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THE EFFECT OF ANIMACY IN REPEATED VISUAL SEARCH

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Abstract

Previous research has indicated that animate entities often attract more attention than inanimate ones. The aim of the present work was to examine whether and how stimulus animacy may affect visual search performance and efficiency in a repeated search paradigm. Fifteen participants (10 female, 5 male; *M* = 23.5 years, *SD* = 2.1 years) were asked to search for a target stimulus within displays of three, six, or nine stimuli. The stimuli were pixel images representing animals (e.g., hedgehog, snail, owl; animate condition), objects of common usage (e.g., car, mug, computer; inanimate condition) or upper-case letters (control condition). The stimuli were presented on a computer screen in the form of a circle with a radius of 8° around the center point. At the beginning of each trial, the target was presented at this center point, and the participants' task was to locate this target in the peripheral circle and to click on it as quickly and accurately as possible. The target was always present. Furthermore, the search display stayed either the same within a block of 90 searches (repeated display) or changed after each search (unrepeated display). All three factors (stimulus type, search condition and set size) were varied block wise, resulting in 1620 searches (18 blocks of 90 trials) for each participant in total. The order of the blocks was randomized for each participant. Manual response times revealed that participants needed longer to find an animate target than an inanimate and letter target in a changing search environment, while, in repeated displays, such a disadvantage for animates occurred only in larger displays. In addition, animacy had some impact on search efficiency, regardless of whether the search was repeated or not. Together, these results suggest that stimulus animacy may affect visual search performance negatively, especially in changing search environments.

Keywords: *Visual search, animacy, attention.*

1. Introduction

Imagine you are sitting on the couch and looking for a book on the bookshelf. The process you must execute for finding the book is visual search, which is defined as the search for a desired object (the target), among irrelevant objects (the distractors). In visual search paradigms, a target stimulus is usually presented visually or auditorily and the participant's task is to find it among a varying number of distractors (e.g., Eckstein, 2011; Wolfe, 2020). If the target differs from the distractors in more than one dimension (e.g., when searching for a red square in a display of green squares and red circles), the search times typically increase with the number of distractors in the display (Treisman & Gelade, 1980). In contrast, if the target and the distractors differ in only one dimension (e.g., when searching for a red square among green squares), the number of distractors usually does not affect search time. Previous research has indicated that we can keep track of object locations we have already searched through (e.g., Kristjánsson, 2000) and can utilize information of previously inspected distractors to speed up a search if we must search the same display once again (Höfler, Gilchrist, & Körner, 2014, 2015; Körner & Gilchrist, 2007). Also, when the same search display is repeatedly presented for several times, response times decrease over time compared to a situation when the displays changes partially or fully after each trial (Solman & Smilek, 2010). This suggests that stable environments not only foster the use of memory during a visual search but also build memory for distractors inspected during the search. However, other findings showed no evidence that repeated visual search was supported by memory processes when a localization task ("where is the always present target located?") compared to a two-alternative forced-choice task ("is the target absent or present?") was used (Kunar, Flusberg, & Wolfe, 2008).

While there is much research on the question of how memory processes affect (repeated) visual search performance, only a few studies addressed the questions of whether and how animacy of the stimuli might influence a (repeated) search. New, Cosmides, and Tooby (2007) proposed the animate-monitoring hypothesis, suggesting that attention is stronger and faster allocated to human and non-human animals as compared to non-living objects. Indeed, with regard to several non-search tasks, stimulus animacy has been identified as an important factor for task performance (e.g, Bailey & Lang, 2022; Bonin, Gelin, & Bugaiska, 2014; Calvillo, & Hawkins, 2016). For instance, in an inattentional blindness task, Calvillo and Jackson (2014) showed that participants detected unexpected objects more frequently when these objects were animate than inanimate, and more frequently when they were under a low vs. high perceptual load. Also, using an RSVP task to test for attentional blink, Guerrero and Calvillo (2016) showed that animate objects were detected more often than inanimate objects. With regard to visual search, one of the few papers that addressed animacy were Loucks, Reise, Gahite, and Fleming (2023). In their Experiment 1, they showed that participants found an animate (mammal or non-mammal) target faster compared to an inanimate target. In contrast, Long, Störmer, and Alvarez (2017) showed that participants needed *more* time to find an animate than an inanimate target (Experiment 1). However, animate targets were still found faster when embedded among inanimate vs. animate distractors. In the current experiment, we aimed to test whether and how animacy of the target object may influence search performance and efficiency when a display is searched repeatedly. To this end, we adopted the experimental design from Kunar et al. (2008) and had participants search a repeated or unrepeated displays 90 times for a target stimulus that was always present. The displays included either three, six, or nine items which were either animate or inanimate objects or letters for control. In line with previous research, we expected that the search for animate objects should be overall faster than the search for inanimate objects and letters (Loucks et al., 2023) and that participants should be faster and more efficient irrespective of whether the search was repeated or unrepeated (Kunar et al., 2008).

2. Methods

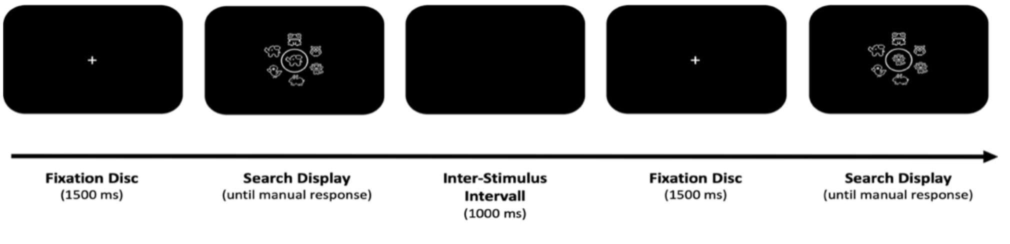
2.1. Participants

Fifteen participants (10 female, 5 male; M = 23.5, SD = 2.1) took part in the experiment. The sample size was determined based on the sample used in Kunar et al. (2008). All participants were right-handed and had normal or corrected-to-normal vision. They gave written informed consent prior participation. The experiment was approved by the ethic committee of the University of Graz.

2.2. Stimuli, design, & procedure

All stimulus images were in the size of 22 x 22 px (0.9°) and presented in gray (RGB: 140/140/140) on a black background (see Figure 1). The letter stimuli were upper case letters randomly sampled from 22 letters of the Roman alphabet (I, L, M, and W were omitted) and presented in Arial using Adobe Photoshop Elements 9. Both the animate and inanimate images were pixel images created with Gimp 2.8. All animate stimuli were animals (e.g., hedgehog, snail, owl) while the inanimate stimuli were objects of common usage (e.g., car, mug, or computer). The experimental setup was created using Experiment Builder 1.10.165 (SR Research). Participants sat in a quiet, darkened and sound-proof cabin approximately 63 cm away from a 21” monitor (resolution: 1152 x 864 pixel). A chin rest was used to minimize head movements. At the beginning of a trial, a central fixation cross was presented for 1500 ms, followed by the search display that consisted of three, six, or nine search objects (letters, animate, or inanimate objects), positioned evenly around the circumference of an imaginary circle with a radius of 8°, centered on fixation (see Figure 1). The target was presented in the center of this circle. Participant’s task was to locate the – always present – target in the peripheral circle and respond to it via mouse click as quickly and accurately as possible (see Kunar et al., 2008). We measured participant’s search times from the onset of the search display until the mouse click. After this, the display was cleared for 1000 ms and a new trial started. In the repeated condition, the display remained the same throughout one block of 90 trials, while in the unrepeated condition, a new display was presented in each trial. All three factors (stimulus condition, search condition and set size) were varied within subject and presented block wise in a random order. This resulted in 1620 searches (18 blocks of 90 trials) for each participant in total. The entire session lasted approximately 90 minutes.

Figure 1. Sequence of events in a trial (set size 6, animate & repeated condition).



3. Results

3.1. Error analysis

A search was considered as correct if a participant clicked via mouse on the correct object in the outer circle within a radius of 20px from the center of the target. Across individual means, the error rates were generally low (unrepeated condition: 1.6% – 7.3%; repeated condition: 1.7% – 8.9%). A 2 (Search) x 3 (Stimuli) x 3 (Set Size) repeated-measures analysis of variance (ANOVA) showed significant main effects of Search, $F(1,14) = 4.97$, $p = .043$, $\eta^2_p = .26$ with a slightly higher error rate in the repeated ($M = 8.9$, $SD = 1.7$) than in the unrepeated condition ($M = 7.3$, $SD = 1.6$, and Set Size, $F(1.35, 19.03) = 5.22$, $p = .025$, $\eta^2_p = .27$ (Greenhouse-Geisser corrected). However, posttests (Bonferroni-corrected *t*-tests) showed no difference between any set sizes. Also, neither the third main effect of Stimuli nor any interaction reached significance (all *p*s > .05). For the following analysis, we included only trials in which the target was found correctly and in which the individual search times were within the range of 2.5 standard deviations from the group mean (91.3% of all searches).

3.2. Response times

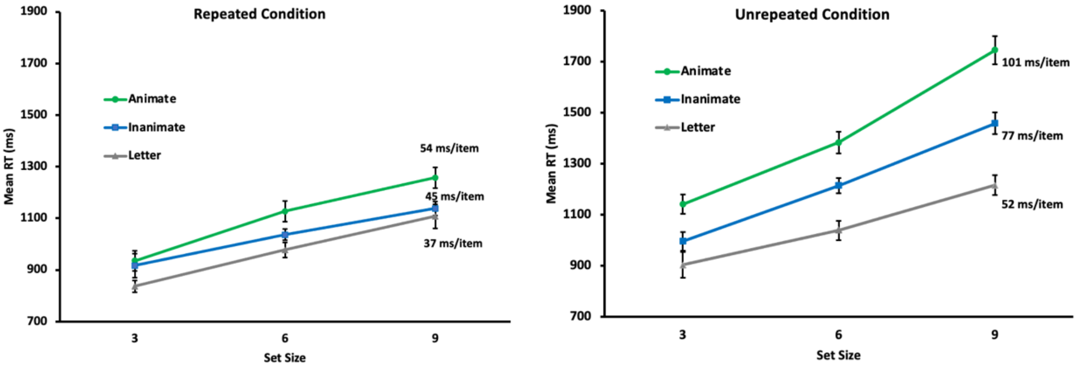
Average response times regarding the different conditions are shown in Table 1. For analysis, we conducted two within-subjects ANOVAS separately for the two search conditions (repeated, unrepeated).

Table 1. Average response times (standard deviations) for the repeated and unrepeated condition, depending on stimulus type (animate, inanimate, letters) and set size.

		Set size		
Condition		3	6	9
Repeated	Animate	936 (140)	1128 (121)	1257 (135)
	Inanimate	917 (117)	1037 (141)	1138 (137)
	Letters	837 (124)	977 (135)	1108 (170)
Unrepeated	Animate	1142 (130)	1384 (178)	1746 (207)
	Inanimate	997 (131)	1215 (156)	1459 (211)
	Letters	904 (128)	1040 (142)	1217 (193)

A 3 (Stimuli) x 3 (Set Size) within-subjects ANOVA for the repeated condition showed significant main effects of Stimuli, $F(2, 28) = 31.75$, $p < .001$, $\eta^2_p = .69$ and Set Size, $F(1.39, 1.42) = 119.32$, $p < .001$, $\eta^2_p = .90$. The interaction was also significant, $F(4, 56) = 3.17$, $p = .020$, $\eta^2_p = .19$. Bonferroni-corrected t-tests showed that, for all set sizes, a letter target was always found faster than an animate or inanimate target (see Figure 2, left). This might be due to the increased stimulus complexity of both animate and inanimate stimuli compared to the letter stimuli. More interestingly, while we did not find any differences in response times between animate and inanimate targets for set sizes three and six, for set size nine, participants needed significantly more time to find an animate target than an inanimate target, $t(14) = 5.79$, $p = .002$. This suggests that the effect of animacy was more likely to come into play when a more demanding search - as it is the case for larger displays - had to be performed.

Figure 2. Mean response times (RT) for each set size (3, 6, 9) and search efficiency (ms per item) for the repeated (lef) and unrepeated (right) search condition. Error bars represent the normalized 95% confidence intervals (Cousineau, 2005; Morey, 2008).



In the unrepeated search condition, a 3 (Stimuli) x 3 (Set Size) within-subjects ANOVA showed significant main effects of Stimuli, $F(1.22, 17.08) = 142.80$, $p < .001$, $\eta^2_p = .91$ and Set Size, $F(2, 28) = 254.30$, $p < .001$, $\eta^2_p = .95$. The interaction was also significant, $F(4, 56) = 23.60$, $p < .001$, $\eta^2_p = .63$. Again, Bonferroni-corrected *t*-tests were applied as posttests. As in the repeated condition, a letter target was found faster than an animate or inanimate target for all set sizes, reflecting a basic effect of stimulus complexity. However, in contrast to repeated searches, participants needed more time to find an animate than an inanimate target regardless of set size. This suggests that, when participants always searched a new search display, object's animacy might have already affected the search even in smaller displays.

3.3. Search efficiency

To analyze the search efficiency for the repeated and unrepeated search condition, we calculated the search slopes by plotting the reaction times against the set size for each type of stimuli (see Figure 2). The slope represents the additional cost of each item added in a display. That is, a shallow slope can be interpretated as an efficient search in contrast to a steeper slope which indicates a more inefficient search. In the repeated condition, a one-way ANOVA showed significant main effects of Stimuli, $F(2, 28) = 5.74$, $p = .008$, $\eta^2_p = .29$. Bonferroni-corrected *t*-tests showed only a steeper slope for animate compared to inanimate targets, $t(14) = 3.86$, $p = .005$. No difference was found between letter targets and animate ($p = .399$) or inanimate targets ($p = .384$). Also, in the unrepeated condition, we found a significant effect of stimuli, $F(1.43, 19.99) = 41.30$, $p < .001$, $\eta^2_p = .75$ with steeper slopes for animate ($M = 101$ ms, $SD = 21$ ms) than for inanimate targets ($M = 77$, $SD = 21$, $t(14) = 3.65$, $p = .007$) or for letters ($M = 52$, $SD = 19$, $t(14) = 8.52$, $p < .001$). Furthermore, we found also steeper slopes for inanimate targets than for letters, $t(14) = 7.42$, $p < .001$. Together, these results again suggest that participants were more inefficient when searching for aminates than for inanimate stimuli regardless of whether the search display was repeated or unrepeated.

4. Discussion

The aim of this paper was to examine whether and how stimulus animacy affects performance and efficiency in a repeated visual search paradigm. While Loucks et al. (2023) found a benefit for animate compared to inanimate stimuli in a visual search task, in our study, we basically found the opposite effect. Except for smaller repeated displays, in which searches lasted equally long for both categories, search performance was worse for animates than for inanimates in all other cases. One reason for this inconsistent finding might be that Loucks et al. presented two target templates (one animate, one inanimate) prior the search display which both required attentional and working-memory resources. Based on the animate monitoring hypothesis (New et al., 2007), the animate target may have attracted more attention in their experiment, which may have in turn led to a preference for animate over inanimate stimuli also in the subsequent (mixed) search display. In our experiment, no such prioritization effects and selective guidance, respectively, were possible because we presented a unique target template before search and the display always consisted of the same stimulus category.

On the other hand, we replicated the results from Long et al. (2017) who showed that, overall, participants needed longer to find animate compared to inanimate targets when searching in either uniform displays (i.e., all stimuli of the same category) or mixed displays (i.e., stimuli of different categories). Still, the disadvantage of animate objects over inanimate objects in terms of search performance in our case contradicts the expectation that animacy leads to attentional capture. However, when Bugaiska et al. (2019) had participants perform an animacy Stroop task, they found that participants also took longer to name the color of the ink color of an animate word compared to an inanimate word, irrespective of whether the response was orally or manually. They argued that the more pronounced interference for animate words is because they do automatically capture more attention such that it takes participants longer to overcome the task-irrelevant feature of the stimulus. Also, when testing for the effect of reward stimuli, Watson et al. (2020) showed that participants' disengagement from high-reward distractors was delayed as it took them longer to look away from these distractors. Accordingly, in our study, the disadvantage for animates might be also caused by a delayed disengagement from these stimuli. That is, participants might have needed longer to disengage from the centrally presented animate vs. inanimate target to initiate the search processes. As we neither tracked the eye movements nor the mouse movements of the participants during the search, we cannot test these assumptions conclusively. Also, the stimulus categories used in this experiment were selected on an ad hoc basis. Hence, we cannot rule out that factors such as e.g., low-level stimulus features (e.g., visual properties) or emotional characteristics of the stimuli influenced the observed findings. Future research is therefore necessary to address these issues.

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