were presented with 60 words. These included 20 distractors, one from each of the 20 categories, 20 generated words, 10 from each room, and 20 read words, 10 from each room. Subjects were asked to determine for each whether it had appeared in room I (referred to as "the first room used, that is, the computer room/the office room"), in room 2 ("the second room used, that is, the office room/the computer room"), or in neither. The subjects were informed that the three categories were equally represented in the test. This testing procedure was used because it allowed us to test occurrence and context memory simultaneously rather than in succession, thus avoiding the effects of possible differences in the decay function of the two types of memory.

In the second test, the context-identification test, subjects were presented with the 40 "old" words, and were asked to judge for each whether it had appeared in the office room or in the computer room. Hence, context memory was checked again, this time in relation to all the response terms encountered during the experimental phases (i. e.. including "old" words that might have been classified as "new" in the first test).

Results

Subjects failed to generate the solicited word in 2.8% of the trials, and the results from these trials were eliminated from the analyses.

We shall first examine the results for the first, classification test, in which subjects classified 60 words into those appearing in room 1 (the first room for each subject), room 2 (the second room), and new words. For each subject the proportions of each type of response were calculated separately for the read and the generated words. Table 2 presents the means of these proportions for items that actually appeared in room 1 and in room 2, and for "new" items.

Two separate scores were derived for each subject. The first, occurrence-memory score, was based on the success of distinguishing "old" from "new" items regardless of their context of occurrence. It was defined as the proportion of "room J" plus "room 2" responses out of all old items (i.e., words that actually appeared in either of the two rooms). These scores were calculated separately for the generated and the read words, and were not corrected for guessing, because the correction is identical for input and output events (that is, the design does not permit assessment of false - alarm rate for the two types of events separately). The results for occurrence memory were consistent with previous findings (e.g., Slamecka & Graf, 1978) in indicating a clear advantage for generated over

Table 2. Mean proportions or' "Room 1," "Room 2," and "New" responses for the "Read" and "Generate" pairs which appeared in room 1, in room 2, or did not appear in the experiment (Experiment 1).

	Room 1		Room 2		New
	Read	Generate	Read	Generate	
Judgment					
"Room 1"	.470	.666	.276	.137	.144
"Room 2"	.261	.297	.364	.803	.073
"New"	.269	.037	.360	.060	.783

read words. Generated words yielded a .952 hit rate, compared to .685 for read words, F (1,23) = 98.22, p <.OOO1.

The second, context-memory score, reflected the memory of the circumstances of occurrence. In calculating this score we took into account only "old" items that were correctly classified as such by the subject. Context memory was then defined as the proportion of those items that were correctly classified with regard to the two rooms (i.e., the number of correct room-1 and room-2 responses divided by the number of old items that were correctly classified as old). The results also showed better context memory of generated than of read words, with means of .768 and .607, respectively, F (1,23) = 24.46, p <.001. However, a two-way analysis of variance (ANOVA) contrasting occurrence and context memory of read and generated responses yielded a significant interaction, indicating that the superiority of generated over read words was less pronounced for context memory than for occurrence memory, F (1,23) = 8.17, p <.01. This interaction is depicted in Figure 1, left panel.

The second, context-identification test, also yielded better context memory of generated words (.744) than of read words (.561), consistently with the results of the first memory test. An ANOVA comparing these means with those obtained for occurrence memory on the first test again yielded a significant interaction, indicating a weaker generation effect for context memory than for occurrence memory, F (1,21) = 5.97, p <.05.[1]

Discussion

Experiment 1 used a generation task to compare occurrence memory and context memory for read words (input) and generated words (output). The results for occurrence memory indicated a markedly superior performance for the generated words over that for the read words, consistent with the well-documented generation effect. Context memory also evidenced a superiority of output over input targets, but this superiority was significantly less pronounced than that observed for occurrence memory.

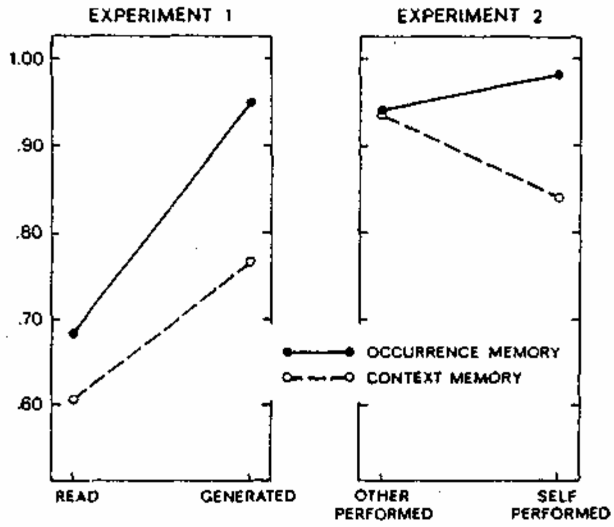

Fig. 1. Mean proportions for occurrence and context memory of input and output events in Experiments 1 and 2.

Although the results did not yield the expected output inferiority for context memory, the interactive pattern found suggests that the generation effect is more strongly observed with regard to the memory of the mere occurrence of an event than for that of the contextual circumstances of the event. If contextual information is critical for the retrieval of specific episodes, then these results imply that the advantage of output over input events should be more pronounced in situations that require retrieval of a type event than in those requiring retrieval of a particular token episode.

Experiment 2

Experiment 2 sought to extend the results of Experiment 1 to a situation in which subjects either perform certain acts or watch others performing these acts. The procedure was borrowed from studies investigating the memory of subject-performed tasks (SPTs; Cohen, 1981). As noted above, these studies reported consistently superior memory performance for SPTs than for information generated by a source external to the subject (Engelkamp, 1990; Helstrup, 1987; but see Cohen, 1983). All previous SPT studies focussed on occurrence memory, and the aim of Experiment 2 was to contrast occurrence and context memory of self-performed acts with that of other-performed acts. The experiment was conducted simultaneously in two separate rooms. In each room, one experimenter and two subjects were seated facing each other across the table. In each trial a sentence depicting a minitask (e.g., "raise your hands") was exposed, and one of the subjects had then to "communicate the act" to the other subject by performing it. When this phase was completed, two subjects, one from each room, changed places, while the other two subjects remained in their seats, and the same procedure was repeated. Memory was tested as in the first experiment.

This procedure was designed to simulate certain aspects of everyday interactions. In the course of a day or a week

[1] Two subjects failed to fill out the second memory test. This analysis was therefore based on only 22 subjects.

we normally engage in different types of interaction (e.g., conversations), each involving different people and/or different contexts. Thus, we have often to retain not only what we have heard, but also where and from whom, and not only what we have said, but also where and to whom. Imperfect contextual integration of input, for example, may result in being able to retrieve a particular piece of news, but not its source. Similarly, imperfect contextualization of output may result in repeating the same talk to the same audience (as often occurs when a lecturer teaches the same course several times). Thus, in Experiment 2 we sought to determine the extent of contextualization of input and output events by having subjects engage in different "encounters," each involving a different social environment.

Half of the minitasks used in Experiment 2 had to be performed by means of external objects, while the remaining involved mainly bodily parts. If we find a reduced output advantage for context memory against occurrence memory, a comparison of the two types of minitask may facilitate interpretation of this interaction. If subjects have difficulty in retaining the contextual circumstances of their actions because the processes underlying task performance draw attention away from the external situation, then we should expect a smaller impairment in context memory for minitasks requiring the manipulation of an external object than for those involving only the subject's own body. Moreover, a comparison between subjects who change rooms and those who remain in the same room may help determine the extent to which increased differentiation between the two learning phases (e.g., by changing rooms) can facilitate context memory of output events.

Method

Subjects. Forty psychology students (28 females and J 2 males) participated in the experiment for course credit. Their age averaged 23.8 years (range 19-30).

Stimuli. A list of 72 sentences depicting different minitasks was compiled from various sources, the majority from Cohen (1981). Of these, 48 were used for learning (old), and 24 were included as distractors (new) in the recognition test. Half of the minitasks in the old and new sets required the manipulation of an external object (e.g., "stir the water in the cup"), while the other half involved mainly bodily actions (e. g., "stand up and then sit down").

Forty-eight sentences were printed on 13 x 10-cm cards. Each sentence was printed twice on the same card, in opposite reading directions, so that when the card was folded in the middle, each sentence was visible only from one side. On each card an arrow appeared on one side only, at the end of the sentence. Two identical copies of the 48 cards were prepared.

Design and procedure. The experiment was conducted simultaneously in two separate rooms, each room including one experimenter and two subjects. In each of the two learning phases of the experiment, the subjects were presented with a series of 24 minitasks, with each of the subjects required to perform half of them. Between the two phases, two subjects, one from each room, changed places with each other. The memory tests took place in a third room.

Subjects signed up for the experiment in groups of four subjects each. They were assigned randomly to the two experimental rooms, two subjects per room. The same procedure was conducted simultaneously in the two rooms by two female experimenters. The two rooms were identical in size (4x4 m). color (yellow walls), and architecture (a square shape with two windows on one wall), and included identical arrangements of one table (0.5 x 1 m) and three chairs. All the objects needed for performing the 24 minitasks were displayed on each of the tables, in identical arrangements. On each table there was also a metal board, bent in the middle, on which the partially folded stimulus cards could be displayed.

The two subjects in each room sat opposite each other, with the experimenter sitting at the head of the table. They were told that they were participating in an experiment on communication processes, with each subject having to perform certain tasks while the other was watching. They were instructed that, upon presentation of each card, each of them should read the sentence silently, and that the subject facing the side of the arrow should also perform the task. When the task required the manipulation of an external object, the performing subject had to use the appropriate object present on the table, and put it back in its original location. Subjects were asked to pay attention when the task was performed by their partner.

In phase 1 of the experiment, the first set of 24 sentences was presented in each room. The same order of presentation was used for all subjects. This order was random except that each subject served as the actor on every other minitask, and that the requirement to use an external object changed every two minitasks. Each card remained in sight for 5 s.

Subjects who completed the task were asked to wait outside the room (for a period that did not exceed a few minutes). When all four subjects had finished, two subjects, one from each room, returned to their seats, while the other two subjects exchanged seats (rooms) between them. Phase 2 was then conducted. It was identical to phase 1, except that the second set of 24 minitasks was employed. The experimenters remained in the same room throughout the entire learning session.

When phase 2 was completed, all four subjects moved to a third room for memory testing. They were presented with a printed, randomly arranged list of the 72 minitasks, and asked to classify each into three categories according to whether they had appeared in phase 1, in phase 2, or in neither ("new").

Results

Occurrence memory and context memory. For each subject, the proportions of each type of response ("phase 1," "phase 2," and "new") were calculated separately for tasks that had been performed by self (output), for tasks performed by the other partner (input), and for tasks that were not used in the experiment. Table 3 presents the means of these proportions calculated across all subjects.

Occurrence and context memory scores were calculated for each subject according to the procedure used in Experiment 1. Although occurrence memory performance was very high, with .962 of all old items correctly classified as nondistractors, it was nevertheless significantly higher for output (.983) than for input events (.942), $F(1,39) = 22.36$, $p < .0001$. These results accord with those of previous studies (e.g., Helstrup, 1987) and of Experiment 1, in demonstrating an output advantage for occurrence memory.

The results for context memory, on the other hand yielded a significantly inferior performance for subject-performed (.841) than for other-performed (.936) minitasks, $F(1,39) = 53.08$, $p < .0001$. This inferiority results mainly from subjects' tendency to classify minitasks performed by them in phase 1 as occurring in phase 2.

Thus, the results of Experiment 2 indicate that although output events are monitored better for occurrence than input events, they are monitored less effectively with regard to context. This interactive pattern, depicted in Figure 1, right panel, was further substantiated by an overall two-

Table 3. Mean proportions of "Phase I," "Phase *2,"* and "New" responses as a function of actor (self vs. other) for minitasks performed in phase i, phase 2, or not performed (Experiment *2).*

Stimulus	Phase I		Phase 2		New
Actor	Self	Other	Self	Other	
Judgment					
"Phase 1 "	.740	.879	.073	.052	.012
"Phase 2"	.239	.067	.915	.885	.019
"New"	.021	.054	.012	.063	.969

Table 4. Mean occurrence-memory and context-memory scores as a function of actor (self vs. other) for minitasks requiring an object and those not requiring one (Experiment *2).*

	Occurrence memory		Context memory	
Actor	Self	Other	Self	Other
Minitask				
Without object	.973	.908	.852	.915
With object	.994	.975	.831	.956

Table 5. Mean occurrence-memory and context-memory scores as a function of actor (self vs. other) for subjects who remained in the same room and subjects who changed rooms (Experiment 2).

	Occurrence memory		Context memory	
Actor	Self	Other	Self	Other
Room changing				
Remained in room	.985	.967	.858	.945
Changed rooms	.981	.916	.824	.927

way ANOVA, Actor (self vs. other) x Memory Measure (occurrence vs. context), which yielded a highly significant interaction, 7^(1,39) = 76.83, p <.0001.

We also examined the effects of two variables, which may help explain the interactive pattern noted above, whether or not the minitask required the use of an external object, and whether or not the subject changed rooms between the two learning phases.

The effects of object manipulation. Table 4 presents mean occurrence and context memory scores as a function of actor (self vs. other) and type of minitask (with vs. without object).

As far as occurrence memory is concerned, a two-way ANOVA, Actor x Type of Minitask, indicated better memory for minitasks requiring an object (.984) than for those not requiring one (.941), F (1,39) = 26.10, p <.0001. The superiority of the minitasks requiring an object was significant for self-performed, F (1,39) - 4.53, p <.05, as well as for other-performed tasks, F (1,39) = 24.71, p <.0001.

A similar two-way ANOVA on context memory scores yielded F(1,39) = 52.49, p <.0001 for Actor, F <1 for Type of Minitask, and F (1,39) = 4.35, p <.05 for the interaction. The superiority of minitasks requiring an object was significant for other-performed tasks, F *(*1,39) = 7.51, p <.01, but not for self-performed tasks, F <1.

It should be noted that the superior occurrence memory for self-performed than for other-performed tasks was significant for minitasks requiring an object, F (1,39) = 8.83, p <.01, as well as for those not requiring an object, F(1,39) = 17.13, p <.001. Similarly, the inferior context memory for self-performed compared with other-performed minitasks was significant for minitasks requiring an object, $F($ 1,39) = 43.14, p <.0001, as well as for those not requiring one, F (1,39) =9.71, p <.01.

The effects of changing rooms. Table 5 presents the means of occurrence and context memory as a function of actor (self vs. other) for subjects who changed rooms and for those who remained in the same room.

As far as occurrence memory is concerned, subjects who remained in the same room performed somewhat better (.976) than those who changed rooms (.949), *F(l,38)* - 6,55, p <.02. The superiority of self-performed over other-performed minitasks was significant for subjects who changed rooms, F (1,19) = *19.59,* p <.001, as well as for those who remained in the same room, F (1,19) = 7.03, p <.02.

The results for context memory showed no significant effects for room change, F (1,38) = J .54, or for the interaction, F <1. The superiority of other-performed over self-performed minitasks was significant for subjects who changed rooms, $F($ 1,19) = *38.26,* p <.0001, as well as for those who did not, F (1,19) = 18.26, p <.001.

Discussion

Experiment 2 yielded a crossover interaction, with occurrence memory evidencing a significant output superiority and context memory indicating a significant output inferiority. This implies that many more self-performed than other-performed actions are remembered in a manner that is noncontextualized - that is, in a manner that does not afford retrieval of the specific episode. These results further corroborate the interactive pattern observed in Experiment 1, where output superiority was less pronounced for context memory than for occurrence memory.

The results of Experiment 2 parallel those reported by Engelkamp et al., (1989). They had subjects study pairs of action verbs under instructions either to imagine oneself or to imagine somebody else performing the actions. Equivalent performance was found for cued recall and free recall under other-performance instructions, whereas self-performance instructions yielded inferior cued-recall in comparison with free-recall scores. These results suggest that self-performance encoding is less conducive to the relational integration of each target with its corresponding contextual cue than other-performance encoding.

As far as object manipulation is concerned, this was found to have a beneficial effect on occurrence memory, which is consistent with previous studies (see Engelkamp, 1990). More important is the observation that object manipulation exerted very different effects on occurrence and context memory. As may be seen in Table 4, SPTs that required manipulation of an external object yielded both the highest occurrence-memory performance and the lowest context-memory performance. This result is inconsistent with the proposition that the use of an external object causes more attention to be directed towards the external context, and should therefore improve context memory. It would appear that for self-performed tasks the use of an external object contributes to the distinctiveness of the act, but not to its relation to the particular environmental setting. Perhaps, as Engelkamp (1990) argued, objects tend to induce visual-imaginal encoding, and this type of encoding should be beneficial for contextual integration. This benefit, however, accrues with input events (other-performed tasks), whereas with output events, the object is more likely to be assimilated into the action itself.

As for room changing (see Table 5), this was found to impair memory, but this impairment was significant only for occurrence memory. Changing rooms might have been expected to contribute to a greater contextual differentiation between the acts performed in the two rooms, particularly because it also involved a change of experimenter. This, however, did not occur.

In sum, the effects of object manipulation and room changing do not help specify the processes that mediate the interactive pattern obtained between type of event (input vs. output) and type of memory (occurrence vs. context). However, they seem to underscore further the point that occurrence memory and context memory may be differently affected by different variables (Craik, 1989).

General discussion

The present research was motivated by an apparent inconsistency between two sets of observations. On the one hand, a great number of memory studies reported superior memory for responses generated by the subject (e.g., generated verbal responses, one's own actions) than for stimuli originating from the external environment (e.g., verbal stimuli presented for future recall, another subject's actions, etc.). This output-superiority effect was demonstrated consistently over a variety of experimental conditions (Helstrup, 1987, Slamecka & Graf, 1978). On the other hand, however, scattered observations from everyday life point to several memory difficulties that appear to be specific to the memory of one's own past actions (Koriat & Ben-Zur, 1988).

This discrepancy could be taken to support the claim, implied by some theorists (e.g., Neisser, 1978, 1988; but see Banaji & Crowder, 1989), that memory processes in natural settings differ qualitatively from those investigated in the laboratory so as to prohibit the generalization from one context of inquiry to the other. The present work, in contrast, was predicated on the assumption that the apparent inconsistency does not reflect the operation of qualitatively different mechanisms. Rather, it occurs because the study of memory of action in natural settings tends to tap different processes than those apparently investigated in the laboratory.

We propose that input events undergo a deeper contextual integration than one's own actions, and that this should explain some of the differences observed between memory of input and that of output events. That is, the encoding of contextual information is inherently more difficult for output than for input events. Therefore, whenever memory must rely on the contextual cues of an event (as is the case in many everyday life conditions), it will be relatively more impaired for output than for input events.

This predicted interactive pattern was most clearly observed for the two-person SPT procedure of Experiment 2. Memory of occurrence was superior for self-performed acts than for other-performed acts, consistently with the extensive research indicating superior performance for SPTs than for the comparable input information. Context memory, in contrast, evidenced the opposite effect of superior performance for other-performed than for self-performed tasks. This pattern conforms to our proposition that in a two-person interaction the other's actions undergo a deeper contextual integration than one's own actions. Experiment 1, which utilized the procedure used in the study of the generation effect (Slamecka & Graf, 1978) yielded a weaker interactive pattern than that observed in Experiment 2. Both occurrence memory and context memory were superior for generated verbal responses than for read responses, but the effect was significantly less pronounced for context memory.

Consider first the results of Experiment 2, which yielded a clear interactive pattern. What are the psychological processes that could explain this pattern? Three general classes of explanations may be offered, which are not mutually exclusive. The first, *attentional* explanation, emphasizes the fact that task performance not only makes heavier demands on the subject's attentional resources, but also diverts part of the subject's attention towards the internal processes underlying response generation, thus resulting in the withdrawal of attention from the external environment at large (Zimmer & Engelkamp, 1989). In fact, the direction of attention towards internal mental processes has been invoked as a possible explanation of the generation effect (e.g., Slamecka & Katsaiti, 1987). Generated responses are remembered better because subjects may utilize cues pertaining to the internal processes associated with their generation. Thus, perhaps the same process that is responsible for the superiority of output events in occurrence memory also gives rise to their inferior contextual integration.

This account accords well with the view recently advocated by Craik (1989). Working on the assumption that the integration of events with their contexts is critical for the subsequent retrieval of these events, he argued that attention plays an important role in this contextual integration, and should exert a greater effect on memory of context than on memory of occurrence. Consistently with this view, he cited an unpublished study by Alan Allport which indicated that divided attention during the learning of a list of words had little effect on their subsequent recognition, but impaired memory of the context of occurrence. Although Craik's analysis was confined to the memory of input events, it may be extended to accommodate the interactive pattern observed in Experiment 2 by the assumption that the performance of a task makes heavier attentional demands on the subject than having to watch another person perform that task. Therefore less spared attention should be available for the contextual integration of output events than for the contextual integration of input events.

The attentional account involves several difficulties. Allport's results failed to be replicated in the subsequent experiments by Craik, and in fact some authors have advanced the view that the encoding of contextual information, e.g., the temporal and spatial attributes of a target event, is automatic and does not require attention (Hasher & Zacks, 1979). Furthermore, it is not clear that action performance does make greater attentional demands than the perception of external stimuli. For example, it has been argued that the action elements of SPTs are automatically encoded (Backman et al., 1986). Thus, at present the attentional explanation must be entertained with caution.

A second class of explanation derives from the work of Engelkamp and his associates, and focusses on *integrative* processes. They presented evidence suggesting that motor encoding is very efficient for the retention of item-specific information, but is relatively inefficient for extracting and representing relational information. Thus, the use of contextual cues during learning and testing improves performance under visual-imagery encoding, but not under motor-encoding conditions (Engelkamp, 1986; Engelkamp et al., 1989; Helstrup, 1989). Similarly, organizational factors were found to play a less important role under motor than under standard, verbal-learning instructions. These results suggest that motor encoding is less efficient than visual encoding for integrating information either between an event and its contextual cues, or across different events. This is because the activation of motor programs diverts attention from relational properties (see above), or because such activation stresses the intra-program organization at the expense of extra-program relations (see below).

The third class of explanations focusses on the *cognitive structuring* of the situation. Thus, the account we have advocated is in terms of the structuring of the person - environment interaction. Subjects tend to structure their interaction with the external environment as occurring along the interface between their own responses, on the one hand, and the external stimuli on the other hand. The subject's behavior therefore tends to be organized with his/her own internal processes rather than with the external environment. This organization should result in a greater contextual integration of input events than of output events.

The structuring account may be formulated in terms of Baddeley's conception of domains of recollection (1982). Externally driven and internally driven events may be said to represent distinct domains of processing, each with its characteristic associative network. Perhaps the action programs underlying self-generated acts contribute to the internal organization of the pertinent sensorimotor elements around the main action schema, and at the same time weaken the association between these elements and those belonging to the external domain (see also Engelkamp, 1990). Such organization may be expected to improve memory of occurrence while impairing memory of context. In contrast, externally driven events are perceived as belonging to the same domain as their environmental surround, and are more likely to be integrated with their environmental context;

Finally, one question that remains open pertains to the difference between the results of Experiments 1 and 2. Although both experiments yielded significant interactions between type of event (input vs. output) and type of memory measure (occurrence vs. context), the predicted crossover interaction was obtained only in Experiment 2. It has been argued previously that both SPTs and response generation have much in common in terms of the underlying processes (Nilsson & Cohen, 1988). Thus, perhaps the difference in the results of the two experiments derives from differences in procedural details. Since the generation task in Experiment 1 apparently makes a lesser cognitive demand on the activation of motor programs than SPTs do, this may explain why this task yielded only a relative, and not an absolute, decrease in context memory. Alternatively, the difference in the results may derive from the way in which the context was manipulated. In Experiment 2 the "context" of an act included the partner who performed the act or observed it. Since different subjects differ in their characteristic way of performing a task, perhaps these differences contributed to the superior contextual integration of input events. The analogy from everyday memory is the comparison between telling a story (or a joke) and listening to one. It would seem that subjects should remember from whom they heard a particular story better than to whom they told it. Thus, the attributes of the partner who performs an act or carries out a conversation constitute a richer "context" than the attributes of the experimental room. Therefore, the performing partner might attract more attention than the room, and stronger ties might be formed between the nature of the act and the person performing it than between that act and attributes of the room.

In sum, the present study was motivated by an apparent discrepancy between the results of laboratory studies and some naturalistic observations pertaining to the memory for action. On the basis of the present study we may tentatively propose that these differences are more apparent than real, deriving in part from the fact that laboratory studies focussed mostly on occurrence memory, whereas in everyday life memory of action rests heavily on the retrieval of contextual information.

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