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Visual Cognition

ISSN: 1350-6285 (Print) 1464-0716 (Online) Journal homepage: http://www.tandfonline.com/loi/pvis20

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VISUAL COGNITION
https://doi.org/10.1080/13506285.2018.1508102

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Attention capture during visual search: The consequences of distractor appeal, familiarity, and frequency

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ABSTRACT
Visual distractions can lure our attention and impede our everyday performance, especially if they are highly meaningful and appealing to the observer. The current research assessed how semantically rich, personally relevant distractors (i.e., cartoon characters), either appealing or neutral, capture attention and whether the frequency with which we encounter these distractors can impact the effects. Participants were slower to identify a target letter in the presence of a neutral distractor relative to an appealing distractor, reflecting covert attentional capture. However, this effect reversed when appealing distractors appeared less frequently than neutral distractors. Collectively, the evidence suggests that the amount of capture observed overall likely depends on the interplay between a distractor's semantic salience (i.e., the amount of meaningful knowledge an observer has about the distractor), its affective salience (i.e., how the observer feels about the distractor), and how frequently it is encountered.

ARTICLE HISTORY
Received 26 September 2016
Accepted 25 July 2018

KEYWORDS
Visual attention; attention capture; affect; frequency; eye movements

Everyday we are confronted with things in our environment that compete for our attention. The ability to ignore distracting, task-irrelevant items can facilitate our ability to successfully search for and identify the task-relevant target items within a cluttered space. Doing so requires precise coordination of many aspects of cognition, such as visual attention, perception, and memory (e.g., Eckstein, 2011; Nakayama & Martini, 2011). Frequently, however, irrelevant distractors will capture attention, which can slow search performance and increase the frequency of errors. These impairments are particularly problematic for real-world applications of visual search, such as airport security, radiology, childcare, and many others. Therefore, to mitigate negative occupational and everyday life consequences, it is important to better understand the conditions in which appealing distractors will capture our attention.

There are a variety of factors that determine whether attention will involuntarily shift to task-irrelevant distractors – a process referred to as attentional capture (Theeuwes, 1992, 2010). For example, visually salient items can capture attention, such as those that appear abruptly (e.g., Brockmole & Henderson, 2005a, 2005b; Jonides & Yantis, 1988; Yantis & Jonides, 1990) or that are a unique colour (e.g., Matsukura, Brockmole, & Henderson, 2009; Theeuwes, 1992, 1994; Theeuwes & Burger, 1998). However, these effects are often contingent on whether distractors share similar bottom-up properties with target items (e.g., Anderson & Folk, 2012; Bacon & Egeth, 1994; Folk & Remington, 1998; Folk, Remington, & Johnston, 1992; Folk & Remington, 2006; Gibson & Jiang, 1998; Gibson & Kelsey, 1998; Wyble, Folk, & Potter, 2013) or how frequently they occur in sequence (e.g., Lamy, Antebi, Aviani, & Carmel, 2008; Maljkovic & Nakayama, 1994; Olivers & Humphreys, 2002; Pollmann et al., 2003; Watson & Humphreys, 1997, 1998, 2000; Watson, Humphreys, & Olivers, 2003). Semantic associations can likewise direct attention: distractors that are semantically associated with a target item are more quickly and accurately identified than unrelated distractors (e.g., attention is involuntarily directed to a monkey when the target is a banana; De Groot, Huettig, & Olivers, 2016; Moores, Laiti, & Chelazzi, 2003) – especially when these items appear in the same visual hemifield (Telling, Kumar, Meyer, & Humphreys, 2010). Collectively, these findings indicate that attention is subject to being captured by irrelevant distractors that are visually salient, infrequent, or share some visual and/or semantic overlap with targets.

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Although attentional capture is often contingent on visual or semantic similarities across distractor and target items, semantically informative distractors can capture attention even if they differ from target items in location, physical features, and identity (Forster & Lavie, 2008a, 2008b). For example, in a situation in which participants searched for a target letter within a defined search area, Forster and Lavie (2008b) demonstrated that a meaningful cartoon character presented outside the search area captured attention more than less meaningful, amorphous figures (Forster & Lavie, 2008b). A conclusion that can be drawn from these findings is that semantic richness, even when irrelevant to a task at hand, is a powerful magnet for attention and that increasing semantic meaning among irrelevant distractors increases attentional capture. However, Biggs, Kreager, Gibson, Villano, and Crowell (2012) noted that the situation may be more complicated. They argued that increasing a distractor's semantic meaning could also generate affective value if an observer possessed a personal investment or sentiment for the stimuli, such as a beloved cartoon character. Under this argument, affective value mediates effects of semantic meaning on attention capture. The confound of meaning and affect could be present in previous studies (i.e., Forster & Lavie, 2008a, 2008b), which utilized well-known cartoon characters from popular media as "meaningful" stimuli that may have also prompted affective responses.

The confound between meaning and affect denotes a challenge to disentangle experimentally. Specifically, a highly meaningful stimulus is likely to evoke some form of affect, and positive or negative affect may not fully develop without the individual first knowing what the stimulus represents. In a first step to separate semantic meaning and personal appeal, Biggs et al. (2012) showed that participants who were provided detailed information about an otherwise meaningless symbol were *less* distracted by that symbol in a visual search task than participants who were not previously informed of the symbol's meaning. Therefore, the authors argued that increasing an observer's semantic understanding of a particular distractor – thus, increasing the distractor's meaningfulness – could actually *decrease* the corresponding attentional capture. Biggs et al. (2012) went further to show that capture by more meaningful distractors can be restored if they are also appealing. Specifically, avid baseball fans were equally distracted by their favourite (appealing) team's logo and by a team's logo that they did not already know (meaningless). These findings suggest that a highly meaningful distractor will maintain its capacity to capture attention if it is also highly appealing to the observer. As such, Biggs et al. (2012) concluded that the degree to which a distractor will capture attention depends on the interplay between its semantic salience (i.e., the amount of meaningful knowledge an observer has about the distractor) and its affective salience (i.e., how the observer feels about the distractor). Higher levels of semantic salience actually decrease capture, whereas higher levels of affective salience increase capture. Therefore, the authors argued that the amount of capture observed overall depends on where a distractor falls along these two competing dimensions.

Despite the progress made by Biggs et al. (2012), a question remains as to how affective salience impacts rates of attentional capture independently of semantic salience. Biggs et al. (2012) compared distractors that were high in both semantic and affective salience to distractors that were low in both semantic and affective salience. Hence, it is unknown how affective salience impacts attentional capture when semantic salience is held constant. To what extent will appealing distractors capture attention in comparison to neutral distractors (distractors that observers find neither appealing nor unappealing) when both distractors are equally meaningful to the observer? The purpose of Experiment 1 was to answer this question by examining how increasing affective salience of non-target distractors might affect attentional capture when their semantic salience is held relatively constant in a visual search task.

According to Biggs et al. (2012), appealing distractors (i.e., high affective salience) should capture attention more than neutral distractors (i.e., low affective salience). This prediction is also supported by research suggesting that attention can be biased toward positive-emotion stimuli (Brosch, Sander, & Scherer, 2007; Brosch, Sander, Pourtois, & Scherer, 2008), especially when the distractors are highly relevant to the observer (Field et al., 2007; Field, Mogg, Zetteler, & Bradley, 2004; Harris et al., 2018; Ro, Friggel, & Lavie, 2009). However, to preview our findings, we show that this prediction does not hold. Experiments 2 and 3 then investigated possible reasons for this incongruity. Experiment 2 focused on effects of attentional disengagement and Experiment 3 focused on effects of distractor frequency. Our findings will suggest that the amount of capture observed depends on where the distractor falls along the competing dimensions of semantic salience, affective salience, and how frequently observers experience the distractor, and that these factors need to be considered together when attempting to understand the conditions in which everyday distractors will capture our attention.

Experiment 1

Experiment 1 assessed the role of personal appeal on attentional capture independent of semantic salience. Several measures were taken to hold semantic salience relatively constant while varying affective salience. First, participants in this study were self-identified devout fans of the popular Pokémon franchise, which consists of an animated series, movies, books, and games centred on fictional creatures called Pokémon. Because Pokémon is popular among college-aged adults, the franchise provides a suitable fan base with substantial knowledge about a wide variety of characters. Moreover, Pokémon fans by definition have at least some positive affect for the characters in question. This combination of high knowledge and variable affect for different characters provides an appropriate set of distractors for Experiment 1. Secondly, prior to the task participants selected two Pokémon from a group of 151 possible characters. They selected one character as their personal favourite (appealing distractor) and one character for which they felt no emotional appeal (neutral distractor), thus, varying the affective salience of the distractors. Critically, participants were instructed to choose characters they knew equally well to minimize differences in the semantic salience of the characters.

The measures taken in the current research to hold semantic salience relatively constant were designed so that participants would view a personally appealing distractor and an equally meaningful neutral distractor. This approach is notably different from using a simpler neutral distractor (e.g., a real world object) because the neutral Pokémon characters should have similar backstories and potential meaning as the appealing characters – only without the corresponding increase in positive affect. Thus, appealing and neutral distractors should vary more in affective salience than semantic salience. Given the highly integrated relationship between semantic and affective salience, however, we considered the possibility that participants might be unable to self-select appealing and neutral distractors that are truly equal in semantic salience. Therefore, participants also completed a post-task survey that quantified the appeal and familiarity of the chosen characters. Differences in familiarity ratings between individuals' selected appealing and neutral characters were used as covariates in the analyses to statistically control for any possible lingering effects of semantic salience.

In the main task, participants searched for target letters among non-target letters, with the appealing and neutral characters appearing as distractors in the periphery on some trials. If appealing distractors capture attention more than equally meaningful neutral distractors, it was expected that search performance would be slower in appealing-distractor trials as opposed to neutral-distractor trials. Eye movements were recorded during the visual search task to provide an additional index of attentional capture and to determine whether distractors captured covert or overt attentional processes. If distractors capture attention overtly, eye gaze would be directed to the distractors when attention is captured (e.g., Brockmole & Henderson, 2005a, 2005b; Theeuwes, De Vries, & Godijn, 2003; Theeuwes, Kramer, Hahn, & Irwin, 1998; Theeuwes, Kramer, Hahn, Irwin, & Zelinsky, 1999). If so, and if appealing distractors were to capture attention more than neutral distractors, it was predicted that saccades would be directed to the appealing distractors more often to than the neutral distractors. Furthermore, eye gaze might progress less efficiently to the target letter when the appealing distractor is present, as distractors can reduce the proportion of correct saccades toward target items (Van Zoest, Donk, & Theeuwes, 2004). That said, because participants were instructed to maintain gaze on the centre of the screen, they might rarely look toward the distractors or the target letters. Any differences in search performance would then be best explained by covert attentional mechanisms.

Methods

Participants

Participants were twenty college-aged adults (*M* age $= 20$ years, $SD = 1.1$ years, female $= 8$) from the

University of Notre Dame who volunteered for course credit.[1] Participants were recruited with the following advertisement:

> "Do you love Pokémon? Can you name all of the original 151? Do you play the games, collect the cards, and watch the show? If so, then this study is for you! You must love Pokémon to participate in this study!"

Therefore, participants were self-selected Pokémon fans who reported being very familiar with each of the characters and actively engaged with Pokémon related activities.[2]

Stimuli and apparatus

The main task was to search for an X or an N among an array of letters. Each search display consisted of six letters arranged in a circle with a radius of 2.7°. Search arrays were presented at the centre of the display. The arrays contained five O's and either an X or an N (i.e., the *target*). Low perceptual load displays were used to encourage attention capture (Lavie, 1995; 2005; Lavie & Cox, 1997; Khetrapal, 2010; Murphy, Groeger, & Greene, 2016), the rate of which we could then assess across distractor types. All letters were presented in 20 point Calibri black font. On half of the trials, a single task-irrelevant cartoon character (i.e., the *distractor*) was presented. These distractors were pre-selected by each participant from a set of 151 cartoon characters from the Pokémon franchise (see details regarding the selection process below). Distractor images were presented in colour and subtended 4.5° × 4.5° and appeared 8.5° to either the left or the right of the centre of the display.

Stimuli were presented on a 22″ LCD monitor with a screen refresh rate of 60-Hz. Throughout the task, participants' eye movements were sampled at a rate of 1,000 Hz using an EyeLink 2 K eye tracking system (SR Research, Inc.). A chin and forehead rest maintained a viewing distance of 57 cm. The eye tracker was calibrated using nine-point-calibration at the beginning of the experiment. A one-point calibration was used before each trial to correct for drift in the eye tracker signal over time. Responses were registered by pressing one of two keys on a standard QWERTY keyboard.

Procedure

After providing informed consent, participants were asked to identify one Pokémon character that was extremely appealing to them. To do this, each participant was instructed to chose one character that they would rank a 9 on a 1-9 Likert scale (1 representing strong dislike and 9 representing strong positive appeal). We refer to this character as the *appealing distractor* within the search task. Participants were then instructed to identify one Pokémon character that they ranked a "5" on the same Likert scale. It was stressed to participants that this second Pokémon character needed to be one that they knew well, were familiar with, but had no positive or negative feelings toward. We therefore refer to this character as the *neutral distractor* within the search task. Hence, the distractors used during the search task were chosen on a participant-by-participant basis.

On each trial, participants first fixated on a black dot in the centre of the screen and pressed the space bar to begin each trial (i.e., one-point eye tracking calibration). As illustrated in Figure 1a, this dot was replaced by a central fixation cross. Participants were instructed to maintain fixation at this location for the duration of the trial. After 1,000 ms, the fixation cross was replaced by the search display, which remained on the screen for 8,000 ms or until the participant responded. On 50% of the trials, the distractor image appeared either to the left or the right of the search display, with appealing and neutral distractors appearing equally often. Participants were instructed to identify the target letter as quickly and accurately as possible while ignoring all other stimuli.

Participants completed 10 practice trials to ensure their understanding of the task and procedures. Data from these practice trials was not recorded. Following practice, participants completed 5 blocks of experimental trials. Target letter (X or N) was counterbalanced with distractor type (appealing or neutral) and distractor location (left or right) with a repetition factor of 15, yielding a within-block total of 120 trials and an across-experiment total of 600 trials. Accuracy and response times (RT) in milliseconds were recorded. To measure attentional costs associated with distractors (i.e., capture), we subtracted the average RT for distractor-absent trials from the average RT for trials with distractors for each distractor type on a subject-by-subject basis. Similarly, average error rates for distractor-absent trials were subtracted from average error rates for trials with distractors for each distractor type.

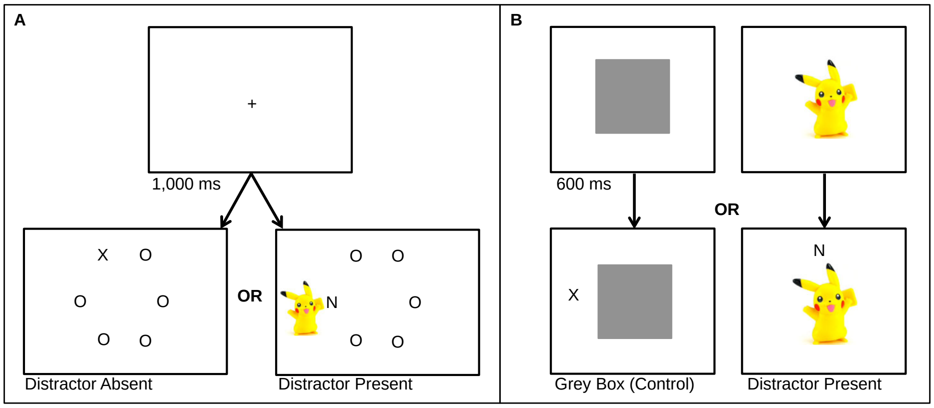

Figure 1. (A) Example trial sequence for Experiments 1 and 3. (B) Example trial sequence for Experiment 2. Distractor images appeared in the same colour as used in the Pokémon franchise. The character displayed here was taken from Shutterstock (https://www.shutterstock.com), a photography company that provides royalty-free images. For images used in the actual experiment, see https://www.pokemon.com/us/pokedex.

After the search task, each participant completed a demographic and opinion survey (see **Appendix A**). The purpose of this survey was two-fold. First, we wanted to quantify the appeal and familiarity of the distractors chosen by each participant. To do this, using a 1-9 Likert scale, participants rated the appeal and familiarity of each distractor they selected for the task (cf., Xie & Zhang, 2017). Second, we wanted to characterize the participant sample in terms of knowledge and engagement with Pokémon and its related activities. Using the same Likert scale, participants reported how familiar they were and how well they liked the Pokémon franchise in general. Participants also reported how often they participated in Pokémon related activities. These responses were referenced for descriptive purposes only and not included in any analyses (see **Appendix B**).

Results

The results are divided into three sections. First, we discuss findings from the survey of participant attitudes toward Pokémon. Second, we discuss responses (both RT and accuracy) in terms of the attentional costs associated with appealing and neutral distractors. Finally, we discuss eye movement behaviour and its relationship to responses.

Survey

Three participants reported a rating of 5 or less in both familiarity and liking for Pokémon in general. These participants were excluded from further analyses, as they did not meet any reasonable criteria of being classified as a Pokémon fan. Therefore, seventeen participants total were included in the survey and response analyses.

The survey results verified our manipulation of distractor appeal. A Wilcoxon Signed-rank test showed that participants ranked their favourite characters ($M = 8.35$, $SE = .19$) as more appealing than their neutral character ($M = 5.06$, $SE = .20$), $Z = -3.64$, $p < .01$. However, the survey also showed that participants were more familiar with the appealing distractors ($M = 8.00$, $SE = .26$) than the neutral distractors ($M = 6.65$, $SE = .35$), $Z = -2.98$, $p < .01$. Whether this difference arose from a misunderstanding of the survey question, a failure to follow instructions, or an objective difficulty in separating semantic and affective salience is unknown. In any case, we must acknowledge that participants may not have chosen characters that were equally familiar. To control for this inequality, differences in familiarity ratings between each participant's favourite character and chosen neutral character was treated as a covariate in the following analyses. See **Appendix C** for information about specific Pokémon characters selected as appealing versus neutral stimuli.

Responses

Average accuracy on the search task was 98% ($SE = 2\%$). A one-way within-subject analysis of covariance (ANCOVA) for cost in error rates with the difference in distractor familiarity as a covariate showed that accuracy costs were equal across appealing-distractor ($M = -.001\%$, $SE = .003\%$) and neutral-distractor ($M =$

−.001%, $SE = .003\%$) trials, $F(1,15) < 1$, and there were no effects of distractor familiarity, $F(1,15) < 1$.

Only correct responses were used for RT analyses. A one-way within-subject ANCOVA for RT costs with the difference in distractor familiarity as a covariate revealed a main effect of distractor type, $F(1,15) = 4.84$, $p = .044$, $\eta_p^2 = .244$. Surprisingly, neutral-distractor trials showed a greater RT cost ($M = 23.6$ ms, $SE = 5.44$ ms) than appealing-distractor trials ($M = 12.8$ ms, $SE = 5.05$ ms). These effects of distractor appeal did not vary across differences with distractor familiarity; $F(1,15) < 1$. These findings indicate that the neutral distractors slowed RT more than the appealing distractors relative to trials on which no distractors were present. As such, affective appeal seems to be *inversely* related to attention capture.

One important alternative possibility to consider is that neutral and appealing distractors have differences in visual characteristics that are known to capture attention. Given the wide wide variety of characters selected (**Appendix C**) it would be unlikely that such systematicity would be present in our stimuli. That said, data trumps conjecture. While it would be difficult assess every possible featural difference, we aimed to evaluate the strength of this alternative explanation by considering the degree to which luminance, one potent visual factor known to evoke attention capture (e.g., Turatto & Galfano, 2000) may have differed across distractor types. For each selected character, we calculated average luminance on a normalized 0-1 scale, with larger values indicating greater luminance. A paired sampled *t*-test showed no difference between appealing ($M = .372$, $SE = .057$) and neutral distractors ($M = .404$, $SE = .019$), $t(16) = -1.42$, $p = .174$. Furthermore, when the difference between luminance scores of appealing and neutral distractors was included as an additional covariate in the ANCOVA analyses reported above, the main effect of distractor type persisted, $F(1,14) = 3.97$, $p = .066$, $\eta_p^2 = .221$, and the effects of distractor appeal did not vary across differences in distractor luminance, $F(1,14) < 1$. These findings indicate that differences in luminance across distractor types did not account for differences in RT and belittles the possibility that visual factors (rather than affective ones) drove the capture effects previously described. Therefore, we think it is unlikely that physical characteristics of preferred stimuli alone can fully account for the differences in RT across appealing- and neutral-distractor trials.

Eye tracking

Eye movements were recorded during the visual search task to determine whether covert or overt attentional processes explained differences in RT between appealing-distractor and neutral-distractor trials. Saccades were operationally defined as changes in recorded fixation position that exceeded 0.2° with either (a) a velocity that exceeded 30°/s or (b) an acceleration that exceeded $9{,}500°/s^2$. A total of fourteen participants were included in the eye tracking analyses, as three participants were removed due to error in the initial calibration process. Only trials with correct responses were analyzed.

Eye gaze away from central fixation: Despite instructions to the contrary, participants moved their eyes away from the central fixation point (area subtending $1.6° \times 1.6°$) on 68% of all correct trials. In this context, *gaze costs* were measured by subtracting the percentage of distractor-absent trials on which gaze moved away from fixation from the percentage of appealing and neutral trials on which gaze moved from fixation, respectively. A one-way within-subject ANCOVA with the difference in distractor familiarity as a covariate revealed no difference in these attentional costs ($M = 68\%$, $SE = 8\%$ for neutral-distractor trials and $M = 64\%$, $SE = 8\%$ of appealing-distractor trials), $F(1,12) = 2.17$, $p = .166$, $\eta_p^2 = .153$. Furthermore, there was no interaction with differences with distractor familiarity, $F(1,12) < 1$. These findings indicate that participants were equally likely to look away from central fixation across neutral-distractor and appealing-distractor trials.

Given the high frequency with which participants looked away from the central fixation point, we also considered the elapsed time between the onset of the search array and the first saccade across conditions. Across all trials, participants' gaze lingered at the central fixation point for 187 ms, on average. *Saccade initiation costs* were measured by subtracting the average dwell time for distractor-absent trials from the average dwell time for distractor trials for each distractor type. A one-way within-subject ANCOVA with the difference in distractor familiarity as a covariate showed that saccade initiation costs were equal across neutral-distractor ($M = -7.32$ ms, $SE = 5.62$ ms) and appealing-distractor ($M = -.709$ ms, $SE = 5.44$ ms) trials, $F(1,12) < 1$, and there was no interaction with distractor familiarity, $F(1,12) < 1$. These findings suggest that distractors did not influence when the eyes moved away from central fixation. Considered collectively, these findings indicate that the RT costs associated with distractor presence were not related to gaze when considering the frequency and speed of initial eye movements away from the starting fixation point at the beginning of the trial. We next consider whether differences in RT between appealing- and neutral-distractor trials could be explained by differences in the allocation of gaze to the peripheral distractors.

Eye gaze to distractors: Any difference in how often participants looked at appealing and neutral distractors could account for differences in search RT. In trials containing a distractor (regardless of distractor type), participants fixated on distractors on only 2% of trials, with eight participants fixating distractors on less than 1% of trials. By comparison, in distractor-absent trials, the regions of the screen that could be occupied by distractors on distractor-present trials were on average fixated on .10% ($SE = .10\%$) of trials. Therefore, differences between distractor present and distractor absent trials could not be meaningfully calculated, and, thus, we only analyzed distractor-present trials. A one-way within-subject ANCOVA with the difference in distractor familiarity as a covariate showed no difference in the rates with which distractors were fixated across neutral-distractor ($M = 2\%$, $SE = .72\%$) and appealing-distractor ($M = 3\%$, $SE = 2\%$) trials; $F(1,12) = 1.12$, $p = .311$, $\eta_p^2 = .085$. No interaction with distractor familiarity was observed; $F(1,12) < 1$. As such, findings show that participants rarely looked at the distractors regardless of distractor type, and, when they do, each type of distractors was fixated at equal rates. Thus, overt shifts of attention to distractors could not adequately account for observed differences in search RT.

Although participants rarely looked at distractors, it is nevertheless possible that distractors had some influence on gaze. That is, participants may have initially looked in the direction of distractors while not fixating on the distractors directly. To examine this possibility, we analyzed trials on which 1) the eyes moved away from central fixation, 2) a distractor was present, and 3) the distractor and the target letter appeared on opposite sides of the display. This allowed for a clear assessment of whether the first saccade away from central fixation initially moved in the direction of the distractor. In total, only 7% of all trials were analyzed. The percentage of trials with the first saccade away from central fixation moving in the direction of the distractor within each trial type was calculated. A one-way within-subject ANCOVA with the difference in distractor familiarity as a covariate showed no difference across neutral-distractor ($M = 16\%$, $SE = 3\%$) and appealing-distractor ($M = 18\%$, $SE = 5\%$) trials, $F(1,12) = 1.68$, $p = .219$, $\eta_p^2 = .123$, and these effects did not vary as a function of distractor familiarity; $F(1,12) = 2.02$, $p = .180$, $\eta_p^2 = .144$. Considered collectively, differences in search performance across appealing-distractor and neutral-distractor trials were not explained by the frequency with which eye gaze moved toward or fixated on distractors. Thus, the frequency with which gaze was directed to the target letter was next examined.

Eye gaze to target: On average, participants fixated directly on the target on 38% of trials. *Targeting costs* associated with distractors were measured by subtracting the percentage of distractor-absent trials on which search targets were fixated from the corresponding percentage of distractor-present trials for each distractor type. A one-way within-subject ANCOVA with the difference in distractor familiarity as a covariate showed that participants had a slightly greater tendency to fixate on the target letter in neutral-distractor ($M = 4\%$, $SE = 2\%$) trials compared to appealing-distractor ($M = 1\%$, $SE = 2\%$) trials, $F(1, 12) = 4.65$, $p = .052$, $\eta_p^2 = .279$. Additionally, there was no effect of distractor familiarity, $F(1,12) = 1.75$, $p = .211$, $\eta_p^2 = .127$. These findings indicate that participants had a greater tendency to fixate on the target letter when a neutral distractor was present as opposed to an appealing distractor, which is consistent with the idea that neutral distractors affected attention more than appealing distractors. Moreover, this might account for the differences in RTs between neutral-distractor and appealing-distractor trials.

Discussion

The results from Experiment 1 indicate that neutral distractors slowed search RT more than appealing distractors in a visual search task. Differences in familiarity between distractor type could not explain disparities in performance as this variable was minimized by participant recruitment, task procedures, and controlled for in the analyses. Eye tracking analyses did not show any evidence that differences in RT were explained by fixations on or saccades toward the distractors, suggesting covert distraction by task-irrelevant distractors. Instead, it is possible that differences in RT are explained by a greater tendency for participants to fixate on the target letter in neutral-distractor trials. Considered collectively, findings in Experiment 1 contradict previous arguments made by Biggs et al. (2012) that increasing affective salience should also increase attentional capture.

There are, however, a few alternative explanations that could account for this incongruity. One possibility for the differential impact of distractor type on search time is that rather than the RT costs we observed reflecting differences in attentional capture (a shift of attention toward a new object), they instead reflect differences in attentional disengagement (how long it takes attention to shift away from an attended object). For instance, disengagement from task-irrelevant stimuli can be delayed according to stimulus properties, such as novelty (Brockmole & Boot, 2009) and colour (Blakely, Wright, Dehili, Boot, & Brockmole, 2012; Boot & Brockmole, 2010; Brockmole & Boot, 2009). If true here, both the neutral and the appealing distractors might have captured attention equally, but the neutral distractors may have held attention longer once captured. If attention disengaged from the neutral distractors slower than the appealing distractors, overall RT would be slower for trials containing the neutral distractors. Therefore, the purpose of Experiment 2 was to assess any potential disengagement effects involving appealing and neutral distractors.

Experiment 2

While Experiment 1 showed that neutral distractors slowed RT more than appealing distractors, it was unclear if this slow down was due to greater attentional capture or delayed attentional disengagement. To differentiate between these possibilities, Experiment 2 assessed how quickly attention can be disengaged from positive and neural distractors that are already within the focus of attention. To do this, we used task procedures similar to those used in Experiment 4 of Biggs et al. (2012), which identified differences in attentional disengagement between negative and positive stimuli. Participants first focused on a central distractor, which was either their favourite or neutral Pokémon character (same selection procedure as in Experiment 1). Participants then had to disengage their attention from the distractor and shift it to the search array to identify a peripheral target letter. Stimuli were presented at fixation for 600 ms to ensure that participants had the opportunity to fully identify the image presented at fixation prior to target onset. This approach ensures that stimulus identification and its relative positive or negative influence can take full effect, which limits any potential differences in RT to disengagement issues and not any concurrent stimulus identification issues. If findings from Experiment 1 were due to the speed of attentional disengagement, attention should disengage more slowly from the neutral distractors than from the appealing distractors. This finding would indicate that the RT for neutral-distractor trials found in the Experiment 1 could be at least partially explained by how attention is disengaged from distractors. If attentional disengagement time is similar for the appealing and neutral distractors, the slower RT in the previous experiment would best reflect how distractors are capturing attention.

Methods

Participants

A new sample of sixteen college-aged fans of Pokémon (M age = 19 years, SD = 1.3, female = 4) from the University of Notre Dame community, participated in the study in exchange for course credit.[3] Participants were recruited by the same methods used in Experiment 1.

Stimuli and apparatus

The task displays are illustrated in Figure 1b. The display consisted of a centrally fixated appealing or neutral colour image subtending 4.5° × 4.5° visual angle at a viewing distance of 57 cm. These images were considered distractor images, as they were irrelevant to the target identification task. The target letters were an X or an N in size 20 Calibri black font and would appear either to the left, right, above, or below the distractor at a fixation-to-centre distance of 4.5°. Timing and presentation of the stimuli were controlled by SR Research Experiment Builder software (SR Research, Inc.) on a 22″ LCD monitor set to 60-Hz refresh rate.

Procedure

Prior to the task, each participant selected an appealing and a neutral Pokémon character following the same procedures used in Experiment 1. In the main task, a fixation cross appeared in the centre of the screen for 500 ms, followed by a centrally located distractor image. The distractors were the appealing character (25% of trials) and neutral character (25% of trials) selected at the outset of the experimental session. On the remaining 50% of trials, a grey square was presented instead of a character to serve as a distractor-absent control. After a 600 ms delay, either an X or an N appeared in the periphery to the left, right, above, or below the central distractor. Participants were instructed to identify the letter as quickly and accurately as possible using a computer keyboard press to respond. All stimuli remained on the screen until the participants responded (or 8 s elapsed). Accuracy and RT in milliseconds were recorded. To measure *disengagement costs*, we subtracted the average RT for distractor-absent trials from the average RT for trials with distractors for each distractor type on a subject-by-subject basis. Similarly, average error rates for distractor-absent trials were subtracted from average error rates for trials with distractors for each distractor type.

Participants completed 10 practice trials to ensure understanding of the task and procedures. Data from these practice trials was not recorded. Following practice, participants completed 5 blocks of experimental trials. Within each block, search target identity (X or N), search target position (left, right, above or below the central image), and distractor image (appealing, neutral, or grey box), were fully crossed with a replication factor of 16, yielding a within-block total of 128 trials and an across-experiment total of 640 trials. After finishing the task, each participant completed the same demographic and opinion survey as in Experiment 1.

Results

As in Experiment 1, we first discuss the post-test survey data and then turn to analyses of RT and accuracy.

Survey

One participant reported 5 or less in both familiarity and liking for Pokémon in general. This participant was excluded from further analyses, as they did not meet the study criteria of being a Pokémon fan. Therefore, fifteen participants were included in all analyses.

Participants were instructed to choose an appealing Pokémon character that would rank a 9 and a neutral Pokémon they would rank a 5 on a 1-9 Likert scale. A Wilcoxon Signed-rank test showed that appealing distracters ($M = 8.27$, $SE = .28$) were ranked higher than neutral distractors ($M = 4.80$, $SE = .17$), $Z = -3.35$, $p < .01$. This indicates that the appealing distractors were better liked than the neutral distractors.

Participants were also instructed to choose appealing and neutral Pokémon characters that were equally familiar. As in Experiment 1, a Wilcoxon Signed-rank test showed that participants were more familiar with the appealing distractors ($M = 8.33$, $SE = .21$) than the neutral distractors ($M = 6.13$, $SE = .35$), $Z = -3.24$, $p < .001$. This finding again raises the possibility that participants may not have chosen characters that were equally familiar to them. Therefore, the difference between how participants ranked their favourite character and their neutral character on familiarity was used as a covariate in the analyses to control for semantic salience and to isolate effects of appeal.

Responses

On average, accuracy was 95% ($SE = 3\%$). A one-way within-subject ANCOVA for *accuracy costs* with the difference in distractor familiarity as a covariate showed no difference across appealing-distractor ($M = .002\%$, $SE = .006\%$) and neutral-distractor ($M = .009\%$, $SE = .006\%$) trials, $F(1,13) < 1$. There was also no distractor type by distractor familiarity interaction, $F(1,13) = 1.42$, $p = .255$, $\eta_p^2 = .098$. Therefore, participants performed equally well across distractor types.

Only correct responses were used for RT analyses. A one-way within-subject ANCOVA for *RT costs* with the difference in distractor familiarity as a covariate showed no difference in disengagement across appealing-distractor ($M = -6.68$ ms, $SE = 4.29$ ms) and neutral-distractor ($M = -6.67$ ms, $SE = 5.26$ ms) trials, $F(1,13) < 1$. There was no interaction between distractor type and the difference in distractor familiarity, $F(1,13) < 1$. Therefore, these findings indicate that participants disengaged attention from the neutral and appealing distractors with equal speed. We further ascertained that disengagement was similar across neutral and appealing distractors by performing a Bayesian repeated measures ANCOVA on the RT costs with the difference in distractor familiarity as a covariate (JASP 0.8.3.1). This analysis provides a Bayes factor representing the likelihood of a finding under the null hypothesis (no difference) and the alternative hypothesis (Leppink, O'Sullivan, & Winston, 2017; Rouder, Speckman, Sun, Morey, & Iverson, 2009). The observed pattern of results was nearly three times more likely under the null hypothesis ($BF_{01} = 2.93$).

Discussion

Experiment 2 demonstrated that participants were equally able to disengage attention from appealing and neutral distractors. This finding coincides with research that did not find differences in disengagement between other positive and neutral stimuli, such as words (Fox, Russo, Bowles, & Dutton, 2001) and faces (Georgiou et al., 2005). Because attention disengaged from these appealing and neutral distractors equally, it is likely that the slower RT in neutral-distractor trials found in Experiment 1 reflects a capture of attention by neutral distractors rather than slowed attentional disengagement. The question still remains, however, why a neutral distractor would capture attention more than an appealing distractor.

Just as in Experiment 1, participants in Experiment 2 reported being less familiar with their neutral distractor than with their appealing distractor. Collapsing across experiments, the differences in appeal and familiarity ratings were not correlated ($\rho = .191$, $p = .296$), suggesting that these ratings were largely independent. To assess the stability of this relationship across experiments, we conducted a 2 (experiment: 1 vs 2) × 2 (rating type: appeal vs familiarity) mixed ANOVA and showed no differences ratings across experiments, $F(1,30) < 1$. We did show that differences in appeal ratings were larger ($M = 3.38$, $SE = .22$) than differences in familiarity ratings ($M = 1.78$, $SE = .24$), $F(1,30) = 29.3$, $p < .001$, $\eta_p^2 = .494$, but there was no rating type by experiment interaction, $F(1,30) = 1.30$, $p = .264$, $\eta_p^2 = .041$. Collectively, these findings suggest that differences in appeal and familiarity ratings were stable across experiments. Although the difference in familiarity did not explain findings in Experiments 1 or 2, it does suggest that participants did not, or were unable to, choose equally familiar distractors despite explicit instructions to do so. These differences in familiarity may be due to differences in exposure between appealing and neutral stimuli, which may in turn have an impact on attentional processing. We explored this possibility further in Experiment 3.

Experiment 3

According to Biggs et al. (2012), semantic salience may act as a "gatekeeper" for affective salience in that observers must hold a certain degree of semantic knowledge before establishing an item's affective value. Acquiring this semantic knowledge may require a certain degree of past experience encountering the item, and the frequency with which these encounters occur may also inherently (and independently) bias attention. Indeed, it is well known that distractors that appear more frequently can be less captivating than distractors that appear infrequently (e.g., Cosman & Vecera, 2010; Forster & Lavie, 2008b; Neo & Chua, 2006), as attention is often biased toward stimuli that are new (e.g., Theeuwes, 1994; Yantis, 1996) or unexpected by the observer (e.g., Horstmann, 2002, 2005).

It does not necessarily follow, however, that frequently encountering an item will deepen an observer's semantic knowledge for that item. For example, driving by the same tree everyday may not increase an observer's understanding of what it is to be a tree, nor does it create the type of knowledge and personal memories associated with, say, characters from a favourite cartoon. Given that attention is often biased to new as opposed to old or repeating items (e.g., Olivers & Humphreys, 2002; Pollmann et al., 2003; Watson & Humphreys, 1997, 1998, 2000; Watson, Humphreys, & Olivers, 2003), the frequency with which a distractor is encountered can likely bias attention independently from the semantic knowledge that is gained by the observer (semantic salience) or the affective value (affective salience) that is eventually established. In this way, when assessing semantically rich distractors, the amount of capture observed overall likely depends on where the distractor falls along the competing dimensions of semantic salience, affective salience, and the frequency of encounters.

Following this idea, if participants had encountered their favourite Pokémon character more often in their past everyday life compared to their neutral Pokémon character, it is possible those frequent past encounters could have confounded results from Experiment 1 by biasing attention to the neutral (and less frequently past encountered) distractor. This possibility could at least partially account for the slower RT for neutral-distractor trials found in Experiment 1. Indeed, with experience observers can learn to reject distractors, reduce the amount of attention that is initially captured and better attend to task-relevant information (e.g., Gaspelin & Luck, 2018; Lamy et al., 2008; Maljkovic & Nakayama, 1994; Olivers & Humphreys, 2002; Watson & Humphreys, 2000; Vatterott & Vecera, 2012; Vatterott, Mozer, & Vecera, 2018). As such, if participants in the previous experiments had more past everyday experience interacting with their favourite Pokémon characters, their attention may have been inherently less biased toward these characters than to characters they have encountered less often. This account may partially explain why the neutral distractors captured attention more than the appealing distractors in Experiment 1. Therefore, the purpose of Experiment 3 was to assess whether the frequency of encounters would affect how appealing and neutral distractors capture attention. Although long-term experience cannot be manipulated in a single, relatively short experimental session, short-term changes in experience were used to gauge how affective salience may interact with the frequency with which distractors are encountered to capture attention.

Methods

Participants

A new sample of forty-eight self-identified, college-aged Pokémon fans (M age = 20 years, SD = 1.2, female = 18) from the University of Notre Dame participated in exchange for course credit.[4] Participants were recruited using the same methods as the previous experiments and were randomly assigned to three equally sized groups (discussed below). Sample size was larger in Experiment 3 to account for the between-groups differences created by the experimental manipulation. Each group included approximately the same number of participants as Experiments 1 and 2.

Stimuli, apparatus, and procedure

The stimuli, display, and procedures were the same as in Experiment 1, save the following changes. To assess whether frequency impacts how appealing and neutral distractors capture attention, the frequency with which distractors appeared was varied between participant groups. In the *equal frequency group* (control), the distractors appeared at equal frequencies, replicating the procedures used in Experiment 1. In the *appealing more frequent group*, the appealing distractor appeared on 40% of trials whereas the neutral distractor appeared on 10% of trials. In the *neutral more frequent group*, this rate was reversed so that the appealing distractor appeared on 10% of trials and the neutral distractor appeared on 40% of trials. In all groups, 50% of the trials were distractor-absent. We did not record eye movements in Experiment 3 because the results of Experiment 1 indicated that shifts of gaze are unrelated to RT. Furthermore, the demographic and opinion survey was not administered, although differences in familiarity between appealing and neutral distractors did not impact search performance in Experiment 1.[5]

Results

Overall accuracy was, on average, 96% (SE = 3%). A 3 (group) × 2 (distractor type) mixed ANOVA for cost in error rates showed a marginal but not significant difference across groups, $F(2,45) = 3.02$, $p = .059$, $\eta_p^2 = .118$, but there was no effect of distractor type, $F(1,45) = .26$, $p = .614$, $\eta_p^2 = .006$, and there was no significant group by distractor type interaction, $F(1,45) = .13$, $p = .877$, $\eta_p^2 = .006$. These findings suggest that error rates were similar across appealing-distractor and neutral-distractor trials.

Only correct responses were used for RT analyses. Results are illustrated in Figure 2. A 3 (group) × 2 (distractor type) mixed-model ANOVA showed no overall

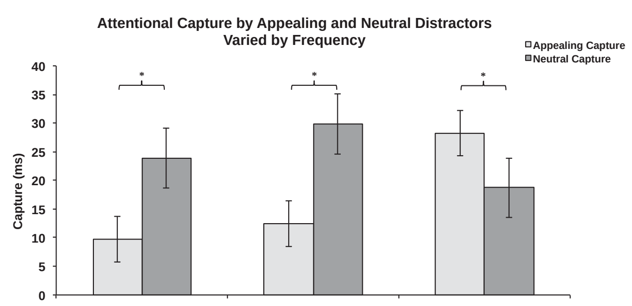

Figure 2. Illustrates the significant interaction between the frequency and affective salience of distractors. *$p < .05$.

main effect for group, $F(1,45) = .88$, $p = .422$, $\eta_p^2 = .04$, but significant difference in distractor type, with a greater RT cost for neutral distractors ($M = 24$ ms, $SE = 3$ ms) compared to appealing distractors ($M = 17$ ms, $SE = 2$ ms), $F(1,45) = 4.66$, $p = .036$, $\eta_p^2 = .09$. This effect was not equivalent across groups, however, as indicated by a reliable distractor type by group interaction, $F(2,45) = 6.26$, $p = .004$, $\eta_p^2 = .22$. Planned comparisons showed that when distractors appeared with equal frequencies, neutral distractors ($M = 24$ ms, $SE = 4$ ms) slowed performance more than appealing distractors ($M = 10$ ms, $SE = 4$ ms), $t(15) = -2.47$, $p = .026$, replicating behavioural results obtained in Experiment 1. Similarly, when the appealing distractor appeared more frequently, costs were greater in trials with neutral distractors ($M = 30$ ms, $SE = 7$ ms) as opposed to trials with appealing distractors ($M = 12$ ms, $SE = 2$ ms), $t(15) = -2.28$, $p = .037$. However, the effect was reversed for participants whose neutral distractor appeared more frequently, with greater costs in trials with appealing distractors ($M = 28$ ms, $SE = 5$ ms) compared to trials with neutral distractors ($M = 19$ ms, $SE = 4$ ms), $t(15) = 2.66$, $p = .018$). Although capture was numerically greater for neutral distractors when they were more frequent compared to appealing distractors when they were more frequent, this difference is not significant, $t(130) = 1.44$, $p = .161$. Collectively, these results demonstrate that neutral distractors captured attention more than appealing distractors, unless the neutral distractors appeared more frequently.

A 3 (group) × 2 (distractor type) mixed-model ANOVA showed no difference in distractor luminance between groups, $F(2,45) = 2.28$, $p = .114$, or across appealing ($M = .38$, $SE = .01$) and neutral distractors ($M = .38$, $SE = .01$), $F(1,45) = .23$, $p = .635$. There was no group by distractor interaction, $F(2,45) = .47$, $p = .629$. These findings suggest that perceptual disparities across distractor conditions did not account for differences in RT.

Discussion

The results from Experiment 3 provided several important findings. First, neutral distractors captured attention more than appealing distractors when both distractors appeared equally often. This finding replicates those found in Experiment 1. Experiment 3 further shows that the frequency with which observers encounter these distractors can affect how their attention is captured. For instance, neutral distractors continued to capture attention more than appealing distractors when they appeared less frequently. However, when the neutral distractors appeared more frequently, they captured attention *less* than appealing distractors. This finding demonstrates that short-term experience can alter the degree to which appealing and neutral distractors will capture attention. Given that distractors merely repeated – no new information about the distractors was provided – semantic salience was held relatively constant throughout the experiment. This suggests that, although acquiring semantic knowledge (to establish affective value) may require a certain degree of past experience with an item, the frequency with which these encounters occur can independently bias attention in favour of the less frequently encountered item (e.g., Horstmann, 2002; 2005; Theeuwes, 1994; Yantis, 1996).

One potential confound within the current paradigm concerns possible influences of inter-trial effects when distractors are repeated on consecutive trials (e.g., Maljkovic & Nakayama, 1994; Olivers & Humphreys, 2002; Pollmann et al., 2003; Watson & Humphreys, 1997, 1998, 2000; Watson, Humphreys, & Olivers, 2003). Given that distractor-absent trials appeared 50% of the time across conditions, however, it is much more likely that by random chance a given trial is preceded (and followed) by a distractor-absent trial rather than a distractor-present trial. This would lead to more "switch" trials for the distractor-present trials and more "repeat" trials for the distractor-absent trials. Indeed, across participants a higher percentage of distractor-absent trials ($M = 50\%$, $SE = .10\%$) were "repeat" trials compared to neutral-distractor ($M = 24\%$, $SE = .10\%$) and appealing-distractor trials ($M = 24\%$, $SE = .10\%$) across all conditions. Looking specifically at the *appealing more frequent* condition, only .94% ($SE = .17\%$) of all trials were neutral-distractor repeat trials. Likewise, in the *neutral more frequent* condition, only 1% ($SE = .18\%$) of all trials were appealing-distractor repeat trials. In fact, three participants in the *appealing more frequent* condition and 3 participants in the *neutral more frequent* condition never received repeat trials for the infrequent distractor. Importantly, only 16% ($SE = .43\%$) of all trials in the *appealing more frequent* condition and 16% ($SE = .52\%$) of all trials in the *neutral* *more frequent condition* were repeat trials for the more frequent distractor. This indicates that the majority of trials were switch trials, suggesting that any intertrial analysis may be less meaningful than that conducted with a paradigm designed to look at such effects. Still, we conducted an exploratory 3 (group) × 2 (distractor type) × 2 (trial type: switch or repeat) mixed ANOVA for cost in RTs to explore the possibility of intertrial effects. If intertrial effects can explain our findings for Experiment 3, we should observe faster search performance for "repeat" rather than "switch" trials. This effect should vary across trial type and across groups, resulting in a three-way interaction. However, we saw no evidence for this hypothesis, $F(4,78) = 1.30$, $p = .285$, $\eta_p^2 = .062$.

Considered collectively, findings from Experiment 3 suggest the possibility that the amount of capture observed overall by semantically rich distractors likely depends on where the distractor falls along the competing dimensions of semantic salience, affective salience, and the frequency of encounters.

General discussion

Past research has shown that an object's semantic meaning may influence whether it will capture attention (Forster & Lavie, 2008b), although this can be confounded by how appealing the object is to the observer (Biggs et al., 2012). The current research investigated how personally appealing distractors capture attention when semantic salience is equated as much as possible. Although Biggs et al. (2012) predicted that increasing affective salience would increase attentional capture, participants in Experiment 1 of the current research were slower to identify a target letter in the presence of a neutral distractor as opposed to an appealing distractor. This effect was not explained by differences in how familiar participants were with each distractor, as this difference was experimentally and statistically controlled for in the analyses. Furthermore, despite research showing that eye gaze might involuntarily saccade to the distractors when attention is captured (e.g., Theeuwes et al., 2003; Theeuwes et al., 1998; Theeuwes et al., 1999), eye gaze rarely fixated on the distractors and, thus, could not explain differences in search performance.

To assess whether differences in reaction times could be partially explained by how attention is disengaged from distractors, Experiment 2 assessed how quickly attention disengages from appealing and neutral stimuli once they are already within the focus of attention. Participants showed no difference in their ability to identify a peripheral target letter, regardless of which distractor appeared. This finding indicates that participants could equally disengage their attention from appealing and neutral distractors, suggesting that differences in RT in Experiment 1 are best explained by attentional capture rather than attentional disengagement. Collectively, findings from Experiments 1 and 2 contradict the prediction made by Biggs et al. (2012) that increasing affective salience should increase attentional capture.

An important distinction is that the first two experiments controlled for semantic salience by presenting distractors participants knew well. Participants chose these familiar distractors and could distinguish between neutral and positive affect, although there were still differences regarding the relative familiarity of each distractor type. This suggests that participants did not, or were unable to, choose equally familiar characters despite explicit instructions. The variance is understandable, though, given that individuals might intentionally seek out their favourite characters during various forms of gameplay or fan-related activities in everyday life. Any differences in past encounters between neutral and appealing distractors could begin to explain why neutral distractors captured more attention than appealing distractors. For instance, frequently encountering a distractor can also introduce biases that are independent of acquiring additional semantic knowledge, lending a possible explanation for why neutral distractor capture attention more than appealing distractors in Experiment 1. Under this view, the amount of capture observed overall, therefore, likely depends on where the distractor falls along the competing dimensions of semantic salience, affective salience, and the frequency of encounters.

Lending a possible explanation for why neutral distractors captured attention more than appealing distractors, Experiment 3 assessed whether short-term changes in experience with each distractor could impact capture. Neutral distractors captured attention more than appealing distractors when each distractor type appeared at equal frequencies. This finding replicated Experiment 1. Moreover, neutral distractors continued to capture more attention when they appeared less frequently than appealing distractors; however, this effect reversed when appealing distractors appeared less frequently. This finding suggests that differences in short-term experience can impact how distractors will capture attention despite the distractor's affective value. Biggs et al. (2012) had argued that semantic salience can act as a "gatekeeper" for affective salience in that observers might need to possess a certain degree of semantic knowledge before establishing an item's affective value. While experience can act as the "gatekeeper's key" by affording observers the opportunity to obtain this knowledge and evaluate at item's appeal, as the current research shows, experience can also bias attention toward an item that is encountered less frequently regardless of items' affective value.

Attentional biases deriving from past experience are further illustrated in research showing capture by items that are unexpected (Horstmann, 2002; 2005), infrequent (Forster & Lavie, 2008b), or active in visual working memory from a recent encounter (e.g., Carlisle & Woodman, 2011a, 2011b; Dombrowe, Olivers, & Donk, 2010; Downing & Dodds, 2004; Olivers, 2009; Olivers, Meijer, & Theeuwes, 2006; Soto, Heinke, Humphreys, & Blanco, 2005; Soto & Humphreys, 2007; Woodman & Luck, 2007). Past research suggests that as an item is encountered more frequently, a robust representation of that item can become established in long-term memory (e.g., Carlisle, Arita, Pardo, & Woodman, 2011; Neisser, 1963; Wolfe, 2012; Woodman, Carlisle, & Reinhart, 2013) and lose attentional priority (Gunseli, Olivers, & Meeter, 2016; Hutchinson & Turk-Browne, 2012; Olivers, 2011). The current research further suggests that repeating distractor items decreased attentional capture regardless of the distractor's affective value.

Under the current conditions, experience highly influenced attentional capture regardless of the distractor's appeal. However, one untested possibility is that affect might become more influential on attention if affective salience of the appealing distractors is substantially influenced by additional factors. Evidence for this idea is illustrated in research showing positive stimuli that are highly relevant to the needs and goals of the observer can bias attention over neutral stimuli (Brosch et al., 2008; Brosch et al., 2007). For example, frequent smokers (who likely often encounter smoking-related items) shifted their gaze quicker to and remained fixated longer on smoking-related pictures than nonsmoking related pictures (Field, Mogg, & Bradley, 2004), and their attention can shift to these pictures even without explicit awareness (Harris et al., 2018). Similar attentional biases are exhibited in alcoholics for alcohol-related stimuli (Field et al., 2007; Field, Mogg, Zetteler, & Bradley, 2004). Collectively, this past research suggests that if affective salience is substantially elevated – or even coupled with need and addiction – attentional capture may become more influenced by affective salience and less by past experience.

What remains unclear is whether affective representations exist within bottom-up, top-down, or experienced-based attentional biases. Awh, Belopolsky, and Theeuwes (2012) argued that affective salience is often described as a stimulus-driven process. Therefore, while affect cannot be easily defined by low-level features, the authors categorized affect as a bottom-up property. However, Biggs et al. (2012) argued that affective salience is influenced by the observer's semantic-based knowledge. As such, evaluation of an affective-salient distractor may rely on the expectations, knowledge, and current state of the observer within the given context – ostensibly functioning as a top-down bias. Additionally, past experience can affect an observer's interpretation of the stimulus, particularly if that stimulus is considered rewarding to the observer (Hickey, Chelazzi, & Theeuwes, 2010a, 2010b). This interpretation can persist regardless of reoccurring, less rewarding conditions (Anderson & Yantis, 2013; Anderson, Laurent, & Yantis, 2011). To disentangle this uncertainty, further research should explore whether affective representations can be dissociated from other selection biases. Such work would lead to better predictions about the conditions in which everyday appealing distractors will capture attention.

Given the low perceptual load search display used in the current research, it is possible that a relatively large, colourful distractor would initially capture attention due to its physical properties as opposed its semantic identification. For instance, De Groot et al. (2016) showed that, depending on the timing of the target and distractor presentation, stimulus-based biases typically capture attention before semantic biases, although these biases operate largely independently.

One conflicting result, though, is that a large and perceptual salient stimulus can produce no attentional capture if the participant knows more about the stimulus, even if the stimulus in question is identical across meaningful and meaningless conditions (Biggs et al., 2012). These conflicting findings suggest a rather complicated relationship between knowledge about a stimulus and whether it captures attention due to its meaning. In the current research, participants chose their appealing and neutral distractors prior to the experiment, thus, activating all associated bottom-up, top-down, and experienced-based properties regarding the distractors in working memory. Although there were no differences in luminance across appealing and neutral distractors, it is possible that other physical properties of the distractors (e.g., colour and shape) assisted with early identification of the peripheral distractors during the search task. For instance, if the appealing distractor was red and the neutral distractor was blue, participants might be able to identify distractors – thus, activating associated semantic knowledge – based on the red or blue colour alone. Moreover, past research has shown that at least some semantic information can be extracted from peripheral vision – prior to shifts in attention – which assists with subsequent attention and gaze allocation. To illustrate, gaze has a tendency to shift to more semantically informative peripheral regions within a scene rather than less semantically informative and background regions, suggesting that at least some peripheral information is extracted to evaluate the regions that are more or less semantically informative to complete task goals prior to saccade initiation (e.g., Antes, 1974; Mackworth & Morandi, 1967; Loftus & Mackworth, 1978; Tatler, Brockmole, & Carpenter, 2017). This idea is consistent with the eye tracking results shown here as gaze allocation was more likely to fixate on the task-relevant target letter rather than the distractor. Furthermore, the idea that semantically meaningful, personally relevant distractors are easily identified preattentively is consistent with the results shown here that disruptions in attention were better explained by attentional capture rather than attentional disengagement. It is unclear in the current work, however, which features are necessary for peripheral identification of distractors, and future work could assess the time frame that distractors are identified preattentiavely. Thus, when investigating how semantically rich distractors capture attention, it is important to consider how all types of selection biases interact to derive accurate predictions.

Conclusion

In summary, we often encounter distractors that lure our attention away from current task demands. Although a distractor's semantic meaning and affective value can impact whether our attention will be captured, the current research demonstrates that the frequency with which we encounter these distractors strongly impacts how our focus is involuntarily directed. Therefore, the amount of capture observed overall likely depends on where the distractor falls along the competing dimensions of semantic salience, affective salience, and the frequency of encounters. This interactive relationship between these factors may account for why we can unintentionally notice or routinely ignore the enticing distractors we encounter everyday.

Notes

1. We later conducted four post-hoc power analyses using 80% power and effect sizes as found in four studies that used similar paradigms to the one used in the current work (Cohen's $d = 2.16$, $N = 16$; Forster & Lavie, 2008a Experiment 1; $F = 67.9$, $N = 14$; Forster & Lavie, 2008b Experiment 3; $F = 4.12$, $N = 18$; Biggs et al., 2012 Experiment 2; $F = 9.03$; $N = 22$; Biggs et al., 2012 Experiment 3). To account for differences in reported values, we converted *t*-values and *F*-values (Lakens, 2013) for our sample size calculations (G*Power; Faul, Erdfelder, Lang, & Buchner, 2007). These calculations revealed four different target sample sizes: $N = 4$ (Forster & Lavie, 2008a Experiment 1), $N = 4$ (Forster & Lavie, 2008b Experiment 3), $N = 22$ (Biggs et al., 2012 Experiment 2), and $N = 37$ (Biggs et al., 2012 Experiment 3). The average of these four sample size calculations was 16.8 participants.
2. Recruitment and data collection occurred prior to the release of Pokémon Go, a popular augmented reality game that was released the summer of 2016. Therefore, participants were self-selected fans prior to Pokémon Go, which repopularized the Pokémon franchise.
3. The sample size for Experiment 2 was similar to that of Experiment 1. We later conducted four power analyses using 80% power and effect sizes as found in four published studies that used a similar disengagement paradigm as the one used here ($F = 4.06$, $N = 22$; Biggs et al., 2012 Experiment 4; $F = 11.43$, $N = 40$; Boot & Brockmole, 2010 Experiment 1; $t = 2.40$, $N = 8$; Brockmole & Boot, 2009 Experiment 2; $t = 2.87$, $N = 20$, Wright, Boot, & Brockmole, 2015). These calculations revealed four different target sample sizes: $N = 45$ (Biggs et al., 2012, Experiment 4), $N = 30$ (Boot & Brockmole, 2010 Experiment 1), $N = 13$ (Brockmole & Boot, 2009), and $N = 22$

(Wright, Boot, & Brockmole, 2015). The average of these four sample size calculations was N = 27.5, and, thus, we suggest that a more ideal sample size would have consisted of at least twenty-eight participants.

4. We later conducted a post-hoc power analyses using 80% power and the effect size as found in Experiment 1 (η_p^2 = .244), which revealed an approximated target sample size of at least thirty-six participants in total. Therefore, we believe our sample size for Experiment 3 was appropriate.
5. Because demographic and opinion surveys were not administered, which was used as an exclusionary criteria in the previous two experiments, data from all participants were analyzed.

Acknowledgement

The authors have no financial or non-financial competing interests in this manuscript. The views expressed in this article are those of the author and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, nor the U.S. Government. LT Biggs is a military service member. This work was prepared as part of his official duties. Title 17 U.S.C. §105 provides that 'Copyright protection under this title is not available for any work of the United States Government.' Title 17 U.S.C. §101 defines a U.S. Government work as a work prepared by a military service member or employee of the U.S. Government as part of that person's official duties.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Appendices

Appendix 1

Appendix A1. List of survey questions for Experiments 1 and 2

For the following questions, indicate what number best describes how you feel:

1 = strongly dislike   5 = neutral   9 = strongly like

1.) How much do you like Pokémon IN GENERAL?

2.) How much do you like your FAVOURITE Pokémon?

3.) How much do you like your Neutral Pokémon?

For the following questions, indicate what number best describes how you feel:

1 = very unfamiliar   5 = neutral   9 = very familiar

1.) How familiar are you with Pokémon IN GENERAL?

2.) How familiar are you with your FAVORITE Pokémon?

3.) How familiar are you with your NEUTRAL Pokémon?

How often do you participate in the following Pokémon activities NOW?

Never   Less than once a month   Once a month   2-3 times a month   Once a week   2-3 times a week   Daily

Card collecting: ___   Video games: ___   Movies: ___

Comic books: ___   TV show: ___   Collecting figurines: ___

How often do you participate in the following Pokémon activities IN THE PAST?

Card collecting: ___   Video games: ___   Movies: ___

Comic books: ___   TV show: ___   Collecting figurines: ___

Note. Survey questions were completed at the end of Experiments 1 and 2 to obtain quantitative measures of distractor appeal and familiarity and to characterize the participant sample in terms of knowledge and engagement with Pokémon related activities.

Appendix 2

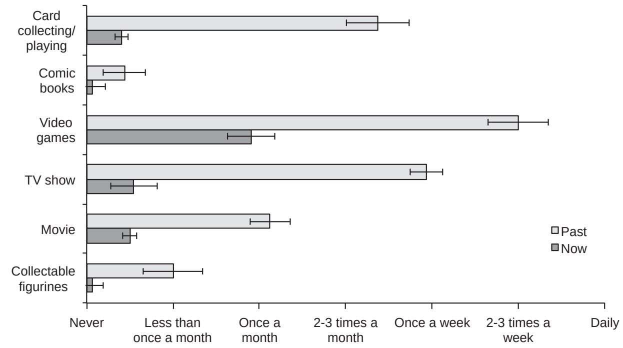

Figure A1. Summary of survey responses characterizing the participant sample from Experiments 1 and 2 in terms of engagement with Pokémon related activities. Values represent average responses with standard error bars.

Appendix 3

Appendix A3. List and Frequency of Pokémon Characters Selected as Distractors

Pokémon	Favourite	Neutral	Pokémon	Favourite	Neutral
Alakazam	6	2	Machamp	1	2
Articuno	1	0	Machop	0	2
Bellsprout	0	1	Magmar	1	0
Blastoise	1	0	Magnemite	0	1
Bulbasaur	1	2	Magneton	0	1
Butterfree	0	2	Mewtwo	1	0
Caterpie	0	1	Mr. Mime	0	1
Chansey	1	1	Nidoking	0	1
Charizard	8	1	Nidoqueen	0	1
Charmander	5	0	Nidoranfemale	1	0
Charmeleon	1	0	Nidorino	0	1
Dewgong	1	0	Onix	0	1
Diglett	1	4	Paras	0	1
Ditto	0	1	Persian	0	1
Dragonair	2	0	Pidgeotto	0	1
Dragonite	1	0	Pikachu	7	0
Eevee	2	4	Poliwhirl	0	3
Exeggutor	0	2	Poliwrath	0	2
Farfetchd	0	1	Rattata	0	1
Gastly	0	1	Rhydon	1	0
Gengar	1	0	Sandslash	0	1
Golem	1	0	Scyther	1	0
Graveler	0	1	Seaking	0	1
Growlithe	0	1	Seel	1	1
Gyrados	2	1	Snorlax	1	0
Haunter	1	0	Squirtle	6	3
Horsea	1	1	Starmie	1	1
Hypno	0	1	Staryu	0	4
Ivysaur	0	1	Tauros	0	1
Jigglypuff	1	0	Tentacruel	0	1
Jolteon	1	0	Voltorb	0	2
Kabutops	1	0	Vulpix	1	0
Lapras	3	0			