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Alerting enhances attentional bias for salient stimuli: Evidence from a global/local processing task

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ABSTRACT

The present study examined the role of alerting in modulating attentional bias to salient events. In a global/local processing task, participants were presented with a large arrow (global level) comprised of smaller arrows (local level) pointing in the same or opposite directions and had to indicate the direction of the large or small arrows in different blocks. Saliency of the global and local levels was manipulated, creating global-salient and local-salient conditions. Alerting signals were presented in half of the trials prior to the target. Results revealed a double dissociation in the effects of alerting on global/local interference effects. In a global salient condition, alerting increased global interference and decreased local interference. In a local salient condition, alerting reduced global interference and increased local interference. We demonstrate that within a single task, alerting can increase and reduce conflict based on perceptual saliency. These findings help to better understand disorders like hemispatial neglect in which both arousal and attention to salient events are impaired. These results also challenge previous theories suggesting that alerting acts to increase conflict interference. We argue that alerting is an adaptive mechanism that diverts attention to salient events, but comes at a cost when selective attention to less salient details is required.

1. Introduction

Arousal, a critical aspect in shaping behavior, is closely related to phenomena such as sleep, stress, motivation and attention (Aston-Jones & Cohen, 2005). Posner and Petersen's (1990) influential attention networks model suggested that achieving and maintaining an optimal level of arousal during performance is one of several fundamental aspects of attention.

Phasic alerting refers to a transient increase in arousal following a task-irrelevant alerting cue. These cues are often considered beneficial for performance because reaction times (RTs) to an imperative target are faster following alerting compared with a no-alert condition (i.e., alerting effect). The alerting effect was found to be closely linked to distribution of norepinephrine (Coull, Nobre, & Frith, 2001; Witte & Marrocco, 1997). Norepinephrine projections from the locus coeruleus in the brain stem innervate almost the entire brain (Sara, 2009), so it seems reasonable that changes in the level of arousal modulate a variety of brain functions. The present study was aimed at examining the role of arousal in modulating attentional bias for salient stimuli. Previous literature suggests that these two functions are closely related.

Hemispatial neglect is a disorder that can be caused following a brain lesion (usually the right hemisphere), resulting in difficulty to attend and report objects in the contralesional spatial field. This difficulty is explained by impaired attention to salient objects in the contralesional

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visual field, rather than abnormalities in early visual mechanisms (for review see Corbetta & Shulman, 2011). Interestingly, arousal is a core non-spatial deficit in neglect. Robertson, Mattingley, Rorden, and Driver (1998) reported that phasic alerting of neglect patients can ameliorate their spatial deficit. Later studies showed alertness training programs can also help improve spatial deficits in neglect (e.g., DeGutis & Van Vleet, 2010). Corbetta and Shulman suggested that the difficulty of patients suffering from neglect to code stimulus saliency results from impaired interaction between ventral brain regions in the parietal cortex that are implemented in arousal and dorsal brain regions that are linked with coding of saliency. However, a clear behavioral indication for the link between alerting and visual saliency in healthy participants is limited or indirect.

Recently it was reported that phasic alerting can improve detection of sub-threshold stimuli and improve conscious perceptual sensitivity in healthy participants (Botta, Lupiáñez, & Chica, 2014; Kusnir, Chica, Mitsumasu, & Bartolomeo, 2011). Enhanced sensitivity for salient features following alerting cues could be the underlying mechanism of these effects. Furthermore, many studies reported greater influence of salient distractors following an alerting cue. Most evidence for this effect came from a widely used comprehensive test of attention named the "attention network test" (ANT; Fan, McCandliss, Sommer, Raz, & Posner, 2002). In this test, participants perform a flanker task—respond to a central target while ignoring irrelevant flankers in close proximity. One condition includes presentation of alerting cues prior to the target. Many studies show that flanker interference is increased following alerting cues compared with a no-alert condition (see MacLeod et al., 2010). Various interpretations were suggested for this effect, including direct inhibition of cognitive control following the alerting cue (Callejas, Lupiáñez, Funes, & Tudela, 2005), facilitated translation of a stimulus into a response (Fischer, Plessow, & Kiesel, 2010, 2012) and our own account of wider attentional scope following alerting cues (Weinbach & Henik, 2012a). However, in the studies mentioned, the relative saliency of the irrelevant information compared to the relevant information was not taken into account. This is important in case alerting increases attention to salient visual stimuli. In the current study we directly manipulated alerting and saliency in a task designed to evaluate perceptual processing.

The global/local processing task (Navon, 1977) allows examining attention and perception of hierarchical visual stimuli. In one version of this task, participants are required to attend a large arrow comprised of smaller arrows (Weinbach & Henik, 2011), and respond according to the direction of the large arrow (global level) or small arrows (local level) in different blocks. The large and small arrows can be either congruent (i.e., pointing to the same direction) or incongruent (i.e., pointing in opposite directions). The difference in RTs between incongruent and congruent targets (i.e., congruency effect) allows measuring the interference caused by the irrelevant dimension. For example, in the "attend-local" block, the congruency effect represents "global interference" (i.e., extent of global arrow interference on performance when attending local arrows). In the "attend-global" block, the congruency effect represents "local interference" (i.e., extent of local arrows interference on performance when attending the global arrow). Weinbach and Henik (2011) demonstrated that in the framework of this task, alerting increased global interference, while local interference remained intact. It was suggested that alerting improves attention to global visual events at the expense of attention to details. However, saliency was not manipulated in this task. As in most global/local tasks, a global processing bias was evident by a larger global compared to local interference (for review see Kimchi, 1992).

The common global processing bias effect is largely explained by the fact that the global figure is often more salient than the local details. However, Mevorach, Humphreys, and Shalev (2006) created a global/local task in which the relative global-to-local saliency was manipulated to create a global or local salient condition (see Fig. 1 for illustration). It was shown that when local features were more salient than the global figure, the common larger global-to-local interference was reversed to greater local-to-global interference. This study and many that followed used this saliency manipulation to reveal the involvement of the right parietal cortex in diverting attention to salient events and the left parietal cortex in selection of low saliency stimuli (Bardi, Kanai, Mapelli, & Walsh, 2013; Mevorach, Hodsoll, Allen, Shalev, & Humphreys, 2010; Mevorach, Humphreys, & Shalev, 2009; Mevorach, Shalev, Allen, & Humphreys, 2009; Mevorach et al., 2006; Romei, Driver, Schyns, & Thut, 2011).

In the present study, we used similar saliency manipulations on global and local features to achieve deeper understanding of the role phasic alerting takes in prioritizing processing of salient visual features.

We manipulated alerting and saliency in the framework of the global/local task, similar to Weinbach and Henik (2011), and compared the effects of alerting on global and local interference under a global-salient and a local-salient condition (see a/b and c/d in Fig. 1, respectively). If alerting only facilitates attention to global stimuli, irrespective of saliency, alerting should increase global interference compared with a no-alert condition in both global and local saliency conditions. However, if alerting has a general role in biasing selection of salient features,

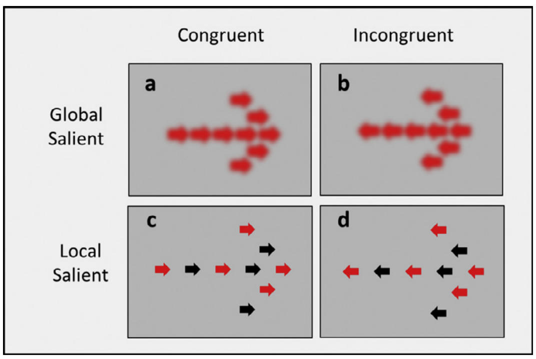

Fig. 1. Example of the stimuli presented in the global and local tasks.

irrespective of the activated perceptual processing mode, then when the local information is irrelevant and salient, alerting should increase its influence and cause greater local interference compared with a no-alert condition. In addition, when the relevant target (global or local) is more salient than the irrelevant distractors, alerting should enhance attention to the relevant information and reduce the influence of the less salient irrelevant information (global or local) compared with a no-alert condition.

2. Methods

2.1. Participants

Thirty-two undergraduate students from the Department of Psychology at Ben-Gurion University of the Negev took part in this experiment (14 males, three left-handed, aged 23–27 years) for course credit. All participants gave informed consent prior to inclusion in the study.

2.2. Apparatus

Data collection and stimuli presentation were controlled by a DELL OptiPlex 760 v Pro computer with an Intel core 2 duo processor E8400 3 GHz. Stimuli were presented on a DELL E198PF 19″ LCD monitor. E-Prime software (Psychology Software Tools, Pittsburgh, PA) was used for programming, presentation of stimuli, and timing operations. Responses were collected through a keyboard and headphones were used to deliver an auditory alerting cue.

2.3. Stimuli

All visual stimuli were presented at the center of a screen on a light gray background. A "+" fixation subtended a 0.5° visual angle. The hierarchical stimulus was a large arrow made of small arrows pointing in the same direction (i.e., congruent) or in opposite directions (i.e., incongruent) (see Fig. 1). The local arrows always subtended a visual angle of 1.2° in width. In the global-salient condition, all local arrows were presented in the same color (red), the distance between two adjacent local arrows was 0.5° and the image was blurred using GNU Image Manipulation Program 2.6.11 (see a/b in Fig. 1). The global figure in this condition subtended a visual angle of 6.7° in width. In the local-salient condition, the image was not blurred, the distance between each local arrow was 1.2° and the stimulus contained both red and black arrows (see c/d in Fig. 1). The global figure in this condition subtended a visual angle of 11.6° in width. For the alerting signal, a 50 ms, 2000 Hz sound was delivered via headphones in half of the trials.

2.4. Procedure and design

Participants were seated approximately 60 cm from the computer screen and completed a global task (i.e., responding to a large arrow while ignoring the small arrows) and a local task (i.e., responding to the small arrows while ignoring the large arrow) in separate blocks. Global and local salient conditions were intermixed within a block. Each task began with a block of 10 training trials, followed by four consecutive blocks, two of each task (96 trials per block). The order of tasks was counter-balanced between participants. Left and right choices were indicated by left and right key presses (the letters 'c' and 'm' on the keyboard, respectively) using both hands.

The time frame for the global and local tasks was similar; in trials that included an alerting tone (half of trials), fixation lasted for 2000 ms and then a 50 ms auditory "beep" sound was delivered. Following a random interval of 100–500 ms from the "beep" onset, the target appeared. This cue-to-target interval allowed alerting to reach its greatest impact on perception (Weinbach & Henik, 2012b, 2013). In the no-alerting trials, time intervals were matched as if there was a cue. The target remained in view until a response was made or 2000 ms passed. After response, a blank screen appeared for 1000 ms.

3. Results

Erroneous response trials and post-error trials were excluded from RT analysis (4.2% of trials). In addition, RTs above and below 2.5 *SD* from the mean of each subject across each experimental condition were excluded (2.86% of the remaining trials). Three participants were excluded from analysis for having near chance level accuracy or for misunderstanding instructions. RTs were analyzed using a repeated measures analysis of variance (ANOVA) with task (attend global or local), saliency (global or local salient), alerting (with alerting or no alerting) and congruency (congruent or incongruent) as independent variables. Table 1 shows mean RTs and error rates per condition.

3.1. The effects of saliency on perceptual processing

In order to examine whether the saliency manipulation induced global/local processing bias, we examined global and local interference effects and general RTs for global and local stimuli under the different saliency conditions only for the no-alerting condition. The global interference effect was measured as mean RT in the incongruent condition minus mean RT in the congruent condition in the attend-local task (i.e., interference from the global arrow when responding to local arrows) and the local interference effect was measured similarly but in the attend-global task (i.e., interference from local arrows when responding to the global arrow).[1]

[1] It is safe to assume that all of the findings reported concerning global and local interference effects were a result of RT changes in the incongruent conditions rather than in the congruent conditions. This can be recognized when examining the alerting effects under the different congruency conditions (see also Weinbach & Henik, 2011). The alerting effects were the same in all of the congruent conditions between the tasks and under the difference saliency conditions. The alerting effects differed only between the incongruent conditions. In addition, previous studies that included a neutral condition showed that larger congruency effects following an alerting cue were a result of larger interference effects (i.e., incongruent RTs compared with neutral condition RTs) while facilitation effects (i.e., neutral RTs compared with congruent RTs) were not modulated by alerting (Weinbach & Henik, 2012a).

Table 1
Mean reaction time and error rates.

Task	Congruency	Saliency			
		Global salient		Local salient	
		No alerting	Alerting	No alerting	Alerting
Attend-local	Congruent	500 (0.4%)	463 (0.8%)	469 (0.5%)	444 (0.4%)
	Incongruent	557 (8.2%)	541 (7.1%)	497 (1%)	457 (0.9%)
	Global interference effect	57	78	28	13
Attend-global	Congruent	433 (0.6%)	403 (0.2%)	431(0.5%)	397 (0%)
	Incongruent	456 (1.9%)	410 (0.9%)	488 (3%)	470 (5.1%)
	Local interference effect	23	7	57	73

Note: RT is in milliseconds. Error rate percentage is in parentheses. The global interference effects represent mean RT in the incongruent condition minus mean RT in the congruent condition in the attend-local task. The local interference effects represent mean RT in the incongruent condition minus mean RT in the congruent condition in the attend-global task.

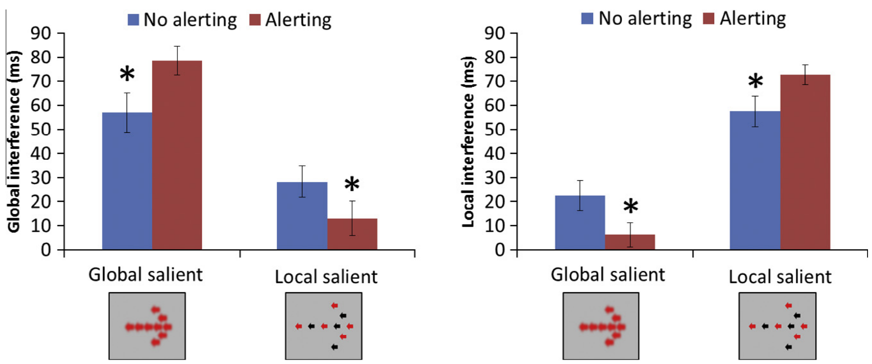

Fig. 2. The left graph displays global interference as a function of alerting and saliency. The *y*-axis represents global interference which was measured as incongruent RT minus congruent RT in the local task (i.e., attend local, ignore global). The *x*-axis represents the saliency conditions. Blue represents trials with no alerting cue and red represents trials with an alerting cue. In the right graph the *y*-axis represents local interference which was measured as incongruent RT minus congruent RT in the global task (i.e., attend global, ignore local). The error bars represent within-participants confidence intervals (Cousineau, 2005; Morey, 2008). Below the *x*-axis there is an example of the saliency manipulation. $^{*}p < .05$.

The results indicated that when the global dimension was salient, the global interference effect was larger than the local interference effect, $F(1,28) = 8.62$, $p < .01$, $\eta^2_p = .23$. When the local arrows were salient, the local interference was larger than the global interference, $F(1,28) = 8.64$, $p < .01$, $\eta^2_p = .23$.

With respect to global/local target identification, when attending the local elements, RTs were faster when the local elements were more salient compared to when they were less salient, $F(1,28) = 68.79$, $p < .0001$, $\eta^2_p = .71$. When attending the global figure, RTs were faster when the global dimension was more salient compared to when it was less salient, $F(1,28) = 13.18$, $p < .01$, $\eta^2_p = .32$. However, this difference was driven by the incongruent condition, $F(1,28) = 20.75$, $p < .0001$, $\eta^2_p = .42$, rather than the congruent condition, $F < 1$.

3.2. The effects of saliency and alerting on global/local interference effects

The 4-way interaction between task, saliency, alerting and congruency was significant, $F(1,28) = 17.73$, $p < .001$, $\eta^2_p = .38$. Fig. 2 depicts the global and local interference effects as a function of saliency and alerting. When the global dimension was salient, global interference was larger following an alerting cue compared with a no-alerting condition (78 ms vs. 57 ms, respectively, $F(1,28) = 5.74$, $p < .05$, $\eta^2_p = .17$). Interestingly, when participants attended the salient global dimension, alerting significantly reduced the local interference compared with the no-alerting condition (7 ms vs. 23 ms, respectively, $F(1,28) = 6.15$, $p < .05$, $\eta^2_p = .18$). More critically, when the local dimension was salient, an opposite pattern was revealed; in the attend-global task, alerting induced larger local interference compared with the no-alerting condition (73 ms vs. 57 ms, respectively, $F(1,28) = 9.96$, $p < .01$, $\eta^2_p = .26$), and in the attend-local task, alerting reduced global interference compared with the no-alerting condition (13 ms vs. 28 ms, respectively, $F(1,28) = 4.22$, $p < .05$, $\eta^2_p = .13$).

4. Discussion

Results of the present study demonstrate the role of alerting in biasing attention to salient events in the visual field. In a global/local processing task, hierarchical stimuli (large arrows comprised of smaller arrows) were presented to participants who attended to the global or local forms in different blocks. Saliency of the stimuli was manipulated to create a global or local salient condition. These conditions induced a global or local processing bias as a function of stimulus saliency.[2] Importantly, saliency produced a double dissociation in effects of alerting on global vs. local interference: in the global-salient condition, alerting increased global interference and reduced local interference; in the local-salient condition, alerting reduced global interference and increased local interference. In other words, the activated perceptual processing mode and the relevance of the stimuli to the task were less important than the saliency of the stimuli presented. When the irrelevant information was salient, alerting increased its negative influence on performance. When the relevant information was salient, alerting increased its positive influence and conflict from the distractors was reduced. These results are in line with Mevorach and colleagues' suggestion that global and local processing bias is largely explained by saliency (Mevorach et al., 2006). More importantly, alerting modulated the impact of relevant or irrelevant information based on their saliency.

Results of the current study shed light on several topics currently discussed in the literature on alerting and attention. For example, hemispatial neglect is a disorder in which both arousal and attention to salient objects in the contralesional visual field are impaired (Corbetta & Shulman, 2011). Corbetta and Shulman (2011) suggested that in hemispatial neglect, the difficulty in coding saliency in the contralesional hemifield is a result of impairment in the interaction between ventral brain regions in the parietal cortex, which are implemented in arousal, and dorsal brain regions, which are associated with coding of saliency. We showed how alerting cues that are known to induce high arousal for a brief period in time (Sturm & Willmes, 2001) can bias attention towards processing of salient features. This provides direct behavioral support for the link between arousal and coding of saliency in healthy participants. In addition, enhanced attention to salient events following an alerting cue can account for findings showing that alerting can ameliorate spatial bias in hemispatial neglect (Chica, Thiebaut de Schotten, Toba, et al., 2011; Robertson et al., 1998) and increase conscious perceptual sensitivity (Botta et al., 2014).

Another finding from the current study that is worth noting is that in situations in which the target was more salient than distractors, alerting significantly reduced the distractors' interference. This relates to studies that discuss an ubiquitous finding of increased interference following an alerting cue (for review see MacLeod et al., 2010). Most evidence for this effect came from the flanker task. In this task participants attend a central target and attempt to ignore salient flankers in close proximity. Flanker interference is increased following an alerting cue. Initially, it was suggested that alerting acts to inhibit cognitive control (Callejas et al., 2005). Although subsequent reports challenged this interpretation (Böckler, Alpay, & Stürmer, 2011; Fischer et al., 2012; Weinbach & Henik, 2012a), the present study shows that alerting can improve conflict resolution when a target is more salient than distractors. It could very well be that in the flanker task, increased attention to salient flankers following an alerting cue results in greater flanker interference. This is in line with our previous results indicating greater attentional scope under an alert state (Weinbach & Henik, 2012a), making irrelevant flankers more accessible for processing. However, the present results are not in line with our previous suggestion of enhanced global processing bias when one is highly aroused (Weinbach & Henik, 2011). Here we showed that the activated perceptual processing mode is less important than the saliency of the features presented. Whether alerting has residual effects on global processing, irrespective of saliency, is an interesting question for future studies.

[2] There is an asymmetry in the results for global/local interference effects as a function of saliency and the effects found for global/local target identification. It seems that in the current work, the saliency manipulation was more effective for global/local interference effects but was not strong enough to induce RT advantage for identifying salient global targets compared with less salient global targets in the congruent condition. Similar asymmetry was also reported in previous studies using the saliency manipulation used in the current study (Mevorach, Humphreys, et al., 2009; Tsvetanov, Mevorach, Allen, & Humphreys, 2013). The asymmetry between these effects can be explained by the fact that global/local identification and the global/local interference effects were found to be dissociable and supported by different mechanisms (Amirkhiabani & Lovegrove, 1999; Lamb & Robertson, 1989). Results of the current study imply that global/local identification effects are less sensitive to saliency manipulations in comparison to interference effects.

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References

Amirkhiabani, G., & Lovegrove, W. J. (1999). Do the global advantage and interference effects covary? *Perception & Psychophysics, 61*, 1308–1319.

Aston-Jones, G., & Cohen, J. D. (2005). An integrative theory of locus coeruleus-norepinephrine function: Adaptive gain and optimal performance. *Annual Review of Neuroscience, 28*, 403–450. http://dx.doi.org/10.1146/annurev.neuro.28.061604.135709.

Bardi, L., Kanai, R., Mapelli, D., & Walsh, V. (2013). Direct current stimulation (tDCS) reveals parietal asymmetry in local/global and salience-based selection. *Cortex, 49*, 850–860.

Böckler, A., Alpay, G., & Stürmer, B. (2011). Accessory stimuli affect the emergence of conflict, not conflict control: A simon-task ERP study. *Experimental Psychology, 58*, 102–109.

Botta, F., Lupiáñez, J., & Chica, A. B. (2014). When endogenous spatial attention improves conscious perception: Effects of alerting and bottom-up activation. *Consciousness and Cognition, 23*, 63–73.

Callejas, A., Lupiáñez, J., Funes, M. J., & Tudela, P. (2005). Modulations among the alerting, orienting and executive control networks. *Experimental Brain Research, 167*, 27–37. http://dx.doi.org/10.1007/s00221-005-2365-z.

Chica, A. B., Thiebaut de Schotten, M., Toba, M., Malhotra, P., Lupianez, J., et al. (2011). Attention networks and their interactions after right-hemisphere damage. *Cortex, 48*, 654–663.

Corbetta, M., & Shulman, G. L. (2011). Spatial neglect and attention networks. *Annual Review of Neuroscience, 34*, 569–599.

Coull, J., Nobre, A., & Frith, C. (2001). The noradrenergic alpha 2 agonist clonidine modulates behavioural and neuroanatomical correlates of human attentional orienting and alerting. *Cerebral Cortex, 11*, 73–84.

Cousineau, D. (2005). Confidence intervals in within-subject designs: A simpler solution to Loftus and Masson's method. *Tutorials in Quantitative Methods for Psychology, 1*, 42–45.

DeGutis, J. M., & Van Vleet, T. M. (2010). Tonic and phasic alertness training: A novel behavioral therapy to improve spatial and non-spatial attention in patients with hemispatial neglect. *Frontiers in Human Neuroscience, 4*(60), 1–17. http://dx.doi.org/10.3389/fnhum.2010.00060.

Fan, J., McCandliss, B. D., Sommer, T., Raz, A., & Posner, M. I. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience, 14*, 340–347.

Fischer, R., Plessow, F., & Kiesel, A. (2010). Auditory warning signals affect mechanisms of response selection: Evidence from a Simon task. *Experimental Psychology, 57*, 89–97.

Fischer, R., Plessow, F., & Kiesel, A. (2012). The effects of alerting signals in action control: Activation of S-R associations or inhibition of executive control processes? *Psychological Research, 76*, 317–328.

Kimchi, R. (1992). Primacy of wholistic processing and global/local paradigm: A critical review. *Psychological Bulletin, 112*, 24–38.

Kusnir, F., Chica, A. B., Mitsumasu, M. A., & Bartolomeo, P. (2011). Phasic auditory alerting improves visual conscious perception. *Consciousness and Cognition, 20*, 1201–1210.

Lamb, M. R., & Robertson, L. C. (1989). Do response time advantage and interference reflect the order of processing of global- and local-level information? *Perception & Psychophysics, 46*, 254–258.

MacLeod, J. W., Lawrence, M. A., McConnell, M. M., Eskes, G. A., Klein, R. M., & Shore, D. I. (2010). Appraising the ANT: Psychometric and theoretical considerations of the attention network test. *Neuropsychology, 24*, 637–659.

Mevorach, C., Hodsoll, J., Allen, H., Shalev, L., & Humphreys, G. (2010). Ignoring the elephant in the room: A neural circuit to downregulate salience. *The Journal of Neuroscience, 30*, 6072–6079. http://dx.doi.org/10.1523/JNEUROSCI.0241-10.2010.

Mevorach, C., Humphreys, G. W., & Shalev, L. (2006). Opposite biases in salience-based selection for the left and right posterior parietal cortex. *Nature Neuroscience, 9*, 740–742.

Mevorach, C., Humphreys, G. W., & Shalev, L. (2009). Reflexive and preparatory selection and suppression of salient information in the right and left posterior parietal cortex. *Journal of Cognitive Neuroscience, 21*, 1204–1214.

Mevorach, C., Shalev, L., Allen, H. A., & Humphreys, G. W. (2009). The left intraparietal sulcus modulates the selection of low salient stimuli. *Journal of Cognitive Neuroscience, 21*, 303–315.

Morey, R. D. (2008). Confidence intervals from normalized data: A correction to Cousineau (2005). *Reason, 4*, 61–64.

Navon, D. (1977). Forest before trees: The precedence of global features in visual perception. *Cognitive Psychology, 9*, 353–383.

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience, 13*, 25–42.

Robertson, I. H., Mattingley, J. B., Rorden, C., & Driver, J. (1998). Phasic alerting of neglect patients overcomes their spatial deficit in visual awareness. *Nature, 395*, 169–172. http://dx.doi.org/10.1038/25993.

Romei, V., Driver, J., Schyns, P. G., & Thut, G. (2011). Rhythmic TMS over parietal cortex links distinct brain frequencies to global versus local visual processing. *Current Biology, 21*, 334–337.

Sara, S. J. (2009). The locus coeruleus and noradrenergic modulation of cognition. *Nature Reviews Neuroscience, 10*, 211–223.

Sturm, W., & Willmes, K. (2001). On the functional neuroanatomy of intrinsic and phasic alertness. *NeuroImage, 14*, S76–S84.

Tsvetanov, K. A., Mevorach, C., Allen, H., & Humphreys, G. W. (2013). Age-related differences in selection by visual saliency. *Attention, Perception, & Psychophysics, 75*, 1382–1394.

Weinbach, N., & Henik, A. (2011). Phasic alertness can modulate executive control by enhancing global processing of visual stimuli. *Cognition, 121*, 454–458.

Weinbach, N., & Henik, A. (2012a). The relationship between alertness and executive control. *Journal of Experimental Psychology: Human Perception and Performance, 38*, 1530–1540. http://dx.doi.org/10.1037/a0027875.

Weinbach, N., & Henik, A. (2012b). Temporal orienting and alerting – The same or different? *Frontiers in Psychology, 3*(236), 1–3. http://dx.doi.org/10.3389/fpsyg.2012.00236.

Weinbach, N., & Henik, A. (2013). The interaction between alerting and executive control: Dissociating phasic arousal and temporal expectancy. *Attention, Perception, & Psychophysics, 75*, 1374–1381.

Witte, E., & Marrocco, R. (1997). Alteration of brain noradrenergic activity in rhesus monkeys affects the alerting component of covert orienting. *Psychopharmacology, 132*, 315–323.