Episodic Cuing of Past Events

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Abstract

We present three experiments on the utility of using episodic cuing as a means of reminding people of past events that are similar to the current situation, and so could be useful in increasing current performance. This work is of interest for augmented cognition because it provides insights into what sorts of memory assistance are helpful or harmful. The issues addressed here is to try to understand under what circumstances people benefit by such reminders. In each experiment, subjects needed to learn how a factory operated. In this case, specific clients varied on each trial, and thereby served as episodic information. During the testing phase, subjects were required to demonstrate what they had learned either with or without the use of the episodic cues. In Experiment 1, we manipulated the spacing between exposures (massed or distributed), the frequency of exposure (few or many), and the delay of exposure (short or long). The expectation was that episodic cuing would be more beneficial when memory was worse. What was found was that episodic cuing facilitated performance at long delays, and with massed practice. However, there was no differential benefit as a function of frequency. Finally, there was some evidence that episodic cuing might hurt performance after short delays. In Experiment 2, we manipulated frequency again, along with the degree of overlap each task had with the task number. The expectation was that, the more overlap a given task had with others, the greater the benefit of the episodic cue. The results of this study was a cost of an episodic cue for frequent events and a benefit of an episodic cue when there was no overlap with other tasks. In Experiment 3, we looked at the ability to remember relational information. The results of this study did not show any benefit of episodic cuing. So, we find that cognition can be augmented by the use of episodic cues. However, there are some situations in which these have either no effect, or may actually be harmful.

1 Augmented Cognition

An area of increasing in the field of human-computer interaction is augmented cognition. In essence, augmented cognition is any means of accentuating a person's mental abilities by monitoring their current knowledge state, and the state of the current situation, and providing critical knowledge relative to the person's goals.

One role for an augmented cognition device is to remind people of things that would already be stored in the person's memory, and which would be helpful in the current situation (Copeland, Magliano & Radvansky, in press). People regularly forget information that is needed to successfully complete a current task, and may not even realize it at the time that they know information that may be helpful. One way to aid the remembering process is through memory cuing in which a person is provided with a reminder of some type.

One type of reminding is of previous, similar experiences. We will refer to this as ***episodic cuing***. This is in contrast to other types of memory cuing, including semantic cuing of general world knowledge, feature cuing of components of the to-be-remembered knowledge, and contextual cuing, such as what is reflected by the encoding specificity phenomenon, in which the learning context can help facilitate later retrieval. Episodic cuing, in comparison, involves reminding people of a specific event in their past, as a means of helping them remember the critical piece of knowledge.

For example, suppose a person is trying to remember how to write a program that will present video to a screen, but this is something that the person does not do regularly, and their knowledge on this topic is scanty. However, the person has done this before, and if they can remember what they had done before, this will be helpful in the current situation.

The current study attempts to identify whether this sort of information is useful to people. Specifically, people were given a set of experiences, each with a unique event identifier. During these experiences, people were trying to learn responses to particular circumstances. After training, memory for actions to be taken was tested. This was done under two conditions. Either people were simply asked to remember what actions should be taken for each condition, or they were asked this information along with an episodic cue that reminded them of a specific event.

In many cases, providing people with a memory cue of some sort helps them remember later. This is generally true of semantic, contextual, and feature cuing. However, in some cases, memory may actually be worse. A clear example of this is the part set cuing effect (Nickerson, 1984; Slamecka, 1968). In this effect, people are less likely to remember any given piece of information if they have already been provided with one or more members of a set than if they had been told nothing.

2 Overview of Experiments

In all three experiments, people were presented with the task of learning how to run a factory. During training, on each trial, people were given a number of pieces of information. These included (a) a task number, (b) the three actions or steps that had to be done for that task number, (c) the name of the client for that specific task, and (d) the client's need. Components (a) and (b) served as general semantic information because they were repeated across trials, whereas (c) and (d) were more episodic information because they were presented on only a single trial.

On each trial, people were allowed to study the information for as long as they liked. Then, they were given a recall test in which they were to recall all four components. This was done to ensure that people were attending to the information as a set during training. Once training was complete, people were given a final recall test in which they were given task numbers and they were to recall the three actions that went with each number, In addition, on half of the trials, episodic cue information, in the form of a client's name and need were also provided, and people were encouraged to use this information to remember.

2.1 Experiment 1

Thirty-seven people were tested in Experiment 1. This experiment manipulated three aspects of the learning situation to assess how episodic cuing would influence performance. These were (a) delay, (b) frequency, and (c) type of practice. For the delay factor, it is well known that, all else being equal, information that has been encountered more recently is more available in memory than information that is older (Ebbinghaus, 1885/1964). As such, older memory traces are more likely to be weaker and are more likely to benefit from episodic cuing. To assess this, the last time a person encountered a given task number was either during the first (long delay) or the second half of the training period (short delay).

For the frequency factor, it is generally true that information that has been encountered frequently is going to be easier to remember than information that has been encountered infrequently (e.g., Taft, 1979). As such, memory traces for infrequently encountered information should be weaker, and so, more likely to benefit from episodic cuing. To assess this, a given task number was encountered either 2 or 8 times during the course of a training period.

Finally, for the type of practice factor, it has been well-established that information that is practiced in a distributed manner, in which there are multiple learning opportunities at diverse periods of time, is better remembered than information that is practiced in a massed manner, in which all of the learning opportunities are lumped together (Glenberg & Lehmann, 1980). As such, memory traces for massed practiced information should be weaker than distributed practice information, and so should be more likely to benefit from episodic cuing. To assess this, during training, the trials for a given task number were either lumped together in the training sequence (massed practice), or were spread out (distributed practice).

2.1.1 *Results and Discussion*

The accuracy data were submitted to a 2 (Cue Type) X 2 (Delay) X 2 (Type of Practice) X 2 (Frequency) repeated measures Analysis of Variance (ANOVA). Overall, episodic cuing helped memory performance, with people having greater recall when episodic cues were presented ($M = .37$) rather than absent ($M = .30$), $F(1, 36) = 9.61$, $MSE = .073$, $p = .004$. As for the effect of delay, people were more accurate after short ($M = .37$) rather than long delays ($M = 28$), $F(1, 36) = 988$, $MSE = .179$, $p = .003$, which replicates previous findings. Importantly, the Cue X Delay interaction was significant, $F(1, 36) = 10.92$, $MSE = .082$, $p = .002$. Specifically, episodic cuing had no influence on performance at short delays (.01 difference in the opposite direction predicted), $F < 1$, whereas performance was better with an episodic cue at a long delay ($M = .35$) relative to when no such cue was provided ($M = .20$), $F(1, 36) = 27.25$, $MSE = .058$, $p < .001$. This is consistent with the predictions outlined above.

For frequency, it was the case that more frequently experienced tasks were better remembered ($M = .42$) than infrequent tasks ($M = .25$), $F(1, 36) = 49.99$, $MSE = .090$, $p < .001$. Importantly, while performance was generally better for episodically cued than uncued recalls, the amount of benefit was essentially the same in both cases, with an increase of .09 for the infrequent trials, and .04 for the frequent trials, $F < 1$.

For type of practice, as expected, performance was better with distributed ($M = .38$) than with massed practice ($M = .29$), $F(1, 36) = 5.50$, $MSE = .202$, $p = .03$. Importantly, the Cue X Practice interaction was significant, $F(1, 36) = 5.26$, $MSE = .072$, $p = .03$. Specifically, while there was very little benefit from the episodic cue for distributed practice (a benefit of .01), $F < 1$, for massed practice, people did much better when they got an episodic cue (.35) than when they did not (.23), $F(1, 36) = 15.96$, $MSE = .073$, $p < .001$.

Thus, overall, episodic cuing did aid performance. More specifically, episodic cuing was beneficial when memory traces were weaker because of factors affecting the learning situation.

2.2 Experiment 2

Forty-six people were tested in Experiment 2. This experiment was similar to Experiment 1, except that there were two factors that were manipulated to assess the impact of episodic cuing on memory performance. These were (a) frequency and (b) amount of overlap. For the frequency factor, the only difference in Experiment 2 was that task numbers were repeated either 2 or 6 times during training.

For action overlap, it is well-established that when different classes of information have greater overlap with others, this can produce interference in memory retrieval. That is, when a person tries to remember any one piece of information, if there are related but irrelevant memories, this can produce interference in the retrieval process, making memory performance worse (Anderson, 1974; Radvansky & Zacks 1991). Overlap was operationalized in the current study in terms of the number of actions a given task number in the factory environment were shared with other task numbers. In this experiment, a given task number could have 0, 1, 2, or all 3 actions associated with other task numbers.

2.2.1 *Results and Discussion*

The accuracy data were submitted to a 2 (Cue Type) X 2 (Frequency) X 4 (Overlap) repeated measures Analysis of Variance (ANOVA). In comparison to Experiment 1, in Experiment 2, there was no overall improvement with episodic cuing. Specifically, people recalled task components similarly when they were cued ($M = .28$) as when they were uncued ($M = .29$), $F < 1$. This shift in outcome may have occurred because of the overlap of the task components. Specifically, because there is now substantial competition at retrieval from related but irrelevant memory traces, the additional information provided by the cue is not sufficient to overcome this interference.

For frequency, in this case more frequently experienced tasks was actually remembered worse ($M = .27$) than infrequent tasks ($M = .31$), although this was only marginally significant, $F(1,45) = 2.76$, $MSE = .137$, $p = .10$. This is because more often repeated information may be more likely to elicit its competitors, thereby reducing performance. Importantly, while performance was generally better for episodically uncued than cued recalls, this cost on memory performance was largely confined to the frequent trials (.28 and .25 for uncued and cued trials respectively), with no change in performance for the infrequent trials (*M* = .31 for both cue conditions), although the interaction was not significant, $F < 1$.

For the amount of overlap factor, performance was similar across the various levels of overlap (*M* = .30, .30, .30. and .27 for overlap of 0 to 3 task components, respectively), $F < 1$. Importantly, the Cue X Overlap interaction was marginally significant, $F(3, 135) = 2.01$, $MSE = .053$, $p = .10$. Specifically, while there was some nominal, but nonsignificant, benefit from the episodic cue for the 0 overlap cases (*M* = .27 and .32 for uncued and cued conditions, respectively), for the 1 (*M* = .33 and .27 for uncued and cued conditions, respectively) and 2 overlap cases (*M* = .32 and .28 for uncued and cued conditions, respectively), suggesting that when there is interference proving an episodic cue for one of those events complicates the retrieval process, making it harder for the other memory traces to overcome the interference they are experience in the retrieval process. The one caveat to this is the fact that for the complete overlap condition, performance was the same in both the uncued and cued conditions (*M* = .27).

Thus, in contrast to Experiment 1, episodic cuing actually harmed performance in a number of cases. In this more realistic situation, in which a person is trying to retrieve general information that is related to other information in memory, the overlapping concepts in memory caused an episodic cue to have an overall complicating effect. The only case where a clear benefit of episodic cuing was observed was when there was no overlap with other tasks.

2.3 Experiment 3

Twenty-nine people were tested in Experiment 3. Again, this experiment was similar to the other two, except that Experiment 3 focused on memory for relational information (how the actions went together) rather than content information (what the actions were). To this end, people were required to learn 7 different relational structures among the three actions. People were not required to learn the identity of the actions of a given task because they were always present throughout testing. What people did have to remember was how the processing among the actions should be arranged. For example, one structure was a linear structure in which the output of one action was fed to a second, and the output of the second was fed to a third. Alternatively, another structure was a divergent structure in which the output of one action was fed into the two other actions, which were not related to one another. Thus, in this experiment there is a shift to a different type of knowledge than what was assessed in Experiments 1 and 2.

2.3.1 Results and Discussion

Like Experiment 2, there was no overall improvement with episodic cuing, but there was actually a nominal deficit when people were given episodic cues (*M* = .16) than when they were not (*M* = .18), $F(1, 28) = 2.68.$, $MSE = .053$, $p = .11$. This may be because in this experiment as well, there is some overlap between the actions of multiple tasks. However, it is more difficult to draw conclusions from this experiment because of the generally low level of performance. Although people were explicitly told at the beginning that they should focus on learning the structural relations among components, and the fact that this is the information that was emphasized during learning, people had a great deal of difficulty learning. As such, the impact of the episodic cuing manipulation would be muted.

3 Conclusions

In three experiments we looked at the impact of episodic cuing on memory performance from the perspective that such a form of cuing could be exploited by a personalized augmented cognition system that had a high degree of familiarity with a user's prior experiences. Such a system could remind a user of similar experiences in the past in which the person was either successful, or had failed (in the hope of avoiding previous mistakes). The results of our three experiments show that episodic cueing can alter performance. In some cases, performance was actually enhanced, with people remembering more when they were reminded of an event in the past that was similar to the current one. This was more likely to occur when there had been a longer delay from when the information had last been needed, and when people had engaged in massed practice. Performance was generally unaffected by how often a person had been asked to use that information, except where there were significant sources of interference. In those latter cases, greater experience with a certain class of action was actually hindered by the inclusion of additional event-specific information. More generally, when there is overlap of concepts with different sets of information in memory, performance is hurt by the addition of episodic cues.

Thus, it appears that the development of augmented cognition technologies can be facilitated by including a process of episodic cuing. However, such cuing should be done judiciously. It should be confined to cases where the knowledge base is relatively isolated to a given person's other general world knowledge. In addition, it should also be confined to situations in which it can reasonably be expected that the memory traces are no longer highly available. Providing episodic cue information when the information is highly available may actually have a distractive effect, and hurt performance.

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