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Intentional forgetting: Note-taking as a naturalistic example

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Abstract In the present study, we examined whether note-taking as a memory aid may provide a naturalistic example of intentional forgetting. In the first experiment, participants played Concentration, a memory card game in which the identity and location of pairs of cards need to be remembered. Before the game started, half of the participants were allowed to study the cards, and the other half made notes that were then unexpectedly taken away. No significant differences emerged between the two groups for remembering identity information, but the study group remembered significantly more location information than did the note-taking group. In a second experiment, we examined whether note-takers would show signs of proactive interference while playing Concentration repeatedly. The results indicated that they did not. The findings suggest that participants adopted an intentional-forgetting strategy when using notes to store certain types of information.

Keywords Directed forgetting · Memory · Mnemonics

Forgetting, which is often thought of as a memory problem, can be beneficial under certain circumstances. *Intentional forgetting* is the deliberate elimination or suppression of certain information that was once processed for potential future retrieval. Individuals encounter copious amounts of information every day that they might process but then no longer need to remember, or at least not at a particular point in time. Researchers suggest that intentional-forgetting strategies are widely used in everyday life to filter out or inhibit unnecessary information from both long-term and short-term memory (Bjork, 1972). Traditionally, two directed-forgetting paradigms have been used to study intentional forgetting, which differ in when participants are informed whether or not they need to remember particular stimuli. In the *item method*, the cue to forget or remember a stimulus is presented after each item is presented. Alternatively, the instructions to forget or remember can be given after the presentation of a list of items, known as the *list method*. Regardless of method, participants are then typically asked to remember all of the words, including those they were told to forget. Evidence for intentional forgetting is found when participants recall significantly more of the to-be-remembered items than of the to-be-forgotten items (MacLeod, 1998). When recognition tests are used, a difference is usually only found for the item method (Block, 1971; MacLeod, 1975).

Researchers investigating intentional forgetting have predominately used words as the stimuli and told participants which stimuli they should forget. Though this has allowed experimenters to manipulate and control different variables more easily, it is still rather artificial. How intentional forgetting might occur spontaneously in a natural situation has not been as well addressed. Some research has examined more naturalistic stimuli, including pictures (e.g., Quinlan, Taylor, & Fawcett, 2010), autobiographical memories (e.g., Joslyn & Oakes, 2005), events (e.g., Fawcett, Taylor, & Nadel, 2013), descriptions of people (e.g., Johnson, 1994), and a phone number (Gottlob, Golding, & Hauselt, 2006). Other research has looked at different populations of individuals, such as those suffering from depression (e.g., Joormann, Hertel, Brozovich, & Gotlib, 2005), borderline personality disorder (Korfine & Hooley, 2000), and anorexia nervosa (Tekcan, Taş, Topçuoğlu, & Yücel, 2008), and shown that performance on traditional intentional-forgetting tasks can vary with these populations, depending on the type of study words. Specifically, participants were less likely to forget words that were disorder relevant; for example, participants who had been diagnosed with an eating disorder had greater difficulty forgetting words like "chocolate" or "thin" (Tekcan et al., 2008).

Some studies have tried to situate intentional forgetting in more real-world contexts. For example, Shapiro, Lindsey, and

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Krishnan (2006) examined how intentional forgetting may operate when consumers need to update their memories with new product information. They found that participants could use intentional forgetting to influence their memory of product information as well as their product preference. Golding and Long (1998) reviewed research dealing with the effects of telling participants to discredit or ignore certain information on performance, such as studies on hindsight bias or jurors' decision-making after judges tell them to dismiss inadmissible evidence. In these types of studies, the instructions to forget are not always effective. Thus, jurors in the forget condition frequently behave more similarly to those who are not given instructions to forget. These findings indicate that though intentional forgetting can occur in the "real world," it may not be as easily accomplished as the studies with word stimuli portray. Furthermore, whereas these studies are suggestive of how intentional forgetting might happen naturalistically, they still frequently involve telling participants to forget and the information that they should forget. An exception was the second experiment by Shapiro et al., in which they used advertisements to subtly suggest that participants should forget certain product attributes. Even though the forget instruction was less direct, they still found evidence for intentional forgetting.

Another naturalistic situation in which intentional forgetting might occur is taking notes as a memory aid. Think of the panic that individuals feel when they think that they have misplaced their calendar. One function for external symbols is as an external memory store (Donald, 1991; Sutton, 2010). Individuals need to process the information in orderto decide how to externally represent it, but then they can forget that information, which could be interpreted as intentional forgetting. The suggestion has been that individuals do not bother to engage in more active rehearsal, but instead rely on the external memory store (Sparrow, Liu, & Wegner, 2011). Eskritt, Lee, and Donald (2001) examined how participants used note-taking to aid their memory during a memory card game, Concentration. In Concentration, participants have to remember both the identity and location of various pairs of cards to be successful at the task. One group of participants was allowed to study the cards before the game started, whereas the other group were told they could make notes to help them when they played the game later; however, the experimenters unexpectedly took away the note-takers' notes before they played. Eskritt et al. found that the note-takers' performance was not only significantly worse than that of the group that had studied the cards, but that they actually performed similarly to participants who did not have the opportunity to see the cards ahead of time. The notes contained detailed information on both the identity and location of the cards, so the note-taking group must have attended to and processed that information. In fact, determining how to represent the location information in particular was not that easy a task, as even 9- to 10-year-olds struggle with how to do so (Eskritt & Lee, 2002; Eskritt & McLeod, 2008). Therefore, participants engaged in some relatively elaborative processing of the cards in order to make their notes, and yet their performance did not reflect this, suggesting that they did not remember the information.

Eskritt et al. (2001) performed an additional experiment to explore whether participants were not remembering anything from the pregame opportunity to see the cards, or whether they could remember some types of information. The researchers found that, when they tested the note-taking group's ability to recognize the identities of the different cards, the group's performance was no different from the performance of those who had studied the cards ahead of time. On the other hand, the note-taking group made significantly more errors in recalling the locations of the cards. Eskritt et al. concluded that their participants were using their notes as a form of external memory to store part of the information, the location information, but that participants kept the other type of information, the identity information, stored in memory.

Participants' memory for location information in the study by Eskritt et al. (2001) showed a pattern of results similar to that found in the intentional-forgetting studies. Moreover, even though participants in Eskritt et al.'s study were not asked to intentionally forget any particular information, they appeared to do so. Unfortunately, a confound in their procedure made Eskritt et al.'s results difficult to interpret. Specifically, a recognition test was used to examine memory for the identities of the cards, whereas location information was assessed using a recall test. Though the presence of a confound does not negate the explanation that participants were using intentional forgetting as a strategy, the presence of the confound does make it more difficult to address how the type of information may have influenced the use of the intentional-forgetting strategy, since participants' memory for identity information could not be compared with their memory of location information.

A procedure similar to that of Eskritt et al. (2001) provides a naturalistic approach to study how people organize their memory and spontaneously use intentional forgetting. Two experiments were conducted to explore whether participants might use intentional forgetting as part of their note-taking strategy. The first experiment was designed to see whether we could replicate the findings of Eskritt et al. while fixing the confound in their procedure. We used the Concentration memory game employed by Eskritt et al., but we assessed participants' memory for the identity and location of the cards using either recall tests or recognition tests. If participants in the note-taking group were intentionally forgetting the location information, as was suggested by the results of Eskritt et al., then they should not remember as much location information as would participants in the study group. On the other hand, if they store identity information in memory, no difference should emerge for either the recall or recognition tests across groups.

Experiment 1

Method

Participants A group of 94 undergraduate students (73 females, 21 males; mean age = 27.9, *SD* = 9.7) participated in the study for partial course credit. Due to equipment failure, the data from three participants could not be obtained. Therefore, the data from only 91 participants were used.

Materials Three different decks of cards were used. The first deck was for the practice game. It contained four matched pairs depicting different zoo animals. Two larger experimental decks contained 16 matched pairs, for a total of 32 cards. All of the cards depicted common objects (e.g., a car or snowman). Additionally, the same types of objects were used for each deck (e.g., two different cars). Each picture was chosen so that the picture-identity resemblances were roughly equivalent across the sets, but that the difference between the pictures was obvious.

The stimuli for the recognition test included one identity poster board and 32 location poster boards. The identity poster board contained the 32 pictures from both decks of cards. The positions of the various cards on the board were randomly determined. For the 32 recognition location poster boards, each board contained location information on one matched pair, with four different options for location information. One option contained the correct location, whereas the other three were incorrect. For the latter choices, the locations for both cards were incorrect and were randomly determined.

Rules of the game To play Concentration, the cards are shuffled and then placed face down in an array. Participants pick one card and then turn over a second card, looking for the first card's match. If the cards match, the participant removes the cards from the array. If they do not match, the participant turns the cards back over and tries again. Participants continue in this manner until all of the pairs have been found. The objective of the game is to remove all of the cards from the array in as few turns as possible. A turn is considered over when a player turns over two cards that do not match or has matched all of the cards. Therefore, as long as a player is finding matching pairs of cards, the same turn continues.

Procedure Each participant was tested individually. Participants were explained the rules of Concentration and then played the game with the practice deck to ensure that they understood the game. After that, participants were assigned to one of four groups, in a counterbalanced order: recall note-taking (n = 24), recall study (n = 24), recognition note-taking (n = 21), and recognition study (n = 22). In addition, half of the participants played with one of the experimental decks, and half with the other experimental deck. Before playing the game, all cards were placed face up in a prearranged 8 × 4 array. Participants in the note-taking conditions were given paper and markers and told that they could "write or draw anything you want to, to help win the game in fewer turns." All participants in these two groups produced notes. In the study groups, participants were told that they could "study the cards ahead of time so that you can win the game in fewer turns." The note-taking and study groups were yoked together so that a participant in the study group was given the same amount of time to study the cards as a participant in the note-taking group took to make their notes. Once participants were finished making notes or studying the cards, the cards were turned over, and the note-taking groups' notes were unexpectedly taken away. Participants were then tested on their memory for the identity and location information.

To measure participants' memory for the identities of the cards, those in the recognition groups were first shown the identity poster board and then asked to point to the cards that they recognized. Afterward, they were asked to indicate the correct location for each pair of cards from the options available on the location poster boards. In the recall groups, participants were asked to write down as many of the cards as they could remember. In order to assess the location information, they were asked to indicate the locations of the cards they had recalled on a sheet containing blank cards in an 8 × 4 array. They were not permitted to add any more cards to the identity list once they had started the location task, as a similar opportunity could not be given to the recognition groups. All participants were given as long as they wished to complete the tasks. The procedure was videotaped for later scoring and took approximately 15 min.

Results

Note-takers took between 1 and 8.1 min to make their notes (M = 3.32, SD = 1.7). Three quarters of the note-takers (75.6%) used a grid strategy to record the identity and location information (see Fig. 1 for an example). The next most common strategy was to use coordinates (15.6%). Two participants (4.4%) just made a long list of the cards in their order of placement in the array, and another two illustrated the relationships between pairs of cards, but without reference to the other, surrounding cards. All of the note-takers, except one who used a coordinate strategy, included information about the identities of cards in their notes.[1] Sometimes, however, the information included was quite impoverished, such as using just a letter to represent a card. All note-takers also included at least some location information, but the location information using the list or pair information strategies was limited.

[1] The one participant who did not include explicit identity information coded card pairs by listing the coordinates of matching cards together.

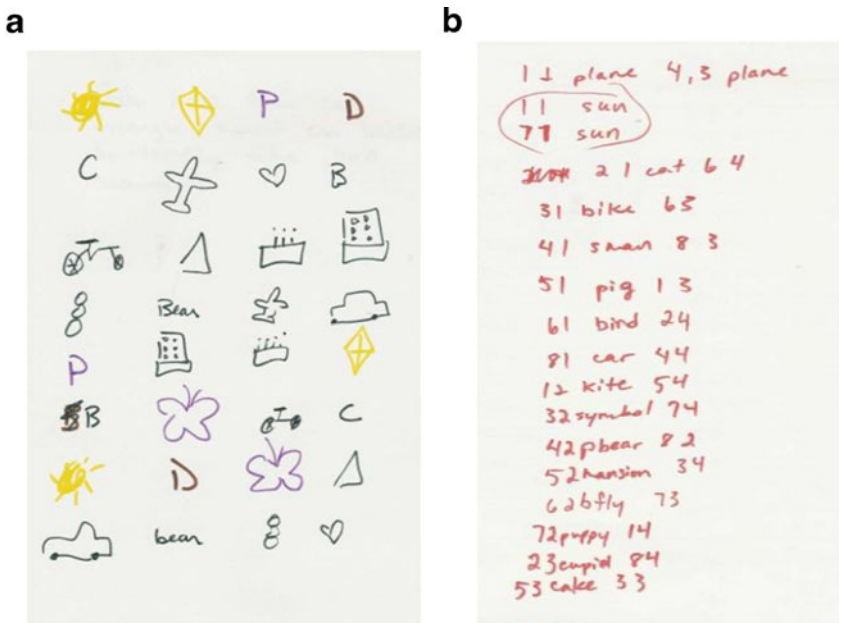

Fig. 1 Examples of the (**a**) grid and (**b**) coordinate note-taking strategies used by participants in Experiment 1

Figure 2 illustrates participants' performance in the two groups across the different memory tests. A 2 (group) × 2 (test type) between-group analysis of variance (ANOVA) was conducted on participants' identity scores. The identity score was the number of cards correctly remembered, but to correct for guessing, participants lost one point for falsely identifying a card that was not from their deck. The maximum number of errors made by participants was six, although in general few intrusions occurred (M = 0.47, SD = 1.2). No significant differences were found between groups. Participants in both the note-taking and study groups were similar in their performance for identifying cards, $F(1, 87) = 0.35$, $MSE = 0.45$, $p > .05$, $\eta^2 = .00$, regardless of whether a recognition[2] or recall test was used, $F(1, 87) = 2.3$, $MSE = 0.43$, $p > .05$, $\eta^2 = .03$. The interaction also was not significant, $F(1, 87) = 1.4$, $MSE = 0.61$, $p > .05$, $\eta^2 = .02$.

Another 2 (group) × 2 (test type) between-group ANOVA was conducted to examine participants' ability to remember the locations of the cards. For the location information, the scores were based on proportions correct, as participants had to remember the identities of the cards in order to be able to remember their locations. Therefore, depending on the number of cards identified, different participants were asked to locate different numbers of cards. Significant main effects were found for both group, $F(1, 87) = 5.79$, $MSE = 0.05$, $p < .05$, $\eta^2 = .10$, and test type, $F(1, 87) = 277.1$, $MSE = 0.03$, $p < .05$, $\eta^2 = .76$. Participants remembered the locations of more cards when a recognition test was used rather than a recall test. However, participants also remembered more location information in the study than in the note-taking groups, regardless of the type of test.[3] The interaction was not significant, $F(1, 87) = 0.02$, $MSE = 0.03$, $p > .05$, $\eta^2 = .00$.

Discussion

The purpose of the first experiment was to explore whether or not participants would show evidence of intentional forgetting when using note taking for memory purposes. As in Eskritt et al. (2001), regardless of group, participants did not differ in their memory for the identity of cards. Eskritt et al. argued that participants were selectively remembering different types of information. They thought that participants needed to remember the identity information in order to use the notes effectively to store and retrieve the location information. Anecdotally, Eskritt et al. reported that participants did not check to determine whether they had seen a card's pair before; they either recalled the label for the previously seen

[2] Responses of participants in the recognition groups could be thought of in terms of making a yes/no decision, and therefore their ability to discriminate between cards from the two different decks could be measured by using signal detection theory. Values of d' were calculated for the note-takers (M = 2.86, SD = 1.17) and for those in the study group (M = 3.10, SD = 1.10) by comparing the proportions of hits and false alarms. A t test indicated no significant difference between the two groups in their ability to discriminate, $t(42) = 0.71$, $p = .48$.

[3] Pearson correlations were also conducted in order to detect possible relationships between memory performance and the time taken to make notes or study the cards. No significant relationships were found between memory for identity (r = .12, n.s.) or location information (r = –.13, n.s.) for participants in the two note-taking groups. Study time was also unrelated to remembering identity information for participants in the control groups (r = .10, n.s.); however, these groups did remember more location information, the longer that they had to study the cards (r = .33, $p < .05$). Thus, the length of exposure to the cards previous to the memory test appears to have influenced only the control groups' memory performance, and only for location information.

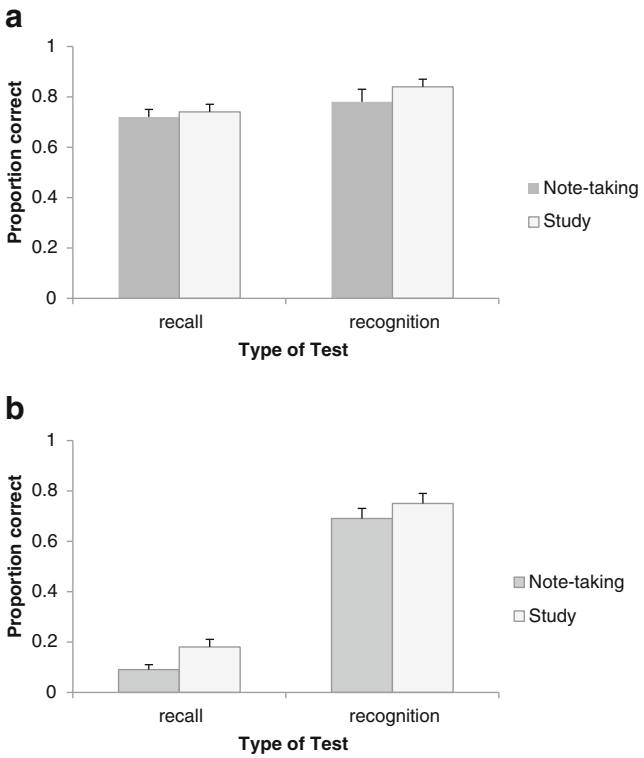

Fig. 2 Experiment 1: Participants' performance on the recall and recognition tests in the note-taking and study groups for (**a**) identity and (**b**) location information. Error bars indicate standard errors

card and searched their notes for its location, or generated a symbol for the new card and added it to their notes.

In contrast, the note-takers in the present experiment remembered significantly less about location information than did those in the study groups. As note-takers needed to process the location information to produce their notes, their poorer performance could be interpreted as them intentionally forgetting the location information, but keeping in memory the identities of the cards seen. It is interesting that participants would intentionally forget one type of information but not another. However, other explanations are possible for the lack of a difference for identity information. People are remarkably good at remembering pictures (Standing, Conezio, & Haber, 1970), and therefore no difference might be expected because the task was too easy. Although Fig. 2 shows that performance on the memory tests for identity information was quite good, performance was not at ceiling. Furthermore, research has found evidence for intentional forgetting using pictures (Hauswald & Kissler, 2008; Hourihan, Ozubko, & MacLeod, 2009; Quinlan et al., 2010) or faces (Goernert, Corenblum, & Otani, 2011) as stimuli, though the effect tends to be weaker than with words. That being said, the number of stimuli to remember in the present experiment was small, and the presentation of stimuli was self-paced.

Another possibility is that in producing their notes, many of the participants explicitly identified the cards by creating drawings or words to represent them. This explicit representation of cards may be analogous to research that has been done on intentional forgetting and the generation effect (MacLeod & Daniels, 2000), the production effect (Hourihan & MacLeod, 2008), or the enactment effect (Earles & Kersten, 2002). The directed-forgetting effect is lost when participants are asked to process stimuli in a more distinctive manner, such as performing an action or saying the words. These studies have not examined the role that drawing might have on intentional forgetting, but it is not unreasonable to think that the act of choosing how to represent an object and physically doing so would make that information more distinctive. The production effect has been found with writing and typing, though it is not as robust (Forrin, MacLeod, & Ozubko, 2012). On the other hand, the representations used to represent the cards by many participants in the present experiment were often quite simple, like using a single letter.

Furthermore, this explanation does not necessarily explain why participants did not remember the location information. The lack of difference may have been due to the manipulation being between subjects, when the effect is usually found with within-subjects designs. However, a recent meta-analysis has demonstrated that the production effect can be found between subjects, though it is not as strong (Fawcett, 2013). Although location information was often not explicitly written in the notes, but instead indicated by the relationship between the objects depicted (except among those using the coordinate system), location information was still represented. Participants needed to consider how to denote location and to notice the locations of cards in order to make their notes. Thus, the question of whether the reflection on how to explicitly represent a card, regardless of how simple, explains the lack of difference between conditions for identity information, or whether the choice is more intentional by the participants, needs to be investigated further.

In the first experiment, we examined the possibility that participants were using intentional forgetting, not directed forgetting. Participants were not instructed to forget particular information, as is done in the directed-forgetting paradigms. Although directed forgetting can be used to investigate intentional forgetting, the two ideas are not identical. Therefore, we inferred that participants chose not to remember the location information, on the basis of their performance in comparison to that of the control groups. Of course, in directed-forgetting studies, if memory performance is better for remember words than for forget words, the experimenters infer that participants followed their instructions to forget and were able to forget the appropriate words. Nevertheless, converging evidence for intentional forgetting with note-taking would be desirable to support our conclusion.

One phenomenon that could be used to address whether or not intentional forgetting is the correct explanation for the results of Experiment 1 is that of proactive interference.

Proactive interference occurs when the ability to remember recently learned information is impaired by previously learned information (Underwood, 1957). Research has demonstrated that the instructions to intentionally forget certain words in a list can provide a release from proactive interference (Bjork, 1970; MacLeod, 1998). One would expect that playing the Concentration game repeatedly would result in poorer performance over time, due to proactive interference. Would playing the Concentration game multiple times also impair memory performance if participants were making notes during the games? If participants were using intentional forgetting, one would predict not. The second experiment was designed to address this prediction.

Experiment 2

In the second experiment, we explored whether or not note-taking could provide a release from proactive interference. Participants played the Concentration game five times. The note-taking group was allowed to take notes for the first four games, and played without notes for their last game. The control group played all five games without notes. A comparison was then made between the memory performance of participants during the fifth game for those playing the game without notes (analogous to the study group of the first experiment) and the performance of those making notes. If note-takers engage in intentional forgetting of location information and therefore are not as susceptible to proactive interference, they should take fewer turns to win the fifth game than would the control group.

Method

Participants A group of 36 undergraduate students (30 females, 6 males; mean age = 20.4, *SD* = 4.0) recruited from introductory psychology classes participated in the study for partial course credit. Participants were divided evenly between the note-taking and control groups. Three additional participants were recruited, but their data were not used. Two of these participants did not make notes when given the opportunity to do so, and the third participant's performance was impaired due to a psychoactive substance.

Materials The practice deck of eight cards from the first experiment was again employed. As well, 30 cards from the decks used in Experiment 1 constituted the experimental deck for the present experiment.

Procedure The participants were tested individually. They again started by playing a game of Concentration with the practice deck to ensure that they understood the rules. Participants were then randomly assigned to either the note-taking or the control group. Participants in the note-taking group played five games of Concentration with the experimental deck laid out in a 5 × 6 array. For the first four games, they were given the opportunity to make notes *during* the game. Participants were again instructed that they could "write or draw anything you want to while playing the game to help you win the game in fewer turns." For the fifth game, participants played Concentration without taking notes.

Participants in the control group played one more game of Concentration with the experimental deck than did the note-taking group (i.e., six games). They played the first five games without the opportunity to make notes. Therefore, both groups played their fifth game without notes. The control group then played one additional game in which they were permitted to make notes during the game, in order to ensure that they would if given the opportunity. The procedure took approximately 25 min to complete. No restrictions were made on how long participants could take to complete a game.

Results

As in the first experiment, participants predominately used a grid strategy to organize the identity and location information for the cards in their notes (n = 29, 80.6%). The other seven participants (19.4%) used a coordinate system instead. Performance in the Concentration game was measured by the number of turns that it took to win the game. A turn was considered over when a player turned over two cards that did not match or when no pairs of cards were left to match. Thus, as with an error measure, the more turns that it took to win the game, the poorer the performance. Participants' performance over the five games is presented in Fig. 3.

Perfect performance in the game in general could not be determined, as the cards were randomly placed face down in the array, and the orders in which participants saw the different cards would vary, depending on which cards they chose to flip over on any one turn. As a means of estimating optimal performance, a computer simulation was run 10,000 times to

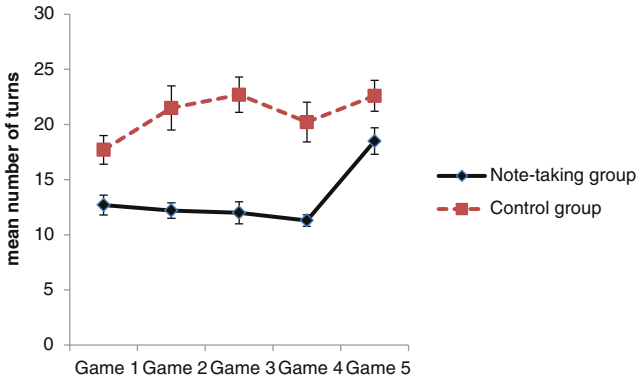

Fig. 3 Experiment 2: Mean numbers of turns to win each of the five games of Concentration by participants in the note-taking and control groups. Error bars indicate standard errors

obtain a distribution of the numbers of turns it would take to win the game with 30 cards and perfect memory. The simulation was designed so that the computer did not "know" the identity or location of the cards at the beginning of the game. The simulation kept track of the location and identity of cards as they were "revealed" and obtained a match if it was possible to do so. Otherwise, cards were chosen at random. The numbers of turns to win across games were normally distributed, ranging from 5 to 11 turns, with the mean number of turns being 8.51 (SD = 0.84).

A 2 (group) × 5 (game) mixed ANOVA was conducted to compare the numbers of turns taken by participants in both groups across the five games. Significant main effects were found for both group, $F(1, 34) = 26.71$, $MSE = 0.97$, $p < .05$, $\eta^2 = .44$, and game, $F(4, 136) = 8.87$, $MSE = 1.15$, $p < .05$, $\eta^2 = .21$, which were qualified by a significant Group × Game interaction, $F(4, 136) = 4.40$, $MSE = 0.97$, $p < .05$, $\eta^2 = .12$. Post hoc analyses indicated that participants in the note-taking group performed significantly better than those in the control group across all of the games ($p < .05$). Critically, this was true even for the fifth game, in which neither group was permitted to take notes (note-taking, $M = 18.5$, $SD = 5.1$; control, $M = 22.6$, $SD = 6.4$). Note-takers' performance in the fifth game did not differ significantly from the control group's performance in their first or fourth game. Note-takers also did significantly better in their first four games, when they were allowed to take notes, than in their last game, when they could not. The control group did significantly better in their first game than in their second, third, and fifth games. No significant differences emerged between the performance in the control group's fourth game and their other games.

Discussion

The second experiment was designed to test whether or not note-taking as a memory aid could provide a release from proactive interference, as would be predicted if note-takers were using intentional forgetting as part of their note-taking strategy. Note-takers did rely on their notes as a memory aid, as was evidenced by their superior performance, in comparison with both their own performance when they did not make notes and the performance of the control group. Furthermore, their performance did not deteriorate across the games they played with notes, demonstrating no signs of proactive interference while note-taking. The control group, on the other hand, showed an immediate increase in the number of turns after the first game.

In the critical fifth game, in which neither group was given the opportunity to make notes, the note-taking group outperformed the control group. In fact, the note-taking group's performance was not significantly different from the performance of the control group in their first game. Thus, as predicted, the use of notes as a memory aid can protect participants from proactive interference not only while they are using notes, but also in a memory task after notes have been employed. These findings provide further evidence that note-takers use intentional forgetting for at least some types of information.

General discussion

The purpose of the present study was to explore whether note-taking as a memory aid may provide a naturalistic example of intentional forgetting. One might predict that the note-taking group should show evidence of having better memory for the identity and location of the cards, as it could be argued that the form of studying that they were engaged in was more active and elaborative than the forms used by the study group (Di Vesta & Gray, 1972). The first experiment replicated the findings of Eskritt et al. (2001), however, demonstrating that participants in the note-taking group remembered significantly less location information than did participants in the study group. These results are suggestive that note-takers intentionally forgot the location information.

The results of the second experiment provided converging evidence for this interpretation. Note-taking provided a release from proactive interference when the Concentration game was played multiple times. Note-takers did not suffer from proactive interference either when using notes during the memory task or in the last game, when they played without using notes. It is important to note that note-takers were required to attend to and process the identity and location information in order to make and then use their notes each turn. Yet, their performance on the fifth game was more similar to the control group's performance on their first game. Not unlike a person using a day planner to keep track of appointments, the results indicate that participants relied on their notes as an external store for the cards' locations.

That location information was the type of information intentionally forgotten is in and of itself interesting, independent of the context in which it occurred. It could be argued that Golding and Keenan (1985) examined intentional forgetting for location information as well. They wanted to see whether participants would show intentional forgetting for a set of verbal directions, in which the to-be-forgotten information was presented as making a mistake in the directions. They found evidence for directed forgetting when participants' memories were tested with a drawing task, but not with a verbal test.

Another task somewhat similar to the present task was conducted by Sparrow et al. (2011). They examined participants' memory for facts that they typed into a computer and for the different folders where the facts were saved. When the researchers tested participants' location and fact memory, they found that participants were able to recall the location where

the information was saved better than the facts themselves. It was not the case that participants could not remember the facts on their own; in another experiment, Sparrow et al. found that participants were able to remember more facts when they thought that the computer had not saved what they had typed, as compared with facts that they thought had been successfully saved. Sparrow et al. suggested that this situation was similar to directed-forgetting studies, with participants thinking that they were free to forget the information that had been saved on the computer, but that they needed to remember information that had been erased.

That these participants were more proficient at recalling location information (i.e., the folders in which facts were saved) may appear to be the opposite of what we found. On the surface it is, but in both cases, participants were remembering the easier information and relying on an external memory store for the more difficult information. In Sparrow et al.'s study, participants had considerably fewer folders to keep track of, relative to the number of facts, making the "where" information easier to recall. In the present study, identity information would have been easier to remember for a number of reasons, including that each pair consisted of two identical cards in different locations and that distinguishing between the identities of the cards would have been easier than differentiating between the various locations. Therefore, it appears likely that participants do not intentionally forget only one specific type of information, independent of the task at hand, but rather can use intentional forgetting flexibly when employing external resources to lessen their cognitive load and enhance memory performance. They will rely on the external store for the more difficult information, and use the easier information to help access or organize the externally stored information (Eskritt et al., 2001; Sparrow et al., 2011).

The use of more naturalistic stimuli means that the present paradigm is some different from typical directed-forgetting paradigms using words as stimuli. One important difference has to do with the relevance of the information to be forgotten (Golding & Keenan, 1985). When participants are asked to forget a word in a list, the word can be considered no longer relevant to the task. On the other hand, the location information in the present experiment was still necessary for the task. Other studies looking at intentional forgetting in naturalistic contexts have found that when to-be-forgotten information is relevant to the task, participants are likely still to be influenced by that information. For example, when a judge tells jurors that some evidence is inadmissible, jurors tend still to be influenced by that information in their decision-making (Golding & Long, 1998). When more naturalistic studies try to control for relevance, evidence for intentional forgetting tends to be found again (Golding & Keenan, 1985).

So, why were participants able to intentionally forget relevant information in the present study? A number of different processes have been offered to explain intentional forgetting, such as differential rehearsal (Basden, Basden, & Gargano, 1993), retrieval inhibition (Geiselman, Bjork, & Fishman, 1983) and contextual change (Sahakyan & Kelley, 2002). In comparing the results of our first experiment to those from the two traditional methods of examining intentional forgetting, our results are more similar to those from studies using the item method. Participants in the note-taking group demonstrated poorer memory for location information, regardless of whether they were tested using a recall or recognition task. Typically, only studies using the item method reveal an intentional-forgetting effect with a recognition test (MacLeod, 1998). It is generally thought that differential rehearsal is involved with intentional forgetting for the item method (Basden et al., 1993). Participants maintain the presented word in memory until they receive the "forget" or "remember" cue, in order to determine whether or not they should actively rehearse the item. Likewise, the participants in the present study needed to process and consider location information to produce their notes, but if they intended their notes as an external memory store, they did not need to actively rehearse that information afterward.

However, the list and item methods are just procedures that are typically used to observe intentional forgetting. The different processes that theorists debate being involved in the two methods are likely involved in intentional forgetting (and remembering) to different degrees that vary with the task demands. For example, Fawcett et al. (2013) recently introduced the event method for testing directed forgetting, which uses videotaped events as stimuli. They found that participants were less likely to show intentional forgetting for more general information about the events, as opposed to more specific details, which we would argue is similar to our suggestion that participants remember the easier information, which they can then use to access the more difficult information in an external store. Although Fawcett et al.'s task is too recently developed for the underlying processes to have yet been identified, they argued that the combination of processes is likely to be different from the combinations involved in either the list or the item method.

Therefore, the paradigm used in the present study may not be directly analogous to either the list or the item method. Differential rehearsal seems to be the most likely explanation for the process involved for intentional forgetting when external storage is involved (Sparrow et al., 2011). As in an incidental-learning task, participants process the required information to make their notes, but then do not attend to it further. However, rehearsal may not be the only process to consider. Participants in the present study also demonstrated that they could selectively remember one type of information over another, which might be explained by the contextual-change hypothesis. This hypothesis has been suggested to play a role with the list method of testing, in that the items in the list to remember are proposed to be easier to recall

because participants generate an internal context change between the two lists (Sahakyan & Kelley, 2002). Cues at retrieval match the encoding cues for the to-be-remembered list better than those for the to-be-forgotten list of words. Typically, selectively forgetting only some information within a list is not found with the list method (Geiselman et al., 1983; Sahakyan, 2004). However, Delaney, Nghiem, and Waldum (2009) reported that a selective intentional-forgetting effect is possible under some conditions. In particular, the ability to group information together within the list, separate from other information, appears to influence the ability to intentionally forget. Participants in the first study were able to remember one class of information, the identity of the cards, and to intentionally forget another type, the location information. Perhaps the use of notes helps provide support for the use of context to better separate the type of information to intentionally forget.

Research has suggested that inhibition may also play a role in intentional forgetting for both the list (Geiselman et al., 1983) and item (Lee, Lee, & Fawcett, 2013) methods. It may potentially do so with the present paradigm, as well. Eskritt (2005) reported that, whereas 9- to 10-year-olds are capable of producing notes that are just as functional as those of undergraduates, they are not as hampered by the notes' removal as undergraduates are: Children's ability to remember location suffered when they lost access to their notes, but they could recall more location information than could the undergraduates. This finding might be explained by the children not being as capable of inhibiting location information, which benefits their performance when access to notes is lost. On the other hand, the findings may also be explained by the contextual-change hypothesis, in that the children were not as able to separate the location information from the identity information as adults could.

Therefore, further research will be necessary to directly test what processes may be involved with intentional forgetting with note-taking. To further complicate the issue, note-taking can also aid in the encoding of information (Di Vesta & Gray, 1972), depending on its purpose. One issue that tends to be overlooked in the literature on intentional forgetting is the purpose for intentional forgetting. The assumption is often that the information to be forgotten can be forgotten permanently, like forgetting an old phone number after getting a new one, and this is frequently how intentional forgetting is tested. However, intentional forgetting may occur to stop some information from interfering with the present task (Lehman & Malmberg, 2011). Such information may still be useful at a future time—for example, the location information in the present experiment. In the literature, it is recognized that different explanations may account for list-method as opposed to item-method intentional forgetting, but otherwise, theorists rarely explicitly consider the different roles that intentional forgetting may play in memory. Perhaps the types of processes involved will vary, depending on the purpose for intentionally forgetting in different situations.

In the present study, we investigated the relationship between external memory use and intentional forgetting. However, that participants used intentional forgetting as part of their note-taking strategy for our task does not mean that individuals always do so. A large literature within educational psychology concerns the use of note-taking as an aid to encoding information better, versus using the notes as an external memory store (Eskritt & Lee, 2007), and the purpose for note-taking may influence whether or not intentional forgetting is involved. Because external memory aids are so common, memory research needs to explore further how their use incorporates different memory processes. Furthermore, individual differences in reliance on intentional forgetting are likely to emerge as part of using notes. As participants played the Concentration game with notes in the second experiment, almost all of them would turn over a card, and if they recognized the card, would check their notes for its pair's location. However, a couple of participants used their notes as a "back-up"; they frequently relied on their own memory for a card's location, unless they could not remember it or made a mistake. They were less likely to have been using intentional forgetting, but this distinction would have been lost in the group data. The results of the present study indicate that note-taking for memory purposes may provide a naturalistic example of intentional forgetting, but further exploration will be necessary in order for researchers to fully understand the role that intentional forgetting plays, individual differences in its use, and the processes it involves.

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References

Basden, B. H., Basden, D. R., & Gargano, G. J. (1993). Directed forgetting in implicit and explicit memory tests: A comparison of methods. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19,* 603–616.

Bjork, R. A. (1970). Positive forgetting: The noninterference of items intentionally forgotten. *Journal of Verbal Learning and Verbal Behavior, 9,* 255–268. doi:10.1016/S0022-5371(70)80059-7

Bjork, R. A. (1972). Theoretical implications of directed forgetting. In A. W. Melton & W. Martin (Eds.), *Coding processes in human memory* (pp. 217–235). Washington, DC: Winston.

Block, R. A. (1971). Effects of instructions to forget in short-term memory. *Journal of Experimental Psychology, 89,* 1–9.

Delaney, P. F., Nghiem, K. N., & Wladum, E. R. (2009). The selective directed forgetting effect: Can people forget only part of a text? *Quarterly Journal of Experimental Psychology, 62,* 1542–1550.

Di Vesta, F. J., & Gray, G. S. (1972). Listening and note-taking. *Journal of Educational Psychology, 63,* 8–14.

Donald, M. (1991). *Origins of the modern mind: Three stages in the evolution of culture and cognition*. Cambridge, MA: Harvard University Press.

Earles, J. L., & Kersten, A. W. (2002). Directed forgetting of actions by younger and older adults. *Psychonomic Bulletin & Review, 9,* 383–388.

Eskritt, M. (2005). Children's and adult's use of notation and its influence on memory strategies. In S. Shohov (Ed.), *Advances in psychology* (pp. 33–38). New York, NY: Nova Sciences.

Eskritt, M., & Lee, K. (2002). "Remember where you last saw that card": Children's production of external symbols as a memory aid. *Developmental Psychology, 38,* 254–266. doi:10.1037/0012-1649.38.2.254

Eskritt, M., & Lee, K. (2007). The impact of notation on cognition & its development: Theoretical perspectives and empirical evidence. In E. Teubal, J. Dockrell, & L. Tolchinsky (Eds.), *Notational knowledge: Developmental and historical perspectives* (pp. 233–256). Rotterdam, The Netherlands: Sense Publishers.

Eskritt, M., Lee, K., & Donald, M. (2001). The influence of symbolic literacy on memory: Testing Plato's hypothesis. *Canadian Journal of Experimental Psychology, 55,* 39–50.

Eskritt, M., & McLeod, K. (2008). Children's note taking as a mnemonic tool. *Journal of Experimental Child Psychology, 101,* 52–74.

Fawcett, J. M. (2013). The production effect benefits performance in between-subject designs: A meta-analysis. *Acta Psychologica, 142,* 1–5.

Fawcett, J. M., Taylor, T. L., & Nadel, L. (2013). Intentional forgetting diminishes memory for continuous events. *Memory, 21,* 675–694. doi:10.1080/09658211.2012.748078

Forrin, N. D., Macleod, C. M., & Ozubko, J. D. (2012). Widening the boundaries of the production effect. *Memory & Cognition, 40,* 1046–1055. doi:10.3758/s13421-012-0210-8

Geiselman, R. E., Bjork, R. A., & Fishman, D. L. (1983). Disrupted retrieval in directed forgetting: A link with posthypnotic amnesia. *Journal of Experimental Psychology. General, 112,* 58–72.

Goernert, P. N., Corenblum, B., & Otani, H. (2011). Directed forgetting of faces: The role of response criterion. *Quarterly Journal of Experimental Psychology, 64,* 1930–1938.

Golding, J. M., & Keenan, J. M. (1985). Direct forgetting and memory for directions to a destination. *American Journal of Psychology, 98,* 579–590.

Golding, J. M., & Long, D. L. (1998). There's more to intentional forgetting than directed forgetting: An integrative review. In J. M. Golding & C. M. MacLeod (Eds.), *Intentional forgetting: Interdisciplinary approaches* (pp. 1–57). Mahwah, NJ: Erlbaum.

Gottlob, L. R., Golding, J. M., & Hauselt, W. J. (2006). Directed forgetting of a single item. *Journal of General Psychology, 133,* 67–80.

Hauswald, A., & Kissler, J. (2008). Directed forgetting of complex pictures in an item method paradigm. *Memory, 16,* 797–809.

Hourihan, K. L., & MacLeod, C. M. (2008). Directed forgetting meets the production effect: Distinctive processing is resistant to intentional forgetting. *Canadian Journal of Experimental Psychology, 62,* 242–246. doi:10.1037/1196-1961.62.4.242

Hourihan, K. L., Ozubko, J. D., & MacLeod, C. M. (2009). Directed forgetting of visual symbols: Evidence for nonverbal selective rehearsal. *Memory & Cognition, 37,* 1059–1068. doi:10.3758/MC.37.8.1059

Johnson, H. M. (1994). Processes of successful intentional forgetting. *Psychological Bulletin, 116,* 274–292.

Joormann, J., Hertel, P. T., Brozovich, F., & Gotlib, I. H. (2005). Remembering the good, forgetting the bad: Intentional forgetting of emotional material in depression. *Journal of Abnormal Psychology, 114,* 640–648. doi:10.1037/0021-843X.114.4.640

Joslyn, S. L., & Oakes, M. A. (2005). Directed forgetting of autobiographical events. *Memory & Cognition, 33,* 577–587. doi:10.3758/BF03195325

Korfine, L., & Hooley, J. M. (2000). Directed forgetting of emotional stimuli in borderline personality disorder. *Journal of Abnormal Psychology, 109,* 214–221.

Lee, Y., Lee, H., & Fawcett, J. M. (2013). Intentional forgetting reduces color-naming interference: Evidence from item-method directed forgetting. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 39,* 220–236.

Lehman, M., & Malmberg, K. J. (2011). Overcoming the effects of intentional forgetting. *Memory & Cognition, 39,* 335–347.

MacLeod, C. M. (1975). Long-term recognition and recall following directed forgetting. *Journal of Experimental Psychology: Human Learning and Memory, 1,* 271–279.

MacLeod, C. M. (1998). Directed forgetting. In J. M. Golding & C. M. MacLeod (Eds.), *Intentional forgetting: Interdisciplinary approaches* (pp. 1–57). Mahwah, NJ: Erlbaum.

MacLeod, C. M., & Daniels, K. A. (2000). Direct versus indirect tests of memory: Directed forgetting meets the generation effect. *Psychonomic Bulletin & Review, 7,* 354–359.

Quinlan, C. K., Taylor, T. L., & Fawcett, J. M. (2010). Directed forgetting: Comparing pictures and words. *Canadian Journal of Experimental Psychology, 64,* 41–46.

Sahakyan, L. (2004). Destructive effects of "forget" instructions. *Psychonomic Bulletin & Review, 11,* 555–559.

Sahakyan, L., & Kelley, C. M. (2002). A contextual change account of directed forgetting effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28,* 1064–1072. doi:10.1037/0278-7393.28.6.1064

Shapiro, S., Lindsey, C., & Krishnan, H. S. (2006). Intentional forgetting as a facilitator for recalling new product attributes. *Journal of Experimental Psychology. Applied, 12,* 251–263. doi:10.1037/1076-898X.12.4.251

Sparrow, B., Liu, J., & Wegner, D. M. (2011). Google effects on memory: Cognitive consequences of having information at our fingertips. *Science, 333,* 776–778. doi:10.1126/science.1207745

Standing, L., Conezio, J., & Haber, R. N. (1970). Perception and memory for pictures: Single-trial learning of 2500 visual stimuli. *Psychonomic Science, 19,* 73–74.

Sutton, J. (2010). Exograms and interdisciplinarity: History, the extended mind, and the civilizing process. In R. Menary (Ed.), *The extended mind* (pp. 189–225). Cambridge, MA: MIT Press.

Tekcan, A. I., Taş, A. C., Topçuoğlu, V., & Yücel, B. (2008). Memory bias in anorexia nervosa: Evidence from directed forgetting. *Journal of Behavior Therapy and Experimental Psychiatry, 39,* 369–380.

Underwood, B. J. (1957). Interference and forgetting. *Psychological Review, 64,* 49–60. doi:10.1037/h0044616