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REMEMBERING THAT I DID IT: PROCESSES AND DEFICITS IN OUTPUT MONITORING

Asher Koriat and Hasida Ben-Zur
University of Haifa, Haifa, Israel

ABSTRACT

When people have to remember to do something, they must also keep a record of having done it so as not to repeat it. The present paper examines the processes of output monitoring — judging that a planned act has been performed. Two types of processes are distinguished, those that mark the completion of a planned act on-line, and those that rely on a retrospective judgment that it was carried out. Deficient output monitoring may result in a failure to perform the act, in repeating it, or in checking to make sure that it has been performed. Some experimental evidence pertinent to the processes and deficits of output monitoring is reviewed.

THEORETICAL BACKGROUND

There has been a growing interest in recent years in the investigation of prospective memory, i.e. remembering to carry out an act in the future. A prospective memory episode may be divided into three stages. In the encoding; stage, we instruct ourselves to perform an act in the future, sometimes using an external aid (e.g. tie a knot in the handkerchief) to help us probe our memory at the proper time. In the retrieval stage, we retrieve the instruction and execute the planned act. In the cancellation stage, we take note of the fact that the act has been performed so as not to repeat it.

The present paper focuses on processes related to the third stage, which are analogous to untying the knot in the handkerchief. When several acts are planned for future execution, some method must be used for output monitoring, i.e. recording which acts have been carried out and which must still be performed. Deficient output monitoring can result in two types of errors: (a) failure to perform the act, stemming from the mistaken belief that it has already been performed and (b) repetition of the act (e.g. telling the same joke a second time), stemming from the false belief that it has not been performed. Uncertainty about whether the act has been performed or not may also lead to some confirmatory checking (e.g. "Have I told this story before?").

Little effort has been devoted to the study of output monitoring mechanisms and their failures. According to Lewin (1935), the intention to perform a task creates a tension system which is released when the task is completed. If the task is interrupted, the unreleased tension presses towards task resumption and results in superior recall for the interrupted activity (see Van Bergen, 1968).

Lewin's model was cast in energetic terms. In this model repetition behaviour would be seen to derive from a motivational deficit (incomplete tension discharge). A similar assumption underlies some of the work on the perseveration behaviour of patients with frontal lobe lesions, who are often aware of the inappropriateness of their behaviour, but cannot avoid it. Similarly, obsessive compulsives tend to check and recheck that a task has been accomplished even though they 'know' it has (see Reed, 1985)- Such action repetitions are more readily interpretable in terms of impaired control than in terms of impaired monitoring.

A cognitively-oriented perspective on output monitoring is provided by the work on slips of action, reality monitoring, and the memory for remembered events. Reason's research on slips of action (1983) provides some clues for the kind of on-line monitoring required for the execution of planned actions. According to Reason, highly practiced activities are executed automatically, and only a very brief record of the immediately preceding act is retained in memory. For such activities some sort of 'program counter' is apparently required to check off actions as they are executed. A failure in the operation of this counter may result either in repeating an act or in omitting it. For less routinized actions, attention must be deployed at critical decision points, otherwise behaviour may branch off into an unplanned subroutine.

Some of the work on reality monitoring examined the question of how a person decides whether he has performed an act or has only imagined it. This question is critical for prospective memory, in which the act is 'remembered' or 'planned' in advance of its performance. Anderson (1984) found that memories of actual activity are readily confused with memories of imagined activity, and that when such a confusion occurs people tend to assume that an activity was performed when in fact it was only imagined. It would appear that a failure to perform an act should be particularly likely when it is contemplated and planned in detail in advance.

Output monitoring has also been examined in the context of the free recall task. In this task subjects are expected to recall as many words as they can without repeating the words. This assumes that they can remember the words they have already recalled (Gardiner, Passmore, Herriot & Klee, 1977). According to Murdock's model of this task (1974), the presentation of the stimulus list leaves behind a store of available items ('input pool') from which items are sampled randomly with replacement. Each recalled item is saved in an 'output pool', and every sampled item is compared against this pool before recall. This model, then, assumes that output monitoring is carried out by retaining a separate listing of the recalled words, not by erasing them from the input pool.

PROCESSES OF OUTPUT MONITORING

How then does one keep track of what actions have already been accomplished? Apart from the ideas outlined above, there has been little systematic effort to answer this question. As a preliminary step in this direction we may distinguish two types of processes for output monitoring, on-line and retrospective. Both of these may be associated with external mnemonic aids ('external') or not ('internal'). On-line processes take place when the act is

completed, and are responsible for erasing the plan or checking it off as one that has been executed. Thus, a secretary who is asked to give a message to Mr. Jones, may tear up a written note when the task is accomplished (external), and/or erase the respective plan from a hypothetical 'mental scratch pad' (internal). Lewin's notion of tension discharge and Reason's notion of a program counter illustrate possible on-line mechanisms. Retrospective processes, in contrast, take place when the occasion for performing the planned act emerges. Thus, when the secretary sees Mr. Jones, she may scrutinize her memory for evidence that the plan has been executed (internal), or simply check her memo pad to see if Mr. Jones' note is still there (external). Murdock's model of free recall illustrates a retrospective monitoring mechanism in which planned acts are not erased upon completion, but a record of these acts is retained for future reference to avoid repetitions.

If planned acts are successfully erased on-line when they are completed, they would not be activated on a second similar encounter. However, since the on-line cancellation is apparently not perfect (e.g. the nagging thoughts that we might have forgotten to lock the door), we often have to rely on retrospective evidence to confirm that the act has been performed.

Common practices from everyday life suggest several methods of on-line monitoring, each of which can serve as an analogue for a mental operation. These operations may have different cognitive and behavioural implications. First, the plan may simply be erased, thus updating the mental scratch pad after each action has been completed. This is probably the cognitive analogue of Lewin's model. Second, a tag may be attached to the plan to distinguish it from those not yet executed. This implies that executed and unexecuted plans are equally likely to be activated, unless it is assumed that tagged and untagged plans undergo different fates. Third, completed plans may be simply forgotten (assuming that unexecuted plans are occasionally refreshed), or replaced by other plans (assuming a limited-capacity store of prospective plans). Fourth, the plans may be executed according to a predetermined order, and once a plan has been executed, an index is moved to the next plan in the queue.

Even if no cancellation process takes place upon task completion, the performance of an action normally leaves behind some external or internal residues, and these can be utilized in retrospect to judge that the act has been carried out. The most obvious of the external residues are the actual consequences of the act. Since planned acts are normally intended to achieve goals, we may confirm their execution by examining these goals (e.g. tasting the coffee to determine that we have added a sweetener). Some acts, however, do not result in tangible enough consequences to enable confirmation. This is probably why people are more likely to tell a story a second time than to try to lock the door a second time. Of course, if external aids are used to mark task completion on-line (e.g. marking completed activities in an appointment book), these aids may be utilized for retrospective monitoring.

In the absence of external cues we have to rely on internal evidence, such as the memory of the action and its context. The retrospective monitoring of output events differs from that of input events in some significant aspects. Since prospective plans are

contemplated in advance of their performance, errors may result from confusing the memories of performed and imagined actions. With routine, repeated activities, it is necessary to retrieve a particular episode. In uniquely specifying this episode we may have to rely on details that are incidental to the plan itself. Often, output events (e.g. stories told) represent a subset of input events (e.g. stories heard), and therefore output monitoring must depend on list differentiation (attributing the memory specifically to output occurrence). Finally, performing planned acts in everyday life is normally embedded in a stream of ongoing activity. This can contribute to the creation of rich contextual cues, but may also interfere with the retaining of a lucid record of the act.

SOME EXPERIMENTAL EVIDENCE

The foregoing discussion was based primarily on the examination of common practices as well as on data from an exploratory interview study (25 young people) on the memory of having performed planned acts. Systematic experimental work is badly lacking in order to answer some basic questions. There is no conclusive evidence that prospective plans are cancelled or tagged on-line upon completion to reduce the likelihood of their being reactivated in the future. The nature of this cancellation/tagging is also not clear. Some of the work on memory updating may be pertinent, suggesting that the encoding of new information does not destroy or make inaccessible the out-of-date information. Judging from the variety of common secretarial practices for encoding task completion on-line, it is likely that the respective internal mechanisms are also quite varied.

More is known about retrospective monitoring. The work on the memory for subject-performed tasks suggests that the processes underlying the retrospective monitoring of output events may differ from those underlying the monitoring of input events. Also pertinent is the work on reality monitoring, which indicates some of the possible causes for deficient monitoring. It should be noted, however, that the experimental paradigms employed in these areas of research do not capture some critical aspects of the performance of subject-initiated, pre-planned acts in everyday life.

In our interview study we found little evidence for internal on-line processes, perhaps because these are not readily accessible to introspection, but obtained some clues regarding retrospective monitoring. For example, in answering the question "have you put your shoes on this morning?" most subjects relied on their sensing that they had their shoes on. Apparently in many instances scrutinizing the environment is easier and perhaps safer than scrutinizing our memory.

Other questions on routine activities (e.g. locking the door) indicated that subjects had to retrieve episodic details, sometimes incidental to the plan itself (e.g. dropping the keys) to ascertain that the act had been performed. Such seemingly irrelevant details appeared to aid in specifying the particular episode. Negative answers to such questions apparently relied on reconstructing the day's activities, and sometimes on imagining oneself performing the act and failing to retrieve the respective personalized episode. This reliance on episodic, contextual data in confirming past performance may relate to Reed's proposition (1985) that the excessive checking of compulsive persons is due not to uncertainty about the factual content of remembering, but to uncertainty about the personalized, episodic aspect of this content.

There is some evidence on the kind of behaviours likely to ensue from deficient output monitoring: action omission, action repetition, and checking. Omitting the act may result from simply forgetting to execute the plan, but may also derive from falsely believing that the act has been carried out. Our interview subjects estimated the percentage of such false beliefs to be 13-*2%* for communicating information to someone, 5-^X for buying a certain item in the supermarket, and *3-5%* for adding a sweetener to tea or coffee.

Subjects also reported indulging in some checking behavior in such activities as locking the apartment door (7-9X), turning off the lights before leaving *(5.2%),* and locking the car *(lk.1%).* Of all the instances in which a checking operation was undertaken only in 9-OX of the cases was it discovered that the planned act had not been performed. This percentage varied from l.O% for the apartment door to 17•*)%* for the lights. Previous results indicated that excessive checking is related to a deficiency in memory monitoring: a poor memory for the actions performed (see Reed, 1985). Our results suggest that excessive checking is also quite frequent when the outcome of false positives is costly.

Repeating planned acts appears to be less frequent among normal subjects than action omission (Wilkins & Baddeley, 1978), and is infrequent among the slips of action studied by Reason (1983). This, however, need not be true for all types of activities. Our interview subjects, for example, reported that when they communicate a message, a story, or a joke, in 10.*3%* of the cases they discover that they have done so before.

The investigation of repetitions in free recall suggests that covert repetitions occur rather frequently but are inhibited, unless subjects are instructed to emit all responses that come to mind (Bousfield & Rosner, 1970). Gardiner et al. (1977) reported a higher frequency of repetitions with oral than with written recall, and an increased proportion of repetitions when subjects' response-produced feedback was impaired. These studies suggest that output monitoring during recall depends in part on a retrospective judgement.

Several experiments that we have carried out recently focused on age differences in output monitoring. Everyday observations suggest that the tendency to repeat planned acts is stronger among the elderly (e.g. telling the same story twice, taking a medicine more often than prescribed). We sought to substantiate this observation as well as relate it to a deficiency in output monitoring. In the first experiment subjects learned a list of semantically related words for five study-recall trials. Although older subjects recalled fewer words (13-21) than the younger subjects (22.26), the likelihood of repeating the words was higher among the older (.216) than among the younger subjects [.120; F(l.38)=5-77, E<-05]. This result was replicated in a second Experiment using a list of unrelated words. The number of words recalled averaged 15.67 for the young subjects, and 9.60 for the

elderly, whereas the likelihood of repeating a word was .129 For the young subjects and .195 for the elderly (F(l,58)=5.67, g<.05). A second task examined the idea that the Frequent repetitions of older-people derive from the error of judging previously performed actions as not performed. A second list was used for one study-recall trial, and following recall the subjects were presented again with the study words and asked to indicate the words they had recalled. The proportion of false alarms (judging unrecalled words as recalled) averaged .069 and .046, for the older and younger subjects, respectively, and did not differ significantly. In contrast, the proportion of misses (judging a recalled word as unrecalled) averaged .350 and .082 for the older and younger subjects, respectively [t(58) = 4.60; £ <.0001]. Also, for the older group the proportion of misses in the output recognition task correlated .40 (g<.05) with the proportion of repetitions in the free-recall task, further supporting the conclusion that repetitions in old age stem from deficient output monitoring.

Altogether the evidence available suggests that the processes underlying output monitoring may differ in significant ways from those underlying input monitoring. Output monitoring is clearly an important aspect of the performance of planned actions in everyday life, and merits further research efforts.

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