Why are some People Inattentionally Blind and can Training reduce its frequency of occurrence?

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Abstract

Inattentional Blindness (IB) occurs when an observer who is engaged in a resource consuming task fails to notice an unexpected although salient stimulus appearing in his/her visual field. The incidence of IB can be affected by changes in stimulus-driven properties of the display, but very little research has examined individual differences in propensity for IB. The current research examines individual differences in working memory capacity, processing styles (flicker task) and inhibition (Stroop task) in predicting IB. In addition, the influence of training on IB is also examined. Experiment 1 showed that although there were no differences between IB and NIB individuals (not inattentionally blind), in terms of processing styles, individuals with lower working memory capacity (WMC) were more likely to be IB. Experiment 2 examined differences in inhibition and working memory, and found that working memory predicted the probability of IB whereas inhibition did not. Levels of IB, however, were also influenced by prior training. Compared to no training, training on a task using the same primary task as that used in the IB task produced greater reductions in IB, as did training on a different task, where the effects were smaller, but significant. We conclude that IB is related to working memory capacity and that training can influence the incidence of IB.

Keywords: Inattentional Blindness; working memory capacity; processing styles; inhibition; training.

Introduction

Inattentional blindness (IB) describes the situation in which an observer, who is engaged in a resource-consuming task, fails to notice an unexpected stimulus appearing in front of their eyes. IB individuals have no difficulty seeing this object (and show great surprise) when the scene is observed for a second time but without any additional task. Inattentional blindness occurs in everyday life and can be of minimal importance (e.g., failing to notice your friend at the cinema as you search for a vacant seat) or can have catastrophic consequences (failing to notice a rogue aeroplane in the flight path when flying). Research has examined the stimulus components of the visual display that influence the probability of IB occurring, but very little has examined individual differences in IB. In all of the above studies it is apparent that even though individuals are presented with the same physical environment in which they are presented with exactly the same stimuli, they do not have the same subjective experience. Why is it that some individuals are inattentionally blind whereas others are not?

Visual attention can be directed at different levels of a visual scene, with focus on the more holistic, global level or on the more analytic, local level. IB individuals may differ from NIBs (Not Inattentionally Blind) in their processing style, with IBs adopting a narrower focus of attention than NIBs, rendering them less likely to notice the unexpected stimulus. If this were the case, then we might expect that IBs would be more focused on local aspects of a processing task relative to NIBs, with NIBs being more focused on global aspects of the task. Navon (1977) found that global differences were detected more frequently than local differences, but manipulation of attentional set may bias perception to one level or the other (Hoffman, 1980).

An alternative explanation is that IB is associated with a lack of processing resources, and so the irrelevant stimulus is simply not processed or is subjected to minimal processing before being filtered out. We have previously found working memory capacity (WMC) differences correlated with IB such that those who demonstrated IB had significantly lower WMC than those who were NIB (Hannon & Richards, 2005, 2007; Davelaar, Hannon, & Richards, 2004). We found support for Simons and Jensen (2009) in showing no differences between NIBs and IBs in performance on the primary task; however, we did find robust individual differences in WMC, which predicted IB.

In Experiment 1, we examine both of these hypotheses using a global-local flicker task, to measure differences in processing style, an operation span task (OSPAN) to measure working memory differences, and an IB task. If IB individuals are characterized by a bias for a local level of analysis, then we would predict a greater sensitivity for local changes in a visual display compared to NIBs, and greater sensitivity for global changes for NIBs compared to IBs. If the limited resources hypothesis were supported, then we would expect lower WMC for IBs compared to NIBs.

Experiment 1

Method

Participants 77 participants were tested, but data from 9 were removed (7 misunderstood the task, 1 for dyslexia and 1 was outside the age range). The mean age of the remaining 68 participants was 27.43 (SD = 9.45, range 18 to 56 years). There were 42 females.

Design and Procedure Participants completed the OSPAN (Turner & Engle, 1989) and the global-local flicker tasks (counterbalanced) and then an IB task (Most et al., 2000).

Task 1: Operation Span task Participants are required to solve simple mathematical equations while memorising unrelated words, with word lists varying between 2 and 5 words per set. For example: 'does (10÷2) – 3 = 2 ? sea'. Three sets of each list length are presented in an apparent random order but fixed across participants. List length is unknown to participants until the cue ??? appears, when they must then write down the words they can remember from that set, in the exact order they appeared. Scoring on this task consists of summing the recalled words for only those sets recalled completely and in the correct order, with scores having a possible range of between 0 and 42.

Task 2. Global-Local Flicker Task: The flicker task was adapted from Austen and Enns (2000). Two large (global) letters (E and S) were created using letters also E and S (local component; see Figure 1).

Global Congruent		Global Incongruent	
S	E	S	E
SSSS S SSSS S SSSS	EEEE E EEEE E EEEE	EEEE E EEEE E EEEE	SSSS S SSSS S SSSS

Figure 1: Global and local letters for Flicker Task.

50% of the local letters were consistent with the global letter and 50% inconsistent. Each stimulus measured 48 x 78 pixels, and was shown in displays of alternating frames of 1, 3 or 5 items. Set size 1 examined change detection during focused attention, and set size 3 and 5 examined change detection during distributed attention. Each display appeared for 225 ms with a blank frame interleaved for 225 ms. This alternation gave the appearance of a flickering display, which continued until the participant pressed the *M* key on the keyboard to indicate that a change had occurred (either a local or a global change) or the *Z* key to indicate that no change had occurred. A change occurred on 50% of trials, and half of these changes were local and the other half global. Items appeared randomly in one of nine squares of an imaginary 3 x 3 matrix. There was a practice block of 48 trials followed by 3 experimental blocks of 80 trials.

Task 3: IB Task IB was measured using a task from D. J. Simons' (2003) 'Surprising studies of visual awareness' DVD. This task was based on an original task by Most et al. (2000) in which four black and four white letters (Ls and Ts) move haphazardly around the screen, frequently 'hitting' the borders of the display. Participants were asked to track the four white letters (2 Ls and 2 Ts) but to ignore the four black letters. They were required to count the number of times the white letters hit the border during the 17 sec duration of the DVD. After 5 secs, a red cross moved across the centre of the screen from right to left, taking 7 seconds. Participants were asked how many 'hits' there were, and whether they saw anything else on the screen.

Results

Out of the 68 participants, 36 (53%) failed to notice the moving red cross and were therefore classified as 'IB'. The remaining participants reported seeing the red cross, and were classified as 'NIB'.

Local Global Flicker Task An examination of accuracy and response latencies on the *focal attentional* task (set size 1) revealed no differences between IB and NIB individuals for global or local trials. A comparison of change trials (collapsed over local and global) and no-change trials showed faster responses for change than no-change (1430 ms, SE = 35 and 1715 ms, SE = 71, respectively; $F(1,66) = 32$, $p<.001$, $\eta^2_p=.33$) but no accuracy differences. Change detection during *distributed attention* was examined. An ANOVA with display (local, global), set size (3, 5) as within-subjects factors and blindness status (IB, NIB) as a between-subjects factor revealed faster responses for global than local changes (2932 ms, SE = 104, and 3165 ms, SE = 116, respectively; $F(1,66) = 5.95$, $p=.02$, $\eta^2_p=0.08$), and for set size 3 than for 5 (means of 2620, SE = 76 and 3478, SE = 136, respectively; $F(1,66) = 84.13$, $p=.02$, $\eta^2_p=0.56$. A non-parametric Signal Detection Analysis (Snodgrass & Corwin, 1988) was applied to the accuracy data for set sizes 3 and 5 combined (see Table 1). Sensitivity was greater for global than local displays (means of 4.12, SE=.19, and 3.75, SE = .19, respectively; $F(1,66) = 13.60$, $p<.001$, $\eta^2_p=0.17$), but there were no differences involving inattentional blindness status (*F*s <1). There were no significant effects from the analysis of the response bias scores.

Table 1: Mean response latencies (ms), sensitivity, response bias for the global-local flicker task. Not Inattentionally Blind (NIB) and Inattentionally Blind (IB) individuals (SDs in parentheses)

		NIBs		IBs	
Set Size		3	5	3	5
Latency:	Global	2427	3368	2563	3371
		(587)	(919)	(711)	(1453)
	Local	2655	3440	2834	3732
		(691)	(896)	(889)	(1565)
Sensitivity:	Global	4.07		4.18	
		(1.48)		(1.65)	
	Local	3.57		3.94	
		(1.55)		(1.62)	
Response Bias:	Global	0.99		0.98	
		(0.01)		(0.85)	
	Local	0.99		0.97	
		(0.03)		(0.15)	

IB and Working Memory Capacity The IB individuals had lower OSPAN scores than the NIB individuals (means of 15.11 SD = 7.75 and 19.56, SD = 6.62 respectively; $t(66) = 2.57$, p=.013, η^2_p= .09), indicating that lower WMC is associated with IB.

IB, Working Memory Capacity and Sensitivity to Local and Global Visual Changes In order to examine the influence of WMC and sensitivity to global and local changes in predicting the probability of IB, a simultaneous entry logistic regression was performed. IB was the outcome variable and age, sex and latency differences (global minus local latencies) were predictors (see Table 2)[1]. This analysis revealed that only OSPAN was a significant predictor.

Table 2: Results of simultaneous entry logistic regression for Experiment 1.

		95% CI for exp b		
	B(SE)	Lower	Exp b	Upper
Constant	1.43 (1.13)			
OSPAN*	-0.09 (0.04)	0.85	0.92	0.99
Age	0.01 (0.03)	0.96	1.01	1.06
Sex	-0.23 (0.53)	0.28	0.80	2.24
Global-Local response Latency Difference	0.00 (0.00)	1.00	1.00	1.00

Note R^2 = .10 (Cox & Snell), .13 (Nagelkereke). Model = $\chi^2(4)$ 7.19, p=.13. *p<.05.

Discussion

Inattentional Blindness was observed in 53% of the sample, and this is consistent with our own and other research, e.g., Most et al. (2000). There were no differences between local and global detection when attention was focused, but when attention was divided all participants showed increased sensitivity for global than local visual changes on the flicker task (in line with Navon, 1977; and Austen & Enns, 2000). There were no differences between the IBs and NIBs, showing no support for the notion that IB individuals are characterized by an increase in analytical processing compared to NIB individuals. However, the IBs were shown to have lower WMC than the NIBs, which supports our earlier research in this area. The logistic regression gives weight to this conclusion, showing that only OSPAN significantly predicted the probability of IB, with the latency difference on local and global displays playing no role.

We have shown that WMC is very important in IB, but there may be additional influential variables. One such proposal is that IB individuals fail to notice the unexpected stimulus because they have successfully inhibited it. This proposal will be examined in Experiment 2. We will also examine the effects of training on the incidence of IB.

[1] Additional analyses with sensitivity difference between local and global performance did not predict IB.

Experiment 2

The ability to inhibit an irrelevant stimulus is an extremely useful process in most circumstances, as it ensures that the individual maintains attentional focus on the task goal thereby avoiding the disruptive influence of irrelevant information. However, such a process brings with it potential costs, as in the case of the appearance of an ostensibly irrelevant stimulus that is highly significant. The tendency to have good inhibitory processes is correlated with high levels of working memory capacity (WMC). WMC is viewed by many researchers as involving controlled attention (e.g., Turner & Engle, 1989). Bleckley et al. (2003) propose that there are differences in attentional control between high and low WMC individuals, with the former having a more flexible discontiguous attentional allocation whereas the latter have a spotlight of attention, which is a continuous but less flexible mode of attentional allocation. They argue that high WMC individuals are more able to inhibit and control attention. Kane et al. (2001) found no difference between high and low WMC individuals in a prosaccade task, but compared to low WMC individuals, high WMC individuals had superior performance on the antisaccade task in which the saccade towards the cue had to be suppressed in favour of a saccade in the opposite direction. If IB is as a result of inhibitory processes, then it is predicted that individuals with high levels of inhibition will be more likely to be IB. It might also be expected from this perspective that IB would be associated with higher levels of WMC.

In the current experiment, we directly compare an inhibition hypothesis with a reduced capacity hypothesis, and we look at the effects of training on IB. As participants become more practiced there should be a corresponding increase in available attentional resources. We therefore predict that training will decrease the incidence of IB. However, an alternative prediction from the inhibition hypotheses is that an increase in available resources will enable irrelevant stimuli to be successfully inhibited, with a corresponding increase in the incidence of IB. Whether practice on video games can improve attentional perceptual tasks is a matter for debate. Green and Bavelier (2007), for example, found improvements on such tasks, whereas Boot et al. (2008) found no effects after 20 hours of practice in non-gamers.

Neisser (1979) describes a study where individuals were presented with a video scene in which a woman with an umbrella walks through a basketball game. Prior to this, participants had completed an easier task, a more difficult task, or no task. Neisser concludes that people fail to see an unexpected object in situations where they believe the task to be difficult. Although essential details are missing from the account of this study, it does suggest that practice may have a beneficial effect on reducing incidences of IB. The current study examines the incidence of IB after (a) no training, (b) after training on the same task as the primary task in the final IB task (i.e., counting white Ls and Ts) and (c) after training on a different task (i.e., counting diamonds and triangles). We predict that training will reduce the incidence of IB compared to the no training control condition. By having a same and different training condition, we will be able to examine whether general training on the task will transfer to a different but similar task. We will also examine whether training, inhibition or WMC predicts the incidence of IB.

Method

Participants 87 participants took part, but 3 were excluded because they misunderstood the IB task and 2 for misunderstanding the Stroop task. A total of 82 participants (62 females) with a mean age of 32.37 (SD = 7.90; range 21 to 56 years) took part in the experiment.

Design and Procedure Participants were randomly allocated to one of three training conditions (Control, Same and Different). However, before completing this final task (Task 3), all participants performed two additional tasks that were counterbalanced across participants. Task 1 was the Automatic Operation Span (AOSPAN) task of Unsworth et al. (2005) and Task 2 was a Stroop task.

Task 1: AOSPAN task The Automated Operation Span Task (AOSPAN) measures WMC, and was used here for three reasons. First, the task is performed alone, thereby reducing anxiety levels. Anxiety is predicted to use working memory resources (e.g., Eysenck et al., 2007) and may increase the error in measuring WMC. Second, the task is less reliant on language, as letters rather than words are presented. Finally, using a different OSPAN task allows us to test the WMC hypothesis under different circumstances.

In the AOSPAN task, a series of maths problems are presented that need to solve as quickly as possible. Each problem is followed by a letter for later recall. The total number of letters recalled at the end of each trial being calculated. In the first practice phase, a number of letters are presented for 800 ms (with this being the same for all experimental blocks). A 4 x 3 matrix of letters (F, H, J, K, L, N, P, Q, R, S, T, Y) is then presented. Participants click a box next to the appropriate letters in the exact order they had appeared. Feedback is given on the number of letters recalled in the right order. In the second practice phase, a series of 15 maths problems, e.g. '(1*2) + 1 = ?' are presented, to be solved as quickly as possible. On the next screen a possible answer e.g. '3' and two boxes with 'True' or 'False' is presented. Participants check the correct box, and accuracy feedback is given. Average solution times are calculated (plus 2.5 SD), and are used as a time limit for the maths portion of the task. Speed errors are recorded for responses outside this limit, which discourages participants from using strategies to help recall. In the third practice session, both the letter recall and the maths problems are performed. The experimental trials comprised three sets of each set size (3, 4, 5, 6, 7), producing a total of 75 letters and 75 maths problems. Order of set sizes is randomized. Five scores are calculated: The 'Operation Span' (total number of perfectly recalled sets); the 'Total Number Correct' (total number of letters recalled in the correct position); 'Maths errors' is divided into 'speed errors' and 'accuracy errors'.

Task 2: Stroop Task There were four colour–word conditions. In the control (neutral) condition, strings of XXXs were printed in coloured inks. In the congruent condition, the word and colour of the ink matched. In the ignored repeated condition, ink colour and word colour name conflicted, but in addition, the colour of the ink on trial *n* corresponded to the word on trial $n-1$. In the incongruent condition, each word again was the name of a colour, which conflicted with the coloured ink, but there was no such relationship between successive trials here.

There were 8 experimental blocks, each comprising trials of the same type (e.g., all control trials). There were 2 blocks for each of the 4 types of trials. Within each block, there were 32 trials, and the four colours (red, green, yellow and blue) appeared an equal number of times. After each of the 8 blocks, participants were allowed to take a short break

Each trial began with a fixation cross for 500 ms, which was replaced by the target (colour word or row of Xs) presented in one of the four colours. Colours were identified using colour-coded keys on the keyboard. There was a practice block of 20 trials at the start of the experiment.

Task 3: Training and IB Task

We predict that training will reduce the levels of IB, and therefore to allow for training effects the IB task was made more difficult with the number of bounces off the border increasing from 12 in Experiment 1 to 16 in Experiment 2. The task was programmed in Matlab and was based on that of Most et al. (2000). As before, those who reported the presence of the red plus sign were deemed to be NIBs and those who were unable to report its presence were IBs.

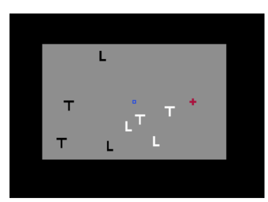

Figure 2: A still frame from the IB task, showing the red cross transversing the screen.

Control Condition Here participants were presented with the IB task without any pre-training (Figure 2).

Different Training Condition In this condition (Figure 3), participants were presented with two training sessions with moving diamonds and triangles that bounced off the screen. Each training screen lasted for 17 sec. Participants were then presented with the IB task (Figure 2). The instructions were the same as for the IB task, i.e., to count the number of times the white items (in this case, diamonds and triangles) hit the border between the grey and white areas.

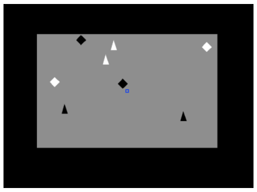

Figure 3: A still frame from the *different* training task.

Same Training Condition: Here there were two training sessions involving 4 Ls and 4 Ts moving across the screen and hitting the border (as in Figure 2, but without the unexpected stimulus). The two training programs in this condition matched those in the *different* condition in terms of the random seed used to generate the movements, so that the direction and number of 'hits' were the same. Following these, the critical IB task was presented. Participants were instructed to count the number of times the white items (in this case, Ls and Ts) hit the grey/black border.

Results

Training effects on incidence of IB The number of IBs and NIBs in the three training conditions were subjected to chi-square analyses (Figure 4). There was a significant association between the incidence of IB and training (χ^2 = 17.01, N = 82, *df* = 2, *p*<.001, Φ = .46). There were more IBs than NIBs in the control condition compared to the same (χ^2 = 17.04, N = 57, *df* = 1, *p*<.001, Φ = .55) and compared to the different training condition (χ^2 = 3.86, N = 60, *df* = 1, *p*=.05, Φ = .25). In addition, there were more IBs than NIBs in the different compared to the same training conditions (χ^2 = 4.07, N = 47, *df* = 1, *p*=.03, Φ = .32).

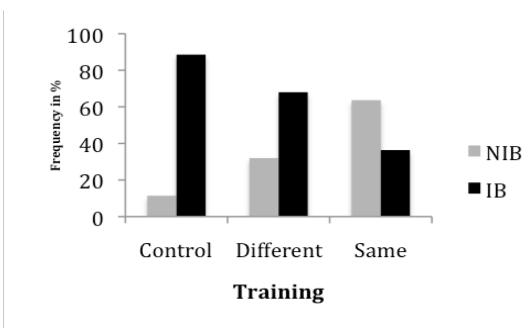

Figure 4: Frequencies of Inattentionally Blind (IBs) and Not Inattentionally Blind (NIBs) by training.

Working memory capacity and IB An analysis of AOSPAN scores in the three training conditions revealed that overall, the IBs had lower AOSPAN scores than the NIBs (means of 44.68, CI_{95} = 39.57, 49.79 and 55.41, CI_{95} = 48.10, 63.62, respectively; *F* (1,76) = 6.04, *p*=.016, η^2_p = .074). There were no differences between the training conditions, nor interactions involving training or IB. Thus, it appears that IBs tend to have lower WMC than NIBs but WMC is not influential in identifying which individuals would benefit from training in order to reduce their chances of displaying IB.

Facilitation, inhibition (Stroop), and IB An analysis of the Stroop data with condition (congruent, control, incongruent, ignored repetition) as a within-subjects factor and training (control, same, different) and IB (IB, NIB) as between-subjects factors was performed. There was a main effect of condition (*F* (3,228) = 11.79, *p*<.001, η^2_p = .134), with no facilitation for control compared to congruent (means of 830, SD = 155 and 836 ms, SD = 174, respectively) but significant inhibition with RTs to incongruent being significantly faster than ignored repetition (means of 880 SD = 185 and 910 ms, SD = 199, respectively; *t*(81) = 2.54, *p* =.013, η^2_p = .074). There were no main or interaction effects involving IB, and therefore no evidence from the Stroop task that IB is associated with increases in inhibition.

Working memory; inhibition; training, and IB To test the relative contributions of training, WMC and inhibition in predicting the probability of inattentional blindness, simultaneous entry logistic regression was performed where IB was the outcome variable and training, inhibition, age, sex, and AOSPAN scores were the predictors (Table 3). Both AOSPAN and Training predicted the probability of IB, but inhibition did not. There were significant effects of different training compared to control, and for different compared to same training.

Table 3: Results of simultaneous entry logistic regression for Experiment 2.

		95% CI for exp b		
	B(SE)	Lower	Exp b	Upper
Constant	2.27 (1.56)			
Training**				
Control vs. Different**	1.42 (0.43)	1.77	4.12	9.60
Same vs. Different*	-1.25 (0.40)	0.13	0.29	0.62
AOSPAN*	-0.04 (0.02)	0.93	0.96	1.00
Age	0.01 (0.04)	0.94	1.01	1.10
Sex	0.00 (0.67)	0.27	1.00	1.01

Note R^2 = .24 (Cox & Snell), .34 (Nagelkereke). Model = χ^2(3) 22.90, *p*<.001. **p*<.05, ***p*<.001

Discussion

Again, we have demonstrated the relationship between IB and WMC, with low WMC being more likely to be IB than high WMC individuals. Although inhibition was observed in the group as a whole, the IBs did not display greater inhibition on the Stroop task. Training had a significant effect on the incidence of IB, with training on a task that is similar to the IB task reducing IB compared to both *control* (no training) and *different* training. Training on a similar task (*same)* rather than a *different* task is also beneficial. These findings suggest that IB can be manipulated by training, which may have implications for training of, for example, drivers and pilots. These data support the idea that training frees up resources, which increase the probability that the unexpected stimulus will be detected. We found no support for the idea that this proposed increase in resources results in increased inhibition of the unexpected stimulus.

General Discussion

In two experiments we have demonstrated robust effects of WMC on predicting the likelihood of IB. We have shown this using both the standard OSPAN task and the automated AOSPAN task. We have further demonstrated that there were no differences in processing styles on the flicker task, and no differences in terms of inhibition. Of particular interest were the effects of training on the incidence of IB, and here we showed clearly that training on a task similar to the IB task produces the greatest benefits in terms of reducing IB but there are also some benefits to be gained from training on a different IB task. The predicted increase in attentional resources from training appears to make the unexpected stimulus more likely to be seen rather than less, and is therefore consistent with a working memory rather than an inhibition account of IB.

Further research is necessary to examine different types of training over different time scales. For example, do the effects endure over long intervals? Neisser (1979) argues that it is the perception of difficulty that is important in determining whether an unexpected stimulus is detected. If individuals expect the primary task to be difficult, then they are more likely to fail to detect the unexpected stimulus. Systematic variations of these variables need to be performed to examine their effects on IB. We also predict a dual route model, in which low WMC individuals fail to notice the irrelevant stimulus because they do not have sufficient resources to process information outside the goals of the primary task, whereas high WMC individuals, who do show IB, do so because they are actively inhibiting the irrelevant stimulus. Research is currently underway to examine all of these proposals.

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References

Austen, E. & Enns, J.T. (2000). Change detection. Paying attention to detail. *Psyche,* 6(11).

Bleckley, M.K., Durso, F.T., Crutchfield, J.M., Engle, R.W., & Khanna, M.M. (2003). Individual differences in working memory capacity predict visual attentional allocation. *Psychononmic Bulletin & Review,* 10, 884-889.

Boot, W.R., Kramer, A.F., Simons, D.J., Fabiani, M., & Gratton, G. (2008). The effects of video game playing on attention, memory, and executive control. *Acta Psychologia,* 129, 387-398.

Davelaar, E. J., Hannon, E. M. & Richards, A. (2005). Strategy use in the operation span task. In (Eds). *Proceedings of the 27th Annual Meeting of the Cognitive Science Society. Stresa:* Cognitive Science Society.

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M.G., (2007). Anxiety and cognitive performance: attentional control theory. *Emotion*, 7, 336-353.

Green, C.S., & Bavelier, D. (2007).Action video game experience alters the spatial resolution of attention. *Psychological Science,* 18, 88-94.

Hannon, E. M., & Richards, A. (2005). Individual differences in inattentional blindness. Paper presented at *BPS Cognitive Section,* University of Leeds, Leeds.

Hannon, E. M., & Richards, A. (2007). Inattentional Blindness: An Investigation into the effects of Working Memory Capacity and Processing Speed – An Individual Differences Approach. In (Eds) *Proceedings of the 2nd European Cognitive Science Conference, Delphi:* pp 486-491.

Hoffman, J. E. (1980). Interaction between global and local levels of a form. *Journal Of Experimental Psychology: Human Perception and Performance* 6, 222-234.

Kane, M.J., Bleckley, K.M., Conway, A.R.A., & Engle, R.W. (2001). A controlled-attention view of working-memory capacity. *Journal of Experimental Psychology: General,* 130, 169-183.

Most, S. B., Simons, D. J., Scholl, B. J., & Chabris, C. F. (2000). Sustained inattentional blindness: The role of location in the detection of unexpected dynamic events. *Psyche, 6*(14).

Navon, D. (1977). Forest Before Trees: The Precedence of Global Features in Visual Perception. *Cognitive Psychology,* 353-383.

Neisser, U. (1979). The control of information pickup in selective looking. In A.D. Pick (ed.) *Perception and its development*. (pp. 201-219). Lawrence Erlbaum Associates, Hillsdale, New Jersey.

Simons, D. J. (2003) Surprising studies of visual awareness (DVD). Champaign, IL: Viscog Productions. http://www.viscog.com.

Simons, D. J. & Jensen, M.S. (2009). The effects of individual differences and task difficulty on inattentional blindness *Psychonomic Bulletin & Review, 16,* 398-403.

Snodgrass, J.G., & Corwin, J. (1988). Pragmatics of measuring recognition memory: applications to dementia and amnesia. *Journal of Experimental Psychology: General,* 177, 34-50.

Turner, M.L., & Engle, R. W (1989). Is working memory capacity task dependent? *Journal of Memory and Language* 28 (2), 127-154.

Unsworth, N., Heitz, R. P., Schrock, J. C., & Engle, R. W. (2005). An automated version of the operation span task. *Behaviour Research Methods 37(3).* 498-505.