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Directed Forgetting: Comparing Pictures and Words

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The authors investigated directed forgetting as a function of the stimulus type (picture, word) presented at study and test. In an item-method directed forgetting task, study items were presented 1 at a time, each followed with equal probability by an instruction to remember or forget. Participants exhibited greater yes–no recognition of remember than forget items for each of the 4 study–test conditions (picture–picture, picture–word, word–word, word–picture). However, this difference was significantly smaller when pictures were studied than when words were studied. This finding demonstrates that the magnitude of the directed forgetting effect can be reduced by high item memorability, such as when the picture superiority effect is operating. This suggests caution in using pictures at study when the goal of an experiment is to examine potential group differences in the magnitude of the directed forgetting effect.

Keywords: item-method directed forgetting, intentional forgetting, picture superiority, pictures, words

Generally, forgetting is viewed negatively. However, sometimes when information is no longer relevant, it is beneficial to forget so that memory does not become overloaded with irrelevant and potentially interfering information (Bjork, 1970). For example, to remember a friend's new phone number, it helps if we can forget the old one. Intentional forgetting is studied in the laboratory using a paradigm known as *directed forgetting* (Bjork, 1972).

Although there are many variants of the directed forgetting paradigm, most may be classified as using either the list method or the item method (see MacLeod, 1998, for a review); the present study was concerned exclusively with the item-method paradigm. In an item-method task, participants are presented with a series of items, one at a time, each followed with equal probability by an instruction to remember or forget that item. A *directed forgetting effect* is defined as better subsequent memory for remember than for forget items, and occurs for both recall and recognition when the item method is used (see Basden & Basden, 1998, for a review).

Item-method directed forgetting has generally been examined using words as the stimuli at both study and test (e.g., Bjork, 1970; Muther, 1965; MacLeod, 1975, 1989; Woodward & Bjork, 1971). However, pictures have been used at study, particularly when participants are unable to easily process words—for example, in studies using young children (e.g., Lehman, McKinley-Pace, Leonard, Thompson, & Johns, 2001), animals (e.g., Roberts, Mazmanian, & Kraemer, 1984), or certain clinical populations (e.g., mental retardation: Bray, Justice, & Simon, 1978). At test, participants have then been required to recall the verbal referents of the studied pictures or to recognise the studied pictures when presented again.

We are aware of three studies that have examined directed forgetting of pictures in nonclinical adult populations. The first of these presented pictures that were all drawn from a single taxonomic category (e.g., animals; Basden & Basden, 1996). As Hourihan (2008) noted, this introduces the possibility that relatively poorer recall and recognition of the forget items was due to retrieval-induced forgetting (Anderson, 2003) rather than to directed forgetting. Hauswald and Kissler (2008) extended the work of Basden and Basden (1996) using complex visual scenes (instead of taxonomically related line drawings). Although a directed forgetting effect was observed, they suggested that it was smaller in magnitude than previously reported in studies using words; however, no direct comparison between directed forgetting of pictures and words could be performed given that the complex scenes did not map onto a single-word referent.

In the most recent study, Hourihan (2008) presented noncategorized pictures of common objects both at study and at recognition. In one condition, these pictures were mixed with the presentation of words in both phases of the experiment; in another condition, only pictures were presented. Whereas no significant directed forgetting effect was found for pictures when they were shown in mixed presentation with words at both study and recognition, there was a significant directed forgetting effect in the pictures-only condition. Because it was not relevant to Hourihan's purpose, there was no direct comparison of the magnitude of the directed forgetting effect for pictures alone (i.e., at both study and test) versus words alone.

By equating the content of pictures (e.g., picture of a kite) and words (e.g., the word *kite*), and presenting these in factorial combination at study and test, the current experiment provides the first systematic comparison of item-method directed forgetting for picture and word stimuli in a nonclinical human adult population.

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This factorial combination also permits consideration of the effects of item memorability on directed forgetting. In our case, the factorial presentation of pictures and words at study and test (picture–picture, picture–word, word–word, word–picture) creates the possibility for both the picture superiority effect and transfer appropriate processing to contribute to overall item memorability. The *picture superiority effect* refers to the ubiquitous finding that the presentation of pictures (vs. words) at study results in extraordinarily good memory, sometimes yielding greater than 95% correct recognition (Nickerson, 1965; Shepard, 1967). *Transfer appropriate processing* refers to the general finding that memory is improved when there is a match rather than a mismatch between the item processing required at test and that used at study (e.g., Morris, Bransford, & Franks, 1977). Given that high item memorability due to the generation effect has been shown to override directed forgetting (MacLeod & Daniels, 2000), it follows that increased item memorability due to the picture superiority effect and/or transfer appropriate processing might also reduce (or even eliminate) the directed forgetting effect.

The operation of a picture superiority effect in our paradigm will be revealed as a main effect of study condition, with overall better recognition of studied pictures than studied words. If increased item memorability due to the picture superiority effect reduces the magnitude of the directed forgetting effect, this will be revealed as an interaction of study condition with memory instruction such that the directed forgetting effect will be smaller for studied pictures than for studied words.

The operation of transfer appropriate processing will be revealed as an interaction of study and test conditions in overall recognition. If increased item memorability due to transfer appropriate processing reduces the magnitude of the directed forgetting effect, this will be revealed as an interaction of study and test condition with memory instruction, such that the directed forgetting effect will be smaller for conditions that match (picture–picture and word–word) than for conditions that mismatch (picture–word and word–picture).

Considering both the picture superiority effect and transfer appropriate processing in combination, the picture–picture condition has the potential to benefit from both effects, the picture–word condition should benefit from the picture superiority effect only, the word–word condition should benefit from transfer appropriate processing only, and the word–picture condition should benefit from neither. Thus, to the extent that the picture superiority effect and transfer appropriate processing both serve to increase item memorability in our study, the magnitude of the directed forgetting effect should differ across the study–test conditions, such that it will be smallest in the picture–picture condition, largest in the word–picture condition, and of intermediate size in the picture–word and word–word conditions.

Method

Participants

Altogether, data from 24 participants were collected in each of the four study–test conditions (for a total of 96 participants). Initially, 16 participants were alternately assigned to the picture–word and word–picture conditions before 16 more were alternately assigned to the picture–picture and word–word conditions; later, to increase statistical power, 32 participants were alternately assigned to each of the four conditions (i.e., adding 8 to each condition). In exchange for their participation, participants received course credit in an eligible psychology class at Dalhousie University. Participants were tested individually in a 45-min session. All participants reported normal or corrected-to-normal vision and a good understanding of the English language.

Stimuli and Apparatus

PsyScope 5.1.2 (Cohen, MacWhinney, Flatt, & Provost, 1993) was used to conduct the experiment on a G4-400 Macintosh computer equipped with a 17-in. Macintosh Studio Display colour monitor, a standard Macintosh Universal Serial Bus keyboard, and Sony MDR-XD100 stereo headphones. All stimuli were displayed on the computer monitor against a uniform white background. The pictures consisted of 200 coloured two-dimensional line drawings created by Rossion and Pourtois (2004). The majority of pictures were 16-bit RGB colour (a few were 32 bit); all pictures had a resolution of 72 × 72 dpi and were saved in PCT format (for further details, see Rossion & Pourtois). The words were the corresponding names of those pictures (e.g., picture of a kite, the word *kite*); Rossion and Pourtois demonstrated high correspondence between these pictures and their names. Words and pictures were centred in an invisible square port that, from a viewing distance of approximately 47 cm, measured 5.8 degrees of visual angle on a side. All text including the fixation stimulus (+), memory instructions, study words, and task instructions were presented in black Times New Roman size 24 font. The remember and forget memory instructions were letter strings presented in the centre of the computer monitor—*RRRRR* for remember and *FFFFF* for forget. To alert participants to the start of each study trial, a computer-generated system beep was played over the headphones. At recognition, words and pictures were again centred in an invisible square port that measured 5.8 degrees of visual angle on a side. Responses made during the recognition task were displayed in a black 1-point outline rectangle, measuring 4.1 degrees of visual angle horizontally and 2.7 degrees of visual angle vertically.

Procedure

Before beginning the experiment, the experimenter provided verbal instructions, which were later reiterated on the computer monitor. Participants were told that they would be presented with a series of pictures or words, one at a time in the centre of the computer monitor, each followed with equal probability by an instruction to remember or forget that item. Participants were told that they would be given a recognition test at the end of the experiment; there was no indication that they would be tested for both remember and forget items and no mention was made about the nature of the stimuli that would be used in this recognition test (pictures vs. words).

Each participant was tested in one of four between-subjects conditions. These four conditions corresponded to the factorial combination of study item (picture, word) and test item (picture, word). The resulting conditions were picture–picture, picture–word, word–word, and word–picture. Customized software was used before testing each participant to randomly assign items (pictures and their single-word referents) to remember ($n = 50$), forget ($n = 50$), and recognition foil ($n = 100$) picture and word lists; each participant therefore had a unique combination of remember, forget, and foil items.

Study phase. The study phase consisted of 100 trials. Each trial began with a 1,500-ms fixation interval, during which the fixation stimulus (+) appeared alone in the centre of the computer monitor. The onset of the fixation stimulus was accompanied by a system beep presented over the headphones at a comfortable hearing level. The fixation interval was followed by a picture or word (depending on the condition) that was centred on the computer monitor for 2,000 ms. This item was chosen randomly without replacement from the 50 remember items and the 50 forget items. Following a further 500-ms interval during which a blank screen was presented, the corresponding remember or forget memory instruction (*RRRRR* or *FFFFF*) appeared in the centre of the computer monitor for 1,000 ms. At the end of each trial, there was a 3,500-ms intertrial interval during which no stimuli were presented. The total duration of all events in each study trial was 8,500 ms, from the beginning of the fixation to the end of the intertrial interval (similar to that used by Fawcett & Taylor, 2008; Hourihan, Goldberg, & Taylor, 2007; Wylie, Foxe, & Taylor, 2008).

There were six buffer trials—three at the beginning and three at the end of the study phase—to minimise primacy and recency effects. The buffer trials were identical to the study trials except that all buffer trials were followed by a remember instruction and were not tested for recognition. Also, the same buffer stimuli (e.g., a picture of an apple or the word *apple*) were used for all participants.

Recognition phase. Following the last trial in the study phase, participants began the "yes/no" recognition phase. Instructions for performing this task appeared at the top of the computer monitor and remained visible throughout the recognition phase. Participants were informed that they would be presented with items one at a time, some of which had been presented during the study phase. In the picture test conditions, participants were shown pictures one at a time and were required to decide whether each had been presented at study (picture–picture) or whether the word referent for the object depicted in the picture had been presented at study (word–picture). In the word test conditions, participants were shown words one at a time and were required to decide whether each had been presented at study (word–word) or whether a picture of the named item had been presented (picture–word). Items for the recognition phase were selected randomly without replacement from the pool of remember, forget, and foil items and were presented one at a time beneath the instructions. For each item, participants were required to press the *y* key on the computer keyboard if the presented item (or its corresponding picture/word) had occurred at study or the *n* key if it had not. Participants were instructed that they should respond *y* to all items that had been presented at study regardless of the memory instruction. Keyboard responses were visible on the computer monitor and could be self-corrected using the *backspace* key. Participants were instructed to hit the space bar to submit their response and proceed to the next trial. Each item remained visible until the response was submitted. There was no time limit for making or submitting a response.

The recognition phase consisted of 200 trials. For each study–test condition, the 50 remember and 50 forget items (pictures or words) that had been presented in the study phase were tested along with 100 unstudied foil items of the appropriate item type (picture or word). Thus, in the picture–picture condition, the remember and forget study pictures were randomly intermixed with 100 unstudied foil pictures. In the picture–word condition, participants were tested with words that corresponded to the 50 remember and 50 forget pictures that had been presented in the study phase; these were randomly intermixed with 100 unstudied foil words. In the word–word condition, the remember and forget study words were randomly intermixed with 100 unstudied foil words. And, in the word–picture condition, participants were tested for the pictures corresponding to the 50 remember and 50 forget words that had been presented in the study phase; these were randomly intermixed with 100 unstudied foil pictures. On completion of the recognition phase, participants were debriefed.

Results

The data from one participant in the picture–picture condition were excluded because the participant failed to comply with the task demands (by writing down the names of the pictures during the study phase). The data from the remaining 95 participants were analysed.

The proportions of "yes" responses made in the recognition test are shown in Figure 1 as a function of study–test condition (picture–picture, picture–word, word–word, word–picture) and item type (remember, forget, foil).

The proportions of false alarms made to unstudied foils on the recognition test were analysed in a one-way analysis of variance (ANOVA), with study–test condition (picture–picture, picture–word, word–word, word–picture) as the between-subjects factor. This analysis revealed no significant difference in the false alarm rate as a function of study–test condition, $F(3, 91) = 1.78$, $MSE = 0.02$, $p > .15$.

The proportion of recognition hits to studied items was examined in a $2 \times 2 \times 2$ ANOVA, with memory instruction (remember,

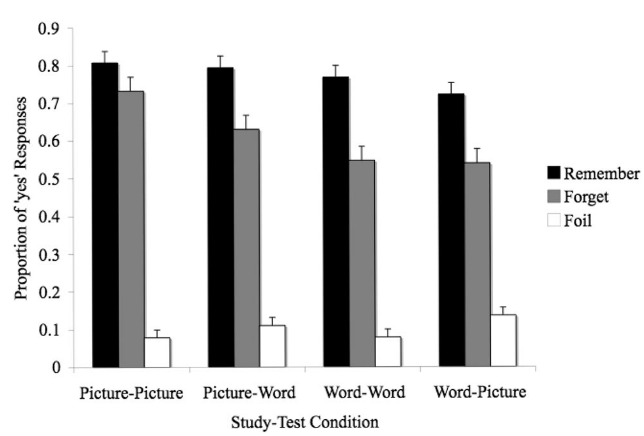

Figure 1. The mean proportions of "yes" responses on a recognition test as a function of word type (remember, forget, foil) and study–test condition (picture–picture, picture–word, word–word, word–picture); error bars represent 1 standard error.

forget) as a within-subjects factor and study condition (picture, word) and test condition (picture, word) as between-subjects factors. A main effect of memory instruction confirmed a significant directed forgetting effect, $F(1, 91) = 83.74$, $MSE = 0.02$, $p < .01$, with overall higher recognition of remember ($M = 0.77$, $SE = 0.02$) than forget items ($M = 0.61$, $SE = 0.02$). It is important to note that in all four study–test conditions, the proportion of recognition hits to forget items was higher than the proportion of false alarms made to unstudied foil items: picture–picture, $t(22) = 17.02$, $p < .01$; picture–word, $t(23) = 11.13$, $p < .01$; word–word, $t(23) = 12.16$, $p < .01$; and word–picture, $t(23) = 11.61$, $p < .01$. This demonstrates that recognition performance for forget items was above floor levels and could be distinguished from response bias.

Consistent with a picture superiority effect, the omnibus ANOVA revealed a significant main effect of study condition, $F(1, 91) = 10.73$, $MSE = 0.04$, $p < .01$, with overall better recognition following the study of pictures ($M = 0.74$, $SE = 0.02$) than the study of words ($M = 0.65$, $SE = 0.02$). There was no main effect of test condition, $F < 1$. There was also no interaction between study and test conditions, $F(1, 91) = 2.04$, $MSE = 0.04$, $p > .15$; this finding runs counter to the prediction that transfer appropriate processing would lead to better overall recognition in the picture–picture and word–word conditions than in the picture–word and word–picture conditions.

The effect of memory instruction (i.e., the directed forgetting effect) interacted with study condition, $F(1, 91) = 5.45$, $MSE = 0.02$, $p < .03$. This can be seen in Figure 1 as a 60% reduction in the magnitude of the directed forgetting effect when a picture was presented at study (average directed forgetting effect = .12) rather than a word (average directed forgetting effect = .20). The interaction of memory instruction and test was not significant, $F(1, 91) = 3.37$, $MSE = 0.02$, $p > .07$. Given that there was evidence of increased item memorability due to the picture superiority effect but not due to transfer appropriate processing, it is perhaps not surprising that the three-way interaction of memory instruction, study condition, and test condition was not significant, $F(1, 91) = 0.68$, $MSE = 0.02$, $p > .40$.

Discussion

Item-method directed forgetting has been proposed to occur primarily at encoding (see MacLeod, 1998; Basden & Basden, 1998, for reviews; however, see Geiselman & Bagheri, 1985; Ullsperger, Mecklinger, & Müller, 2000). According to the selective rehearsal account, items receive maintenance rehearsal until receipt of the memory instruction. If the instruction is to remember, elaborative encoding is engaged to commit that item to memory; if the instruction is to forget, the item is dropped from the rehearsal set and allowed to decay passively (Basden, Basden, & Gargano, 1993). An alternative account—attentional inhibition—argues that following a forget instruction, attentional mechanisms are engaged to actively expunge the item from working memory and to prevent it from regaining easy access to these limited capacity resources (Zacks, Radvansky, & Hasher, 1996); this frees resources for elaborative rehearsal of the remember items.

Consistent with the characterisation of forgetting as an active—rather than a passive—cognitive process, Fawcett and Taylor (2008) found that reaction times to the onset of visual detection probes embedded in the study phase of a standard item-method task are longer following forget than following remember instructions; this result suggests that limited capacity attentional resources are more fully engaged during the instantiation of a forget instruction than during the instantiation of a remember instruction. The role of attention in this active process of forgetting is further suggested by the finding that inhibition of return measured during the study phase of an item-method task—which can be used as an index of attention withdrawal (but not necessarily attentional allocation)—is larger following forget than following remember instructions (Fawcett, 2008; Fawcett & Taylor, 2009; Taylor, 2005; Taylor & Fawcett, 2009). In essence, a forget instruction operates at encoding as a kind of "stop signal" (cf. Logan, 1994), engaging executive control processes to cease the covert commitment of an item to memory (Hourihan & Taylor, 2006) while also slowing the execution of subsequent overt responses and increasing the probability of successfully stopping unwanted responses (Fawcett, 2008; Fawcett & Taylor, 2009). Compared with unintentional forgetting of poorly encoded words on remember trials, successful intentional forgetting on forget trials is associated at encoding with increased activation in prefrontal regions that have been implicated in executive control (Wylie et al., 2008).

To the extent that forgetting in an item-method task depends on the top-down engagement of executive control processes to prevent the commitment of an item to memory, we reasoned that the efficacy of these mechanisms might be limited by stimulus factors that are known to increase item memorability (cf. MacLeod & Daniels, 2000). To this end, our systematic manipulation of study–test stimulus combinations introduced two potential factors that could increase item memorability. One such factor is the picture superiority effect (Madigan, 1983; Paivio, 1991). This describes the robust finding that—all else being equal—there is better memory for studied pictures than for studied words. The other is transfer appropriate processing. This refers to improved memory when item processing at test matches that used at study (Morris et al., 1977).

We used a recognition test to examine item-method directed forgetting for four stimulus combinations at study and test: picture–picture, picture–word, word–word, and word–picture. We observed a significant directed forgetting effect in *all* study–test conditions (as revealed by a significant directed forgetting effect that did not enter into a significant three-way interaction with study condition and test condition). Nevertheless, compared with when words were presented at study, the magnitude of the directed forgetting effect was reduced significantly—by more than 60%—when item memorability was increased by the operation of the picture superiority effect at encoding (see also Hauswald & Kissler, 2008; Hourihan, 2008). That is, when overall recognition memory was high due to the study of pictures versus words, there was a large overall reduction in the magnitude of the directed forgetting effect. This has two implications: The directed forgetting effect is reduced by overall increases in item memorability, but a directed forgetting effect can nevertheless still occur, suggesting that the top-down processes engaged to intentionally forget (cf. Hourihan & Taylor, 2006; Wylie et al., 2008; see also Fawcett & Taylor, 2009) are able—at least under some circumstances—to suppress the commitment of even highly memorable items to memory (however, see MacLeod & Daniels, 2000).

In our results, there was no obvious effect of transfer appropriate processing: Neither overall recognition memory nor the magnitude of the directed forgetting effect was influenced by an interaction of study and test conditions.[1] This finding suggests that the magnitude of the directed forgetting effect in an item-method task might depend critically on manipulations of item memorability that occur at encoding, rather than those that occur at retrieval. Indeed, this would account for the fact that the generation effect, which represents a strong manipulation of encoding, eliminates the item-method directed forgetting effect altogether (MacLeod & Daniels, 2000).

In conclusion, the present experiment demonstrates a directed forgetting effect for both pictures and words in a standard item-method directed forgetting paradigm. Nevertheless, items that are highly memorable can affect the efficacy of top-down mechanisms that are presumably engaged during the instantiation of a forget instruction. Compared with word stimuli, this results in a large reduction in the magnitude of the obtained directed forgetting effect for pictures. This finding is of potential importance to researchers who are interested in studying clinical conditions or developmental trajectories that are predicted to produce relative reductions in the magnitude of the directed forgetting effect: In these cases, the use of pictures at study may reduce the baseline effect and thereby obscure any group differences that might otherwise exist using item-method directed forgetting.

[1] Even though the recognition test was not speeded, reaction times (RTs) associated with pressing the *y* or *n* keys were automatically recorded relative to the onset of the item to be recognized. Consistent with a directed forgetting effect, RTs were significantly faster to correctly recognize a studied remember item (M = 1,434 ms) than to correctly recognize a studied forget item (M = 1,670 ms), $F(1, 91) = 10.03$, $MSE = 267368.80$, $p < .02$. Consistent with a picture superiority effect, there was also a main effect of study condition, with overall faster RTs to correctly recognize studied pictures (M = 1,406 ms) than studied words (M = 1,694 ms), $F(1, 91) = 11.95$, $MSE = 331045.72$, $p < .01$. Although there was no main effect of test condition, $F(1, 91) = 1.07$, $MSE = 331045.72$, $p > .30$, there was a significant interaction of study and test condition, $F(1, 91) = 6.32$, $MSE = 331045.72$, $p < .02$. This interaction was consistent with an overall effect of transfer appropriate processing, such that RTs to correctly recognize a studied item were fastest in the picture–picture condition (M = 1,344 ms) and slowest in the word–picture (M = 1,842 ms) condition, with intermediate values in the picture–word (M = 1,467 ms) and word–word (M = 1,640 ms) conditions. Critically, however, memory instruction did not enter into any significant interactions in the recognition RT data: not with study condition, $F < 1$, test condition, $F(1, 91) = 3.33$, $MSE = 267368.80$, $p > .07$, or study and test condition, $F < 1$. To the extent that the speed to make a correct recognition response indicates the relative "accessibility" of a memory trace, this means that neither the picture superiority effect nor transfer appropriate processing differentially increased the accessibility of remember or forget items.

Rèsumè

La recherche porte sur l'oubli dirigé selon le type de stimulus (image, mot), présenté en deux phases, étude et test. Dans le cadre d'une tâche d'oubli dirigé selon la méthode item, on a présenté aux sujets un élément à la fois, puis on leur a demandé de s'en rappeler ou de l'oublier, dans une proportion équivalente. La reconnaissance oui/non des éléments à se rappeler était plus grande que les éléments à oublier dans les quatre situations étude-test (image-image, image-mot, mot-mot, mot-image). Toutefois, l'écart était de beaucoup plus restreint lorsque des images étaient à étudier, plutôt que des mots. Ces résultats révèlent que l'ampleur de l'effet de l'oubli dirigé peut être réduite par un élément de mémorabilité élevée, comme dans le cas d'une image dont l'effet de supériorité entre en jeu. Cela suggère qu'il faut faire preuve de prudence lorsqu'on utilise des images à étudier si le but de l'expérience est de cerner d'éventuelles différences entre divers groupes dans l'importance de l'effet de l'oubli dirigé.

Mots-clés : oubli dirigé selon la méthode item, oubli intentionnel, supériorité de l'image, images, mots

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