VISUAL COGNITION

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

Attentional capture by entirely irrelevant distractors

Sophie Forster & Nilli Lavie

To cite this article: Sophie Forster & Nilli Lavie (2008) Attentional capture by entirely irrelevant distractors, VISUAL COGNITION, 16:2-3, 200-214, DOI: 10.1080/13506280701465049

To link to this article: https://doi.org/10.1080/13506280701465049

Published online: 27 Feb 2008.

VISUAL COGNITION, 2008, 16 (2/3), 200–214

Psychology Press
Taylor & Francis Group

Attentional capture by entirely irrelevant distractors

Sophie Forster and Nilli Lavie
Department of Psychology, University College London, London, UK

Studies of attentional capture often question whether an irrelevant distractor will capture attention or be successfully ignored (e.g., Folk & Remington, 1998). Here we establish a new measure of attentional capture by distractors that are entirely irrelevant to the task in terms of visual appearance, meaning, and location (colourful cartoon figures presented in the periphery while subjects perform a central letter-search task). The presence of such a distractor significantly increased search RTs, suggesting it captured attention despite its task-irrelevance. Such attentional capture was found regardless of whether the search target was a singleton or not, and for both frequent and infrequent distractors, as well as for meaningful and meaningless distractor stimuli, although the cost was greater for infrequent and meaningful distractors. These results establish stimulus-driven capture by entirely irrelevant distractors and thus provide a demonstration of attentional capture that is more akin to distraction by irrelevant stimuli in daily life.

Two main goals for attention research is (a) to identify what type of goal-irrelevant stimuli will nevertheless distract from the focusing of attention on goal-relevant information, and (b) to determine the conditions under which people can most effectively ignore these distracting stimuli. A popular paradigm that has been used to address these issues is the "attentional capture" paradigm. In studies of attentional capture, subjects typically perform a visual search task focusing on search for a particular target stimulus, for example, a prespecified target letter, shape, or colour (Jonides & Yantis, 1988; Yantis & Jonides, 1990). Such search is disrupted by the presence of a nontarget with a unique "singleton" feature and facilitated when the target carries the singleton feature (e.g., a letter or shape with an abrupt onset, or the only red nontarget in an otherwise homogenous display of all-green stimuli). The singleton feature is irrelevant to the search task, in the sense that the target is defined on the basis of another feature (for instance, in the studies cited previously, the target is defined on the basis of its letter identity or its shape and the odd singleton feature is abrupt onset or colour), and the

Please address all correspondence to Nilli Lavie, Department of Psychology, University College London, Gower Street, London WC1E 6BT, UK. E-mail: n.lavie@ucl.ac.uk

This research was supported by a Wellcome Trust award to NL.

http://www.psypress.com/viscog DOI: 10.1080/13506280701465049

singleton feature is either nonpredictive of the target (e.g., no more likely to appear in the target location than in other locations; Yantis & Jonides, 1984, 1990; see Yantis, 2000, for review) or even only ever presented with a nontarget stimulus (e.g., Theeuwes, 1991, 1992). Given this apparent task-irrelevance, it appears unlikely that subjects will voluntarily pay attention to the singleton feature. The singleton effects on search performance are therefore attributed to capture of attention.

However, a strong view of attentional capture in terms of an involuntary stimulus-driven capture has been challenged by a sizable body of research indicating that the singleton effects in these tasks are modulated by the extent to which the singleton feature is in fact relevant to the attentional settings (for review see Yantis, 2000)—indeed in some cases no attentional capture effects have been found for irrelevant singleton features. For example Folk and colleagues (e.g., Folk & Remington, 1998, 1999; Folk, Remington, & Johnston, 1992) found that spatial capture of attention to the position of the singleton was only found when the singleton feature was the same as the target feature (e.g., both were the only red item) but not when the singleton feature was different to the target.

In addition, even when the singleton distractor feature is clearly different from the target-defining feature (e.g., when the singleton distractor is an odd coloured item and the search target is defined as an odd shape; see Theeuwes, 1995, for review), it has been argued that the singleton is not truly task irrelevant and that the effects of singleton capture are in fact dependant on the attentional settings adopted (Bacon & Egeth, 1994). Since the target is also a singleton in these experiments, the singleton effects on search performance may have been due to a "singleton-detection" search strategy whereby, instead of focusing attention on search for the precise target feature (e.g., shape), subjects may rely on "pop-out" detection. Such a strategy would allow subjects to detect the singleton target in an effortless manner based on parallel processing of all of the display's features but would also leave them open to interference by pop out of the irrelevant singleton feature.

Recent studies have demonstrated attentional capture by certain features such as abrupt onsets and other dynamic events in paradigms designed to rule out explanations of capture effects in terms of goal-oriented strategies or other task-biased attentional settings (Abrams & Christ, 2003; Franconeri & Simons, 2003; Franconeri, Simons, & Jungé, 2004; Lamy & Egeth, 2003). However, these studies have used paradigms in which the task irrelevant feature is presented in a task-relevant location (i.e., one of the positions that a target may appear in) that the participant is therefore required to search. Clearly it cannot be taken for granted that items or features that are highly distracting when the task requires participants to search for the target among them will continue to be distracting when they are presented in a task irrelevant location. Furthermore, one study that did present singleton distractors in an irrelevant peripheral location (Folk, Leber, & Egeth, 2002) found that these distractors captured attention only when they were relevant to the task's attentional settings, having either colour or singleton status in common with the search target.

Thus, although the phenomenon of attentional capture by a unique but entirely irrelevant (in terms of visual features, meaning, *and* location) distractor will often occur in daily life (for example, a colourful pop-up ad in the periphery can distract one from searching for a particular e-mail message in a central "inbox" despite clear irrelevance of the ad to the e-mail text searched for, in terms of visual appearance, position, and content), laboratory studies using the attentional capture paradigm have not reached a clear consensus on whether attentional capture by entirely irrelevant distractors can in fact occur and, if so, which characteristics of the distractor stimulus are critical in producing attentional capture, even when truly irrelevant to the task at hand.

Forster and Lavie (2007) have recently established a new laboratory measure of attentional capture by a truly irrelevant distractor that appears to be more akin to the phenomenon of attentional capture in daily life. They showed that performance of a letter search task is significantly disrupted by the presence (compared to absence) of an irrelevant cartoon figure presented in the periphery on a small percentage of the trials. Since the cartoon figures did not share any visual feature with the search stimuli (they were large and colourful depicting fairly complex 3-D images whereas the search letters were small, grey, 2-D images) and were completely unrelated in both content and display position, the distractor interference effects they produced appear to demonstrate capture of attention by entirely irrelevant distractors. These effects were similar in magnitude to the response competition effects produced by response-relevant (incongruent) distractor letters and, similarly to the response-relevant distractor, the interference from the irrelevant distractors was found only when the relevant task involved low perceptual load but was eliminated in conditions of high perceptual load.

In the present study, we aimed to further establish this phenomenon of attentional capture by irrelevant distractors while characterizing the distractor factors that are critical for producing such attentional capture. To that purpose we presented subjects with a letter search task in the centre of the display, in which they were required to indicate whether an "X" or an "N" target letter was present. Subjects were requested to focus attention on this task and ignore any other stimuli that might appear on the screen. An irrelevant cartoon figure (Experiments 1 and 2) or shape (Experiment 3) was presented on some of the trials and the extent to which it captured attention despite its clear irrelevance to the task was measured by comparing target letter RTs in the presence versus absence of the irrelevant distractor.

In Experiment 1, we examined whether the irrelevant distractor would capture attention and slow down the search RTs regardless of whether performance of the search task could or could not involve a singleton detection strategy. As the irrelevant cartoon distractor was the only one of its kind, it was important to examine whether it is only capable of capturing attention when the target is also a singleton. The interference by an entirely irrelevant distractor in daily life is unlikely to depend on people adopting a singleton detection strategy in their task, for instance in the example of interference by an entirely irrelevant pop-up advert whilst searching for a particular e-mail message, the e-mail search is far more likely to be based on a semantic processing strategy (e.g., searching for the sender's name) than on a singleton detection strategy. We thus hypothesized that the irrelevant distractor in our task would capture attention regardless of whether a singleton detection strategy was used in the task.

In addition, we also examined two other factors that appear to be important for capture of attention by irrelevant distracting stimuli in daily life: the frequency of the distractor occurrence (Experiment 2) and the meaningfulness of the distractor item (Experiment 3).

EXPERIMENT 1

In Experiment 1 we presented the irrelevant cartoon distractor on 10% of the search-task trials while also varying the letter-search task demands.

Participants were asked to search for X or N either among Os, or (in different blocks) among two other angular letters (from the set H, K, E, F, V). As the X or N targets should "pop out" among the homogenous—all Os—nontarget letters, such search is open to a singleton detection strategy. But as the angular X or N target letter is no longer a singleton when presented among other angular letters, a singleton detection strategy is no longer available for this search. If a singleton detection strategy is critical for attentional capture by the irrelevant distractor, then the distractor should only capture attention during search for a singleton target and not during search for a nonsingleton target.

Method

Participants. Eight participants (two males) aged between 18 and 33 ($M = 23$) were recruited from UCL subject pool and participated in return for £3. All participants had normal or corrected-to-normal vision.

Stimuli and procedure. Figure 1 presents an example of the stimuli used in Experiment 1. E-prime was used to run the experiment on a PC with a 15-inch monitor. Viewing distance of 60 cm was maintained with a chin-rest. Each

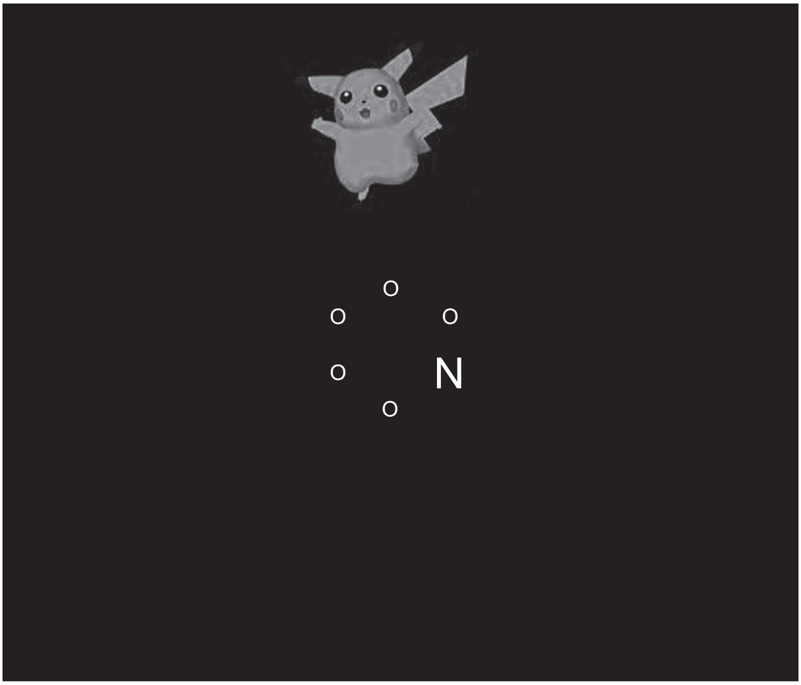

Figure 1. Example stimulus display with an irrelevant distractor in Experiment 1.

trial began with a centrally presented fixation point for 500 ms, followed immediately by a 100 ms presentation of the visual search display. The visual search display consisted of a target letter (either X or N, subtending 0.6° by 0.4°) and five nontarget letters spaced evenly around a circle (1.6° radius). The nontarget letters were either all small Os, subtending 0.15° by 0.12, or two other angular letters of the same dimensions as the target letter (selected at random from the following: E, F, H, V, K) appeared in place of two of the placeholders. The target letter and the two angular nontarget letters always appeared in adjacent positions but, with this restriction, the nontarget letters were equally likely to appear in any of the possible combinations of positions relative to the target (i.e., both to the left of the target, either side of the target, or both to the right of the target).The letters were presented in grey on a black background. The participants were instructed to search the letter circle display for the target letters and respond by pressing 0 for a target letter "X" and 2 for a target letter "N". Participants were instructed emphatically that they should ignore any stimuli other than the letter circle, but were not given any further information such as the characteristics of this "other stimuli". A beep sounded on incorrect responses or failures to respond within 2000 ms.

In addition, on a randomly selected 10% of the trials, one of six cartoon figures (Spiderman, Superman, Spongebob, Mickey Mouse, Donald Duck, and Pikachu from the Pokemon cartoon), subtending 2.8° to 4° vertically by 2.8 to 3.2° horizontally, was presented. Each was equally likely to be either above or below the letter circle with its centre at 4.6° from fixation. For the distractor present trials (24 overall), distractor identity was counterbalanced for each search condition and each distractor identity was equally likely to appear in association with each possible combination of target position and target identity. The distractor position was also counterbalanced with respect to target position and target identity. For the distractor absent trials, target position and identity were counterbalanced. Participants completed 12 practice trials for each search condition followed by eight blocks of 60 trials (half for each search condition) in the order ABBAABBA (this order was counterbalanced between subjects so that half the participants began the experiment with the feature search condition and half began with the singleton search condition; the practice blocks were presented in the same order as the first two experimental blocks).

Results

All RT analyses were performed on correct responses only. Mean RTs and percentage error rates are presented in Table 1.

RTs. A 2×2 ANOVA with the factors of search condition (singleton target, nonsingleton target) and distractor presence (present, absent) revealed a main effect of search condition, $F(1, 7) = 26.92$, $MSE = 2140.60$, $p = .001$, reflecting slower RTs in the nonsingleton compared to the singleton target search conditions. There was also a main effect of distractor presence, $F(1, 7) = 41.38$, $MSE = 386.58$, $p = .001$, reflecting

TABLE 1
Mean RTs and error rates in each condition of distractor presence and search type (SE in parentheses)

		Irrelevant distractor condition	
		Irrelevant distractor present	*Irrelevant distractor absent*
Singleton search	RT (ms)	540 (32)	503 (28)
	% error	10	7
Nonsingleton search	RT (ms)	633 (45)	581 (35)
	% error	13	7

slowed RTs in the presence (vs. absence) of the irrelevant distractor. There was no interaction between distractor presence and search condition, $F(1, 7) = 1.98$, $MSE = 224.61$, $p = .20$. Significant distractor effects were observed in both the nonsingleton target search condition ($M = 52$ ms), $t(7) = 4.97$, $SEM = 10.5$, $p = .002$, and the singleton ($M = 37$ ms), $t(7) = 5.71$, $SEM = 6.52$, $p = .001$, target search condition.

Experiment 1 thus establishes that irrelevant meaningful and salient distractors capture attention regardless of whether the search target is a singleton or not.

In addition, to examine whether the attentional capture effects could just be attributed to the unexpected and perhaps even somewhat surprising nature of the irrelevant distractor, we compared the distractor effects between the first block (in which each of the distractors appeared for the first time) and the remaining blocks (in which each of the distractors was repeated). Although the distractor effects were numerically larger in the first block (M effect = 65 ms) than in the later blocks (M effect = 43 ms), this difference was not significant: $F < 1$ for the interaction in an ANOVA with the factors of block (first block, remaining blocks) and irrelevant distractor condition (present, absent). Moreover, the irrelevant distractor effects were significant both in the first block, $t(7) = 2.42$, $SEM = 26.98$, $p = .046$, and in the later blocks, $t(7) = 5.04$, $SEM = 8.55$, $p = .001$. The distractor effects remained highly significant even when just the last four blocks were analysed (M effect = 30 ms), $t(7) = 5.89$, $SEM = 5.13$, $p = .001$.

Errors. A 2×2 ANOVA with the factors of search condition (singleton, feature) and distractor presence (present, absent) revealed a significant main effect of distractor presence, $F(1, 7) = 10.94$, $MSE = 13.21$, $p = .013$, reflecting a higher percentage of errors when an irrelevant distractor was present compared to when it was absent. Neither the main effect of search condition nor the interaction between search condition and distractor presence were significant on this measure (all Fs < 1).

EXPERIMENT 2

In Experiment 2, we examined whether infrequent occurrence of the irrelevant distractor is critical for producing attentional capture. The irrelevant distractor was always infrequent (occurring on 10% of the trials) in Forster and Lavie's (2007) experiments. In the present experiment, we compared the effects of attentional capture between blocks with infrequent distractor occurrence (on 10% of the trials) and blocks with frequent distractor occurrence (on 50% of the trials).

Method

Participants. Eight participants (two males) aged between 18 and 35 ($M = 22$) and with normal or corrected-to-normal vision were recruited from University College London Psychology Subject Pool. All participants were paid £3 for participation.

Stimuli and procedure. All stimuli and procedures were identical to that of Experiment 1, with the following exceptions. Both frequency conditions were identical to the "singleton target" condition of Experiment 1, with the exception that, whereas the irrelevant distractor was displayed on only 10% of trials in the low frequency condition (as in Experiment 1), in the high frequency condition the irrelevant distractors were displayed on 50% of the trials. Participants completed 12 practice trials in which the irrelevant distractor was never presented, followed by four blocks of each frequency condition. Half the subjects started with four low frequency blocks followed (after a 5 min break) by four high frequency blocks; the reverse order was run for the other half.

Results

All RT analyses were performed on correct responses only. Mean RTs and percentage error rates in each condition of distractor presence and distractor frequency are presented in Table 2.

RTs. A 2×2 ANOVA with the factors of distractor frequency (50%, 10%) and distractor condition (present, absent) revealed no main effect of frequency, $F(1, 7) = 3.13$, $MSE = 1168.96$, $p = .12$: The average target RTs across the irrelevant distractor conditions were similar between the low and high distractor frequency blocks. There was a main effect of irrelevant distractor condition, $F(1, 7) = 25.88$, $MSE = 438.01$, $p < .001$, and RTs were

TABLE 2
Mean RTs and error rates in each condition of distractor presence and distractor frequency (SE in parentheses)

		Distractor condition	
		Irrelevant distractor	*No distractor*
10% frequency	RT (ms)	560 (22)	509 (18)
	% error	9	6
50% frequency	RT (ms)	525 (15)	501 (15)
	% error	8	6

again slower in the presence (vs. absence) of the irrelevant distractor. This main effect was qualified by an interaction with frequency, $F(1, 7) = 40.55$, $p < .001$, reflecting that the RT cost was significantly greater when the distractor was only presented on 10% than on 50% of trials. Note, however, that participants were significantly slowed by the presence of irrelevant distractors in both frequency conditions: For the 10% condition ($M =$ 51 ms), $t(7) = 55.89$, $SEM = 8.67$, $p < .001$; for the 50% condition ($M =$ 24 ms), $t(7) = 3.77$, $SEM = 6.58$, $p = .008$.

The irrelevant distractor was presented a total of 120 times in the high frequency condition and only 24 times in the low frequency condition. In order to clarify that the apparent frequency effect did not merely reflect any effect of the absolute number of times each distractor was presented, RTs for the first 24 irrelevant distractor trials in the high frequency condition (to match the total number of irrelevant distractor trials of the low frequency condition) were examined. The mean RTs for these first 24 irrelevant distractor trials ($M = 534$ ms) did not differ significantly from the mean RTs for all the irrelevant distractor trials in the high frequency condition ($M =$ 525 ms, see Table 2), $t(-7) = -1.17$, $SEM = 7.81$, $p = .280$, and remained significantly shorter compared with the mean RTs on the irrelevant distractor trials in the low frequency condition ($M = 560$ ms), $t(7) = 2.54$, $SEM = 10.11$, $p = .038$. These results confirm that the reduction in the distractor capture effects in the high frequency condition was due to the greater frequency of distractor occurrence rather than to the number of specific distractor image repetitions and any accompanied repetition adaptation effects.

Finally, to examine whether the attentional capture effects in the present experiment could just be attributed to the unexpected and somewhat surprising nature of the irrelevant distractors when they first occur, we compared again the distractor effects between the first block and the remaining blocks. As in Experiment 1, the distractor effects were numerically larger in the first block (M effect = 45 ms) than in the later blocks (M effect = 23 ms), but this difference was not significant $F(1, 7) = 1.20$, $MSE =$ 747.98, $p = .31$, and the distractor effects in the first block approached significance, $t(7) = 2.26$, $SEM = 19.77$, $p = .059$, but were clearly significant in the remaining blocks, $t(7) = 2.26$, $SEM = 7.18$, $p = .014$, and also when just the last four blocks were analysed (M effect = 33 ms), $t(7) = 8.3$, $SEM =$ 4.05, $p = .001$.

Errors. The error data only showed a trend for a higher percentage errors in the presence (vs. absence) of the irrelevant distractor, $F = 3.73$, $MSE = 14.10$, $p = .095$, (all other Fs < 1).

Experiment 2 thus establishes that attentional capture by an entirely irrelevant distractor is greater for an infrequent distractor than for a frequent distractor.

It is important to note though that the irrelevant distractor produced significant attentional capture effect even when presented on 50% of the trials. In this respect, the present results are in contrast with Neo and Chua's (2006) recent findings. Their subjects performed a visual search task on four letters. When one of the nontarget letters was surrounded by abrupt onset dots on 50% of the trials, the onset distractors only captured attention when the target was uncued (and thus the onset letter was search relevant). The capture effect was eliminated when the focusing of attention to the target location was facilitated either by a 100% valid precue or by the target always being presented in the same location. In our paradigm by contrast, despite clear and predictable spatial separation between the target and the irrelevant distractor, the capture effects remained significant even for a distractor that occurred on 50% of the trials. Thus, the present attentional capture effects for the irrelevant distractor cannot be reduced to a simple surprise or novelty effect (cf. Johnston, Hawley, Plewe, Elliott, & Dewitt's, 1990, work on novelty).

EXPERIMENT 3

The irrelevant cartoon stimuli used in Experiments 1 and 2 were meaningful and conveyed fairly rich semantic information involving the different semantic connotations of the cartoon heroes depicted (e.g., Superman vs. Spiderman). In Experiment 3, we examined whether attentional capture by irrelevant distractors is confined to such highly meaningful stimuli or can be found for meaningless shapes as well. Attentional capture effects were compared between blocks in which the irrelevant meaningful cartoon distractors were presented and blocks in which a meaningless shape of similar dimensions to the cartoon figures was presented.

Method

Participants. Fourteen participants (seven males) were recruited from University College London Psychology Subject Pool and were paid £3 for participation. The subjects were aged between 19 and 26 ($M = 23$) and all had normal or corrected-to-normal vision.

Stimuli and procedure. All stimuli and procedures were identical to those used in Experiment 1, with the following exceptions: The "meaningful" condition was identical to the low frequency condition in Experiment 2, with colourful cartoon character distractors presented on 10% of trials. In the "meaningless" condition, a colourful cartoon shape (see Figure 2 for an

Figure 2. Example stimulus display with a meaningless irrelevant distractor in Experiment 2.

example display with the meaningless distractor), subtending $3.1^\circ \times 3.1^\circ$, was presented in place of the cartoon character (i.e., in the same position and at the same frequency). The two distractor meaning conditions were fully counterbalanced with distractor position, target position, and target identity. Participants performed 12 practice trials, followed by four blocks of each distractor meaning condition in the order AAAABBBB, with a 5 min break between each meaning condition (order counterbalanced between participants).

Results

Mean RTs and percentage error rates in each condition of distractor meaning and distractor presence are presented in Table 3.

RTs. A 2×2 distractor presence (present, absent) and distractor meaning (high, low) ANOVA revealed no main effect of distractor meaning, $F(1, 13) = 0.18$, $MSE = 672.02$, $p = .676$, indicating that overall performance in the two blocks was not slowed by the type of distractors present on 10% of

TABLE 3
Mean RT and error rates in each condition of distractor presence and distractor meaning (SE in parentheses)

		Irrelevant distractor condition	
		Irrelevant distractor present	*Irrelevant distractor absent*
High meaning	RT (ms)	526 (14)	470 (11)
	% error	9	7
Low meaning	RT (ms)	516 (13)	474 (12)
	% error	11	6

the block trials. As in Experiment 1, there was a main effect of distractor presence, $F(1, 13) = 67.85$, $MSE = 490.41$, $p = .001$. This effect was qualified by an interaction between distractor presence and distractor meaning, $F(1, 13) = 6.07$, $MSE = 107.37$, $p = .028$, reflecting that although both types of distractors were associated with significant slowing in RTs, this RT cost was significantly greater when the distractors were meaningful ($M = 56$ ms), $t(13) = 8.54$, $SEM = 6.51$, $p < .001$, than when they were meaningless ($M = 42$), $t(13) = 6.44$, $SEM = 6.56$, $p < .001$.

Errors. Except for a trend for a larger percentage of errors in the presence (compared to absence) of the irrelevant distractor, $F(13) = 3.20$, $MSE = 54.91$, $p = .098$, there were no other effects on the error measures (all other Fs < 1.5, ps $> .24$).

Experiment 3 therefore demonstrates that although the semantic meaning of distractors appears to affect the degree to which they are distracting, even meaningless distractors can produce robust attentional capture effects.

GENERAL DISCUSSION

The present experiments demonstrated a new phenomenon of attentional capture by an entirely irrelevant distractor. The distractor stimuli were completely unrelated to the letter task stimuli both in terms of position (the distractor was presented outside of the letter circle in the periphery) and identity (the distractor was a cartoon figure or an abstract shape, whereas the search task stimuli were letters), as well as in terms of visual appearance (the distractor was large and colourful, whereas the search letters were small and monochromatic). Yet the irrelevant distractor produced robust interference effects on the search task performance, suggesting that it captured attention despite being irrelevant to the task at hand.

With respect to previous findings using the paradigm of attentional capture, it is important to note that as the irrelevant distractor in the present experiments clearly shared no visual or semantic features with the task stimuli, it was therefore irrelevant to the attentional settings for the target (cf. Gibson & Kelsey 1998; Johnson, Hutchinson, & Neill, 2001). Moreover, in Experiment 1, we demonstrated that attentional capture by an irrelevant distractor can persist even when the participants are unable to use a singleton search strategy in the central task, therefore ruling out any explanation of the capture effect as being a result of singleton search strategy.

Thus, the distractor interference effects suggest involuntary capture of attention by a truly irrelevant distractor that is clearly not attributed to any top-down relevance to the attentional settings of the letter search task.

The experiments also showed that the effects of attentional capture are greater for rare distractors (occurring on 10% of the trials) compared to more frequent distractors (occurring on 50% of the trials). This effect of distractor frequency is likely to be due to a difference in the overall level of habituation to the presence of a distractor. Presumably subjects are less habituated to the distractor presence when it is fairly rare than when it appears on average on every other trial.

Importantly, however, the attentional capture effects were not confined to the case of rare distractors, the frequent distractors also produced significant attentional capture effects (of a similar magnitude to those typically reported in the attentional capture paradigm, e.g., Theeuwes, 1992, 1994). Thus, the present phenomenon of attentional capture can not be merely due to effects of surprise or novelty (cf. Johnston et al., 1990).

Such accounts are also ruled out by the third experiment. Since meaningless shapes produced a robust capture effect in Experiment 3, this experiment clarified that the attentional capture phenomenon established here cannot be merely due to either the novelty of the cartoon figures (as the shape was repeated 24 times in Experiment 3) or to the semantic processing of the meaningful figures and its potentially higher level of interest compared with that for the search letters. The meaningless figure is unlikely to have raised any interest following a few exposures to it.

Although the results of Experiment 1 allow us to rule out the possibility that our capture results can be attributed to a target related search strategy, Gibson and Kelsey (1998) have suggested that tasks such as ours, in which each trial begins with an abrupt onset, may create a display-wide attentional setting for abrupt onsets (and possibly for other dynamic events). Franconeri et al. (2004) have ruled out the possibility that this display-wide attentional setting is necessary for capture by abrupt onsets, by demonstrating that even when the initiation of a search task is not signalled by an abrupt onset, abrupt onsets continue to capture attention. However, as Franconeri et al.

used a paradigm in which the abrupt onset singletons appeared in a task relevant location, future research should clarify whether abrupt onset singleton distractors that are irrelevant in both content and location (as in our study) continue to capture attention, even when the initiation of the central task is not signalled by an abrupt onset.

Overall, the attentional capture phenomenon revealed in the present experiments appears more akin to capture of attention in daily life, whereby an entirely irrelevant object will still attract attention and distract one from performing a current task. These findings can be accounted for by accounts in which attention is always tuned to detect any unique object in the field (e.g., Yantis, 2000), possibly because such unique objects may convey important information regarding a potentially important change in the environment or perhaps because unique objects are more salient compared with other objects and attention is generally drawn to salient events. Although such a claim is similar to the claims of some attentional capture models (e.g., Theeuwes, 1995), these models have focused on the relevance of salience computations for visual search tasks, whereas here we suggest a more general role for salience in attracting attention that also characterizes situations in which the salient stimuli are not related in any way to the particular search task (and hence there is no need to either compute their salience or consider their salience value when conducting the search task).

Future research should establish the generality of attentional capture by entirely irrelevant distractors (e.g., whether it can be found for relevant tasks that do not involve any search at all, and are performed in a continuous manner, and hence do not involve any attentional settings for abrupt onset) and its boundary conditions. For example, it would be important to examine whether attentional capture effects would be found for salient nonsingleton objects, or conversely, for singleton objects that are less visually salient than those presented in the relevant task (e.g., would monochromatic distractors interfere with performance of a task involving colourful stimuli?). Another important future avenue would be to examine the extent to which laboratory measures of attentional capture by irrelevant distractors correlate with other measures of distractibility in daily life.

REFERENCES

Abrams, R. A., & Christ, S. E. (2003). Motion onset captures attention. *Psychological Science*, *14*, 427–432.

Bacon, W. F., & Egeth, H. E. (1994). Overriding stimulus-driven attentional capture. *Perception and Psychophysics*, *55*, 485–496.

Folk, C. L., Leber, A. B., & Egeth, H. E. (2002). Made you blink! Contingent attentional capture produces a spatial blink. *Perception and Psychophysics*, *64*(5), 741–753.

Folk, C. L., & Remington, R. (1998). Selectivity in distraction by irrelevant featural singletons: Evidence for two forms of attentional capture. *Journal of Experimental Psychology: Human Perception and Performance*, *24*, 847–858.

Folk, C. L., & Remington, R. (1999). Can new objects override attentional control settings? *Perception and Psychophysics*, *61*, 727–739.

Folk, C. L., Remington, R. W., & Johnston, J. C. (1992). Involuntary covert orienting is contingent on attentional control settings. *Journal of Experimental Psychology: Human Perception and Performance*, *18*, 1030–1044.

Forster, S., & Lavie, N. (2007). *Failures to ignore entirely irrelevant distractors: The role of load*. Manuscript submitted for publication.

Franconeri, S. L., & Simons, D. J. (2003). Motion and looming capture attention. *Perception and Psychophysics*, *65*, 999–1010.

Franconeri, S. L., Simons, D. J., & Jungé, J. A. (2004). Searching for stimulus-driven shifts of attention. *Psychonomic Bulletin and Review*, *11*(5), 876–881.

Gibson, B. S., & Kelsey, E. M. (1998). Stimulus-driven attentional capture is contingent on attentional set for displaywide visual features. *Journal of Experimental Psychology: Human Perception and Performance*, *24*, 699–706.

Johnson, J. D., Hutchison, K. A., & Neill, W. T. (2001). Attentional capture by irrelevant color singletons. *Journal of Experimental Psychology: Human Perception and Performance*, *27*, 841–847.

Johnston, W. A., Hawley, K. J., Plewe, S. H., Elliott, J. M. G., & Dewitt, M. J. (1990). Attention capture by novel stimuli. *Journal of Experimental Psychology: General*, *119*, 397–411.

Jonides, J., & Yantis, S. (1988). Uniqueness of abrupt visual onset in capturing attention. *Perception and Psychophysics*, *43*, 346–354.

Lamy, D., & Egeth, H. E. (2003). Attentional capture in singleton-detection and feature-search modes. *Journal of Experimental Psychology: Human Perception and Performance*, *29*, 1003–1020.

Neo, G., & Chua, F. K. (2006). Capturing focused attention. *Perception and Psychophysics*, *68*(8), 1286–1296.

Theeuwes, J. (1991). Exogenous and endogenous control of attention: The effect of visual onsets and offsets. *Perception and Psychophysics*, *49*, 83–90.

Theeuwes, J. (1992). Perceptual selectivity for color and form. *Perception and Psychophysics*, *51*, 599–606.

Theeuwes, J. (1994). Stimulus-driven capture and attentional set: Selective search for color and visual abrupt onsets. *Journal of Experimental Psychology: Human Perception and Performance*, *20*, 799–806.

Theeuwes, J. (1995). Perceptual selectivity for color and form: On the nature of the interference effect. In A. F. Kramer, M. G. H. Coles, & G. D. Logan (Eds.), *Converging operations in the study of visual attention* (pp. 297–314). Washington, DC: American Psychological Association.

Yantis, S. (2000). Goal-directed and stimulus-driven determinants of attentional control. In S. Monsell & J. Driver (Eds.), *Attention and performance: XVIII. Control of cognitive performance* (pp. 73–103). Cambridge, MA: MIT Press.

Yantis, S., & Jonides, J. (1984). Abrupt visual onsets and selective attention: Evidence from visual-search. *Journal of Experimental Psychology: Human Perception and Performance*, *10*, 601–621.

Yantis, S., & Jonides, J. (1990). Abrupt visual onsets and selective attention: Voluntary versus automatic allocation. *Journal of Experimental Psychology: Human Perception and Performance*, *16*, 121–134.