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Attentional control and trait anxiety: Does working memory moderate performance in the antisaccade task?

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Attentional control and trait anxiety: Does working memory moderate performance in the antisaccade task?

by

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Abstract

According to attentional control theory, high anxious individuals experience reduced attentional control as compared to low anxious individuals due to the imbalance between goal-directed and stimulus-driven attentional systems (Eysenck, Derakshan, Santos, & Calvo, 2007). As such, high trait anxious individuals have difficulty resisting distraction, as compared to low trait anxious individuals. Relatedly, research on individual differences in working memory capacity (WMC) holds that those with a high WMC have better attentional control than individuals with a low WMC, and thus are better able to resist distraction (Unsworth, Schrock, & Engle, 2004). The present study examined the hypothesis that high WMC compensates for high trait anxiety in terms of performance on the ability to resist distraction, as measured by the antisaccade task. Participants completed the State-Trait Anxiety Inventory to measure trait anxiety, and the Operation Span and Reading Span tasks to measure WMC. As predicted, trait anxiety and WMC interacted to affect performance on the antisaccade task; individuals who were high trait anxious nonetheless yielded more attentional control on the antisaccade task when they had a high WMC. Some theoretical implications of these results are discussed.

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Anxiety is an aversive emotional state that occurs in situations of real or perceived threat. It is characterized by a sense of apprehension and worry that is typically concerned with potentially negative future outcomes (Otto, Calkins, & Hearon, 2010). Anxiety can be differentiated into state and trait anxiety. Trait anxiety is considered a personality dimension characterized by a stable and chronic propensity to experience moderate to high levels of anxiety, whereas state anxiety is a more acute and transient emotional experience of anxiety (Speilberger, 2010). State anxiety is typically triggered by an interaction between trait anxiety and situational stress — high trait anxious individuals are more likely to experience a situation as threatening or anxiety provoking, and therefore are more likely to experience a state of anxiety than low trait anxious individuals (Eysenck & Calvo, 1992).

Researchers have long recognized the associations between attention and attentional processes and state and trait anxiety (Beck & Clark, 1997; Easterbrook, 1959; Eysenck et al., 1992; Mathews & Mackintosh, 1998). One theoretical framework that accounts for these associations is attentional control theory (Eysenck, Derakshan, Santos, & Calvo, 2007). Attentional control theory proposes that when individuals experience a situation as threatening and feel anxious, they widen the focus of their attention so that detection of potential threat is facilitated. Attentional control theory maintains that anxiety reduces the influence of top-down goal-directed attention (guided by current goals) and as a result there is an increase in the influence of stimulus-driven attention (driven by salient sensory stimuli), disrupting the balance between these two attentional systems. Thus, according to the theory, high anxious individuals experience reduced attentional control as compared to low anxious individuals because attention is more likely to be captured by irrelevant stimuli. Further, due to the reduction in attentional control, high anxious individuals require more cognitive resources to attain comparable performance to low trait anxious individuals in tasks that require attentional control. This increased effort negatively affects processing efficiency (latency) more than processing effectiveness (accuracy) in such tasks (Eysenck et al., 2007). One of the resulting impairments experienced by high anxious individuals is difficulty with resisting distraction.

The Antisaccade Task to Measure Attentional Control Differences Related to Anxiety

Researchers have employed a variety of paradigms to measure the ability to resist distraction (see Eysenck et al., 2007, for a review). A well-established paradigm to measure the ability to override reflexive orienting to distracting stimuli is the antisaccade task (Hallet, 1978). This task requires participants to make a saccade (i.e., a fast eye movement) away (antisaccade) from a visually salient peripheral cue that flickers at high frequency. Performance on the antisaccade task is typically compared to performance on the prosaccade task, in which the participant is required to make an eye movement toward the peripheral cue. In some studies the participant is also required to identify a target presented at the location of the cue or the location opposite the cue (e.g., Kane, Bleckley, Conway, & Engle, 2001; Derakshan, Ansari, Hansard, Shoker, & Eysenck, 2009). This is referred to as the target identification task. The prosaccade task is thought to reflect the prepotent or reflexive response to a salient peripheral cue (Hutton &

Ettinger, 2006), whereas the antisaccade task evaluates the ability to suppress a reflexive saccade toward a salient peripheral cue (a distracting stimulus) and to generate a voluntary saccade toward a static cue in the opposite location. The ability to resist distraction is indexed by correct saccade latencies, and errors on the antisaccade task, such that individuals who are slower and more error prone on this task have more difficulty resisting the distracting stimulus and making a saccade in the correct direction. According to attentional control theory, high trait anxious participants should perform more poorly on the antisaccade task than low trait anxious participants because performance in this task requires attentional control. However, no differences between high and low anxious participants would be expected for the prosaccade task, which involves the dominant, more reflexive response, and thus requires less attentional control.

Derakshan et al. (2009) used the antisaccade task to test several predictions of attentional control theory. Derakshan et al. created groups of high and low trait anxious individuals using scores on the State-Trait Anxiety Inventory (Speilberger, Gorsuch, & Lushene, 1970). High trait anxious participants had significantly slower eye movements than low trait anxious participants on the antisaccade task (mean difference = 27 ms), whereas for the prosaccade task the groups did not differ (mean difference = 6 ms). This finding supports attentional control theory’s prediction that trait anxiety decreases processing efficiency (latency) on an attentionally demanding task (antisaccade), but not on a task requiring little attentional control (the prosaccade task). Derakshan et al. found no corresponding difference between the trait anxious groups for latencies on the target identification task. In addition, Derakshan et al. did not find any group differences in the percentage of antisaccade errors. According to attentional control theory, high anxious individuals put forward more effort (efficiency) to achieve the same performance (accuracy) as low anxious participants, and this explains why there would be group differences in latencies, but not accuracy.

Working Memory Capacity and Attentional Control

Working memory capacity has also been shown to affect attentional control in general (see Barrett, Tugade, & Engle, 2004, for a review) and interference to distraction in particular (e.g., Kane et al., 2001; Unsworth, Shrock, & Engle, 2004). WMC is a temporary form of storage that allows for the manipulation of information and thus determines what information is available for conscious use (Conway et al., 2005).

Researchers have used the antisaccade task to assess the influence of WMC on the ability to resist distraction (Kane et al., 2001; Unsworth, et al., 2004). Kane et al. (2001) compared individuals with high and low WMC, as indexed by the Operation Span task (Turner & Engle, 1989), in two experiments with the antisaccade task. They found that individuals with high WMC performed faster on the antisaccade task and its associated target response task than participants who were low in WMC. Individuals with high WMC also made fewer errors on both the antisaccade and target identification task than individuals with low WMC. No group differences were found on the prosaccade task. Unsworth et al. (2004) replicated these results in a study that examined saccade latencies and errors on the anti- and pro-saccade tasks. Taken together, the results of these two studies support the claim that individuals with high WMC are better able to resist distracting information than individuals with low WMC, as indexed by better performance (i.e., faster and fewer errors) on the antisaccade task and the associated target identification task.

A few investigations have examined the interaction between WMC and anxiety on cognitive performance, but not with the antisaccade task. Johnson and Gronlund (2009) had participants perform a demanding short-term memory task that overloaded the phonological loop, and were instructed to attend to a secondary auditory tone discrimination task only if they had “spare effort”. Johnson and Gronlund found that trait anxiety and WMC interacted to predict performance effectiveness (errors) on the auditory discrimination task, such that the negative effects of anxiety were reduced in individuals with a high WMC capacity. They did not find a significant interaction between WMC and trait anxiety in processing efficiency (latency) on the auditory discrimination task. These findings suggest that when demands on working memory are high, anxiety impairs performance effectiveness, and that these impairments are reduced in those who have a high working memory capacity.

On the other hand, a study investigating the effects of WMC and performance pressure (i.e., monetary incentives and paired peer pressure) on math performance reached the opposite conclusion. Beilock and Carr (2005) found that individuals with a high WMC were most impaired by high-pressure situations (i.e., when in a state of anxiety). Specifically, on challenging math problems, the performance of individuals with a high WMC decreased under performance pressure, but the performance of low WMC individuals was not affected by pressure. It is unclear if the different conclusions reached in these two studies are due to state vs. trait anxiety, to the different tasks employed, or to both factors, but it is clear that more research is needed to understand the impact of WMC and anxiety on attentional control. Eysenck et al. (2007) pointed out that individual differences in WMC may be of "direct relevance to an understanding of anxiety and susceptibility to distraction".

The Present Study

The present study examined the hypothesis that WMC and trait anxiety interact in their influence on attentional control. The present study used the antisaccade task because of its documented ability to measure individual differences in the ability to resist distraction, and because it has been used in separate studies that have investigated either trait anxiety and attentional control, or WMC and attentional control. No previous study has used the antisaccade task to test the hypothesis that WMC moderates the negative impact of anxiety on attentional control. The present study also extended previous research by reporting associations between trait anxiety, WMC, and antisaccade performance in a large continuous sample.

As noted, attentional control theory suggests that anxiety decreases attentional control and thus high anxious individuals are predicted to be more easily distracted than are low anxious individuals. The prediction of attentional control theory is that processing efficiency (latency) is compromised more so than performance effectiveness (errors) on tasks that require attentional control, and thus high trait anxious individuals are expected to have longer latencies than low anxious individuals on the antisaccade task, but not the prosaccade task. With respect to antisaccade errors, the prediction is less clear because there is no straightforward way to determine whether antisaccade latencies have been affected more than errors (as is predicted by attentional control theory). Further, Derakshan et al. (2009) found no effect of trait anxiety on antisaccade errors, whereas Kane et al. (2001) and Unsworth et al. (2004) found that high WMC was associated with fewer errors on the antisaccade task. For these reasons we made no predictions for the pattern of antisaccade errors. Based on previous research that demonstrates an association between WMC and performance on the antisaccade task, it was predicted that WMC would attenuate anxiety's negative influence on antisaccade performance, but not prosaccade performance. That is, high anxious individuals would not experience as much impairment in antisaccade performance when they have a high WMC, as compared to high anxious participants who have a low WMC, due to the documented association between high WMC and superior antisaccade performance (Kane et al., 2001; Unsworth et al., 2004).

Method

Participants

The participants were 174 University of Calgary undergraduate students between the ages of 18 and 50 (M = 22). Inclusion criteria were normal or corrected-to-normal vision and having English as a first language. The majority of participants were female (79%). Participants received bonus course credit for their participation (a 1% addition to their final grade). The Conjoint Faculties Research Ethics Board at the University of Calgary approved this study. Participants gave informed consent prior to their participation in the study.

Measures

Participants completed the State-Trait Anxiety Inventory (STAI) for adults. The STAI is a self-report measure that assesses both trait and state anxiety (Speilberger et al., 1970). The trait anxiety scale (A-Trait) measures the general propensity to experience a range of situations as threatening (Ramanaiah, Franzen, & Schill, 1983). The state anxiety scale (A-State) measures the level of anxiety experienced at a particular moment in time. Overall scores range from 20 to 80 on both scales, with higher scores indicating greater levels of anxiety. Both measures have high levels of internal reliability (>.89; Barnes, Harp, & Jung, 2002). Although both the trait and state version of the STAI were administered, the present study focuses on trait anxiety.

Working Memory Span Tasks

Two measures of working memory capacity were administered: modified versions of both the Operation Span task (OSPAN; Turner & Engle, 1989) and the Reading Span task (RSPAN; Daneman & Carpenter, 1980). The OSPAN task required participants to solve a series of math operations while they attempted to remember a set of unrelated words. Participants were shown a math problem and a to-be-recalled word (e.g. "Is (9/3) – 2 = 1? DOG"). The participant was required to read the math problem aloud and say aloud whether the equation was correct or not ("yes" or "no"); then the participant read the word aloud. When the participant had finished reading the word aloud, the experimenter pressed a key to move on to the next operation-word string trial. This procedure was repeated until a prompt appeared in the display that asks the participant to recall the words in the order in which they were presented.

The RSPAN task is similar to the OSPAN task. Participants were presented with a coherent or a nonsensical sentence and a to-be-recalled letter (e.g., "We were fifty lawns out at sea before we lost sight of land. ? M"). Half of the sentences were nonsensical, with the foreign word (e.g., "lawns") appearing equally as often in the beginning, middle, and end of the sentences. Similar to the OSPAN task, the participant read the sentence aloud, verified whether the sentence made sense or not, and then read the letter aloud. A set of trials is defined by a number of trials (between 2 and five) that is followed by a recall cue, in which the participant is asked to recall the letters in the order that they were presented within the set.

For both tasks the working memory capacity score is the sum of recalled words (or letters) for all sets in which the entire set is recalled in order. Additionally, an accuracy of 85% or more on the processing ("yes"/"no") portion of the task is required to ensure that participants are not simply trading off between solving the problems and remembering the words/letters (see Conway et al., 2005).

The OSPAN and RSPAN tasks have adequate reliability. Estimates of internal consistency range from .70 - .90 (Conway et al., 2005). The OSPAN task has demonstrated good test-re-test reliability (.70 -.80; Conway et al., 2005), however the RSPAN has not shown to be as reliable over time (.40 -.65; MacDonald, Almor, Henderson, Kempler, & Anderson, 2001). The OSPAN and RSPAN have also been shown to correlate well with one another (between .40 and .60; Conway et al., 2005), and predict performance on a large number of higher order cognitive tasks (see Ilkowska & Engle, 2010).

Prosaccade and Antisaccade Tasks

As shown in Figure 1, each trial began with a fixation marker in the center of a computer display and two white square cues positioned horizontally 11° of visual angle to the left and right of the fixation marker. During a trial the fixation marker and the cues were displayed for a period of time that varied randomly between 600 and 2,200 ms, in 200 ms increments. Following this random interval one of the two cues flickered for 400 ms. The computer monitored eye position and required that the participant be looking at the fixation marker at the end of the wait period prior to the onset of the flickering cue. If participants were not fixated on the fixation marker at the of the wait period, the flickering cues would not onset until they had fixated the marker.

Participants were instructed to make an eye movement, as quickly as possible, towards the flickering cue in the prosaccade task or away from the flickering cue to the cue on the other side of the fixation marker in the antisaccade task. Immediately following the offset of the flickering cue a target (a ↑ or ↓) appeared in the location of one of the two cues: in the prosaccade task the target replaced the flickering cue and in the antisaccade task the target replaced the cue opposite the flickering cue. In the opposite location a double-headed arrow (⇕) appeared on the other side of the display to prevent the participant from using an empty space to cue where the target display occurred. Participants were asked to identify, by key press, as quickly and as accurately as possible, whether the target was an "up arrow" (↑) or a "down arrow" (↓). The target was presented until a response was made.

Equipment and Procedure

Participants' eye movements were monitored using an EyeLink 1000 desktop mounted eye-tracking device (SR Research Ltd). This device consists of a desk-mounted camera and infrared Illuminator that tracks the pupil and corneal reflections of one eye at a rate of once per millisecond (1000 Hz). Chin and forehead rests were used to position the head approximately 65 cm away from the computer screen. Participants completed a total of 352 anti- and pro-saccade trials, consisting of four sets of 80 trials: alternating sets of prosaccade and antisaccade trials; each preceded by 8 practice trials. Trials were blocked such that only one task type occurred per set (e.g., 80 antisaccade trials, followed by 80 prosaccade trials, or vice versa) and these were counterbalanced across subjects. Within each 80-trial set the flickering cue was equally likely to appear to the right or left of fixation. For each task, the “up arrow” target (↑) was presented equally as often as a “down arrow” target (↓).

Following the antisaccade and prosaccade tasks, the STAI-trait was administered on a separate computer, after which the participant completed the OSPAN and RSPAN tasks (counterbalanced for order across subjects). The OSPAN and RSPAN trials were presented in sets of two, three, four, and five; the trials in each set were presented in a random order. A total of 42 trials were presented (three sets of two, three, four, and five trials in each set). The different set sizes were presented randomly for each participant, so the number of words to be recalled was not known prior to the recall period.

Data Preparation

Trait anxiet*y*. The sum of the ratings on the 20 items of the STAI-Trait comprised the total trait anxiety score. For seven participants missing values for one of the 20 items were replaced with the participant’s mean score. See Table 1 for the descriptive statistics of the entire sample.

Working memory. Four participants were missing RSPAN data due to computer failures. The data from nine participants were excluded because they did not meet the 85% accuracy cutoff typically employed to score the OPSPAN and RSPAN tasks (e.g., Kane et al., 2001; Unsworth et al., 2004). All-or-nothing load scoring was employed for the OSPAN and RSPAN tasks (see Conway et al., 2005). This procedure is commonly employed in studies examining individual differences in working memory (e.g., Kane et al., 2001; Unsworth et al., 2004). Sets of trials are scored as correct only if all of the items (i.e., a word or letter) are recalled in the correct serial position. Further, sets are scored according to the number of items within the set. Thus, if a participant remembered all four of the to-be-remembered items in a four-item set they received a score of 4; if a participant recalled two of a two-item set they received a score of 2. Total scores can range from zero to 42.

Saccade data. A fixation was defined as an eye-movement that remained stable for 100 ms, and was not followed or preceded by a blink. Fixations were mapped on to areas of interest that were created prior to analyses. The display was divided into four areas of interest. The central fixation area contained the central fixation marker. The left and right areas of interest were on either side of the central fixation area and surrounded the square cues. The fourth interest area consisted of the area of the screen that was not accounted for by the first three areas of interest. For each trial the first saccade (which ended in a fixation) after the onset of the flickering cue was examined. The trial was classified as correct if it was in the appropriate direction as indicated by the task; incorrect if the eye movement was in the inappropriate direction or an eye movement was made outside the two areas of interest; and missing if no eye movement was made.

Data from seven participants were excluded due to persistent eye-tracking failures. Subsequently, the eye-movement data was inspected for missing data, and 7 further participants were excluded because they did not make an eye-movement on more than 45% of trials. For the remaining participants trials with no eye-movements made up 6% of trials. These trials were removed from analysis.

Trials with correct eye movements (antisaccade or prosaccade) were subjected to a non-recursive outlier procedure (Van Selst & Jolicouer, 1994). For each participant, trials with saccade latencies 2.5 SD away from the mean of all trials and condition (task: antisaccade vs. prosaccade; block: 1 vs. 2) were excluded. Outliers represented 1.9% of total trials.

Participants were classified as subject outliers if their mean latencies or percent errors for each task were greater than 3 SD from the sample means (8 participants were excluded: 2 as outliers for latencies and 6 as outliers for errors).[1] These subjects were excluded from additional analyses.

Target identification task data. Latencies were analyzed for correct saccade trials only (i.e., trials in which a saccade was made in the correct direction). For each participant, trials were removed by excluding trials with latencies 2.5 SD away from the mean of all trials and condition (task: antisaccade vs. prosaccade; block: 1 vs. 2). Outliers represented 2.1% of total target identification trials.[2]

An additional eight participants were removed as outliers because their latency or error data was greater than 3 SD from the sample mean on either the pro- or anti-saccade target identification task. In total, 16 subjects were removed as outliers on either the saccade data or target identification data. [3] Table 2 shows the means and standard

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[1] A more conservative 3 SD was used for subject outliers since more data is lost through removal of subject outliers than trial outlier analysis.

[2] There was no difference in the number of trials removed between high or low anxious participants for either the saccade latency trials, or the target identification latency trials.

[3] Thirty eight percent of subject outliers scored in the low anxiety group, 6% in the high anxiety group, and the remaining outliers fell somewhere in between.

deviations for the pro- and anti-saccade data and the target identification data for the entire sample.

Results

Associations between all variables of interest were examined in the entire sample using Pearson product-moment correlations. For the group analyses, high and low trait anxiety groups were created using a quartile split on the trait anxiety scores. An analysis of variance (ANOVA) was used to analyze group differences on anti- and pro- saccade performance. To capitalize on the continuous nature of OSPAN and RSPAN measures of WMC, regression analyses were used to assess for an interaction between WMC and trait anxiety.

Correlations for the Entire Sample

Scatterplots between trait anxiety, working memory tasks (RSPAN and OSPAN) and saccade task variables were examined to rule out the possibility that any of the associations were strongly nonlinear. As noted, the effects of trait anxiety and WMC on the ability to resist distraction have not been reported in a large continuous sample. To examine these associations in the entire sample, a series of one-tailed bivariate correlations was performed. These correlations are presented in Table 3.

Trait anxiety and working memory measures. Trait anxiety was not significantly correlated with OSPAN or RSPAN scores (r = –.08, df = 132 and r = –.03, df = 128; respectively). As expected, the OSPAN and RSPAN scores were positively correlated (r = .43, p < .001, df = 128), consistent with the correlations reported in Conway et al. (2005).

***Trait anxiety and saccade tasks*.** Based on previous research that found high trait anxiety to be associated with slower antisaccade latencies, but not prosaccade latencies (Derakshan et al., 2009), it was hypothesized that trait anxiety would be significantly correlated with antisaccade latencies but not with prosaccade latencies. Contrary to this hypothesis, trait anxiety was not significantly correlated with antisaccade latencies (r = .08, p > .10, df = 132). As expected, trait anxiety was not correlated with prosaccade latencies (r = –.06, p > .10, df = 132). However, trait anxiety was correlated significantly with the saccade difference score (antisaccade latencies – prosaccade latencies; r = .17, p < .05, df = 134). The difference score was calculated to partial out some of the variance associated with individual differences in speed of saccadic generation. Thus, individuals with large difference scores had long antisaccade latencies as compared to their prosaccade latencies. High trait anxiety was associated with larger difference scores, indicating longer antisaccade latencies as compared to prosaccade latencies. Trait anxiety was not associated with any of the other saccade or target identification variables (*r values* < |.10|, *p*s > .10, df = 132).

OSPAN and saccade tasks. Based on previous research with OSPAN and antisaccade performance (Kane et al., 2001; Unsworth et al., 2004), it was expected that OSPAN scores would be significantly correlated with antisaccade data, but not with prosaccade data, because the antisaccade tasks require more attentional control. However, all correlations between OSPAN scores and antisaccade variables (including the difference score) were non-significant (all *r values* < |.13|, *p*s > .05).[4] As expected, there

[4] Despite no significant correlation between OSPAN scores and antisaccade performance in the whole sample, we were able to replicate the significant WMC Group x Task

were no significant correlations between OSPAN scores and performance on the prosaccade task (all *r values* < |.10|).

RSPAN and saccade tasks. It was hypothesized that RSPAN scores would be negatively associated with performance on the antisaccade task, but not with performance on the prosaccade task, because the antisaccade tasks require more attentional control. As predicted, there was a significant negative correlation between RSPAN scores and antisaccade errors ($r = –.15$, $p < .05$, $df = 128$) and target identification latencies associated with the antisaccade task ($r = –.22$, $p < .01$, $df = 128$). A high working memory capacity (as measured by the RSPAN task) was associated with fewer errors on the antisaccade task and faster target identification latencies associated with the antisaccade task. RSPAN scores were not correlated with antisaccade latencies, the difference score, or errors on the antisaccade target identification task (all *r values* < |.10|, *p*s > .10, $df = 128$). There was a significant negative correlation between RSPAN scores and prosaccade target identification latencies ($r = –.16$, $p < .05$, $df = 128$), such that a high working memory capacity was associated with faster latencies on the prosaccade task. There were no other significant correlations between RSPAN and prosaccade performance (all *r values* < |.12|).

Summary of effects for the entire sample. To summarize, there was no association between anti- or pro-saccade task performance and trait anxiety in the sample as a whole. However, there was a significant positive correlation between trait anxiety and saccade difference scores. There was also no association between OSPAN scores and performance on the anti- and pro-saccade tasks. There was a significant negative

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interaction found in Unsowrth et al. (2007) when the sample was split into high and low quartiles based on WMC scores.

correlation between RSPAN scores and antisaccade errors, however, and with target identification latencies associated with the antisaccade task. These negative correlations are consistent with findings that a high WMC is associated with greater attentional control (e.g., Kane et al., 2001; Unsworth et al., 2004).

Group Analyses of Trait Anxiety

Group analyses of trait anxiety were performed because previous research used high and low trait anxiety groups to examine differences in attentional control (e.g., Derakshan et al., 2009). High and low trait anxious groups were created to examine the association between trait anxiety (measured by the STAI) and attentional control (measured by the antisaccade task). The high and low trait anxiety groups were created using a quartile split of trait anxiety scores of the entire sample (N = 134). This resulted in 35 individuals in the high trait anxiety group (mean STAI-T = 54.20, SD = 4.00) and 35 individual in the low trait anxiety group (STAI-T = 30.80, SD = 3.69). Note that the mean STAI-T scores of the high and low trait anxiety groups were very similar to the mean STAI-T scores of Derakshan et al.'s high and low trait anxiety groups (M = 49.50, SD = 5.05 and M = 30.30, SD = 2.88; respectively). Table 4 lists the descriptive statistics for the high and low trait anxious groups.

Task order analyses on all four variables of interest (saccade latencies, saccade errors, target identification latencies, and target identification errors) were first performed, as previous work has demonstrated task order effects in the pro- and anti-saccade tasks (see Kane et al., 2001). These analyses were done to determine whether there were task order effects and whether these effects interacted with trait anxiety group (most especially, a three-way interaction between Anxiety Group, Task, and Order).

The first analysis was a 2 (Anxiety Group: high vs. low) x 2 (Task: antisaccade vs. prosaccade) x 2 (Order: antisaccade first vs. prosaccade first) mixed-model factorial analysis of variance (ANOVA) with saccade latencies as the dependent variable. This analysis determined whether the order in which participants completed the saccade tasks affected performance on the tasks and whether any order effect was different for the two groups. Critically, the ANOVA indicated the absence of a three-way interaction between Anxiety Group, Task, and Order ($F < 1$). The same order analysis was performed with anti- and pro-saccade errors as the dependent variable and no significant interactions emerged (all *p*s > .20). Therefore, the data were collapsed across order in all subsequent analyses of saccade latencies and errors. The ANOVA with anti- and pro-saccade target identification times as the dependent variable did not yield a significant three-way interaction between Anxiety Group, Task, and Order ($F < 1$). Therefore, the target identification latency data are collapsed across order in subsequent analyses.

Finally, for the target identification errors there was a significant Anxiety Group x Task x Order interaction, $F(1, 66) = 4.16$, $MSE = 10.34$, $p < .05$. The percentage of target identification errors was very low (range of 2.4% to 4.71%), however, and therefore it is difficult to interpret this interaction. Generally, high anxious participants who completed the antisaccade first had a larger discrepancy between their anti- and pro-saccade errors than the high anxious participants who completed the antisaccade task second. However, for the low trait anxious group, there is virtually no discrepancy in errors on the anti- and pro-saccade tasks between the two task orders. As will be described below, this interaction is of little interest because there was no anxiety-related group difference on the percentage of target identification errors.

Trait anxiety and attentional control. To examine the effect of trait anxiety on attentional control, mixed-model factorial ANOVAs were performed for each of the variables of interest: saccade latencies, saccade errors, target identification latencies, and target identification errors. It was hypothesized that trait anxiety would interact with task for saccade latencies. No hypotheses were made for the effect of trait anxiety on saccade errors and target identification latencies and errors.

Trait anxiety and saccade latencies. A mixed-model ANOVA was performed in which Trait Anxiety Group (high vs. low) and Task (pro- and anti-saccade latencies) were factors and saccade latencies was the dependent variable. There was a main effect of Task, $F(1, 68) = 220.06$, $p < .001$, $MSE = 222402.86$, partial eta squared = .76, with longer latencies on the antisaccade task (436 ms) than the prosaccade task (356 ms), as was expected. There was no effect of Anxiety Group, $F(1, 68) = 1.20$, $p > .20$, $MSE = 6637.83$, partial eta squared = .02, such that the high and low trait anxiety groups had similar overall latencies (403 ms and 389 ms, respectively). Most important was the significant interaction between Anxiety Group and Task, $F(1, 68) = 6.00$, $p = .017$, $MSE = 6058.86$, partial eta squared = .08. As can be seen in Table 5, the high and low trait anxiety groups had virtually identical prosaccade latencies (356 ms and 355 ms, respectively), whereas the high trait anxiety group had slower antisaccade latencies than the low trait anxiety group (449 ms vs. 422 ms). This is the same interaction that Derkeshan et al. (2009) observed in their data.

The interaction was followed-up by comparing the two groups on their anti-saccade latencies, controlling for prosaccade latencies. By controlling for prosaccade latencies, the two groups were equated on the speed with which they were able to make a saccade, likely a key consideration given that, as noted, longer prosaccade latencies were associated with longer antisaccade latencies (*r* = .68, $p < .01$, *df* = 132). Controlling for individual differences in prosaccade latencies in the analysis ruled out the possibility that the high trait anxious individuals were slower on the antisaccade task merely because their overall saccade latencies were slower. To control for prosaccade latencies, an analysis of covariance (ANCOVA) was performed, with prosaccade latencies entered as the covariate. As expected, the effect of the prosaccade latency covariate was significant, $F(1,67) = 63.45$, $p < .001$, *MSE* =122857.14, partial eta squared = .49. The ANCOVA also revealed a significant main effect of group, $F(1, 67) = 6.32$, $p = .014$, *MSE* = 12230.98, partial eta squared = .09. High trait anxious individuals were significantly slower on the antisaccade task (adjusted *M* = 449 ms) than low trait anxious individuals (adjusted *M* = 422 ms). This outcome confirms that high trait anxiety was associated with slower antisaccade latencies even when individual differences in the speed of saccadic generation were taken into account. This is in line with the account that anxiety leads to decreased use of resources and affects performance efficiency on tasks that require attentional control.

Trait anxiety and percent saccade errors. A mixed-model ANOVA with the percent of saccade errors as the dependent variable revealed a main effect of Task, $F(1, 68) = 56.08$, $p < .001$, *MSE* = 1760.98, partial eta squared = .45, but no Anxiety Group x Task interaction ($F < 1$).

Target identification latencies. A mixed-model ANOVA with target identification latencies as the dependent variable produced a main effect of Task, F(1, 68)

= 85.55, $p < .001$, *MSE* = 179322.22, partial eta squared = .56, but no significant Anxiety Group x Task interaction ($F < 1$).

Percent target identification errors. A mixed-model ANOVA of the percentage of target identification errors produced a main effect of Task, $F(1, 68) = 28.57$, $p < .001$, *MSE* = 77.14, partial eta squared = .30, but no significant Anxiety Group x Task interaction ($F < 1$). As was described above, a three-way interaction involving order was present for the target identification errors, but given the absence of a significant Anxiety Group x Task interaction the interaction with task order was of no interest.

***Summary of group analyses*.** To summarize, these group analyses nicely replicate the findings of Derakshan et al. (2009). An Anxiety Group x Task interaction was found for performance on antisaccade latencies, and this was followed up with an ANCOVA that demonstrated that the group difference in antisaccade performance was not due to slower overall saccade latencies in the high anxious participants. Similar to Derakshan et al. (2009), there were only significant effects of Task for saccade errors, target identification latencies, or target identification errors; there were no significant Anxiety Group x Task interactions for these variables.

Trait anxiety, working memory capacity, and attentional control. To test the hypothesis that a high WMC attenuates the negative influence experienced by those who are high trait anxious, multiple linear regression was used to analyze the antisaccade task variables of interest: saccade latencies, saccade errors, target identification latencies, and target identification errors. Trait anxiety group (dummy coded), working memory measures (either OSPAN or RSPAN score), and the Trait Anxiety Group x WMC interaction term were used as predictors. The interaction was the key effect in the analysis, as an interaction between trait anxiety and WMC in antisaccade performance would be expected if higher WMC has a protective effect for high trait anxious individuals. Hierarchical regression was used for antisaccade latencies and target identification latencies, so that the corresponding prosaccade variables (i.e., prosaccade latencies and prosaccade target identification latencies, respectively) could be entered as a covariate, given that they were strongly correlated with both outcome variables (for prosaccade and antisaccade latencies, $r = .68$, $p < .001$, $df = 132$; for prosaccade and antisaccade target identification latencies, $r = .81$, $p < .001$, $df = 132$). Standard regressions were used for the error variables. As recommended by Aiken and West (1991), the moderator variables (OSPAN or RPSAN) and the interaction terms were centered for the purpose of the analysis. Results of the regression models are shown in Table 6.

OSPAN and antisaccade latencies. Prosaccade latency was entered as a covariate in the first step of the regression. In the second step, Trait Anxiety Group, OSPAN, and the Trait Anxiety Group x OSPAN interaction term were entered simultaneously. Prosaccade latency was a significant covariate, $F(1, 68) = 59.07$, $p < .001$ ($B = .80$, *beta* = .68, $p < .001$).With Trait Anxiety Group, OSPAN scores, and the interaction term entered, the prediction model was statistically significant, $F(4, 64) = 17.44$, $p < .001$, $R^2 = .72$, adjusted $R^2 = .49$. The Trait Anxiety Group predictor was significant, ($B = 25.51$, *beta* = .21, $p = .023$), such that high trait anxiety was associated with longer antisaccade latencies. Most important, the Trait Anxiety Group x OSPAN predictor was not significant ($B = –1.49$, *beta* = –.09, $p > .20$). Thus, OSPAN scores did not moderate antisaccade latencies for either trait anxious group.

OSPAN and antisaccade target identification latencies. The identical hierarchical linear regression was used to predict antisaccade target identification latencies (Figure 4). Prosaccade target identification latency was a significant covariate, $F(1, 68) = 118.49$, $p < .001$, $R^2 = .80$, Adjusted $R^2 = .63$ ($B = .87$, $beta = .80$, $p < .001$). None of the variables entered in the second step were significant predictors of antisaccade target identification times (all *p*s > .20).

RSPAN and antisaccade latencies. The results of the regression analysis are shown in Table 6. Prosaccade latency was a significant covariate, $F(1, 65) = 79.18$, $p < .001$, $R^2 = .74$, Adjusted $R^2 = .54$ ($B = .91$, $beta = .74$, $p < .001$).With Trait Anxiety Group, RSPAN scores, and the interaction term entered on the second step, the prediction model was statistically significant, $F(4, 62) = 24.69$, $p < .001$, $R^2 = .78$, Adjusted $R^2 = .59$. Trait Anxiety Group was a significant predictor of antisaccade latencies ($B = 28.31$, $beta = .23$, $p < .01$), such that high trait anxiety was associated with longer antisaccade latencies. Critically, the Trait Anxiety Group x RSPAN interaction was significant ($B = –3.24$, $beta = –.25$, $p = .02$). As can be seen in Figure 3, for lower RSPAN scores, the high trait anxious group had longer antisaccade latencies than the low trait anxious group, whereas for higher RSPAN scores there was no difference between the high and low trait anxious groups. Thus, WMC (as measured by the RSPAN task) was protective in high anxious individuals on a task that requires attentional control.

RSPAN and antisaccade target identification latencies**.** Prosaccade target identification latency was a significant covariate, $F(1, 65) = 112.55$, $p < .001$, $R^2 = .80$, Adjusted $R^2 = .63$ ($B = .87$, $beta = .80$, $p < .001$). With trait Anxiety Group, RSPAN score, and the Trait Anxiety Group x RSPAN interaction term entered, the prediction model was statistically significant, $F(4, 62) = 33.05$, $p < .001$, $R^2 = .83$, Adjusted $R^2 = .66$. Most important, the Trait Anxiety Group x RSPAN interaction term was significant (B = –4.48, *beta* = –.21, $p < .05$). The interaction was similar to the interaction seen for antisaccade latencies. Specifically, for lower RSPAN scores, the high trait anxious group had longer antisaccade target identification latencies than the low trait anxious group, whereas for higher RSPAN scores the high trait anxious participants were slightly faster than the low trait anxious participants (Figure 5).

Discussion

The purpose of the present study was to investigate the hypothesis that a high WMC provides some protection against the negative impact of trait anxiety on attentional control. This aim was accomplished by examining the impact of WMC on the ability to resist distraction, as measured by the antisaccade task in high and low trait anxious individuals. According to attentional control theory, WMC may be of direct relevance to the negative effects of anxiety on distractibility and this is the first study to directly test this hypothesis.

Although the results of the present study suggest that the effects of trait anxiety and WMC on antisaccade performance are not found throughout the sample, the study did replicate the effects of high and low trait anxiety on attentional control in Derakshan et al (2009). Namely, there was a significant interaction between trait anxiety group and task for saccade latencies. High trait anxious individuals were slower on the antisaccade task (a task that requires attentional control) than low trait anxious individuals, and there was no group difference in prosaccade latencies. Further, when prosaccade latencies were partialled out (i.e., to account for individual differences in speed of saccadic generation), a significant main effect of group on antisaccade latencies remained. Thus, the difference between the trait anxious groups on antisaccade performance was not due to slower overall saccade latencies in high anxious individuals. Also in line with Derakshan et al (2009), there was no evidence for an impact of trait anxiety on antisaccade errors, or antisaccade target identification latencies and errors. It is interesting that anxiety impaired latency, but not errors on the antisaccade task. Attentional control theory predicts that errors are affected only when there is a significant demand (such as a load) on attentional control. It is possible that the antisaccade task is not sufficiently demanding to produce negative effects on error performance. A test of this prediction remains an area for future research. Overall, these findings are in line with attentional control theory's prediction that anxiety impairs latency on tasks that require attentional control.

The regression analyses revealed that a higher WMC, as measured by RSPAN task, conferred a protective effect in the ability to resist distraction and maintain attentional control. The analyses showed that high trait anxious individuals with lower RSPAN scores were slower on the antisaccade task than low anxious participants, however when high anxious participants had higher RSPAN scores, their performance was more similar to that of the low anxious participants. The results suggest that higher WMC makes it easier to resist distraction in high anxious participants. This protective effect was expected, and is in line with the results of Johnson and Gronlund (2009).

OSPAN scores did not interact significantly with trait anxiety for either antisaccade latencies or target identification times. However, the pattern of the OSPAN and trait anxiety interaction for antisaccade latencies is similar to that for RSPAN scores. It may be that the interaction with OSPAN did not reach significance due to restriction of range in the high trait anxious sample. Indeed, OSPAN scores were significantly lower in the high trait anxious participants than in the low trait anxious participants, and this was in contrast to RSPAN scores that did not differ between the two anxiety groups. It may be that the mathematical operations in the OSPAN task are anxiety provoking in high trait anxious participants and this leads to an underestimate of their WMC abilities. For this reason, the RSPAN task may be a better measure of WMC in an anxious population. However, this study did not provide a direct test for this hypothesis and it therefore remains an issue for future investigation.

Some research has shown that WMC is associated with the ability to suppress neutral stimuli (e.g., a white bear) and personally relevant obsessional thoughts (Brewin & Beaton, 2002, Brewin & Smart, 2005). Brewin et al. found that higher working memory was related to more effective thought suppression in non-clinical samples. Another study demonstrated an association between self-reported attentional control and perseverative worry in a sample of individuals with generalized anxiety disorder (Armstrong, Zald, & Olatunji, 2011). In light of the findings that suggest associations between WMC/attentional control and symptoms of anxiety, a potentially important theoretical implication derived from the present study's findings is that individuals who are high anxious and have a lower WMC may be more susceptible to symptoms of anxiety that are associated with attentional control (i.e., intrusive thoughts, worry). Brewin and Beaton (2002) raised the possibility that WMC may account for some of the variance in treatment response. In the case of anxious individuals, a lower WMC may reduce the ability to suppress competing cognitions while new appraisals and coping strategies are considered. Cognitive training to increase working memory capacity may therefore be a beneficial component to typical psychotherapy for anxiety (e.g., Klingberg, 2010; but see Shipstead, Redick, & Engle, 2012).

One limitation of the present study concerns the possible influence of state anxiety on antisaccade performance (this was true of previous work as well, i.e., Derakshan et al., 2009). As expected, trait and state anxiety were highly correlated in the present sample. There was a significant difference between the trait anxiety groups on state anxiety scores: the high trait anxious individuals had significantly higher state anxiety scores. It was not possible with the present design to tease out which aspects of anxiety have effects on attentional control. However, previous work suggests that trait anxiety exerts its effects on executive control (top-down processing), and that state anxiety affects alerting and orienting networks of attention (bottom-up processing). Pacheco-Unguetti, Acosta, Callejas, and Lupianez (2010) used the Attention Network Test (Fan, McCandiss, Sommer, Raz, & Posner, 2002) to assess three networks of attention: alerting, orienting, and executive control, at various levels of anxiety. High trait anxiety was associated with difficulty in the executive control network, whereas state anxiety was associated with over-functioning alerting and orienting networks. Further, neuroscience research (e.g., Bishop, 2009) has shown that trait anxiety is associated with decreased use of prefrontal resources, known to be important in cognitive control mechanisms. These findings from neuroimaging and cognitive psychology research are consistent with the interpretation that trait anxiety negatively impacts attentional control (as measured by antisaccade performance). It would be useful for future research to experimentally manipulate state anxiety so as to tease out which type of anxiety affects attentional control in the context of antisaccade performance.

Another limitation was the use of the all-or-nothing method of scoring the WMC measures. Although this is the most commonly used method of scoring (Conway et al., 2005), it is not the method that yields the most variability. Given that WMC was used as a continuous variable, another method of scoring that captures more individual variation would have been preferable. Unfortunately, due to the way the task was programmed, this was not possible. Finally, the use of an undergraduate sample has the potential to limit the generalizability of the findings, as undergraduate populations tend to be higher in trait anxiety than the general population (e.g., Knight, Waal-Manning, & Spears, 1983).

In conclusion, the present findings are important in three respects. First, the findings replicated those of Derakshan et al. (2009); namely, that high trait anxiety impairs antisaccade latencies, but not errors. This finding is in line with predictions from attentional control theory (Eysenck et al., 2007). Second, the effects of WMC and trait anxiety on attentional control were absent in the current study's continuous sample. Thus, although the study replicates extreme group findings for trait anxiety on saccade latency performance, it appears that these effects are not strong within the continuous sample. Third, and most importantly, the findings demonstrate that high WMC has a protective influence in high trait anxious individuals on antisaccade and target identification latencies (as measured by the RSPAN task). An important question for future research is whether these findings replicate in clinical samples, and whether the interaction between anxiety and working memory capacity has implications for the severity of certain anxiety symptoms.

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Table 1

Descriptive Statistics for the Entire Sample (N = 134)

	Minimum	Maximum	Mean (SD)
Age	18	42	22 (3)
Trait anxiety	22	61	42 (9)
OSPAN	2	38	15 (8)
RSPAN	2	42	16 (8)

Note: SD = Standard deviation.

Table 2

Saccade and Target Identification Data for the Entire Sample (N = 134)

Task	Block	Saccade Task		Target Identification Task	
		Latency	% Error	Latency	% Error
Prosaccade	1	367 (72)	11.4 (10.4)	602 (127)	4.3 (3.7)
	2	350 (63)	11.7 (11.5)	540 (105)	3.2 (3.0)
Antisaccade	1	448 (73)	3.3 (4.8)	527 (116)	3.0 (3.1)
	2	429 (62)	3.3 (4.9)	473 (86)	2.1 (2.2)

Note: Standard deviations in parenthesis.

Table 3

Bivariate Correlations for the Entire Sample (N = 134)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. TRAIT	1	.78*	-.08	-.04	.08	-.06	.17*	-.01	-.09	-.02	-.03	.00	.06
2. STATE		1	-.08	.01	.09	-.02	.14	-.03	-.13	.05	.05	.10	.09
3. OSPAN			1	.43†	-.07	.04	-.13	-.10	-.03	-.13	-.06	-.03	-.09
4. RSPAN				1	-.06	-.03	-.04	-.15*	-.11	-.22†	-.16*	-.07	-.08
5. ANTI					1	.68†	.40†	-.10	.03	.46†	.29†	-.11	.01
6. PRO						1	-.40†	-.14	.09	.37†	.44†	-.13	-.01
7. DIF							1	.05	-.07	.12	-.20*	.03	.02
8. ANTI E								1	.48†	.17*	.08	-.06	.07
9. PRO E									1	.16*	.13	-.02	.00
10. ANTI TR										1	.81†	-.29†	-.16*
11. PRO TR											1	-.33†	-.17*
12. ANTI TE												1	.64†
13. PRO TE													1

Note: TRAIT = Trait anxiety, STATE = State anxiety, OSPAN = OSPAN scores, RSPAN = RSPAN scores, ANTI = Antisaccade latencies, PRO = Prosaccade latencies, DIF = Difference score (Antisaccade latency – Prosaccade latency), ANTI E = Antisaccade errors, PRO E = Prosaccade errors, ANTI TR = Antisaccade target identification latencies, PRO TR = Prosaccade target identification latencies, ANTI TE = Antisaccade target identification errors, PRO TE = Prosaccade target identification errors.

* $p > .05$, † $p < .01$

Table 4

Participant Characteristics for High and Low Trait Anxious Groups

	Low Trait Anxious Participants	High Trait Anxious Participants
N	35	35
Age	21 (3.3)$_a$	22 (2.4)$_a$
STAI–T	30.8 (3.7)$_a$	54.2 (4.0)$_b$
STAI–S	24.6 (4.5)$_a$	47.7 (10.6)$_b$
OPSAN	15.9 (8.6)$_a$	13.5 (5.4)$_b$
RSPAN	18.8 (8.3)$_a$	18.3 (6.7)$_a$

Note: Standard deviations in parenthesis. STAI–T = State Trait Anxiety Inventory – Trait version, STAI–S = State Trait Anxiety Inventory – State version, OSPAN = Operation Span task, RSPAN = Reading Span task. Means in the same row with the same subscript are not significantly different at $p < .05$.

Table 5

Saccade and Target Identification Data for High and Low Trait Anxious Groups

	Task	Low Trait Anxious Group Mean (SD)	High Trait Anxious Group Mean (SD)
Saccade latencies	Anti	422 (60)	449 (61)
	Pro	355 (56)	356 (50)
Saccade errors	Anti	10.8 (10.7)	9.5 (8.4)
	Pro	3.4 (3.8)	2.7 (3.8)
Target identification latencies	Anti	557 (99)	572 (111)
	Pro	491 (90)	495 (103)
Target identification errors	Anti	4.1 (2.6)	4.2 (3.5)
	Pro	2.6 (2.1)	2.7 (2.5)

Note: Errors = percent errors, SD = standard deviation.

Table 6

Regression Analyses for Antisaccade Task Variables

Dependent Variable	Step	Predictors (β in final model)	F	sR^2
Saccade latencies	1	Prosaccade latencies (.69)**	*F*(1,68) = 59.07**	.47
	2	Trait Anxiety Groups (.21)*	*F*(4,65) = 17.44**	.04
		OSPAN (.08)		.00
		Trait Anxiety x OSPAN (-.09)		.01
Saccade errors		Trait Anxiety Groups (-.09)	*F*<1	.01
		OSPAN (-.03)		.00
		Trait Anxiety x OSPAN (-.04)		.00
Identification latencies	1	Prosaccade latencies (.80)**	*F*(1,68) = 118.49**	.59
	2	Trait Anxiety Groups (.07)	*F*(4,65) = 28.87**	.00
		OSPAN (.03)		.00
		Trait Anxiety x OSPAN (.00)		.00
Identification errors		Trait Anxiety Groups (.01)	*F*<1	.00
		OSPAN (-.08)		.00
		Trait Anxiety x OSPAN (.05)		.00
Saccade latencies	1	Prosaccade latencies (.77)**	*F*(1,65) = 79.18**	.56
	2	Trait Anxiety Groups (.23)*	*F*(4,62) = 24.69**	.05
		RSPAN (.19)		.02
		Trait Anxiety x RSPAN (-.25)*		.03
Saccade errors		Trait Anxiety Groups (-.09)	*F*<1	.01
		RSPAN (-.10)		.01
		Trait Anxiety x RSPAN (.12)		.01
Identification latencies	1	Prosaccade latencies (.77)**	*F*(1,65) = 112.54**	.57
	2	Trait Anxiety Groups (.10)	*F*(4,62) = 33.05**	.01
		RSPAN (-.01)		.00
		Trait Anxiety x RSPAN (-.21)*		.02
Identification errors		Trait Anxiety Groups (.01)	*F*<1	.00
		RSPAN (.07)		.02
		Trait Anxiety x RSPAN (.11)		.00

Note: N = 70 for OSPAN analyses, N = 67 for RSPAN analyses; OSPAN = Operation Span task, RSPAN = Reading Span task.

** $p < .001$, * $p < .05$

Figure 1. Antisaccade and Prosaccade Tasks

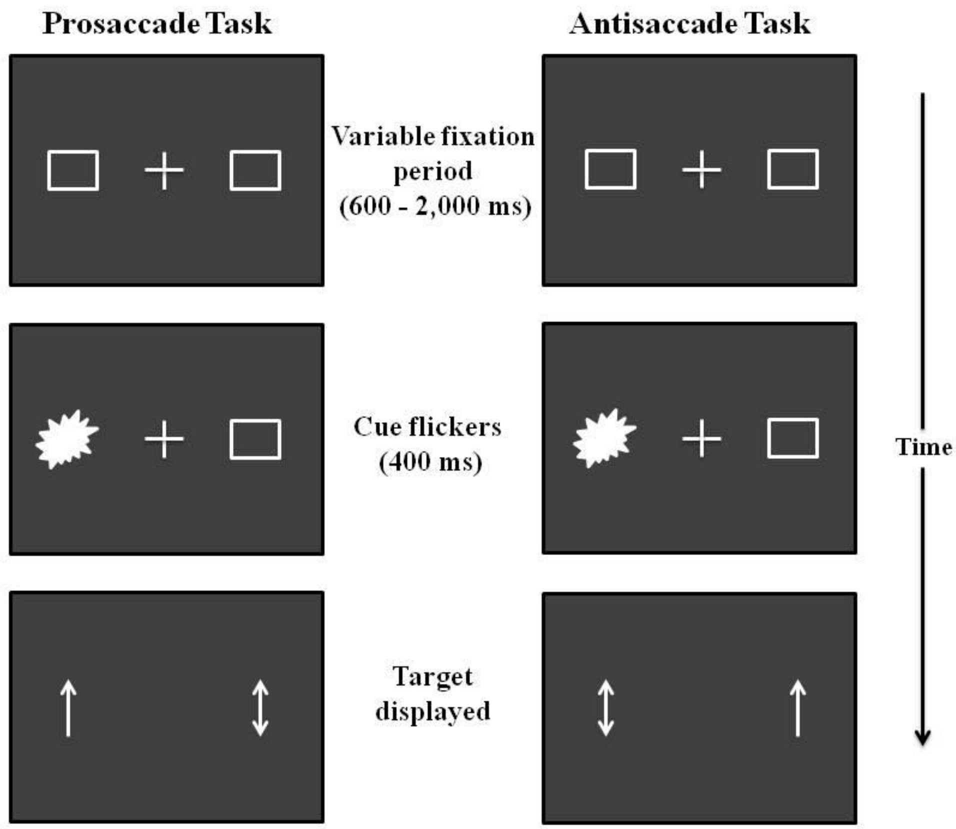


Figure 2. OSPAN and Antisaccade Latencies for High and Low Anxious Groups

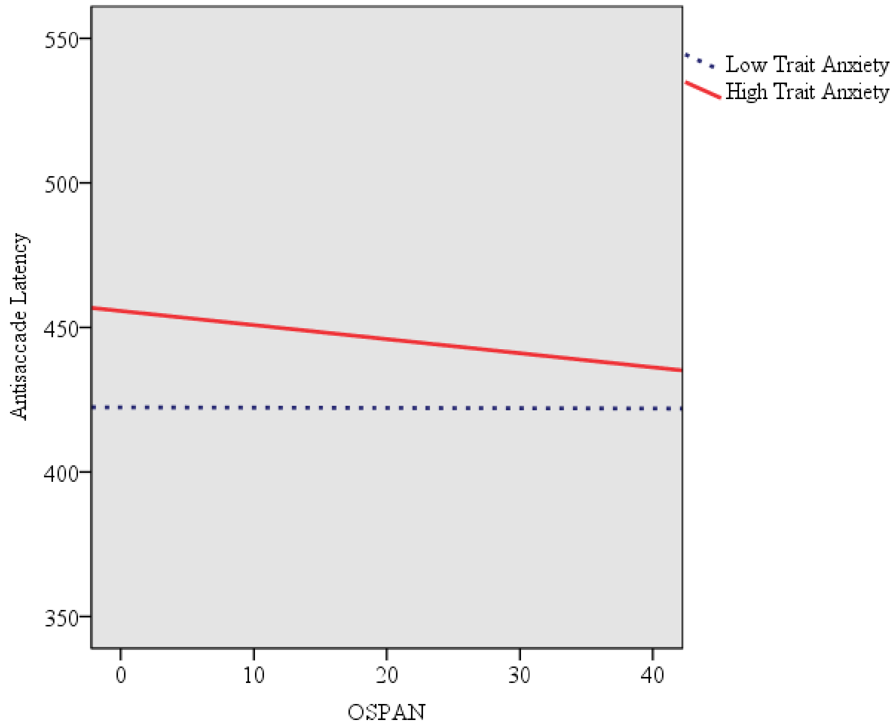


Figure 3. RSPAN and Antisaccade Latencies for High and Low Anxious Groups

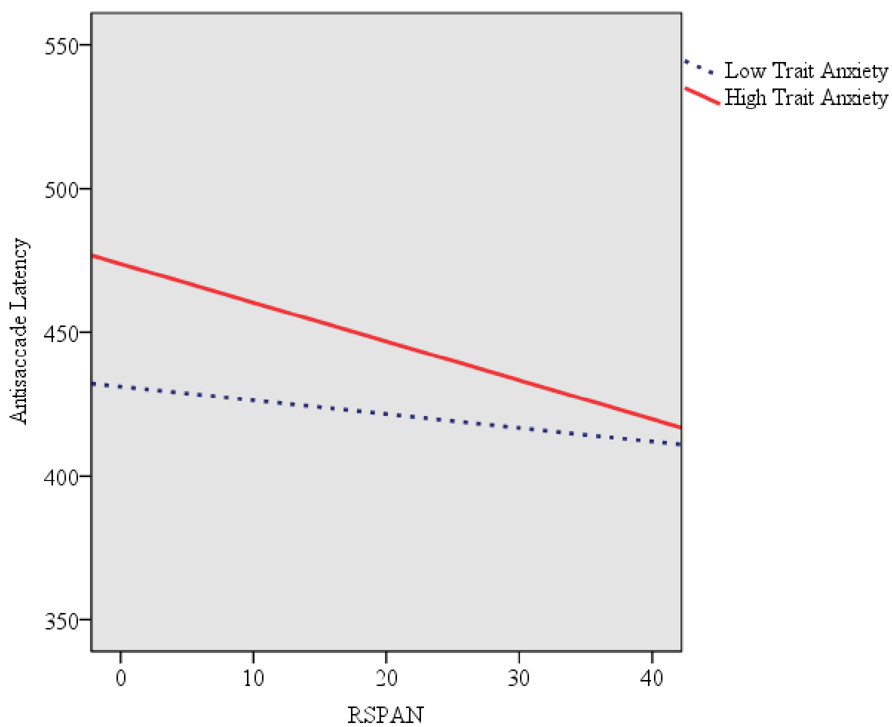


Figure 4. OSPAN and Antisaccade Target Identification Latencies for High and Low Anxious Groups

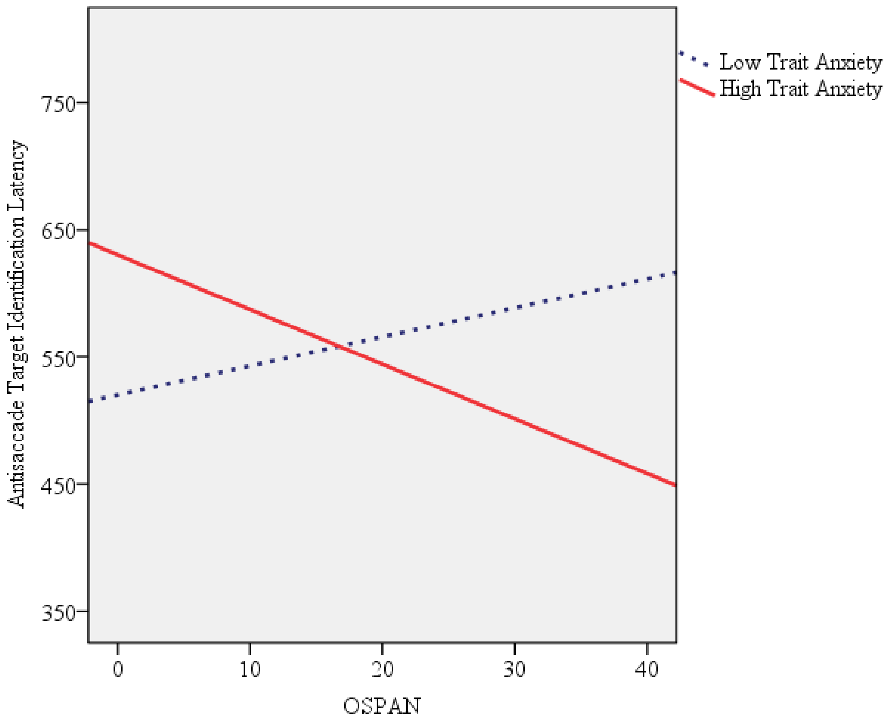
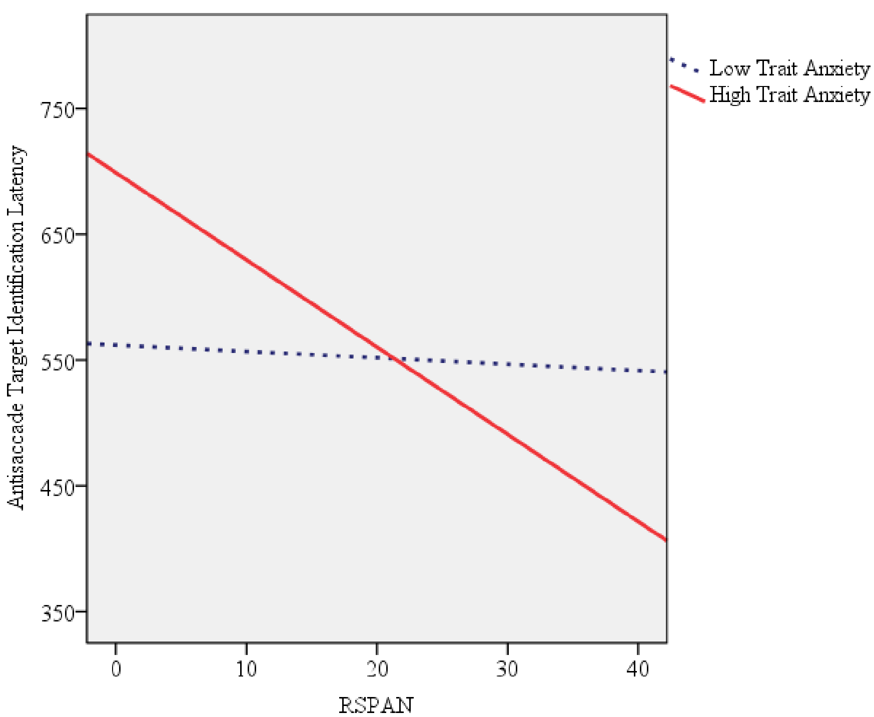


Figure 5. RSPAN and Antisaccade Target Identification Latencies for High and Low Anxious Groups



Appendix A: Consent Form

UNIVERSITY OF CALGARY

Consent Form – RPS Version

Cognitive Sciences Lab

Department of Psychology

Research Project: Individual Differences in Resisting Distracting Information

Principle Investigators: Caitlin Wright, Christopher Sears, Keith Dobson

Supervisors: Christopher Sears, Ph.D.
Keith Dobson, Ph.D.

This consent form, a copy of which has been given to you, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, please ask. Please take the time to read this form carefully and to understand any accompanying information.

The University of Calgary Conjoint Faculties Research Ethics Board has approved this research study.

Purpose of the Study

The purpose of the study is to learn more about individual differences in resisting distracting information.

What Will I Be Asked to Do?

As a participant in this study you will first be asked to complete a computer task. For this task you will sit in front of a computer with your chin placed in a chinrest and your forehead rested against a brace so that large head movements are minimized. A device that sits on the table below the computer display will measure your eye movements, which will allow the computer to determine where you are looking in the computer display. The eye tracking device does not touch your eyes or interfere with your vision in any way. The simple task you will be asked to complete involves looking towards or away from a flashing box. Each trial will begin with a central fixation marker and two empty boxes presented on either side of the fixation marker. You will keep your gaze on the fixation marker and after a short time one of the squares will flash and you will look TOWARDS or AWAY from the flashing box, as quickly and as accurately as possible. The eye tracker will monitor your eyes as you move them toward or away from the cue. Then, an up arrow (↑) or a down arrow (↓) will appear at the location of one of the boxes and you will press a button on a button box placed before you to indicate whether the arrow is an up arrow or a down arrow. You will be asked to make this decision as quickly and as accurately as possible. You will complete 150 trials of this nature, with rest period between every 75 trials. The researcher will go over the instructions verbally before you begin the task. You will have the opportunity to practice this task and to ask questions before you begin. This task will require approximately 10 minutes to complete.

Next, you will be asked to fill out two questionnaires and answer some demographic questions (age, gender, marital status, etc.). These will be completed on a computer and in private. This will take approximately 15 minutes to complete.

After completing the questionnaires, you will be asked to complete two additional computer-based tasks. In one of these tasks you will be presented with either a coherent or nonsensical sentence and a to-be-recalled letter (e.g., "We were fifty lawns out at sea before we lost sight of land. ? M"). You will be asked to read the sentence aloud, verify whether the sentence made sense or not, and then read the letter out loud. You will read between 2 and 5 of these sentences with the aim of remembering the letters following the task. The other memory task is similar. However, instead of sentences you will be presented with a math problem and a to-be-recalled word (e.g. "Is (9/3) – 2 = 1? Dog"). Again the aim is to recall as many words as possible in the correct order. The two tasks together will take approximately 25 minutes to complete. The researcher will go over the instructions verbally before you begin the task and you will have the opportunity to practice this task and to ask questions before you begin.

Participation in this study is entirely voluntary and you can withdraw from the study at any time. It will take approximately 60 minutes to complete the study. You will receive 1.0 bonus credit in exchange for your participation.

After you have finished the researcher will be provide a verbal description of the study's purpose in addition to providing an Information Sheet that includes supplementary information on this area of research. The researcher will be happy to answer any questions you might have about the study.

What Type of Personal Information Will Be Collected?

Should you agree to participate, you will be asked to provide your gender, age, and ethnicity. In addition to this information, the questionnaires will ask you about your emotions, stress level, and behaviours. For example, you will be asked to rate the extent to which you experience different mood states (e.g., I feel calm, I feel worried). You may decline to answer any questions presented during the study if you wish. You will not put your name on any questionnaires. Your questionnaires will be identified by number only and your responses will be kept in complete confidentiality.

Are There Any Risks or Benefits If I Participate?

The benefits of participation in this study include learning about research in psychology in general and the topic of this study in particular.

Collection and Storage of Personal Information:

Participation is completely voluntary and confidential. The data you contribute to this study will be identified by number only and will be kept in complete confidentiality. Each participant will be assigned a number code, and all data for each participant will be filed by this code to ensure confidentiality. Questionnaires will be stored in a locked cabinet separate from the data files and only the investigators and supervisor of this project will have access to these files. Only group information will be summarized for any presentations or publications. Once the data are anonymized and summarized, the data set will be archived for permanent storage by the researchers on a password protected computer. The data from this study will be used for a clinical psychology M.Sc. thesis written by Caitlin Wright, for conference presentations, and for publications in academic journals.

Should you decide to withdraw from the study, you may do so at any time, and any information you provide will be erased.

Signatures

Your signature on this form indicates that you 1) understand to your satisfaction the information provided to you about your participation in this research project, and 2) agree to participate in this study.

Your signature in no way waives your legal rights nor releases the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from this study at any time. You should feel free to ask for clarification or new information throughout your participation.

Participant's Name: (please print) ____

Participant's Signature _________________________________ Date: ________________

Researcher's Name: (please print) ____

Researcher's Signature: ______________________________ Date: ________________

Questions/Concerns

If you have any questions or concerns after you have participated in the study you can contact the researchers for more information (Caitlin Wright at cwrigh@ucalgary.ca or Christopher Sears at sears@ucalgary.ca).

If, after the study, you have concerns regarding your experience, you may register your concerns with Dr. Tavis Campbell, Chair, Psychology Department Ethics Committee (220-7490, t.s.campbell@ucalgary.ca).

If you have any concerns about the way you have been treated as a participant, please contact Russell Burrows, Senior Ethics Resource Officer, Research Services, University of Calgary at (403) 220-3782 (rburrows@ucalgary.ca).

A copy of this consent form has been given to you to keep for your records and reference. The researchers have also kept a copy of the consent form for their records.

Appendix B: Debrief Form

Debriefing Form

Cognitive Sciences Lab

Department of Psychology

Information and debriefing for the study “Resisting Distraction an Eye-tracking Study”

IMPORTANT: We ask that you help us preserve the integrity of our research by not discussing your experiences with other students. Thank you for your understanding and consideration of this request.

As a reminder, the purpose of this study is to learn more about individual differences in resisting distracting information. To measure one’s ability to resist distracting information, we had participants look away from a flashing cue (distracting stimulus) towards the non-flashing cue. We recorded participants’ eye movements to determine whether their initial eye movements were away from the flashing cue and how fast those eye movements were. Those participants who are quicker to orient their attention to the non-flashing cue demonstrate a stronger ability to resist distracting information. Flashing cues have the tendency to capture our attention, but people differ in the extent to which they can resist such distracting information. Past research has found that those who have a higher tendency to experience anxiety or perceive situations as threatening (termed trait anxiety) tend to have difficulty resisting distracting information as compared to individuals with lower trait anxiety (for a review see Eysenck, Derakshan, Santos, & Calvo, 2007). A similar, but unrelated line of research has found that individuals with a higher working memory capacity (as indexed by the number of recalled items following processing tasks) are better able to resist distracting information than those with a lower working memory capacity (i.e. those who remember a smaller number of to be recalled stimuli) (Barrett, Tugade, & Engle, & 2004). We are investigating the joint contribution of trait anxiety and working memory on the ability to resist distraction.

If you have concerns about your answers to the questionnaires and would like to speak to a trained counselor we suggest contacting the Student Counseling Centre, room 375, MacEwan Student Centre. Their office hours are Monday to Friday 9:00 am to 4:00 pm and they can be reached at 220-5893. They are also online at www.ucalgary.ca/counselling/. Counseling sessions are free of charge. The City of Calgary Distress Centre operates a 24-hour crisis line staffed by trained counselors (266-1605) and is also free of charge.

Thanks again for your help with our research. Do you have any questions or concerns?

If you have any questions or concerns after you have participated in the study you can contact the researcher for more information (Caitlin Wright at cwrigh@ucalgary.ca).