Assessing the Role of Attention in the Animacy Effect Through Directed Forgetting

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Abstract

A growing body of research suggests the presence of an attentional component in the memory advantage of animate items. Most research on this animacy effect is focused on remembering, but its effects on forgetting are less well-researched. With the use of pupillometry, we investigated the attentional processes present in the selective remembering and directed forgetting of animate and inanimate items. More specifically, we investigated whether external and internal attention are affected by the animacy status of to-be-remembered and to-be-forgotten words in an item-method directed forgetting task with retro cues, followed by a recognition task for all previously presented items. Our behavioral results demonstrate the directed forgetting effect: accuracy on the recognition task was higher for to-be-remembered words than for to-be-forgotten words. Additionally, we found an advantage of animacy, with higher accuracy for animate words than for inanimate words, regardless of cue. The pupillometry results demonstrate differential internal attention for to-be-remembered and to-be-forgotten words during cueing, with larger pupil sizes for remember cues than for forget cues, but no effect of animacy. We did however find an animacy effect on external attention during stimulus presentation, with smaller pupil sizes for animate words than for inanimate words, which may reflect precision of encoding. This suggests that not internal attention, but external attention is influenced by animacy status, potentially explaining the memory advantage of animate items through the richness-of-encoding hypothesis.

Keywords: animacy effect; directed forgetting; attention; pupillometry; recognition memory

The animacy effect is a well-studied psychological effect which sees animates generally better remembered than inanimates (Nairne et al., 2013, 2017). Despite a growing body of research on the animacy effect, the mechanisms behind it are not quite clear yet. Therefore, in the current study we try to explain why animates are remembered better than inanimates by investigating these mechanisms.

There are multiple possible explanations for the effect of animacy on memory. From a functionalist-evolutionary standpoint, it can be argued that better memory for animates arises from a stronger fitness value, since animates can be seen as potential predators, prey, or social agents (Nairne et al., 2013, 2017). This concerns the 'why' of the animacy effect; an ultimate explanation. Multiple proximate mechanisms have also been proposed. These proximate mechanisms address the 'how' of the animacy effect; the underlying causes and processes behind it. For example, Meinhardt et al. (2018) proposed increased emotional arousal for animates as a proximate mechanism but found that it could not (fully) account for the animacy effect. Furthermore, Kroneisen et al. (2013) identified richness-of-encoding as a potential mechanism, suggesting that animate words cause more distinct memory representations during encoding than inanimate words, leading to more potential retrieval cues for animate words during retrieval. In line with the richness-of-encoding hypothesis, Bonin et al. (2015) suggested that animates trigger more interactive images than inanimates do, leading to better memory performance. While Bonin et al. (2015) failed to establish elaboration as a proximate mechanism, they did not rule out other possible mechanisms, such as attention. A growing body of research suggests that the memory advantage of animate words can be (at least partly) explained by an attentional component; it seems that animate words are not only more likely to be attended to but are also more likely to be attended to for longer times, in comparison to inanimate words (Bugaiska et al., 2019; Leding, 2020; Yang et al., 2012). This attentional prioritization hypothesis is consistent with the functionalist perspective by Nairne et al. (2013), where animates may be remembered more easily than inanimates because of differences in perceptual or attentional focus.

Most research on the animacy effect has been concerned with remembering, but not with forgetting (see Murphy & Castel, 2021, for a notable exception). Considering the possibility that animacy status may influence these two processes differently, research on forgetting can provide insights into the mechanisms behind the animacy effect. Forgetting is a critical process, and a good memory system balances what we need to remember and what not (Bjork & Bjork, 1996; Fawcett & Hulbert, 2020). Research on directed forgetting has shown that we can prioritize what we want to remember and what we want to forget (e.g., Anderson & Hanslmayr, 2014; Macleod, 1975; Tan et al., 2020). The directed forgetting effect shows that words which people are

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instructed to forget are remembered less well than words they are instructed to remember. There is however no consensus on whether directed forgetting is an active or passive process. According to selective rehearsal accounts, to-be-remembered words are actively rehearsed, while to-be-forgotten words are spared from further processing and are thus subject to passive decay (Macleod, 1975; Tan et al., 2020). Other researchers have proposed that forgetting involves more active or effortful processes (Anderson & Hanslmayr, 2014; Cheng et al., 2012; Fawcett & Taylor, 2008; Gao et al., 2023; Thompson et al., 2014). For example, Gao et al. (2023) proposed active inhibition as an important mechanism in directed forgetting. In their ERP study, they found larger P2 amplitudes, indicating more attentional resources, in the forgetting condition than in the remember condition, which they linked to the active inhibition of task-irrelevant information caused by forget cues. Similarly, Thompson et al. (2014) argue that 'withdrawal' of attention accounts for more effortful processes in the forgetting condition, engaging frontal mechanisms to cease rehearsal and preventing encoding to memory.

Murphy and Castel (2022) were the first to investigate the effect of animacy on both selective remembering and directed forgetting. In their study, they employed an item-method directed forgetting task using retro-cues, to investigate the influence of multiple stimulus characteristics including animacy status. Murphy and Castel (2022) suggested that both to-be-remembered and to-be-forgotten information should be similarly impacted by stimulus properties such as animacy because they would receive some initial encoding before the cue to remember or forget. They found a directed forgetting effect, with to-be-remembered words being remembered better than to-be-forgotten words. They also found a memory advantage for animate words, regardless of the cue. This suggests that animate items are not only easier to remember but also harder to forget, consistent with the functionalist perspective of Nairne et al. (2013, 2017). Since animacy status affected to-be-forgotten and to-be-remembered words similarly, Murphy and Castel (2022) suggested that their results are consistent with the selective rehearsal account. Yet, they did not rule out the possibility of other effortful mechanisms that guide attention in successful directed forgetting.

Pupillometry

One way to study attentional processes involved in the animacy effect is by means of pupillometry. Pupillometry is a widely used physiological measure that can access several ongoing mental processes (Mathôt, 2018). There are different ways in which the pupil reacts. Firstly, the pupil is shown to be related to the sympathetic and the parasympathetic nervous system, which explains why the pupil dilates in states of arousal/mental effort and constricts in states of rest. Additionally, there is the pupil light response (PLR), where the pupil typically constricts with increasing levels of brightness and dilates with increasing levels of darkness. The PLR has been shown to reveal covert shifts of visual attention, for both physical (Koevoet et al., 2023; Mathôt et al., 2013) and imagined (Laeng & Sulutvedt, 2013) stimuli, and even for stimuli that lack any sense of brightness (Salvaggio et al., 2022).

Furthermore, the PLR seems to provide insights into external and internal attention when retro-cues are used (Koevoet, Naber, et al., 2024; Koevoet, Strauch, et al., 2024). In this context, external (or perceptual) attention can be understood as the selection and modulation of information as it comes in through the senses, whereas internal attention can be understood as the prioritization of information that is already stored in working memory (Chun et al., 2010). Retro-cues allow for the separation of these types of attention by presenting a cue after the stimulus has already been presented (hence, retro). Koevoet, Naber et al. (2024) have shown that the intensity of *external* attention during stimulus presentation (prior to cue presentation) is reflected in pupil *constriction*. In contrast, the intensity of *internal* attention (or prioritization) during cueing is reflected in pupil *dilation*. These results highlight the intricate interplay between external and internal attention, as reflected in the pupil response.

In sum, there is evidence that one's pupils can provide insight in covert attention shifts, mental imagery, attentional prioritization, mental effort, and arousal. However, since most research is focused on visual perception, it is not clear how well these effects translate to the verbal domain. While there is not yet any pupillometry research on the animacy effect, there has been some pupillometry research on directed forgetting, with verbal stimuli (Lee, 2018; Scholz & Dutke, 2019). Larger pupil sizes, indicating more mental effort and attention, have been typically observed for remember cues in comparison to forget cues and neutral cues. This observation is in line with accounts of selective rehearsal and agrees less well with accounts suggesting that both forgetting and remembering are effortful. In the current study we combine research on animacy and directed forgetting with pupillometry, in order to gain more insight in the attentional processes present in the animacy effect. Specifically, we investigate external and internal attention in a directed forgetting task with the use of retro-cues, and whether this is affected by the animacy status of the presented words. The presentation of (in)animate stimuli before the presentation of cues that indicate the task that is to be performed, allows us to investigate whether they receive differential external and internal attention separately.

Since Murphy and Castel (2022) were the first ones to research the effect of animacy on selective remembering and directed forgetting, we will use their study as the basis for our design and expect to replicate their behavioral results. As in the original experiment, we expect there to be a main effect of directed forgetting, in which to-be-remembered words are better remembered than to-be-forgotten words, and a main effect of animacy, in which animate words are better remembered than inanimate words regardless of cue. This would not only confirm that animacy enhances memory for items we need to remember, but also that animacy makes it more difficult to forget items we need to forget.

Our second aim is to extend the original experiment of Murphy and Castel (2022) by investigating pupil sizes during both stimulus and cue presentation, since this could reveal more about the role of attentional processes in the animacy effect, selective remembering, and directed forgetting. In line with prior research of Lee (2018) and Scholz and Dutke (2019), we predict a main effect of cue, in which pupil size is larger for to-be-remembered words than for to-be-forgotten words, indicating differential internal attention for the remember and forget cues. More importantly, we will investigate whether animacy status influences pupil size during stimulus and cue presentation. The lack of prior pupillometry research on the animacy effect (and the semantic domain in general) makes it difficult to predict how the pupil would differentially respond in animate and inanimate conditions. However, considering that both the animacy effect and the pupil response are likely related to attention (Bugaiska et al., 2019; Koevoet, Naber, et al., 2024; Mathôt, 2018; Yang et al., 2012), it is plausible to predict an effect of animacy on pupil size during stimulus presentation (indicating differential *external* attention), and during cue presentation (indicating differential *internal* attention).

Just like Murphy and Castel (2022), we used an item-method directed forgetting task, but instead of a free recall task during the test phase we used a recognition task with the addition of a remember/know/guess (RKG) paradigm. Because of space constraints, we will only consider the recognition data here.

Method

Participants

A total of 130 participants were recruited at Erasmus University Rotterdam. They received partial course credits in exchange for participation or participated voluntarily. Eighteen participants were excluded from the analysis due to psychological disorders, non-corrected visual impairments, dyslexia, or because they were not native Dutch speaking. An additional five participants were excluded due to missing data, extreme pupil size measurements, or other preprocessing difficulties. The final sample consisted of 107 participants (26 male, 16 left-handed) with a mean age of 21.42 (*SD* = 4.10). Based on an a priori power analysis conducted in G*Power 3.1 (Faul et al., 2007) with the original data by Murphy and Castel (2022), a sample of 105 participants would be needed to establish a significant behavioral effect with a power of $1-\beta = .90$ and an alpha of $\alpha = .05$.

Materials and Apparatus

The set of stimuli consisted of Dutch words selected from the De Deyne et al. (2008) norms. Only words that were clearly animate or inanimate were considered; words that could be considered ambiguous were discarded beforehand. A total of 128 nouns were selected, half of which were animate and half of which were inanimate. The animate and inanimate words were then distributed across two sets, to be used as "old" and "new" stimuli in the experiment, and counterbalanced across participants to minimize order effects. The four sets were matched on number of letters, bigram frequency, age of acquisition, number of orthographic neighbors, orthographic uniqueness point, concept familiarity, imageability, concreteness, valance, arousal, image variability, book frequency, and subtitle frequency, using the anticlust package (Papenberg & Klau, 2021) in R 4.3.0 (R Core Team, 2022). ANOVAs and independent samples t-tests showed no significant differences between the sets and the (in)animate items on any of the matching variables.

Individual stimuli were presented on a 24-inch computer display with a resolution of 1,920 x 1,200 and a grey background. The participants' eyes were monitored using the Tobii Pro Spark eye tracker, which captures gaze and pupil data at a 60 Hz sampling rate. Since the participants' heads were unrestrained, they were asked to move as little as possible. Pupil data was recorded for the right eye only. Participants carried out the task in soundproof cubicles with moderate overhead lighting.

Procedure and Design

The study was approved by the ethics board of the Department of Psychology, Education and Child studies at Erasmus University Rotterdam. Participants gave informed consent when signing up for the experiment. The experiment was run in MATLAB (The MathWorks Inc., 2022), using the Psychophysics Toolbox extensions (Brainard, 1997). Prior to the experiment, a 5-point calibration was carried out. The experiment consisted of two phases, an acquisition phase and a test phase. A schematic representation of the acquisition and test phase can be seen in Figure 1. In the acquisition phase, participants were instructed to remember the words that were followed with 'RRRR' (in Dutch: 'OOOO') and forget the words that were followed with 'FFFF' (in Dutch: 'VVVV'), and that they would be tested afterwards. A total of 64 words were presented in the acquisition phase, in capital letters in the middle of the screen. Each trial started with a centered fixation dot for three seconds, followed by the stimulus for three seconds (e.g., BEAR), and finally with the cue for three seconds (e.g., RRRR).

During the test phase, a total of 128 words were presented in the middle of the screen, half of which were words from the acquisition phase and half of which were new words. Participants were instructed to categorize all words as old or new in a recognition task, regardless of the cue to remember or forget. Additionally, they were asked to categorize words indicated as old as either remember, know, or guess. Each trial started with a centered fixation dot for one second, followed by the stimulus for one second, then the options "OLD" and "NEW". Participants indicated their answers by pressing F, J, or the spacebar, which were spatially aligned with the location of "OLD" and "NEW" (left and right on the screen) and later, if participants chose "OLD", with the location of "REMEMBER", "KNOW", and "GUESS" on the screen (left, right, and bottom on the screen; see also Figure 1). The left/right location of "OLD" and "NEW" was randomized during the trials to avoid automated answers from participants. Participants could take as long as they wished to answer and did not receive feedback.

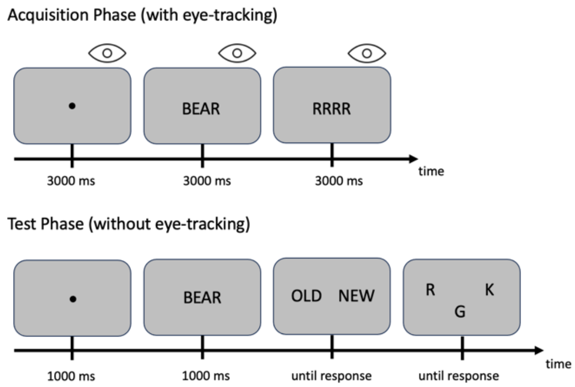

Figure 1: Schematic Representation of Acquisition and Test Phase.[1]

Pupil Analysis

The pupil response (i.e., diameter in millimeters) was analyzed by examining the average pupil size during the two windows of interest; the stimulus presentation time-window (spanning from stimulus onset to its offset), and the retro-cue time window (spanning from the cue onset to its offset). Preprocessing of the pupil data was performed as follows. First, the data was epoched separately for the two time windows, for each trial. Then, missing data from blinks was recovered by linear interpolation, and the data was rescaled into z-scores. Next, a baseline period (100 ms into the two time windows) was subtracted, outliers were removed using a -5 to 5 z-score cut-off, and the data was downsampled from 60 Hz to 10 Hz. Finally, the processed epochs were averaged according to the conditions for each participant, and for each time window separately.

Results

Behavioral Data

We investigated accuracy using hit rates – that is, the proportion correctly recognized "old" words. A 2 X 2 repeated-measures ANOVA was conducted on accuracy with animacy (animate, inanimate) and cue (remember, forget) as within-subject factors. The results replicated those of Murphy and Castel (2022). There was a main effect of cue, with higher accuracy for words cued to remember than for words cued to forget, $F(1, 106) = 161.34$, $p < .001$, partial $\eta^2 = .60$. Additionally, we found a main effect of animacy, with higher accuracy for animate words than for inanimate words, $F(1, 106) = 13.48$, $p < .001$, partial $\eta^2 = .11$. No significant interaction was found between animacy and cue, $F(1, 106) = 1.99$, $p = .161$, partial $\eta^2 = .02$. A visualization of the behavioral results can be found in Figure 2.

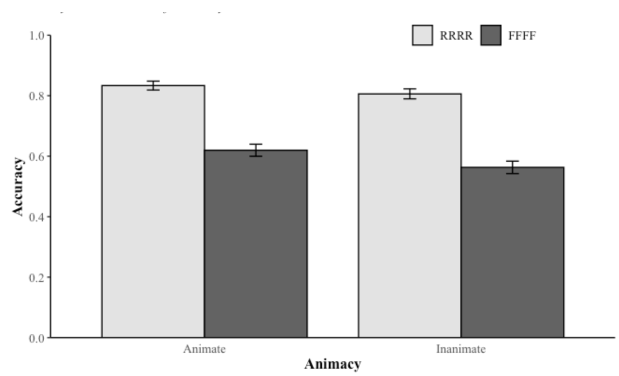

Figure 2: Accuracy as a Function of Animacy and Cue[2]

Pupil Response During Stimulus Presentation

To analyze the pupil response during stimulus presentation, we compared the average pupil size during the stimulus presentation time window in animate and inanimate conditions. A paired samples t-test was carried out on average pupil size for animate and inanimate words. A significantly smaller pupil size was found for animate words compared to inanimate words, $t(106) = -2.00$, $p = .049$, Cohen's $d = -0.20$. A visualization of these results can be found in Figure 3.

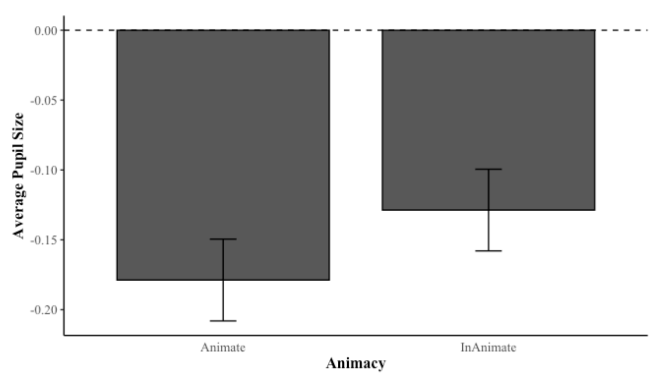

Figure 3: Average Pupil Size During Stimulus Presentation as a Function of Animacy in mm[3]

Pupil Response During Cueing

For the second pupil analysis the pupil response was investigated by comparing average pupil size during the retro-cue time window in the various conditions. Similar to the behavioral analysis, a 2 X 2 repeated-measures ANOVA

[1] For presentation purposes, the information is presented here in English. In the actual experiment all information was presented in Dutch. Schematic eyes indicate times when pupil size was measured.

[2] Error bars reflect the standard error of the mean.

[3] Error bars reflect the standard error of the mean. Negative values represent pupil constriction relative to the baseline.

was conducted on average pupil size with animacy (animate, inanimate) and cue (remember, forget) as within-subject factors. Consistent with earlier pupillometry research on directed forgetting (Lee, 2018; Scholz & Dutke, 2019), there was a main effect of cue, with a larger average pupil size for words cued to remember than for words cued to forget, $F(1, 106) = 58.20$, $p < .001$, partial $\eta^2 = .35$. No significant main effect was found for animacy, $F(1, 106) = 0.10$, $p = .755$, partial $\eta^2 < .01$, and no significant interaction was found between animacy and cue, $F(1, 106) = 0.01$, $p = .917$, partial $\eta^2 < .01$. A visualization of the pupil results can be found in Figure 4.

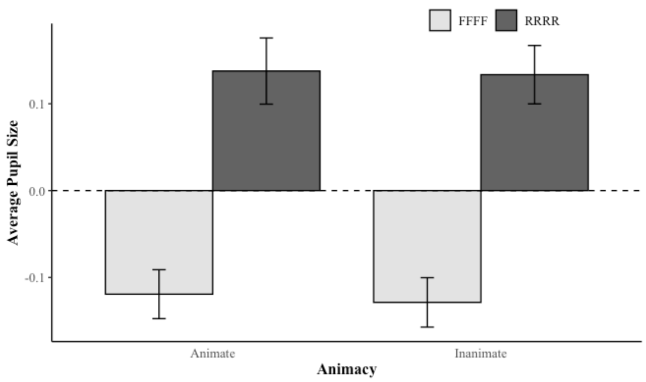

Figure 4: Average Pupil Size During Cue Presentation as a Function of Animacy and Cue in mm[4]

Discussion

Multiple mechanisms have been proposed to explain why and how animates are better remembered than inanimates. One mechanism that has been gaining popularity is attentional prioritization (Bugaiska et al., 2019; Leding, 2020; Yang et al., 2012). The aim of the current study was to combine research on animacy with research on directed forgetting and pupillometry, to gain insight into the attentional processes present in the animacy effect. With the use of retro-cues in a directed forgetting paradigm we investigated whether animacy status resulted in differential external and internal attention, at encoding and cueing respectively.

Consistent with the original experiment of Murphy and Castel (2022), our behavioral analysis demonstrated that animacy status influences both selective remembering and directed forgetting in an item-method directed forgetting paradigm with a recognition task. Specifically, accuracy was not only higher for words cued to remember than for words cued to forget, but also for animate words when compared to inanimate words, regardless of the cue. The lack of interaction between animacy and cue shows that words cued to remember, and words cued to forget, were similarly impacted by animacy status. Our pupil analysis showed differential external attention for animate and inanimate words during encoding, with smaller pupil sizes during the viewing of animate words compared to the viewing of inanimate words. Furthermore, our second pupil analysis showed differential internal attention during retro-cue presentation, with larger pupil sizes for to-be-remembered words than for to-be-forgotten words, consistent with the earlier research of Lee (2018) and Scholz and Dutke (2019). However, we found no main effect of animacy during cueing, nor did we find an interaction effect between animacy and cue. This suggests that animacy status has no effect on the differential internal attention during cue presentation.

Murphy and Castel (2022) were the first ones to investigate the animacy effect on selective remembering and directed forgetting. They explained their results with regard to the selective rehearsal account of directed forgetting, in which both to-be-remembered and to-be-forgotten words would be similarly impacted by animacy status because the words receive some initial encoding prior to the cues. In the current study we successfully replicated their original experiment with our behavioral analysis, providing further evidence for the advantage of animacy status on memory, in which animate items are not only better remembered but also less easily forgotten than inanimate items, adding to the functionalist perspective of Nairne et al. (2013, 2017).

The addition of pupillometry allowed us to investigate attentional processes during the experiment, in order to identify attention as a possible proximate mechanism of the animacy effect. Pupillometry has been shown to be a reliable measure of mental effort, arousal, (internal) attention shifts, and attentional prioritization, but research in the semantic domain remains scarce (Koevoet, Naber, et al., 2024; Koevoet, Strauch, et al., 2024; Mathôt, 2018). The results of the current study are consistent with prior pupillometry research on directed forgetting. While we did not find an effect of animacy on internal attentional prioritization during cue presentation, we did find an effect of animacy on external attention during encoding. These results may be consistent with the richness-of-encoding hypothesis. The richness-of-encoding hypothesis suggests that animate words create more distinct memory representations than inanimate words during encoding (Kroneisen et al., 2013). Earlier pupillometry research has demonstrated an intricate interplay between the pupil response and different stages of (visual) attention (Koevoet, Naber, et al., 2024; Koevoet, Strauch, et al., 2024). Koevoet, Naber, et al. (2024) have furthermore suggested that the intensity of external attention (as reflected in pupil constriction) independently predicts the precision of the encoded items. Within this framework, our results could indicate more precise encoding of animate versus inanimate items. This may be further explored with our remember-know-guess (RKG) data, which allows to assess the precision with which items are encoded. The RKG paradigm is a fruitful way to test the richness-of-encoding hypothesis (see

[4] Error bars reflect the standard error of the mean. Values above the midline indicate pupil dilation relative to the baseline, whereas values below the midline indicate pupil constriction relative to the baseline.

Bonin et al., 2014, and Rawlinson & Kelley, 2021) and can be combined with pupillometry to access attentional processes during encoding. Therefore, we may be able to confirm our findings by showing that animate items are indeed encoded with more precision than inanimate items are, by establishing that they receive proportionally more 'know' responses. We also encourage investigations into the robustness and replicability of the animacy effect on pupil size during stimulus presentation, seeing that the effect is rather small and only just meets the conventional criterion for significance (.05) despite a sample size that is considerably larger than many other pupillometry studies.

A limitation of many studies in the animacy literature, as well as the current one, is the possibility of a response bias in recognition data (Louter & Verheyen, 2024). Specifically, a higher accuracy for animate versus inanimate words may reflect a response bias to indicate animate words as "old", as opposed to a true difference in memory. To address this, we suggest the implementation of a two-alternative forced choice (2AFC) task in future research. The 2AFC task is less susceptible to response biases than the more commonly used old/new recognition task, since it is dependent on the entire memory distribution of both old and new items (Brady et al., 2023).

Another limitation of our study is the lack of pupillometry research in the semantic domain. In a review on the usefulness of pupillometry in studies on lexical access, Rojas et al. (2024) suggested that there likely are distinct dilation components related to word recognition and semantics, but that it might prove to be difficult to isolate these from other response components such as cognitive effort, attention, or memory. Thus, while pupillometry can be a useful method to investigate lexical access and semantic activation, definite conclusions cannot yet be drawn about what the pupil response actually reflects during word processing. Even apart from the interpretation difficulties in pupillometry research, the pupil response is a complex measure. Different ways have been proposed to analyze pupil data, and not all of them are equally sensitive. In the current study we analyzed the pupil response by looking at average pupil sizes during the stimulus presentation and retro-cue time windows, respectively. This reduces the complexity of the analysis while retaining the most important information on pupil size, yet variation in pupil dilation is lost. Especially since the pupil response is not yet very well established within the semantic domain, more complex analyses may be desired, such as generalized additive mixed modelling as argued by van Rij et al. (2019).

Our results seem to be consistent with the selective rehearsal account of directed forgetting, through larger pupil sizes for remember cues than forget cues. Yet, we cannot rule out the possibility of other processes within the directed forgetting condition than mere passive decay, such as active inhibition, without the use of a third neutral cue. This would allow us to investigate differential pupil responses in remember and forget conditions when compared to a neutral condition (e.g., ignore cue). Moreover, research suggests that the duration of the delay interval between the cue-onset and the next trial may be critical to distinguish between active inhibition and selective rehearsal accounts, since longer delays may allow participants to selectively rehearse to-be-remembered items while shorter delays may lead to the inhibition of irrelevant items (Fawcett & Taylor, 2008; Scholz & Dutke, 2019). This may also explain the contrasting results of studies indicating that forgetting is more effortful than remembering, since these effortful components in the forgetting condition are often characterized by early brain activity, measured even before cognitive control (Cheng et al., 2012; Gao et al., 2023). It is thus possible that these different mechanisms do not rule each other out but are merely operating at different time scales (Scholz & Dutke, 2019). In the current study, we employed relatively long delay intervals of 3000 ms, which may have allowed participants to selectively rehearse the to-be-remembered items. The downside of using short intervals in pupillometry research is that they prevent effective measuring of the pupil response, which is relatively slow in nature. Yet, future research on directed forgetting should consider the addition of a third neutral cue and multiple delay intervals to investigate the different mechanisms in the directed forgetting condition.

Conclusion

The present study was the first to investigate the animacy effect in a directed forgetting paradigm using pupillometry. The behavioral results indicate a memory advantage for animate items in both selective remembering and directed forgetting, replicating earlier work by Murphy and Castel (2022). Although we found evidence for differential internal attention for remember and forget cues, we did not detect an effect of animacy status during cueing. However, we did find an effect of animacy on external attention during stimulus presentation, with smaller pupil sizes for animate than for inanimate words. This is in line with the richness-of-encoding hypothesis, where animate words are encoded with higher precision than inanimate words, as reflected in pupil constriction. This suggests that animacy status influences not internal but external attention. Altogether, our results seem to suggest that, during encoding, there is a focus of external attention to animates compared to inanimates, possibly associated with increased precision, explaining the animacy effect on memory. Future research is encouraged to further investigate these proximate mechanisms.

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