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A review of attentional capture: On its automaticity and sensitivity to endogenous control

María Ruz & Juan Lupiáñez*

Universidad de Granada (Spain)

It is well known that irrelevant stimuli can control where we attend. However, in the literature about the so-called attentional capture phenomenon, there has been a great deal of discussion about the extent to which such effects are automatic or rather modulated by endogenous factors. The present article reviews data and theory related to this debate. Although both exogenous and endogenous factors appear to have an influence on attentional allocation, mental sets related to the task at hand seem to be the most influential in modulating attentional capture. As such, although attentional capture appears to be automatic "by default", in that it can occur in the absence of a specific mental set, it seems clear that it can be endogenously modulated.

At any moment thousands of stimuli reach our senses, but only a minority of them are selected for further processing; that is, we attend to a restricted portion of our external and internal environment. More than a century ago it had already been proposed that events can be attended for two reasons. First, attention can be deployed to a stimulus because it is important for achieving some goal. In this case, the intentions and strategies of the observer are in control of the allocation of attention, which in turn enhances the processing of selected events or locations. For example, if we want to hear a friend talking in a crowded environment, then we pay attention to his voice, and this attentional process filters out the irrelevant noise. This is what James called active attention (James, 1890), also known as endogenous attention, in which the control is exerted in a top-down manner. Second, the properties of the environment can attract the attention of the observer independent of his/her intentions. For example, if a car crashes behind us, we will certainly turn abruptly in the direction of the crashing sound. This would be the passive

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side of attentional deployment (James, 1890), also known as exogenous attention, in which the control is exerted in a bottom-up manner.

It is now well known that active/endogenous and passive/exogenous attention processes differ in several characteristics. Posner and Snyder (1975) and Jonides (1981) provided some of the first extended discussion of the distinction between endogenous and exogenous control of attention. According to these authors, top-down orienting is resource-limited, is easily suppressed, is affected by subject's expectancies and by concurrent memory load and requires conscious awareness. On the other hand, bottom-up orienting is resource-free, cannot be suppressed, is unaffected by subject's expectancies or by concurrent memory load and does not require conscious awareness.

Posner's costs and benefits paradigm has been one of the main tools in the study of endogenous and exogenous orienting (Posner, 1980). In this kind of task, a cue is presented before target onset and the time taken to respond to a target in the cued location is compared to the time taken to respond to a target in an uncued location. It is also common to add trials in which no cue is presented. Endogenous orienting is measured using a so-called central or symbolic cue, which usually appears at the centre of the screen (that is, its position is different from the potential target locations) and signals the likely location of the upcoming target. The fact that the cue predicts the likely location of the target encourages the subject to voluntarily attend to the location signalled by the central cue. In contrast, a peripheral cue is employed in the study of exogenous orienting. Here the cue appears in the periphery of the visual field either at or near the location of a potential target, although its position is uncorrelated with target location. Because this type of cue has no predictive value with respect to target location, the subject has no incentive to voluntarily orient her/his attention to the location of the cue.

With both cue types there are valid, invalid and neutral trials. In endogenous orienting studies, the cue reliably points to the actual target location on valid trials, and signals the opposite target location on invalid trials. On neutral trials, either both locations or neither location are signalled. In exogenous orienting studies, the cue appears in the same spatial location as the upcoming target on valid trials, and appears in the location opposite that of the target on invalid trials. On neutral trials, the cue appears in neither potential target location or in both potential target locations simultaneously. By comparing performance for valid, invalid and neutral trials, attentional orienting benefits (valid cue trials minus neutral trials) and costs (invalid cue trials minus neutral trials) can be estimated, with both central and peripheral cues. The usual finding is that, compared to neutral trials, it takes less time to respond to a target presented at the cued location and more time to respond to a target presented at an uncued location. These results are taken as evidence of the orienting of attention to specific spatial locations. The facilitation observed on valid trials with non-informative exogenous cues is used as evidence that attention has been captured automatically by the cue at its spatial location.

Visual search tasks constitute another paradigm employed in the study of attentional deployment. In this type of task the subject has to search for a defined target among a variable number of distractors (see Wolfe, 1998, for an extensive review of the literature). Reaction time or accuracy is measured and plotted as a function of the number of distractors surrounding the target. The change in reaction time as a function of the number of distractors is taken as a marker of the efficiency of visual search. Thus, efficient searches are indicated by target detection performance that is unaffected by the number of non-targets, while inefficient searches are indicated by target detection performance that slows by 40-60 milliseconds with each item that is added to the search display (Wolfe, 1998).

Theories of visual search (Treisman & Gelade, 1980; Treisman & Sato, 1990; Wolfe et al., 1989; Wolfe, 1994) typically acknowledge the existence of two broad search phases. The first stage is often described as preattentive. In this stage, the visual environment is coded on the basis of its basic independent features[1]. This processing is presumed to occur in parallel and without the need of attentional resources. A second attentive stage then occurs, in which attention moves serially[2] through the display, conjoining the independent features coded at particular locations in the previous phase into a single representation. These two phases are used to explain differences in search slopes. In feature searches, in which the slope is near or equal to zero, the searched for feature is said to "pop-out" from the array automatically or preattentively. In this case, search is said to occur in parallel across the display. In contrast, conjunction searches, in which the target is defined by a conjunction of two or more basic features, do require the second attentive stage. Since the target does not pop out preattentively, attention must serially scan the locations of items in the display to determine if a particular conjunction of features is present. In these conditions search time increases with the number of stimuli present in the array. As such, this type of search is said to be serial[3].

Attentional capture is said to occur when an irrelevant item that is unique in some dimension (i.e., a singleton) affects the time to detect a target. Attentional capture can speed performance if the singleton happens to be the target or slow performance if it is a distractor. The idea is that the singleton exogenously or automatically orients attention to its spatial location, thus prioritising or in some way improving the processing of stimuli at that location.

In both cueing and visual search paradigms, the notion that attention can be captured automatically has played an important role in theory development for many years. In cueing studies, an abrupt luminance change (a peripheral

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[1] The number and identity of the visual basic features is topic of great debate among researches. Colour, orientation or curvature are examples of basic features.

[2] There are also models that claim that all the processes work in a parallel manner (see, for example, Duncan and Humphreys, 1989).

[3] The distinction between parallel and serial searches has several theoretical problems. More neutral terms are efficient and inefficient searches (see Wolfe, 1998).

cue) is presumed to automatically orient attention to its spatial location, while in visual search studies, a feature automatically pops out and captures attentional resources. Both effects are presumed to take place without the intention of the observer. However, in recent years the automaticity of attentional capture has become a topic of debate. Several authors have argued that exogenous signals have the capacity to capture attention only when the observer has an optimal attentional set for that capture (Folk, Remington, and Johnston, 1992). Other authors have argued that, although exogenous cues might orient attention to their spatial location automatically, the effect that this attentional capture has on behaviour can be endogenously modulated by the attentional set adopted to deal with the task (Lupiáñez, Milliken, Solano, Weaver, and Tipper, 2001). As such, there is now a burgeoning literature on endogenous influences on effects that had previously been thought of as exogenously or automatically determined.

The remainder of this article is devoted to the exposition and discussion of the main findings and theories that shape this debate. The view that attentional capture depends solely on stimulus saliency and the idea that only certain special events have the ability to automatically capture attention are discussed. Also, evidence for the proposal that attentional capture is always triggered by the set adopted to deal with the task at hand is reviewed. Results support the conclusion that, although attentional capture occurs in the absence of specific mental sets (i.e., it is automatic "by default"), it can be endogenously modulated by the goal adopted to deal with the task.

The dependence of attentional capture on visual salience.

The notion that attention is deployed to the spatial location occupied by an object when it is salient enough gained support from the early experiments of Jan Theeuwes (1991a, 1992, 1994a; see Figure 1 for an illustration of the procedure). In these experiments, search items consisted of shapes with oriented lines inside them, arranged along the circumference of an imaginary circle around the fixation point. Subjects performed a visual search task in which they were required to detect a target defined by a unique salient feature (for example, colour or brightness) and to report whether the line inside this singleton target had either a vertical or a horizontal orientation[4]. In this sense, subjects were said to search for a singleton target[5]. Apart from the singleton target, an irrelevant singleton defined by a different unique feature appeared on some trials. In a control condition in which the targets were not singletons, this task yielded inefficient search slopes (Theeuwes, 1991a). However, when the target was a singleton, the slopes of the search function were flat (see Figure 1 for an illustration of the results). According to Theeuwes (1991a, 1992, 1994a), these results indicated that featural singletons allow an efficient

[4] In this task the defining and the reported attribute of the target (Duncan, 1985) do not overlap. It is a so-called *compound search* task.

[5] For one item to be a singleton two conditions are needed: first, the stimulus must differ from its immediate surround in some dimension and, second, the surround ought to be relatively homogeneous in that dimension (Duncan and Humpreys, 1989).

search. However, the more interesting question concerned the effect of the irrelevant singleton: how would this irrelevant singleton affect the search function?

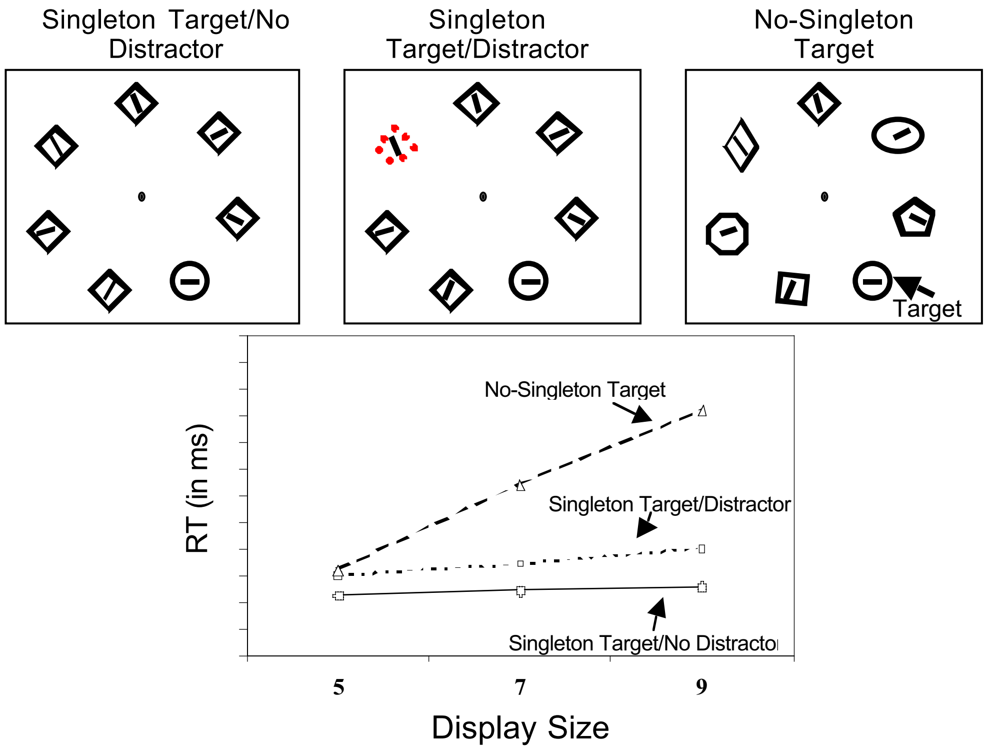

Figure 1: Graphic representation of Theeuwes' attentional capture procedure and usual results. See explanation in the text.

In Theeuwes' (1991a) Experiment 1, participants searched for a luminance singleton or a colour singleton. On half of the trials, an irrelevant singleton in the other dimension was presented (that is, a colour singleton distractor in the luminance singleton target condition and a bright irrelevant singleton in the colour singleton target condition). A control condition with no target singleton was also included. Regardless of whether the target was a colour or a luminance singleton, mean reaction time increased when an irrelevant singleton was present. Furthermore, in Experiments 2 and 3, the tendency for the irrelevant singleton to disrupt performance depended on its relative salience. Thus, in Experiment 2, a unique irrelevant shape did not delay the response but an irrelevant colour singleton did. However, when colour discrimination was made harder and shape discrimination easier in

Experiment 3, the asymmetric interference reversed: this time an irrelevant colour singleton did not disrupt performance but an irrelevant singleton shape did.

In these initial studies by Theeuwes (1991a), subjects did not know the specific feature that defined the target on each trial. Rather, they knew only that they were to search for a unique item in a particular dimension, such as colour, brightness or form.

As such, it may have been that lack of knowledge about a specific feature that defined the search target played a role in attention being captured by the irrelevant singleton. Theeuwes (1992) examined this issue in a subsequent study in which the same feature defined the target across all trials; for example, when the subject searched for a colour singleton its colour was always the same. This procedural change did not change the pattern of results. Colour and shape irrelevant singletons interfered with singleton target search in the other dimension, provided that the irrelevant singletons were sufficiently salient. Irrelevant singletons interfered with search even after extended practice with the task.

In later experiments, Theeuwes (1994a) demonstrated this attentional capture phenomenon with the sudden appearance of irrelevant abrupt onsets. On the basis of all these data, Theeuwes (1994b) proposed a model in which, in this type of parallel search task, the relative saliency of a stimulus attribute determines whether or not attention is directed toward its location. According to this proposal, the visual system calculates preattentively, or automatically, how different each item is from its surrounding elements along all stimulus dimensions. The resulting aggregation of featural difference is then represented in an activation map. Attention then proceeds serially and with no top-down bias to the location that has the highest activity, and selects it for further detailed processing. As this operation is independent from strategic control, selection is determined solely on the basis of differences in features aggregated across stimulus dimensions with no regard for which stimulus dimensions are relevant for the task at hand[6].

However, when observers have to search serially across the display, irrelevant singletons appear not to capture attention. Todd and Kramer (1994) presented subjects with a task in which they had to search for a given variable letter among an array of 4, 9, 16 or 25 letters. All displays contained a colour singleton letter (Experiment 1) or a luminance singleton letter (Experiment 2), which had an equal chance of being the target as any of the other letters. The results showed that the target letter was detected faster when it was the singleton letter. However, this effect only occurred in the two largest display sizes and the slopes of the search functions were indicative of serial search even for singleton targets. On the basis of these results, Todd and Kramer (1994) claimed that the reduction in the search slope for singleton target trials

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[6] The impenetrability of this preattentive phase from top-down signals can also be found in other search models (see, for example, Sagi and Julesz, 1985). Other theories of visual search, however, propose that top-down control modifies the activation levels in the preattentive map (see Wolfe, 1998).

with large set sizes was not due to an attentional capture by the singleton letter[7] but to an attentional misguidance effect. The singleton salience in a master map increases with large display sizes (Treisman & Sato, 1990), which in turn speeds up the processing of the unique items in larger arrays. This heightened salience produces a graded attentional allocation process; once an item is detected, subjects can voluntarily attend to that object given that the search has not yet been started or completed. Thus, the unique object constitutes a landmark from which the search begins or continues (Todd & Kramer, 1994).

Theeuwes (1990) obtained similar results. Subjects searched for horizontal line segments inside shape surrounds (display size could be 4, 8 or 16 items). The displays on each trial contained an irrelevant shape (Experiment 1), an irrelevant colour (Experiment 2), or a sudden change in shape or colour (Experiment 3 and 4). In all experiments, the irrelevant singletons influenced search performance in the largest displays, although this effect only reached statistical significance in Experiment 3. These latter experiments point to the same conclusion as Todd and Kramer's (1994) study. The larger the salience of an item, the greater the effect it has on attentional allocation. Thus, the attentional capture effect that occurs in parallel searches could be due to the greater singleton salience in this kind of task.

Recently, however, Lamy and Tsal (1999) found no effect of irrelevant singleton distractors in a conjunction search task. Subjects had to search for targets letters defined by a conjunction of colour and shape in a display of 6, 8 or 10 coloured letters, arranged in an imaginary circle around the fixation point. On half of the trials, an irrelevant shape or colour singleton distractor was present, and this irrelevant singleton was never the target. Results showed that the presence of an irrelevant singleton distractor slowed responses in target-absent trials, but had no effect on reaction time or accuracy measures in target-present trials. What could be the origin of this discrepancy between the Todd and Kramer (1994) and Lamy and Tsal (1999) results? Due to the fact that in Lamy and Tsal's (1999) search task the irrelevant singleton was never the target, it is likely that subjects actively ignored the irrelevant feature dimensions. In this case, the irrelevant singleton had no chance to affect search times on target-present trials, but left intact the attentional misguidance effect. In any case, active inhibition of attentional capture by irrelevant singletons, if this is what occurred, argues against the notion that capture of attention by singleton objects is strictly automatic.

Do all singletons have the same potential to attract attention?

Yantis and Jonides (1984) showed that target detection in a visual search task was markedly enhanced when the target (a letter) appeared as an abrupt visual onset. In later experiments they also showed (Jonides & Yantis,

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[7] If the singleton had captured attention, flat or near to flat slopes should had been found for singleton targets.

1988) that abrupt onsets were unique in capturing attention, as luminance and colour singletons had no effect on attentional deployment. In their paradigm, after specifying the target letter for the current trial, an array of figure eight shapes appeared (the number depending on the search display size; 2 and 4 items in Experiment 1 and 3, 5 or 7 items in Experiment 2; see Figure 2 of Yantis and Jonides, 1988) for 1000 msec. The array of figure eight was then replaced by the test display. Non-onset test items were constructed by deleting line segments of the previous figure eight placeholders, whereas onset test items appeared in a previously blank position. In the intensity and colour condition, on the other hand, all the letters appeared abruptly, one of them being either a luminance or a colour singleton. In all conditions, singleton and target items were uncorrelated, so that the singleton (onset, luminance, or colour) was as likely to be the target as it was to be any particular distractor.

As shown in Figure 2, the results of this experiment were clear-cut. Search functions were flat when the onset singleton was the target letter, suggesting that the abrupt onset singleton captured attention. In contrast, luminance and colour singletons did not influence attentional deployment at all. Thus, Jonides and Yantis (1988) claimed that abrupt onsets have the unique ability to capture attention automatically. Although other salient features, such as brightness and colour, can be used to efficiently guide a search, they do not attract attention in a purely bottom-up manner (see also Yantis & Egeth, 1999).

In these early experiments, however, a confounding factor was present. In the Yantis and Jonides (1984) and Jonides and Yantis (1988) studies, the abrupt onset could have captured attention due either to its status as an abrupt increase in luminance or to its status as a new object. Yantis and Hillstrom (1994) investigated this issue using a modified paradigm in which the singletons were new equiluminant objects defined by discontinuities in texture, motion or binocular disparity. As in previous experiments, these singletons were as likely to be the target as they were to be any particular distractor. They found that the equiluminant new objects eliminated the display size effect when they were defined by texture, and reduced significantly the search slope when defined by motion or depth. In Experiment 3, they showed that a clearly visible luminance increment in an old object was not enough for attention to be captured. Thus, Yantis and Hillstrom (1994) claimed that a luminance increment is neither necessary nor sufficient to produce attentional capture. That is, only new objects, whether equiluminant or not, capture attention automatically. By this view, stimulus driven selection would be mediated by attentional interrupt signals generated whenever an object file is created (Kahneman, Treisman & Gibbs, 1992). These signals would heighten the priority of the new object in a tagged priority map, which in turn would specify the relative proportion of processing resources devoted to each object (Yantis & Hillstrom, 1994).

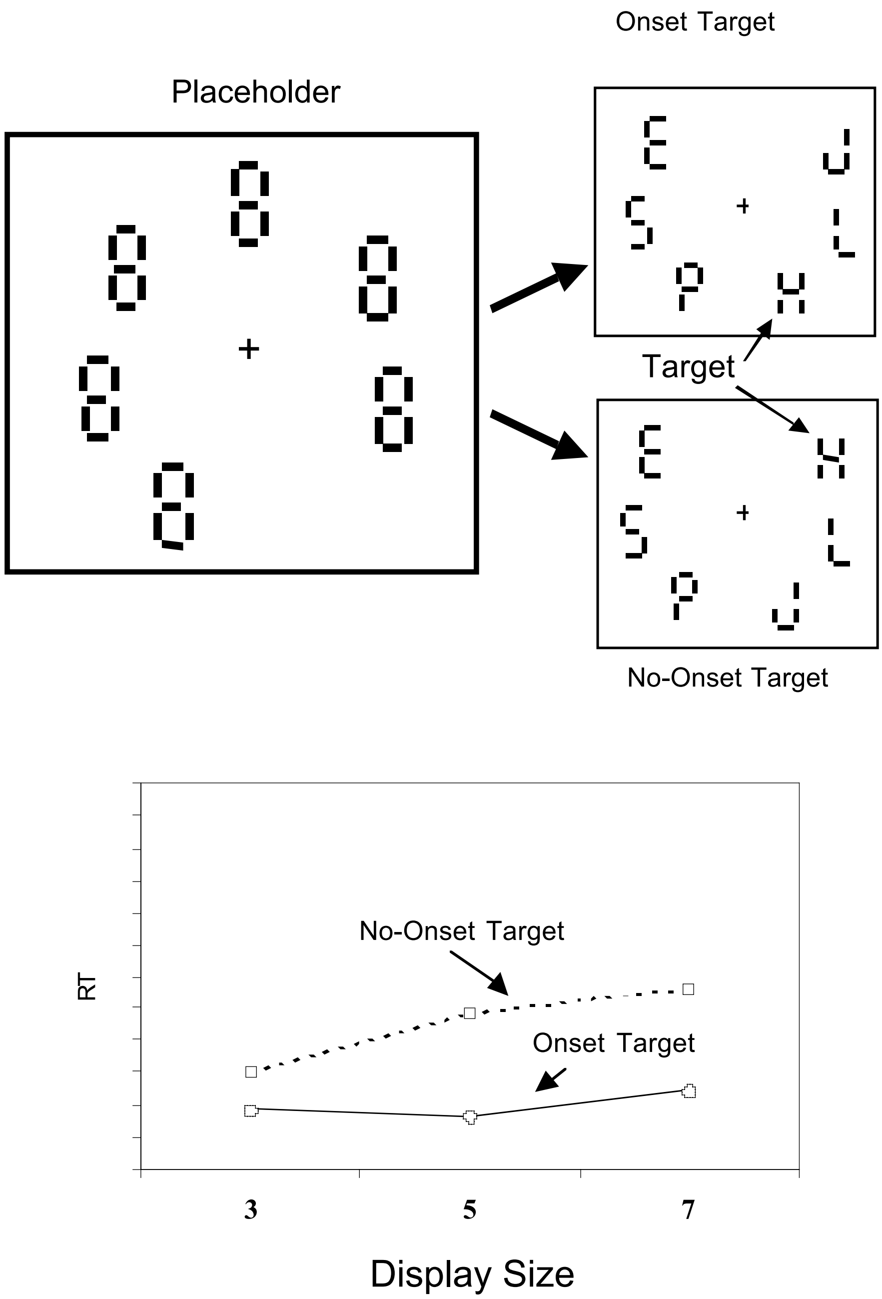

Figure 2: Graphic representation of Yantis' procedure to show attentional capture by new objects, and usual results. See explanation in the text.

This proposal has generated its share of controversy. For example, Theeuwes (1995) reported results in which abrupt luminance changes were necessary for an item to pop out from its background. Subjects were to search for a change in a visual search paradigm. A display of 4, 9 or 19 stimuli (circles with oriented lines inside) was employed, and after 50 or 100 msec a new identical element, the target, was added. The distractors and the background were of the same luminance, and the target was equiluminant, brighter, or dimmer than both the distractors and the background. Thus, if the onset of a new object can be detected preattentively in parallel, search times for the added element should be independent of display size. The results showed, however, that for an added stimulus to pop out a luminance increment was necessary. At near equiluminance the search slopes were steep, but when a luminance increase was introduced search functions became flat. Theeuwes (1995) concluded that an equiluminant change has no access to the preattentive system. That the abrupt onsets did not attract attention even when subjects were set to search for them seems to be at odds with Yantis and Hillstrom's (1994) claim that new objects, rather than luminance increments, preattentively trigger attentional capture. Theeuwes (1995) argues that in Yantis and Hillstrom's (1994) study there was actually a luminance change (onset and offset transients) with new onset objects because of local pixel redistribution.

Oonk and Abrams (1998), however, reported data consistent with the new object account of attentional capture. In their Experiment 1, participants had to detect a target, which appeared in one of two lateral locations. Before the target appeared, either the right or left location was peripherally cued by an equiluminant texture change, creating a new-box object. Results showed that the cue not only produced facilitation at a short 200 msec SOA, but also inhibition of return (IOR)[8] at the long 950 SOA. To avoid criticisms regarding a potential luminance increment accompanying the cue appearance, Oonk and Abrams (1998) used the same cue in Experiment 2 as in Experiment 1, but this time a box was present in the potential cue and target locations throughout the trial. With this manipulation, the cue was no longer a new object because the local texture change took place in one of the peripheral boxes. Thus, if the previous attentional effects were due to a luminance change, in this old-cue condition the validity effect should still be present. However, if the cue captured attention because of its status as a new object, the attentional effects should disappear with an old-object cue. The results supported the latter hypothesis: when the cue was an old object it did not affect performance. Thus, the novelty of the cue seems to be the relevant factor for attentional capture to occur.

Another challenge for the new object account has been offered by Gibson (1996a). According to Gibson, the attentional advantage for onset targets may not be due to their new object status. Instead, the reaction time

[8] IOR is a reversion of the cueing effect at long SOAs, so that responses are longer for cued than for uncued targets (Posner and Cohen, 1984). See Klein (2000) and Lupiáñez, Tudela and Rueda (1999) for reviews.

difference in the experiments of Yantis and colleagues may be due to a perceptual difference between onset and no-onset conditions caused by masking. Gibson's (1996a) rationale is that onsets have an advantage in Yantis' attentional capture paradigm because the figure eight placeholders forwardly mask the no-onset letters. In contrast, onset letters are not masked (see Figure 2). Accordingly, perceptual analysis of no-onset targets is delayed, causing them to lose the competition with onset letters for attentional resources. As a result, onsets appear to capture attention because they compete successfully with distractors that suffer from masking. Gibson (1996a) supported his hypothesis by showing that searches in which all of the elements were onsets were more rapid than searches in which all of the elements were no-onsets. He also reported that bright placeholders in Yantis and colleagues' paradigm caused slower reaction times than dim placeholders. Thus, his results supported the notion that perceptual factors have an influence on an effect that others attribute to attentional capture.

Yantis and Jonides (1996) replied to this critique by arguing that Gibson's (1996a) results are opposite to those predicted by the much of the literature on masking effects. First, the duration of the placeholders in Yantis and colleagues' experiments (1 second) is much longer than the temporal interval during which visible persistence effects occur (200 msec). Second, the inverse intensity-masking rule (Di Lollo & Bischof, 1995) predicts that bright placeholders should produce less masking than dim ones, and consequently reaction time following bright placeholders should be faster than following dim placeholders. As Gibson (1996a) observed the opposite pattern of results, his data are not well accounted for by any known principles of masking.

As an alternative explanation of Gibson's (1996a) results, Yantis and Jonides (1996) suggested that the appearance of a new object triggers the creation of an object file (Kahneman, Treisman & Gibbs, 1992) that captures attention. In turn, the capture of attention speeds subsequent identification processes. The updating of an existing object file, in contrast, may be slower and less efficient. Together, these principles predict that a display that contains just new objects may be processed faster than a display that contains just old objects, which is in accord with the different search times for these two display types in Gibson's (1996a) experiments. Thus, although Gibson (1996a, 1996b) showed that perceptual factors can influence the search for old versus new objects, and that some form of masking might contribute to attentional capture effects, the results of Yantis and colleagues (1984, 1988, 1996), together with results from other laboratories (e.g., Oonk & Abrams, 1998; Folk & Remington, 1999), appear to give a special status to new objects for capturing attention.

To what extent is the capture automatic?

Yantis (1998) and Theeuwes (1994) propose an attentional capture model in which certain stimulus attributes have the potential to orient attention to their spatial location. However, both of these researchers have acknowledged that there are situations in which endogenous control can override attentional capture by a singleton. In particular, when attention is focused on a spatial location prior to the singleton appearance, the unique item does not affect reaction times.

Yantis and Jonides (1990) developed a procedure to test this hypothesis. They introduced an endogenous cue in their abrupt onset paradigm. In their Experiment 1, a central cue that was valid on 80% of the trials[9] pointed to one of the possible item locations 200 ms before the search display appeared. As in previous experiments, the abrupt onset was as likely to be the target as it was to be any particular distractor. If abrupt onsets capture attention irrespective of the attentional state of the observer, the onset effect should remain the same regardless of cue validity. What they found, however, was that the effect of target type (onset/no-onset) was larger for trials in which the endogenous cue did not point to the target location (invalid trials). In a second experiment, they manipulated the stimulus onset asynchrony (SOA) between the appearance of the endogenous cue and the search display. The cue appeared 200 msec before, simultaneous with, or 200 msec after the onset of the search display. The results clearly pointed to the importance of the observer's prior attentional state; there were no reaction time differences on valid trials between onset and no-onset targets when the cue appeared 200 msec prior to the target display. In contrast, when observers had no time to prepare, a singleton effect was revealed; that is, onset targets were detected faster than non-onset targets with simultaneous or delayed cues. In Experiment 3, the utility of the cue was manipulated by changing its predictive value, and the results again demonstrated that the onset/no-onset effect is sensitive to endogenous expectancy. Apparently, focused attention on a particular spatial location can override the distracting effect of onset singletons.

Theeuwes (1991b) reported a similar finding with a slightly different paradigm. Subjects searched for a target letter among non-target letters. In Experiment 1, the SOA between an endogenous cue and the search display was manipulated, with the cue appearing 600 msec prior, 300 msec prior, or 200 msec following the target. The SOA between the search display and a peripheral abrupt onset marker also varied. This abrupt onset marker appeared beside one of the letters in the search display 0, 80 or 160 msec after the search display onset, and was randomly associated with the target location. In the conditions in which the cue preceded the target, the abrupt peripheral marker only had an effect when it occurred at the attended location. Moreover, in this condition the marker delayed the response time to the target. When the cue appeared 200 msec after the search display, however, the appearance of the marker affected performance in all conditions. This set of results is similar to that of Yantis and Jonides (1990) in that, when attention is focused, irrelevant singletons presented at other spatial locations do not attract attentional resources. As such, a provisional conclusion might be that attentional capture is automatic only "by default", as it can be overridden by

[9] That is, the cue correctly predicted target location in eight trials out of ten.

the endogenous focusing of attention at other spatial locations (see also Lamy and Tsal, 1999).

More effects of attentional control settings: The contingent involuntary orienting hypothesis

Some authors have made the stronger claim that attentional capture is always subject to top-down modulation. Folk, Remington and Johnston (1992) presented a series of experiments showing that attentional capture by a singleton stimulus is modulated by the control set that the observers adopt to deal with the task at hand. These authors employed a modified spatial cueing paradigm in which the focal task involved letter discrimination (see figure 3). Prior to appearance of the target, a cue appeared in one of the potential target locations. The critical manipulation was the relationship between the defining dimensions of the cue and those of the target. In Experiment 1, for one group of participants the target was an abrupt onset in one of four potential target locations, with the other three locations remaining empty. For a second group of participants, the target was a unique coloured letter that was accompanied by a white non-target character in each of the other three potential target locations. The prior cue consisted of the abrupt onset of four small white dots surrounding one of the possible target locations. The authors also manipulated the validity of the cue in different blocks of trials. They included valid blocks in which the cue always appeared at the same location as the target letter, invalid blocks in which the cue never appeared at the same location as the target letter, neutral blocks in which the cue appeared in the centre of the screen, and no-cue blocks in which no cue was displayed. Relative to no-cue trials, benefits were expected for valid trials regardless of singleton target type, because the cue had predictive value and should encourage subjects to attend voluntarily to its spatial location. The critical test involved invalid trials: if cues automatically capture attention, then an attentional cost should appear even when subjects try not to attend to the location of the cue.

In accord with these predictions, an attentional benefit was observed on valid trials for both color and onset singleton targets. More interesting, invalid trials produced a significant cost when the target was defined by an onset singleton. This result is consistent with the notion that the abrupt onset cue captured attention automatically. However, invalid trials produced neither a cost nor a benefit when the target was defined by a colour singleton. Thus, the same abrupt onset cue appeared to capture attention when the target-defining attribute was a sudden onset but not when it was a unique colour.

In a second experiment, Folk et al. (1992) examined whether a unique colour cue can capture attention. They used the same two types of targets as in Experiment 1, but this time they employed a cue in which three of the potential target locations were surrounded by four white dots, and the remaining location was surrounded by four red dots. At issue was whether the singleton red cue would capture attention at its spatial location. In the colour target condition, benefits and costs were obtained for valid and invalid trials, respectively. In contrast, no cueing effect was obtained in the onset target condition. Although a further delay in response was obtained for all of the cue conditions (valid, invalid and centre cues) relative to the no cue condition, this effect had no spatial specificity (response time was unrelated to cue location) and was therefore attributed to filtering operations. The critical result, then, was that a colour cue automatically captured attention for singleton colour targets but not for singleton onset targets.

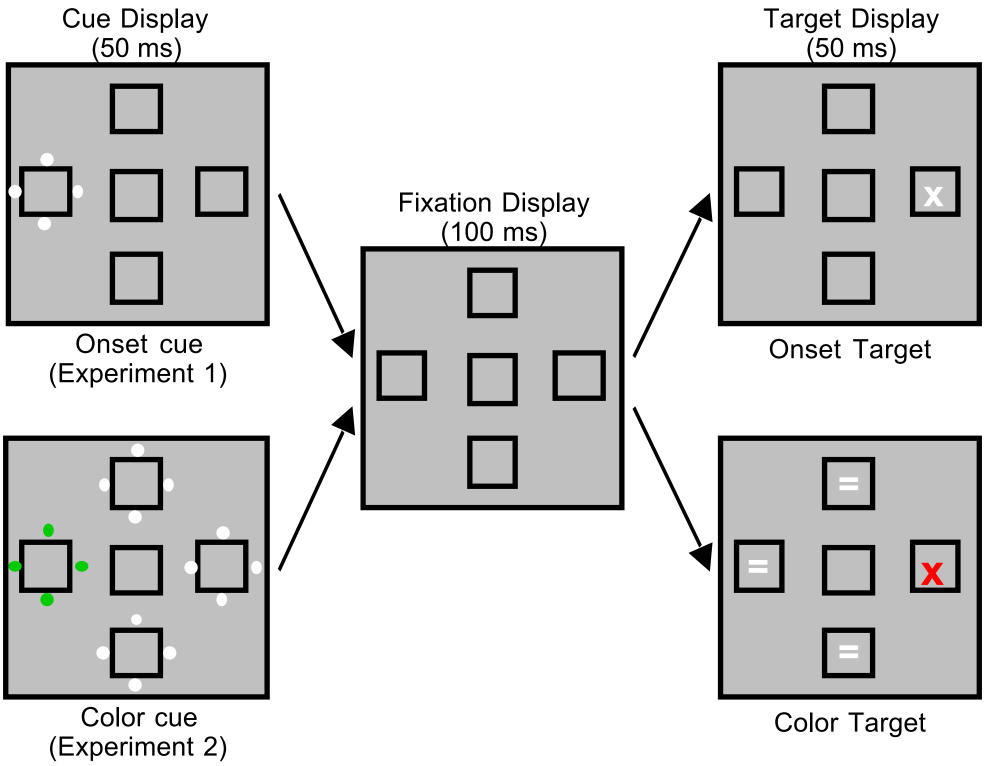

Figure 3: Graphic representation of the procedure and experimental conditions used by Folk et al. (1992). See explanation in the text.

In Experiment 3, onset and colour cues were crossed with onset and colour targets in different blocks of trials, and cue location was uncorrelated with target location. Again, a cueing effect was obtained only when cue and target shared the same defining property (either onset or colour). In a last experiment, Folk et al. (1992, Experiment 4) examined the specific properties that comprise the set that modulates attentional capture. In the previous experiments, the capture could have been driven by cue and target sharing the same broadly defined attribute (onset or colour) or by cue and target sharing specific feature values (e.g., both the cue and target colour were red). In other terms, the contingent orienting effects in prior experiments could have been determined by a set that differentiates between dynamic (abrupt onsets) and static (i.e., colour, shape) properties, or by a set that operates at the level of specific features (i.e., a specific hue in the colour dimension). To address this issue, the authors used a colour cue (green) with a different hue than the target (red). With this manipulation, cue and target were both static elements but had different specific feature values. Despite the dissimilarity in colour between cue and target, invalid trials again produced costs relative to no cue and valid trials.

Across the four experiments, the results from Folk et al. (1992) support the contingent involuntary orienting hypothesis. Folk et al. claim that involuntary orienting to a cue is contingent on whether or not that cue matches with the task-relevant properties that define an attentional set. Furthermore, this attentional set is established on the basis of static and dynamic target properties, rather than on specific stimulus features. They envision a system that can be dynamically reconfigured to deal with the task at hand[10]. Once the appropriate set is established, each stimulus that fulfils the criterion of the current set generates an interrupt signal that involuntarily (irrespective of its behavioural relevance) triggers attentional capture. Once attention is oriented, there is no further possible task set modulation on processing (see also Remington, Folk and McLean, 2001; Pratt, Sekuler and McAuliffe, 2001).

Recently, Arnott, Pratt, Shore and Alain (2001) demonstrated this task set influence on attentional capture using both response time and event-related potentials (ERPs) as dependent measures. Using the Folk et al. (1992) paradigm, Arnott et al. (2001) showed that the N100 component was more negative for cues sharing a task-relevant attribute with the target. Moreover, 50 msec prior to cue appearance a negative going modulation took place in the ERP associated to cues that captured attention. Both of these effects strengthen the notion that task set modulates processing of cues at early stages of sensory processing, as specified in the Folk et al. (1992) hypothesis.

Gibson and Amelio (2000) obtained additional evidence in support of the contingent involuntary orienting hypothesis. They employed a modified cueing paradigm similar to that of Folk et al. (1992), but introduced a cue-target SOA manipulation. As in the Folk et al. (1992) experiments, they used onset and colour cues and targets, but they added two different cue-target SOAs: 100 and 1000 msec. In the 100 msec SOA condition, Gibson and Amelio (2000) replicated previous results; that is, cues only captured attention when they shared their defining property with the target. In the 1000 msec SOA condition, onset cues produced an inhibition of return (IOR) effect when

[10] A closely related view of the human processing system has recently been put forward by DiLollo and cols. (see Di Lollo, Kawahara, Zuvic, and Visser, 2000). These authors claim that an early input system is dynamically reconfigured (in only a limited set of basic components) by prefrontal signals to fulfil the demands of the task at hand. Once the system is reconfigured, the efficiency with which a task is performed depends on whether its characteristics fit the current configuration of the input filters. Moreover, they explicitly deny the existence of a preattentive processing stage: all processing activity demands attention (Di Lollo et al., 2000).

the target was an onset singleton but not when it was a colour singleton. Colour cues, although they produced attentional capture at the short SOA, failed to produce IOR effects for either onset and colour targets. These results were taken as additional evidence for the contingent involuntary orienting hypothesis and for a dissociation between the exogenous orienting of attention and the IOR phenomenon.

How does the contingent involuntary orienting hypothesis explain results obtained with other paradigms?

The contingent involuntary orienting hypothesis argues against the assumption that exogenous cues in Posner's cueing paradigm capture attention automatically, which has been taken for granted for many years. This assumption of automaticity has been nevertheless supported by recent data, which show that even unconscious cues capture attention. McCormick (1997) presented observers with a mixture of endogenous and exogenous cues. These cues appeared in the visual periphery, in one of the two potential target locations, but at the same time they had predictive validity: on 85% of trials the target appeared 500 msec later in the location opposite the cue. The perceptual quality of the cue was also varied. In some blocks of trials the cue could be consciously perceived whereas in other blocks of trials the cue was presented below participants' subjective threshold of consciousness. In the conscious cue trials, a validity effect mediated by expectancies was found; that is, observers were faster on trials in which the target appeared in the spatial location opposite the cue. In the unconscious cue trials, however, the reverse pattern emerged: subjects responded faster on trials in which cue and target shared the same spatial location. The absence of cue awareness prevented subjects from benefiting from the predictive information provided by the cue, but it did not prevent the attentional capture by the abrupt luminance change. From this perspective, it seems that attentional orienting to an abrupt onset is a default setting of the organism which does not depend on conscious awareness to be effective. Similar results have been obtained recently by Danzinger, Kingstone and Rafal (1998), who demonstrated that neglect patients showed cueing effects from extinguished left cues, of which they were not aware.

Folk et al. (1992) claim, however, that exogenous abrupt onset signals capture attention in Posner's cueing paradigm because they share the defining attribute with the target in both detection and discrimination tasks, and not because the capture takes place in an automatic manner. In contrast, others authors have argued that some singletons can capture attention even when there is no deliberate set for any particular attribute (Yantis, 1993). Indeed, this appears to be the case for abrupt onsets[11]. Although Yantis (1993) acknowledged that abrupt onsets do not capture attention in the presence of an attentional set for static singletons, he argued that when the task does not

[11] Although Yantis dealt with this debate referring to abrupt onsets, later results (Yantis & Hillstrom, 1994) changed the special status from abrupt onsets to new objects.

require such a set onsets do capture attention. As such, it may be the case that only abrupt onsets have the capacity to trigger a purely stimulus-driven capture, because they can do so in the absence of a set for onsets. Other featural attributes may not have the capacity to trigger a purely stimulus-driven capture, as they tend to elicit attentional capture only when they match with an appropriate attentional set (Yantis, 1993; Jonides & Yantis, 1988).

Folk, Remington and Johnston (1993) state, on the contrary, that the attentional capture that they show in their experiments is purely bottom-up, as the 100% invalid cues dictate that observers should withhold orienting of attention to the cue. Yet, participants appear unable to do so. Folk et al. (1992, 1993) explain the capture by abrupt onset in Yantis' (1984) paradigm by arguing that subjects in this type of task adopt a “default setting” in which abrupt onsets have priority, perhaps because of their ecological significance. Hence, they claim that attentional control settings influence behaviour all the time (Folk et al., 1993).

In support of this position, Folk and Remington (1999) provided evidence to suggest that the appearance of a new object does not override attentional control settings. They employed their modified spatial cueing paradigm, in which subjects searched for an abrupt onset target or for a colour target. This time they introduced two kinds of distractors prior to the target appearance: new object distractors, in which an additional square briefly brightened in the fixation display, and old object distractors, where one of the fixation display squares briefly appeared in bright white. As in previous experiments, cue and target locations were uncorrelated. The results showed that in the onset target condition the luminance change of both old and new objects attracted attention. However, when observers had an attentional set for colour, neither new nor old objects captured attention. In subsequent experiments, Folk and Remington (1999) showed that these results were neither due to brief cue appearance (Experiment 2) nor to rapid disengaging from the cue location (Experiments 3 and 4). Thus, it seems that orienting to new objects is also under the guidance of top-down attentional control settings.

There are, however, other results that seem to be at odds with the contingent involuntary orienting hypothesis. In Theeuwes' (1991a, 1992, 1994a) experiments, subjects performed a parallel search for colour, shape or onset singletons in arrays that contained a second singleton that was unique in an irrelevant dimension. It is possible that observers adopt a specific attentional set for the dimension they are searching for. According to Folk et al.'s (1992) contingent involuntary orienting hypothesis, if subjects were searching for a dimension-specific singleton, then only singletons defined by that dimension should have captured attention. However, the data showed that any salient singleton captured attention. These results led Theeuwes (1991a, 1992, 1994a,b) to claim that in parallel search situations, selectivity depends on the relative discriminability of the stimulus dimension.

Bacon and Egeth (1994) proposed a hypothesis that seems to account for the diverse results. They claim that when observers are searching for a feature singleton they may adopt a singleton search strategy in which an odd attribute is sought, even though the specific target attribute is known. Thus, although the subject is searching for colour, any salient stimulus in any dimension will attract her or his attention. Within this framework, stimuli capture attention because of the broadness of the attentional set and not because of purely stimulus-driven characteristics such as their physical salience. To test their hypothesis, Bacon and Egeth (1994) replicated Theeuwes's (1992) form singleton search experiment but forced subjects to rely on a "feature search strategy" by making the singleton search mode unproductive. To do so, they included trials with two or three identical targets (Experiment 2) or added additional forms (different from target shape; Experiment 3). By means of these two manipulations, they eliminated the uniqueness of the target in the form dimension, thereby making reliance on a discrepancy detection mode an ineffective strategy. Instead, participants had to rely on a search strategy that focused on a specific feature. In both experiments, attentional capture by the irrelevant singletons was eliminated. Bacon and Egeth (1994) concluded that "goal directed selection of a specific known featural identity may override stimulus-driven capture caused by salient featural singletons" (pp. 493). Thus, although the reasons for relying on a discrepancy detection search strategy are not clear, it seems that this hypothesis can account for Theeuwes' (1991a, 1992, 1994) results in a parsimonious manner.

Theeuwes and Burger (1998) reported a set of findings that helps to specify when top down control overrides the capture of attention by salient stimuli. Subjects engaged in a letter search (the target could be either the letter E or R) among five or seven nontarget letters. One of the nontargets was a singleton colour distractor, and its identity was either compatible with the target letter in that trial (i.e., the target was the letter E and the colour singleton was also an E) or incompatible with it (for example, the target was an E but the distractor identity was an R). Observers were instructed that the colour singleton was never the target. In Experiment 1, in which target and singleton colour changed from trial to trial, a compatibility effect was found: responses on compatible trials were faster than responses on incompatible trials. Theeuwes and Burger (1998) suggested that the compatibility effect occurred because the irrelevant singletons captured attention. In Experiment 3, target colour was known (it was always the same hue) but singleton colour varied from trial to trial. In Experiment 4, singleton colour remained fixed and target colour changed unpredictably. In both experiments a compatibility effect appeared, again signalling an attentional capture by the colour singleton. Only in Experiment 2, in which target and singleton colour did not change, thus being known in advance by the observers, was no compatibility effect found. Theeuwes and Burger (1998) argued that top down control is able to override attentional capture by salient stimuli only when an attentional set for a specific feature value is adopted. The broad set adopted when the target and distractor are not entirely predictable cause attention to be attracted by salient stimuli.

Interpreting reaction time effects: not all RT differences are due to attentional capture and not all absence of RT differences are a marker of no capture.

Folk and Remington (1998) warned that a reaction time effect caused by singleton presence should not invariably lead to an attentional orienting interpretation. They claim that in order to establish any interpretation in terms of the spatial orientation of attention, a test of the location specificity of the obtained result is needed. That is, unless it is shown that subjects are more rapid and/or accurate at the location supposedly visited by attention, a reaction time effect could be due to filtering processes or distraction not related to the orientation of attention in space. To illustrate this point, Folk and Remington (1998) employed their usual modified spatial cueing paradigm but with cues either related or unrelated to target position, so that the location specificity of cueing effects could be evaluated. Subjects engaged in a discrimination task in which the target display was preceded by a singleton colour cue. In different block of trials, the colour of the cue either overlapped with that of the target or had a different hue. Further, across different groups of participants, the colour of the target was either a singleton feature or a non-unique feature, to test for use of a singleton-detection mode (see Bacon & Egeth, 1994). For both singleton and non-singleton targets a location effect (faster reaction time when cue and target appeared in the same spatial location) was observed only when cue and target were displayed in the same colour. In Experiments 2 and 3, a no-cue condition was added to test for potential filtering effects. In addition to the location effects observed in the previous experiment, a filtering cost was found when cue-present and cue-absent blocks were compared; that is, reaction time was longer on cue-present than on cue-absent trials. Furthermore, this distraction effect was unrelated to the spatial position of the cue.

On the basis of these results, Folk and Remington (1998) argued for the existence of two distinct forms of attentional capture. According to this view, visual search studies that have not found evidence of top-down control (Theeuwes, 1991a, 1992, 1994) may actually be measuring filtering effects not related to the orientation of spatial attention. In this type of task, bottom-up factors such as stimulus saliency might be playing an important role: the more salient the singleton, the greater the competition for attentional selection, which would slow the allocation of attention to the target location. On the other hand, results obtained in spatial cueing studies that have shown evidence favouring attentional control settings (Folk et al., 1992, 1994) would be related to changes in the orientation of attention in space. The results of Folk et al. (1998) suggest that attentional control settings can be adopted for specific features, which counters earlier claims that control settings are sensitive only to the distinction between static and dynamic discontinuities (see Folk et al., 1992). These sets are assumed to control the allocation of spatial attention, whereas stimulus saliency plays a role in competition between target and distractor stimuli for attentional selection. In this way, Folk et al.'s (1992, 1998) contingent involuntary orienting hypothesis appears to account for the data on attentional capture in a unitary and parsimonious manner.

Despite its appeal, there are some recent data that may be at odds with the contingent involuntary orienting hypothesis. In a recent paper, Turatto and Galfano (2000, see also Turatto and Galfano, 2001) described three experiments in which spatial attention seemed to be captured by irrelevant singleton stimuli in a search paradigm. Participants searched for the presence or absence of a vertical target among distractor lines with different orientations. This task yielded relatively steep slopes (35 msec per item), indicative of serial search. Turatto and Galfano (2000) used this pattern of data to assert that the task was not being performed in singleton detection mode. The critical manipulation across the series of experiments concerned the location of an irrelevant singleton in the search display. The singleton was defined by a unique colour, form, or onset of a shape surrounding one of the oriented lines. The position of the singleton was uncorrelated with that of the target. A very short exposure time for the search display was used and target detection accuracy as a function of the proximity between the distracting singleton and the target served as the critical dependent measure. As set size was held constant at six items, the distractor and target either had an overlapping location (p0) or they were one, two or three positions apart (p1, p2 and p3, respectively). Following Folk et al.'s (1998) reasoning, if the effect of the irrelevant singleton on target detection were to depend on its spatial proximity to the target, then this effect would be indicative of attentional capture at a specific location. Indeed, this was the pattern of results that was observed. At p0, detection accuracy was higher than at p1, p2 and p3 in all three experiments (colour, form and luminance singletons). Thus, it appears that attention can be captured by a salient singleton in a task in which subjects are not in singleton search mode.

Alternatively, Turatto and Galfano's (2000, 2001) results could be accounted for in terms of attentional misguidance effects (Todd and Kramer, 1994). As explained above, attentional misguidance effects do appear in serial searchs within large display sizes and result from an observer decision to attend to the cue (Yantis, 1998). Turatto and Galfano's (2000) set size (six items), combined with high task difficulty, makes it possible that subjects decided to start searching from the most salient item. Use of this search strategy would explain the benefit for targets that overlapped or were close to the irrelevant singleton. At the same time, there is no straightforward explanation for why subjects would decide to start the search from a completely unpredictive location.

Just as there can be controversy over whether a reliable reaction time effect truly represents a spatially-specific attention capture effect, Theeuwes, Atchley, and Kramer (2000) have pointed out that a null reaction time effect does not necessarily rule out that a singleton has captured attention. Indeed, a singleton could capture attention at a specific location, but then attention may be disengaged from that location before the target appears. In fact, in a series of experiments using Theeuwes' search paradigm they reported that at short singleton-target SOAs, singletons that did not share any relevant attribute with the target had an influence on RT, thus demonstrating attentional capture by singletons unrelated to the attentional set for the task. Interestingly, however, the effect of those singletons had disappeared after 150 ms, while the effect of singletons that shared a defining attribute with the target remained. They conclude from this result that attention is disengaged from the location of task irrelevant singletons soon after being captured. At the same time, attentional set plays a role in producing attention capture effects that can be measured at longer SOAs.

Do attentional capture effects depend on a specific research method?

As described in this review, a large part of the literature on attention capture is founded on the use of two different methods. According to one method (cueing paradigm, e.g., Folk et al., 1992) attentional capture is inferred from performance on a task where a target follows a cue. That is, if the response to a target stimulus is faster when a singleton has previously appeared at the same spatial location (compared to when the singleton cue appears at other location), it is a marker that the cue has captured attention. On the other hand, if the response to a target is the same regardless of cue location, then it is inferred that the singleton cue did not capture attention. A second method used to study attention capture measures the extent to which a salient stimulus within a search display pulls attention to its spatial location (visual-search paradigm). Here, the capture of attention by the singleton is inferred by a flat search slope when the salient item is the target, in contrast to a steep slope when the salient item is a distractor (see Turatto, Galfano, Gardini and Mascetti, 2001).

Generally speaking, the endogenous modulation of the attentional capture has been demonstrated several times using the cueing paradigm. In contrast, the visual search paradigm has produced results that sometimes support and other times do not support the notion of endogenous modulation of attentional capture. Recently, Turatto et al. (2001) have suggested that the absence of attentional capture by salient stimuli in some research studies could be due to a lack of sensitivity inherent to the visual search paradigm. In their experiments, these authors (Turatto et al., 2001) have compared two different methods of the visual search paradigm, the usual *display-size method* (as described above) and their new *distance method* (Turato et al., 2000, 2001). In all three experiments, the results revealed data supportive of attentional capture when examined using their distance method (i.e., greater accuracy and shorter RT when the salient item was close to the target than when it was far away). However, when the same data were examined as is customary in the visual search paradigm (display-size method), it appeared as if singletons did not capture attention (i.e., search slopes were steep even when the singleton happened to be the target).

Therefore, it seems that the research method chosen to explore attentional capture can have consequences for the inferences that are drawn. Although the cueing paradigm seems to have been most fruitful in demonstrating endogenous modulation of attentional capture, this method has the drawback of using performance for the target as a measure of the processing undergone by a cue that appeared previously. In other words, there is no direct measure of performance when the singleton appears. As Theeuwes et al. (2000) note, a singleton could capture attention and yet by the time the target appears attention may be disengaged, making target processing a poor measure of whether attention capture occurred (Theeuwes et al., 2000; but see Arnott et al., 2001). On the other hand, in the visual search paradigm, the target and singleton usually appear at the same time, which solves the problem just described. Results with this paradigm have been somewhat mixed. However, recent research using the distance method (Turato and Galfano, 2000, 2001; Turatto et al., 2001) have shown automatic attentional capture in conditions where the display-size method fails to do so. These recent data suggest that attentional capture may take place in contexts where it has previously been assumed not to occur, and that methods differ in their sensitivity to measure the effects of attentional capture.

Conclusions

In this review, the conditions under which attention is oriented exogenously have been discussed. A range of studies have shown that salient unique features can attract attentional resources, leading to attentional capture. This phenomenon seems to occur unless attention has previously been focused on a different spatial location. The extent to which attentional capture is modulated by attentional control settings was also discussed. The broad picture that emerges from this discussion is that current attentional control settings can affect what captures attention. However, there appear to be situations in which no clear attentional set is established and, nevertheless, special events such as new objects capture attention. Therefore, it can be concluded that attentional capture can take place "by default", but it can also be modified by specific attentional sets.

Returning to the question asked at the beginning of this article, to what extent should attentional capture be regarded as automatic? Automatic processing, as discussed before, can be characterised as occurring independent of the availability of processing resources, not affected by intentions and strategies, and not necessarily tied to conscious processing (Posner & Snyder, 1975; Jonides 1981). Results reviewed in this article make a valuable contributions in relation to evaluating some of these criteria. First, attentional capture can be suppressed (that is, modified by the subject's intentions) when attention is previously focused on a particular spatial location (Yantis & Jonides, 1990; Theeuwes, 1991b). Moreover, when the task participants have to perform is very demanding and requires a focused attentional state (i.e., conjunction search) it seems that attentional capture by irrelevant information is less likely to occur[12] (Lamy & Tsal, 1999). As the attentional state becomes less focused, it is more likely that irrelevant

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[12] This idea is reminiscent on Lavie (1995) account of the changing locus of the selective attention filter. When the task at hand is easy and there are free attentional resources, irrelevant information is processed regardless of the subject's goals. However, when the task the person is dealing with is very demanding and there are no attentional resources left, no irrelevant information is processed at all.

information will affect ongoing processing. Second, attentional capture and the time course of its effects on target processing can be modified by the strategies observers adopt to deal with the task at hand (Folk et al., 1992; Lupiáñez et al., 2001; Lupiáñez and Milliken, 1999; Theeuwes, Atchley, and Kramer, 2000). And finally, it seems that attentional capture and orienting can take place in the absence of conscious perception of the cue, both in normal populations and in neuropsychological patients (McCormick, 1997, Danzinger, Kingstone, & Rafal, 1998). Thus, the general conclusion to be drawn is that attentional capture may be automatic by default, but can be either suppressed or enhanced by endogenous attention processes.

This conclusion raises questions in relation to the notion of automaticity, in particular with regard to the orienting of spatial attention. The classic notion of automaticity is that describes preattentive, hard-wired processors that work in a ballistic manner regardless of current demands and goals. However, the attentional capture literature, together with results in other fields (e.g., Dagenbach and Carr, 1994; Di Lollo et al., 2000), have begun to provide a different view of automatic processing. In this new approach, automatic functioning is set by current demands in a flexible manner to deal successfully with the task at hand. This way, automatic processing can be understood in the context of controlled settings (Jacoby et al., 1993; DiLollo et al., 2000). Automatic effects show up in the organism's behaviour in relation to the controlled context in which they are immersed. Attentional capture and spatial orienting paradigms have proved useful in studying these issues, and they continue to hold promise as a tool for studying automatic processes and how they are controlled by specific attentional sets.

RESUMEN

Una revisión sobre captura atencional: Automaticidad y susceptibilidad de control endógeno. Es bien conocido que estímulos irrelevantes pueden determinar dónde atendemos. Sin embargo, en la literatura sobre el fenómeno de captura atencional, ha habido bastante discusión acerca de hasta qué punto esos efectos son automáticos o son modulados por factores endógenos. En este artículo se revisan los datos y teorías pertinentes a este debate. Aunque tanto los factores exógenos como los endógenos parecen influenciar la asignación de la atención, los estados mentales relacionados con la tarea en curso parecen ser los que modulan en mayor medida la captura atencional. De esta forma, aunque la captura atencional parece ser automática “por defecto”, en el sentido de que se produce en ausencia de un estado mental específico, parece claro que es susceptible de modulación endógena.

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