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Memory for Incomplete Tasks: A Re-examination of the Zeigarnik Effect*

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Abstract*

An important feature of human memory is the ability to retrieve previously unsolved problems, particularly when circumstances are more favorable to their solution. Zeigarnik (1927) has been widely cited for the finding that interrupted tasks are better remembered than completed ones; however, frequent replications and non-replications have been explained in terms of social psychological variables (Prentice, 1944). The present study examines differences in memory for tasks based on completion status by appealing to cognitive variables such as the nature of interruption, time spent during processing, and set size. In one experiment using word problems, subjects were interrupted on half of the problems after a short interval of active problem solving, and completed tasks were in fact better remembered than interrupted ones. However, less processing time was necessarily spent on problems that were interrupted. A second experiment held time constant, allowing subjects to abandon tasks they could not complete. In this experiment, the opposite result occurred, replicating Zeigarnik and showing better access to unsolved problems in free recall. However, enhanced memorability in this study may have resulted from a subject-generated impasse in problem solving rather than "interruption" per se. This successful replication also included set size differences in favor of incomplete problems. Under these conditions, the status of completion can serve as a useful index to past problem situations. These experiments are successful in identifying cognitive variables that explain when one can suspend effort on a failed problem, and recall it at a later time.

Introduction

In the world, we are constantly presented with problems to solve. Learning to operate a new appliance, balancing a checkbook, or doing a crossword puzzle, for example, are just a few of the problems we typically encounter. Sometimes, we are able to solve a problem at the moment that it presents itself; one might have a new appliance operating soon after taking it home from the store. At other times, due to interruption, lack of needed resources, or failed attempts, we are forced to give up work on a problem before we have successfully arrived at a solution. It is easy, for instance, to imagine getting stuck on a crossword puzzle problem and eventually giving up in favor of pursuing other activities. Obviously, it would be to great advantage to be able to retrieve previously unsolved problems in order to retry tasks. There is some suggestion that human cognition is able to take advantage of improved circumstances in order to reattempt previously failed task goals. In order to do so, however, incomplete problems must be stored and retrieved from memory. What, if any, are the differences in the way in which we encode and remember completed versus interrupted problems? Is there a special status in memory for problems we meant to solve, versus those we have already solved?

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Widely-cited results of a classic experiment by Zeigarnik (1927) claim that interrupted problems do indeed hold some special status in memory. In Zeigarnik's experiment, subjects were given approximately 20 tasks to perform. These tasks included mental problems such as arithmetic and puzzles, as well as manual skills including constructing cardboard boxes and creating clay figures. In the course of half of these tasks, subjects were interrupted before finishing the task and were forced to put it aside. The interruption came "when the subject looked most engrossed in his work." This was reported to have occurred when the subject discovered how the problem was to be done but had not yet envisioned the ultimate result. Subjects were allowed to complete the other half of the tasks.

After performing all of the tasks, though not always to completion, the subjects were asked to report all of the problems using a free recall method. Zeigarnik found that unfinished tasks were 90% more likely to be recalled than finished ones. Additionally, in both first and second recall positions, unfinished tasks were mentioned three times as often as completed tasks. Zeigarnik concluded that a significant memory advantage exists for interrupted tasks as compared with completed ones.

While the theory that unsolved problems hold some special status in memory is an appealing one, the results of Zeigarnik's experiment appear somewhat counterintuitive. Any memorial advantage in the Zeigarnik experiment should lie with completed tasks, since a subject logically must spend more time on average on completed tasks. However, though less processing time is presumably spent on interrupted problems, they are recalled more frequently in Zeigarnik's experiment. Zeigarnik accounted for this effect in terms of motivational factors, suggesting that when a subject sets out to perform the operations required by one of the tasks, there develops a "quasi-need" within the subject for the completion of the task. This is like the occurrence of a tension system, where completing the task means resolving the tension system or discharging the quasi-need. Thus, claims Zeigarnik, the memorial advantage enjoyed by interrupted tasks must be due to the continuation of that quasi-need, which motivates retrieval of unsatisfied tasks.

Additional social, motivational, and personality factors have since been suggested to account for results of variations and modifications of the original Zeigarnik experiment. Bogoslavsky and Guthrie (1941) suggested that tension present during the solving of a problem increases the problem's memorability. This hypothesis accounts for their findings that subjects best remembered tasks that followed interrupted tasks, regardless of whether the "follow-up" tasks were themselves interrupted or completed. Other studies discovered contexts where the Zeigarnik effect did not occur. Rosenzweig (1943) hypothesized a form of repression to account for the non-replication of Zeigarnik's results. In this study, in which subjects were told that the tasks comprised an intelligence test, they remembered more completed than interrupted tasks. Others have suggested stress-related factors (Glixman, 1949), individual differences (Alper, 1946), and subject fatigue (Zeigarnik, 1927) to account for discrepancies between their results and the original findings of Zeigarnik. The use of theories based on social, motivational, and personality-related variables to account for memory differences, has met with limited success. Such theories have been unable to explain numerous seemingly contradictory findings (see Prentice, 1944).

A greater degree of success might be met in trying to account for Zeigarnik's original results and some subsequent manipulations in terms of a cognitive model of problem solving. By re-examining the Zeigarnik effect in terms of modern theories of problem representations, goals, and context effects, perhaps we can explain the circumstances under which the Zeigarnik effect will occur, and how it may function within a broader memory and problem solving cognitive architecture. In this article, we examine the Zeigarnik effect, and explore factors including the nature of the interruption, the processing time spent on problems, and the context of set size of the incomplete problems. By examining these cognitive factors, we attempt to account for both the original effect and the variety of studies that at times failed to replicate it.

Experiment 1

In this first experiment, we attempted to match Zeigarnik's methods (1927) as closely as possible, and to replicate the effect of better memory for incomplete problems. However, one necessary change was to employ only problem solving tasks, rather than including manual and artistic tasks as in Zeigarnik. In order to look at the role of cognitive factors in predicting and explaining problem memorability, the following experiment will attempt to replicate Zeigarnik's original results using exclusively cognitive problem solving tasks. Using word problems, we manipulated task interruption versus completion on each problem. Our goal was to determine whether the counterintuitive effect Zeigarnik observed can hold as a memory phenomenon under controlled laboratory conditions.

Method

Subjects. The subjects were 39 undergraduate students (25 female and 14 male) from the University of Michigan. The subjects received credit from an introductory psychology course.

Materials. Twenty word problems, including mathematical, logical, and insight reasoning (from Mosler, 1977), were used in this study. All of the problems were pretested on a separate group of subjects and were selected for successful completion rate, each requiring between 15 seconds and four minutes for solution. Each problem was presented on a separate half-sheet of paper with space below the problem to write a solution. Each problem was presented with a short title such as "The Bridge". Following each problem was a rating scale. For each problem, subjects were asked to rate how confident they were that their answer was correct. A rating of 1 meant "certain it is incorrect" and a score of 7 meant "certain it is correct," and subjects were told to use intermediate values when appropriate.

Design and Procedure. Each subject was tested individually in a one hour session. The subjects were given the following instructions:

> You will be presented with a series of problems. You will work on the problems one at a time. Please work as quickly and accurately as you can. Show your work. Don't guess at a problem; try to solve each one and indicate your best answer. Once you have completed a problem I will give you another one to work on. Each of these problems is randomly paired with a time interval of varying length. I will be stopping you according to these times. Don't worry if you do not get to finish a problem. I will administer another one and you can proceed as instructed. Do you have any questions?

Following these instructions, the subjects were given two practice problems. The first was simple, and every subject completed it between 30 and 210 seconds. The second was very difficult, and every subject was successfully interrupted by the experimenter saying, "Please stop now" between 15 and 60 seconds into the problem. The experimenter followed this practice set procedure with each of the 20 test problems. The test problems were presented in a single random order for all subjects. Each subject was interrupted on half of the problems and allowed to complete the other half. The order of interruption within the problems was counterbalanced by subject. If a problem was to be completed, the subject was allowed enough time to finish and to indicate so (maximum time to completion was 4 minutes). If a problem was scheduled to be interrupted, the experimenter attempted to interrupt the subject when she was "most engrossed in the problem" (Zeigarnik, 1927) (after she had read the problem all the way through, but before she had written a complete answer). Minimum time to interruption was 15 seconds on each problem, and between 15 and 30 seconds for most trials in order to ensure subjects would be stopped before solution. When a subject finished a problem, the subject gave a confidence rating (no ratings were given for unfinished problems). After a subject was interrupted, or a problem was finished and rated, the experimenter removed the problem and administered another. This cycle repeated until all of the problems had been presented.

Immediately after exhausting the problem set, the subject was given a free recall test. Subjects were asked to recall all of the problems that they could remember. They were asked to write only enough to uniquely identify the problem they had in mind. Following Zeigarnik's procedure, the point in free recall was recorded where subjects seemed to exhaust an initial recall spurt.

Results

All of the problem solving answers were scored as "completed" or "not completed" by an independent rater based on the information written by the subjects. All trials in which the planned interruption or completion was not successful were eliminated from the analysis. This constituted 11 out of 680 attempts or 1.6% of the data. Ten out of these eleven discarded trials were trials that should have been interrupted, but were actually completed by the subject.

The free recall was scored by counting a problem as remembered if the written protocol uniquely identified one of the 20 test problems. The range of recall proportions for interrupted tasks was 0 to 0.9 with a mean of .39. The recall proportions for the completed tasks ranged from 0.1 to 0.9 with a mean of .54. This difference was significant, $t(38) = 4.368$, $p=0.00$, with completed tasks recalled more frequently than incomplete problems. The same result obtains when comparing the free recall only up to the point of first pause, as in Zeigarnik's (1927) analysis. For the completed problems, there were no differences in recall whether or not the solutions given were in fact correct (mean proportion of correct problems recalled was .60, of incorrect, .52, $t < 1$).

Another indicator of completion status may be the subject's level of confidence in her answer. Therefore, an analysis was performed using the subject's confidence rating as an independent variable. Due to the concentration of ratings at the ends of the scale (perhaps because, with subjects deciding when to stop working on a problem, they may have had a clear idea of when their answers were correct or incorrect), the seven-point confidence scale was broken down into three parts. There was a main effect of confidence rating, where subjects remembered the problems they answered confidently (above four on the seven point scale) with a mean of .56 recalled, better than those for which they lacked confidence (rated less than four on the seven point scale), with a mean recall of .27, $t(38)=4.349$, $p=0.000$. The completed-confident problems were also recalled better than those rated at the midpoint (for problems rated 4 on the seven point scale, mean number recalled = .32), $t(38)=3.434$, $p=.001$. These completed-confident problems were also recalled significantly more often than the interrupted problems (t(38) = 3.6, p = .001) However, there were no differences in recall proportions for interrupted, completed-unconfident and completed-midpoint problems.

While correctness had no effect on the finding that completed tasks are recalled better than interrupted tasks, the level of confidence the subject has regarding the completion of the tasks does correlate with recall. There is difference in recall for completed-confident and completed-unconfident categories, with the "confident" rated problems more frequently recalled. Confidence may be considered a reflection of how "complete" a subject felt their answer was, so that problems with lower confidence ratings are recalled as frequently as interrupted problems. Because subjects themselves terminated their problem solving efforts, low confidence ratings may indicate having abandoned solution attempts even though incomplete. Higher confidence ratings may indicate subjects' feelings of satisfactory completion for the problems they were allowed to finish.

The above analyses show that free recall memory for completed tasks is better than memory for interrupted tasks. However, this is not surprising given that subjects spent substantially more time, both when solving correctly and solving incorrectly, on the completed problems than on the incomplete problems. This difference is logically required if one wants to manipulate which problems are completed, and keep the set size of the two conditions equal. In Zeigarnik's description of her methodology, there is no information on how long subjects were allowed to work on interrupted compared to completed problems.

It is, of course, possible to correct for the confound of differing times spent on the problem if one is willing to forego control over which problems are interrupted. This can be accomplished by allowing subjects a specified amount of time to work on each problem. One can then compare the memorability of problems completed in the short time interval with those problems left incomplete. In this procedure, subjects are determining which condition a given problem falls into, by either completing or getting stuck on the problem within the time interval. Therefore, the nature of the interruption in this procedure may be more likely to be based on a failure in problem solving attempt, rather than on interruption of ongoing problem processes. In the following experiment, the time interval was kept fairly short (1 minute) in order to ensure that no subject would successfully solve all problems. In addition, because some problems might be quickly solved, subjects were told to continue to check their answers when completed for the full amount of time available for each problem.

Experiment 2

The following experiment uses this timed procedure to look at the effect of holding time constant across completed and incomplete problems. If the greater amount of time spent on completed problems had been preventing an emergence of the Zeigarnik effect in Experiment 1, we expect that the effect will now emerge under equal processing time conditions.

Method

Subjects. Sixty-nine undergraduates at the University of Michigan (34 female and 35 male) participated in the experiment. The subjects received credit towards an introductory psychology course.

Materials. Thirty word problems, requiring mathematical, logical, and spatial reasoning skills, were used in this study. Problems were drawn from numerous published collections (e.g. Friedland, 1970; Müller, 1989; Morris, 1988). All of the problems were pretested on a separate group of subjects, and were found to require approximately thirty seconds to two minutes for solution. Each problem was presented to subjects on a separate sheet of paper with space below the problem for work and solution to be recorded. The problems were contained in workbooks. Each workbook consisted of a problem solving instruction sheet, thirty word problems, and a subsequent recall task.The problems were presented in a different random order to each subject.

Design and Procedure. Subjects were tested in groups of 10 to 20 in one-hour sessions. At the outset of a session, subjects were told that they would be presented with a series of word problems, one on each of the subsequent pages of the workbook. They were to work consistently and diligently throughout the experiment, making every attempt to solve each problem. All work was to be recorded in the space provided underneath each problem. Subjects were told that they would be given exactly one minute in which to work on each problem. To assist in determining when an answer was completed, subjects were asked to circle their answer when finished, and to spend the remainder of the minute checking their work. They were instructed not to circle any part of their work unless they truly believed they had arrived at an adequate solution to the problem posed.

In accordance with the instructions, subjects were given one minute in which to work on each problem. At the end of each minute, they were reminded to circle their solution if they had arrived at one and to go on to the next problem. This procedure continued until all thirty problems had been exhausted.

Immediately following the last problem, subjects were administered a free recall test. Test instructions were as follows:

> Your next task will be to recall as many problems as you can from the first part of the experiment. When

you are told to do so, please jot down problems in the space provided below in the order in which they come to your mind. Write only enough information so that someone else could recognize which of the earlier problems you are referring to. You will have 3 minutes in which to recall the problems.

After three minutes of free recall, subjects were told to stop work on the task.

Results

All of the problem solving answers were scored as "completed" or "incomplete" by the experimenter based on the solution information written and circled by the subjects. Additionally, completed problems were scored as either “correct” or “incorrect” in their solutions. On average, 20 out of the 30 problems were completed by each subject. The remaining 10 problems, a proportion of .33 problems, were left incomplete. Of the completed problems, a mean of 11 were answered correctly, while 8.9 were answered incorrectly.

In free recall responses, subjects recalled a mean of .45 incomplete problems, with proportions ranging from 0 to 1. The recall proportions for completed problems, also ranging from 0 to 1, had a mean of .33. This difference was significant, $t(68)=3.66$, $p=0.000$, indicating that incomplete problems were recalled more frequently than completed ones, and replicating the Zeigarnik effect. A significant difference was found between recall proportions for completed, correctly-answered problems (.37) and those for completed, incorrectly-answered problems (.28), $t(68)=2.59$, $p=.012$, indicating that subjects best recalled the correctly-answered problems. This difference in memorability for correctly answered problems can be contrasted with the results of Experiment 1 in which no difference was found. Finally, memorability of completed, correctly-answered problems and of completed-incorrectly answered problems (the two subcategories of completed problems) can be individually compared to incomplete problems. A significant difference is found between incomplete (.45) versus correctly-answered (.37) problems ($t(68)=2.48$, $p=0.016$), as well as between incomplete (.45) versus incorrectly answered (.28) problems ($t(68)=4.61$, $p=.000$). Thus, incomplete problems are better remembered than either category of completed problems.

From this second experiment, we conclude that the Zeigarnik effect (better memory for incomplete problems) does not depend on a time difference in favor of incomplete problems. At most, subjects who completed the problems and checked their answers for the remaining time spent only marginally less time on the problems than on the ones where they were not able to provide an answer within the one minute interval. With time as nearly equivalent as possible, we still observed enhanced memorability for incomplete problems.

Discussion

There were important differences in the two experiments presented that appear to be critical factors in the occurrence of the Zeigarnik effect. When comparing the replication of Zeigarnik in Experiment 2 to the non-replication of Experiment 1, the large time difference in favor of completed problems in Experiment 1 may account for the finding of better memory for completed problems. In Experiment 2, where time on the problem was equivalent, a memory advantage occurred for incomplete problems that cannot be based on time. Therefore, a possible explanation for Zeigarnik's result, that of unintentionally allowing subjects to spend more time on incomplete problems thereby producing better recall, can be ruled out. Substantial differences in time spent on processing, however, as in Experiment 1, may wash out any existing memorial advantage for incomplete problems.

An additional factor is the nature of interruption in the tasks. In Experiment 1, subjects were stopped in their processing before it could reach completion. From pilot sessions, we learned that subjects must be stopped early in their work on a problem in order to ensure that a particular problem be successfully interrupted. In contrast, in Experiment 2, subjects themselves determined which problems were interrupted through failure to complete the problem. While they may sometimes have simply run out of processing time, there was more frequent opportunity to become "stuck" on a problem, to reach an impasse from which no further processing direction was apparent.

This "stuck" state may be of more interest than simple interruption in terms of comparison to real world problem solving. It is impossible to tell, however, from Zeigarnik's reports, whether her subjects were actually of the interrupted (knowing how to proceed if more time is given) or of the "stuck" (at a problem solving impasse) state in her incomplete conditions. Given the reported results, we might expect that if her subjects were allowed to continue to the point of their own "stuck" state, better memorability (and more time on the problem) may have resulted. If instead, interruption was utilized in other studies, the timing differences alone might account for better memory (and more time) on the completed problems, resulting in the non-replication of the effect.

A final factor that must be considered is the set size of the completed vs. incomplete problems. In Experiment 1, we carefully controlled the two sets to be equivalent by manipulating which problems fell into the two conditions. Even so, a memory advantage for completed problems resulted (again, with longer times on completed problems). In Experiment 2, however, we allowed subjects to determine how many problems fell into completed vs. incomplete categories. The resulting ratio of 2/3 completed to 1/3 incomplete characterized the situation where better memory for incomplete tasks was replicated. Possibily, under these conditions, completion status acts as a recall cue, increasing the likelihood that particular problems from a smaller set will be recalled relative to problems from a larger set. Further experiments are under way attempting to manipulate set size. Results obtained thusfar suggest that when time is held constant and set sizes are equal, no recall advantage is found for either completed or incomplete problems. Thus, set size appears to be a critical factor in determining when the Zeigarnik effect will occur.

That set size equivalence results in elimination of the Zeigarnik effect should not, however, imply that the Zeigarnik effect is irrelevant or unimportant to real-world problem solving. For example, in a set of tasks to be accomplished in a list of errands, most may be completed successfully, leaving as pending problems only a subset of tasks. So, if the completion status alone is working as a cue to facilitate retrieval of past problems, even if only when that set is smaller than the completed, the status of intended tasks has been successfully shown to be an important factor in memory. If information about intention to complete, or failure in completion, can be used as a general memory cue, then task status can be successfully used in retrieval of target items from memory.

Conclusion

We have argued from the evidence of two experiments that the effect first identified by Zeigarnik does in fact have demonstrated replicability as a memory phenomenon. Free recall access to incomplete problems may in fact be better than for completed problems under certain circumstances. In particular, we point to the need to control the amount of time spent in processing, the nature of the interruption, and the relative set size of the two problem conditions. We believe these factors explain the difficulties some studies may have had in replicating the effect, and will serve as a methodological guideline for the study of task interruption. This cognitive explanation is sufficient and more straightforward than appealing to more complex explanations involving individual differences, threat of evaluation, or states of "tension" resulting from blocked tasks (Prentice, 1944).

However, the results we describe have an even greater importance in work on memory for tasks. This is apparent by examining the implications of the finding. Why might memory be designed to note and take advantage of task status in retrieving past problems? What purpose would this memory advantage serve? Obviously, keeping track of the status of problem attempts and being able to use that information in retrieving those past failures would be very useful in the later solution of the interrupted problems. If a goal to solve a problem is not satisfied, information about that failure can be used to preserve and encode the problem in a way that might facilitate its later retrieval. Consequently, failed problems may be more likely to be recalled, and to be pursued for a second time. Such a memory enhancement would assist in bringing to mind past failures so that solution can be reattempted at a later time, perhaps when circumstances will favor success. This cognitive ability is critical for the optimal satisfaction of goals given that many tasks are being pursued. Rather than persist at a difficult problem, effort can be suspended, and work on the goal can be resumed at a later time. The memory effect we have been discussing is an important factor in such an ability.

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