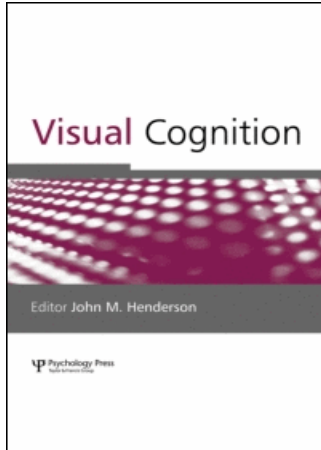


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Introduction

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Introduction

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The notion that certain mental or physical events can capture attention has strong intuitive appeal. Such intuitions are typically based on experiences in which an irrelevant event summons attention away from the demands of a current task. Although this apparent vulnerability to external distractions can be detrimental to the mental and physical health of the organism in some situations (as when the distracting event causes us to have an automobile accident), it may also be beneficial to the mental and physical health of the organism in other situations where adaptation to important environmental change is required (as when the distracting event is itself potentially harmful and therefore to be avoided). Because the consequences of attentional capture can have profound effects (both positive and negative) on our mental and physical well-being, it is necessary to go beyond a simple intuitive understanding of this complex behaviour.

Indeed, scientific interest in attentional capture has grown exponentially over the last 20 years (see Burnham, 2007; Folk & Gibson, 2001; Rauschenberger, 2003; Ruz & Lupianez, 2002; Simons, 2000; and Egeth & Yantis, 1997, for reviews). A good part of this interest stems from the fact that modelling attentional capture has the potential to provide fundamental

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insights into the nature of cognitive control in general. For example, attentional capture provides an important empirical domain for modelling the interaction between “automatic” (bottom-up) and “controlled” (top-down) processing. In addition, characterizing the nature and consequences of attentional capture has obvious and important applied implications. Efficient performance on any task is ultimately dependent on whether limited attentional resources are allocated to stimuli consistent with current behavioural goals.

Despite the clear theoretical and applied importance of attentional capture, a broad survey of this field suggests that the term “capture” means different things to different people. In some cases, it refers to covert shifts of spatial attention, in others involuntary saccades, and in still others general disruption of processing by irrelevant stimuli. The properties that elicit “capture” can also range from abruptly onset or moving lights, to discontinuities in textures, to unexpected tones, to emotionally valenced words or pictures, to directional signs and symbols. Attentional capture has been explored in both the spatial and temporal domains as well as the visual and auditory modalities. There are also a number of different theoretical perspectives on the mechanisms underlying “capture” (both functional and neurophysiological) and the level of cognitive control over capture.

The present special issue of *Visual Cognition* provides a sampling of the diversity of approaches, domains, and theoretical perspectives that currently exist in the study of attentional capture. It is our hope that such efforts will ultimately help the field evaluate the degree to which the term “attentional capture” represents a unitary construct that reflects fundamental theoretical principles and mechanisms. In the remainder of this introduction, we will provide a brief review of the contents of this special issue.

The first three papers in this special issue investigate the measurement and proper interpretation of various effects that have been interpreted to reflect involuntary shifts of spatial attention. Santangelo and Spence address the degree to which irrelevant auditory stimuli can produce the capture of visual spatial attention. Although previous studies have provided evidence for such “cross-modal capture”, such studies have typically relied on response time measures, which may reflect the influence of decision stages rather than perceptual effects related to attention allocation. Santangelo and Spence get around this problem by measuring performance on a temporal order judgement (TOJ) task that has been shown to be influenced by changes in the distribution of spatial attention. They report that stimuli appearing on the same side as an irrelevant, noninformative auditory precue are judged as appearing approximately 20 ms prior to a stimulus appearing simultaneously in the opposite location. This “prior visual entry” effect induced by auditory cues provides important converging evidence for cross-modal attentional capture and also speaks to recent theoretical treatments of

the effects of endogenous versus exogenous cues (e.g., Prinzmetal, McCool, & Park, 2005).

Ester and Awh address in their paper whether attentional capture as evidenced by a slowed response in the presence of an irrelevant singleton (e.g., Theeuwes, 1991, 1992) is due to disruptions at early perceptual processing stages or is due to disruptions at later stages of processing such as response selection. For their experiments, they used the traditional additional singleton paradigm (cf. Theeuwes, 1991, 1992) and replicate the original findings showing an RT costs when the irrelevant singleton was present relative to when it was absent. However, when they used the very same displays under data-limited conditions (brief exposure durations with a backward mask) there was no effect of the singleton on accuracy. Since irrelevant singletons did not interfere in these data-limited conditions, Ester and Awh conclude that the irrelevant singleton interference cannot be due to interference at early but only at later stages of processing. The study is important because it questions whether previous results from the additional singleton paradigm represent genuine attentional capture effects.

A critical debate in the attentional capture literature concerns the extent to which capture is contingent on the goals and intentions of the observer (Burnham, 2007; Folk, Remington, & Johnston, 1992; Gibson & Kelsey, 1998). In an attempt to provide stronger evidence for the hypothesis that capture can be determined solely by stimulus variables, Theeuwes and Burger (1998) developed the identity intrusion paradigm in which a task-irrelevant colour singleton is presented within the context of a serial search task. Theeuwes and Burger showed that the identity of the irrelevant singleton often interacted with the observer's ability to identify the task-relevant target, which suggested that the task-irrelevant singleton captured attention. In the present special issue, Gibson and Bryant argue that the identity intrusion effect observed by Theeuwes and Burger was obtained under conditions of relatively low perceptual load; and, therefore the processing of the irrelevant distractor may reflect the automatic allocation of perceptual resources rather than a spatial shift of attention (Lavie, 1995, 2005). Gibson and Bryant provide support for this perceptual load account of the identity intrusion effect by showing that the magnitude of this effect decreases as perceptual load increases.

The next three papers in this special issue explore the extent to which attentional capture can be modulated by top-down information. Forster and Lavie explore the extent to which the kinds of attentional distraction experienced in everyday life are subject to top-down modulation. The authors point out that in most laboratory studies of capture, stimuli that are deemed "irrelevant" often share subtle features in common with targets, such as potential locations. In everyday life, however, we are often confronted with stimuli that are completely irrelevant to our current task

at hand (i.e., that share no possible features with current behavioural goals). In their new paradigm, subjects performed a centrally presented letter search task, and on a subset of trials a large, irrelevant shape or cartoon figure was presented in the periphery (i.e., a location where the target could never appear), in much the same way a “pop-up” advertisement might appear on a website page. The presence of these peripheral distractors produced significant costs in response time relative to no-distractor trials. Moreover, this effect was larger when the distractors appeared infrequently (see also Godjin & Kramer, as well as Horstmann & Becker, this issue), and when they carried meaning (e.g., a “Pokemon” character). The results suggest a form of purely bottom-up attentional capture that is similar to the kinds of distractions experienced in everyday life.

Folk and Remington continue their work on the impact of top-down set on the ability of salient, but irrelevant, distractors to capture spatial attention. In previous work they have found evidence that the capture of spatial attention is contingent on whether the eliciting stimulus carries features that match current behavioural goals instantiated in “attentional control settings”. Here they address the degree to which attentional control settings can be primed by intertrial context. In a modified spatial cueing paradigm, subjects searched for colour singleton targets whose colour varied from red to green unpredictably across trials, which was assumed to encourage subjects to adopt top-down control settings for colour singletons in general, rather than for a specific colour. Consistent with this assumption, colour singleton cues that also varied unpredictably from red to green produced evidence of capture (i.e., spatial cueing effects) regardless of whether the specific colour of the cue and target matched or not. More importantly, the magnitude of these cueing effects was enhanced when the cue colour matched the colour of the previous target, suggesting that top-down control settings can be primed by intertrial context. Interestingly, a similar effect was not found when subjects were encouraged to adopt a top-down set for a specific colour rather than for colour singletons in general. Thus, intertrial priming of control settings appears relevant only when feature specific parameters are left unspecified. The results provide important new data relevant to how top-down attentional control settings are established and maintained.

Theeuwes and van der Burg used the additional singleton paradigm (Theeuwes, 1991) in which participants either searched for a diamond between circles or a circle between diamonds. In some conditions, the identity of the target singleton for the upcoming trial was cued in advance by either a word cue (e.g., a word saying “diamond”) or a symbolic cue (e.g., a cue showing the shape of a diamond). The important finding was that cueing the identity of upcoming target singleton reduced but did not eliminate attentional capture by the irrelevant colour distractor. It is important to note

that the cue was effective in reducing response time indicating that participants actively used the cue. However, at the same time this top-down “knowledge” could not eliminate the distracting effect of the irrelevant colour singleton. Furthermore, Theeuwes and van der Burg showed that cueing benefits were especially large when a colour distractor was present suggesting that top-down processing plays a large role after attention has been captured to the location of the irrelevant colour distractor. Finally, they confirm some recent findings showing that when no distractor is present, top-down processing plays no role; in those circumstances only priming can facilitate singleton search (see Theeuwes & van der Burg, in press).

The next two papers in this special issue investigate the ability of emotional stimuli to capture attention. An abundance of previous evidence has suggested that the perception of emotional facial expression is automatic and can capture attention even when affect is irrelevant to the task at hand. For instance, previous evidence reported by Eastwood, Smilek, and Merikle (2003) has suggested that negative facial expression can disrupt the ability to process local facial features. In the present special issue, Eastwood, Frischen, Reynolds, Gerritsen, Dubins, and Smilek examine the limits of attentional capture by emotional facial expression by examining the extent to which the effect of negative facial expression on task performance is influenced by the salience of the local facial features as well as by the task set of the observer. Across three experiments, Eastwood et al. provide evidence that the effect of negative facial expression on task performance can be abolished when the to-be-processed local facial features are made salient and observers are set to process local features. However, the effect of negative facial expression can be reinstated when observers are set to process global features, even when local facial features are made salient. These results are important because they illustrate that the effects of emotional facial expression on the allocation of spatial attention may not be purely automatic, but rather depend on interactions between stimulus attributes and attentional set.

Most and Junge follow up on Most’s previous work on “attentional rubbernecking”, in which an irrelevant but emotionally negative picture presented within a rapid sequence of neutral pictures impairs detection of a neutral target picture, producing a phenomenon akin to the “attentional blink” (Raymond, Shapiro, & Arnell, 1992). The new and interesting twist in the present experiments is to explore the impact of emotional distractors that appear both before and *subsequent* to the target in the stream. Consistent with the earlier work, emotional distractors produced a decrement in target detection when they appeared one or two positions prior to the target. A similar effect was found when the distractor appeared one position after the target. Interestingly, however, target detection was significantly *enhanced* when the emotional distractor appeared two positions

beyond the target. The authors propose that when the target and distractor appear close in time, their representations compete for processing resources. When the target and distractor appear further apart in time, they no longer compete for processing resources, but the arousing effect of the emotional content may enhance consolidation processes for the target, similar to the effects of retroactive effects of arousal on long-term memory consolidation (Cahill & McGaugh, 1998). The results have important implications for current theories of the attentional blink.

The next two papers in this special issue investigate the effect of stimulus frequency and surprise on attentional capture. Godijn and Kramer show that an abrupt onset captures the eye much stronger when this onset is unexpected. They used the classic oculomotor capture paradigm (cf. Theeuwes, Kramer, Hahn, & Irwin, 1998; Theeuwes, Kramer, Hahn, Irwin, & Zelinsky, 1999) in which observers have to make a saccade to a uniquely coloured circle. In the original oculomotor capture paradigm, simultaneously with the colour singleton on each trial, an abrupt onset was presented. In Godijn and Kramer's study, there was no onset presented on the first 32 trials and then on Trial 33 an onset was presented. On the remaining trial the onset was also presented. The important finding was that the surprising onset captured the eyes in 28% of the participants. After repeating the presentation of the onset, this percentage dropped to about 5%. The important finding of this study is that the onset had the largest effect on performance when it was completely task irrelevant and not part of the expectations of the observers. The findings are important and consistent with some recent findings suggesting that the extent to which capture occurs depends very much on the frequency of exposure (see e.g., Folk & Remington, 2007; Neo & Chua, 2006). Typically, stimulus-driven capture is more often observed when the occurrence of the event is relatively rare.

Previous accounts of attentional capture have contrasted stimulus-driven and goal-directed control processes. For instance, some researchers (Theeuwes, 1994) have argued that attentional capture can be driven in a purely bottom-up fashion by stimulus salience whereas other researchers have argued that attentional capture occurs only when stimulus properties are consistent with the goals and intentions of the observer (Burnham, 2007; Folk et al., 1992; Gibson & Kelsey, 1998). However, Horstmann (2005) has recently suggested that attentional capture may also occur when stimulus properties are discrepant with current expectations, and he has demonstrated this using the surprise paradigm developed by Gibson and Jiang (1998). A critical aspect of Horstmann's account is that detection of a discrepant expectancy takes approximately 400 ms to develop. In the present special issue, Horstmann and Becker provide additional evidence for this discrepant expectancy account by showing that the 400 ms requirement does not reflect recovery from task set disruption. In addition, they also provide

important evidence that it is prolonged exposure to the discrepant stimulus itself that is critical to developing a discrepant expectancy as opposed to the passage of time per se.

The next two papers in this special issue investigate the kinds of information that can capture attention. Owens and Spehar address the claim suggested by von Mühlenen, Rempel, and Enns (2005) that the extent to which an event captures attention depends on its temporal uniqueness and not so much on the spatial change per se. Von Mühlenen et al. showed that presenting events such as colour changes, motion changes, and sudden onsets 150 ms before the target onset caused the strongest capture. These findings indicate that the time at which a feature occurs is more important than the nature of the feature itself, in contrast to a literature dominated by the investigation of feature types, specifically sudden onsets. By introducing a baseline condition, Owens and Spehar showed that—unlike von Mühlenen et al.—the unique temporal changes did not capture attention. Importantly, they showed that abrupt onsets captured attention but unique colour changes did not. If anything, colour changes caused costs suggesting a unique temporal change make singletons harder to ignore when they occur as distractors but they do not speed up performance when they are targets. The present study confirms the traditional notion that sudden onsets are unique in their ability to capture attention in a genuine bottom-up way.

Very little is known about how long-term memory for specific items influences the distribution of attention during free viewing. To address this gap in knowledge, West Chanon and Hopfinger explore the effect of item memory on the distribution of attention by measuring eye movements during free viewing of visual scenes. In addition, West Chanon and Hopfinger also attempt to extend previous conceptions of attentional capture by measuring not only initial fixations, but also the amount of time the eyes remained fixated on an object. The results of their study suggested that when observers viewed scenes containing a previously studied object together with several new objects, observers tended to fixate the old objects sooner and also to dwell on the old objects longer than the new objects. In addition, West Chanon and Hopfinger also showed that the same pattern of results held regardless whether of observers were led to believe that they would be tested on individual objects or whole scenes, as well as regardless of the different strategies that observers assented to using during free viewing. These findings are important because they provide evidence that item memory can control the spatial distribution of attention independent of task goals or observer intentions, and they also suggest that the empirical investigation of attentional capture may be enhanced by focusing on additional measures such as dwell time.

The study by West Chanon and Hopfinger is also important because it measures capture using more complex, scene-based, stimuli than have

typically been used in the capture literature. The next three papers in this special issue continue this theme. The study by Birmingham, Bischof, and Kingstone examine attentional selection for natural social scenes. Their findings indicate that when people are depicted within natural scenes, attentional selection is preferentially biased toward their eyes. In addition, their findings indicate that the context of the scene is critical to attentional selection in that the selection of gaze information was especially pronounced when the social content and activity level within the scenes was high.

Karacan and Hayhoe extend this line of work further, examining attentional selection within a 3-D virtual reality. These researchers provide a compelling demonstration that semantic consistency and its ability to impact where people fixate involves a complex relationship between the object, its environment, and the familiarity of the environment to the individual.

Brockmole and Henderson take on the classic issue of what roles bottom-up and top-down processes play when new objects capture attention. Their work shows that in more complex real-world scenes salient visual transients can capture attention in a bottom-up manner, but when these transients are less salient it is the meaning of a new object, such as its semantic inconsistency, that drives selection in a top-down manner.

Finally, the paper by Kuhn, Tatler, Findlay, and Cole is fascinating both for its subject matter and its results. Kuhn and colleagues examined how misdirection during a magic trick affects where people look while they view a trick, and how eye fixations affect their ability to detect the secret to a trick. What is particularly fascinating is that, while there is a close coupling between where people look and where they attend, there is also evidence for an important dissociation between fixation and attention, such that detecting a trick is not determined solely by where one fixates.

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