Do the eyes have it?
A comparison of eye-movement and attentional-probe based approaches to indexing attentional control within the anti-saccade paradigm
[Registered Report]

Julian Basanovic, Owen Myles, Colin MacLeod

Centre for the Advancement of Research on Emotion
School of Psychological Science
The University of Western Australia

Corresponding author:
Julian Basanovic
julian.basanovic@uwa.edu.au

Word count: 4267

Acknowledgements:
The research reported in this paper was supported by Australian Research Council Grant FL1701006, and an Australian Government Research Training Program (RTP) Scholarship.

Publication:
This manuscript has passed peer review and has been issued an in principle acceptance (IPA) by the Quarterly Journal of Experimental Psychology, indicating that the article will be published pending successful completion of the study according to the exact methods and analytic procedures outlined, as well as a defensible and evidence-bound interpretation of the results.

Abstract

Individual differences in the ability to control visual attention, often termed 'attentional control', has been of particular interest to cognitive researchers. Researchers' interest in attentional control has led to the development of specific tasks intended to measure this attentional ability. One such task is the anti-saccade task. While attentional performance on the anti-saccade task is typically indexed through the recording of eye movements, increasingly researchers are reporting the use of probe-based methods of indexing attentional performance on the task. Critically, no research has yet determined the convergence of indices of performance yielded by each of these assessment methods, nor compared the reliability of these indices. The purpose of the present study is to examine whether the index of attentional control yielded by a probe-based adaptation of the task converges with the index of attentional control provided by the traditional eye movement task, and whether these alternative approaches have comparable levels of psychometric reliability. The present study will require individuals to complete a probe-based task and an eye movement task and an index of anti-saccade cost will be computed from each. Correlational analyses will determine the degree to which the anti-saccade cost indices provided by each task converge in their assessment of individual differences in attention control. Further analyses will compare the internal consistency of these two anti-saccade cost indices, and their reliability over time.

Word count: 224

Introduction

For decades researchers have been interested in differences in the operation of cognitive processes across individuals, and much of this research has focused on attentional processing of visual information. Specifically, individual differences in the ability to control visual attention, often termed '*attentional control*', has been of particular interest to researchers. Researchers' interest in attentional control has led to the development of specific tasks intended to measure this attentional ability. One such task, described by Hallet (1978), is the anti-saccade task. In this task participants start each trial with their attention on a central fixation point, then a visual stimulus abruptly appears either to the left or right side of visual fixation. Depending on trial type, participants are required to either orient their gaze towards this stimulus (i.e. make a prosaccade), or away from this stimulus (i.e. make an anti-saccade) as quickly as possible. With the assumption that the abrupt onset of the stimulus will encourage a reflexive orientation of gaze toward its location (see Remington, Johnston, & Yantis, 1992), it is believed that an attentional shift away from the stimulus will require attentional control. Consistent with this assumption, participants typically take longer to make the anti-saccade response than the prosaccade response, and this slowing is referred to as the "anti-saccade cost". Because this anti-saccade cost will be lowest in people who have the greatest ability to successfully implement attentional control, the magnitude of the anti-saccade cost is used to provide an index of an individual's ability to effectively execute attentional control.

Based on this reasoning, the anti-saccade task has been widely used in studies that seek to assess the association between a wide variety of psychological variables and individual differences in attentional control (see Hutton, 2008 and Hutton & Ettinger, 2006 for in-depth reviews). These include studies assessing the deficits in attentional control associated with particular types of neuro-behavioural functioning (Currie, Ramsden, Mcarthur, & Maruff, 1991; Guitton, Buchtel, & Douglas, 1985; Kitagawa, Fukushima, & Tashiro, 1994; Pierrot-Deseilligny, 1994; Vidailhet et al., 1994), psychological disorders, such as schizophrenia (Calkins, Curtis, Iacono, & Grove, 2004; Fukushima et al., 1988), and heightened levels of anxiety (Ansari & Derakshan, 2010; Basanovic et al., 2018; Derakshan, Ansari, Hansard, Shoker, & Eysenck, 2009) and depression (De Lissnyder et al., 2012; Jazbec, McClure, Hardin, Pine, & Ernst, 2005; Smyrnis et al., 2003).

Most studies that have used the anti-saccade task have assessed performance through the direct recording of eye movement latencies or the rate of erroneous eye-movement responses using specialized eye tracking systems. However, several researchers have described methods of indexing performance on adaptations of this task that do not involve the recording of eye movement, but instead employ probe discrimination latencies as the dependent measure of interest. For example several studies have, in addition to recording eye movements, described indexing anti-saccade costs by computing the degree to which participants are slower to discriminate the identity of a target probe presented distal to the abrupt onset stimuli during anti-saccade trials, than to discriminate the identity of a target probe presented proximal to the abrupt onset stimulus during pro-saccade trials (Ansari, Derakshan, & Richards, 2008; Derakshan, Ansari, et al., 2009; Klapetek, Jonikaitis, & Deubel, 2016; Wright, Dobson, & Sears, 2014). Other researchers have opted to employ probe-based assessment methods without also recording eye movement (Basanovic, Notebaert, Grafton, Hirsch, & Clarke, 2017; Friedman & Miyake, 2004; Kane, Bleckley, Conway, & Engle, 2001; Miyake et al., 2000; Unsworth, Spillers, Brewer, & McMillan, 2011). Under probe-based methods, the magnitude of slowing to correctly discriminate the identity of target probes distal from the abrupt onset stimulus on anti-saccade trials, as compared to discriminating target probes proximal to the location of this stimulus on prosaccade trials, serves to reveal individual differences in ability to execute attentional control.

Importantly, though some researchers have used attentional probes in an attempt to differentiate attention allocation from saccade execution (Klapetek et al., 2016), commonly researchers adopting probe-based methods to index attentional control have assumed that the measures yielded by this method reflect the same variation in attentional control that is indexed by methods that assess eye movements. However, given that experimental research has demonstrated that it is possible for individuals to orient attention without the presence of corresponding eye movements (Remington, 1980; Shepherd, Findlay, & Hockey, 1986), this assumption is not necessarily valid.

Another reason why probe-based and eye movement-based assessment methods may also not yield equivalent measures of attentional control is that each type of measure will be affected by different types of error variance. For example, in eye movement assessment methods noise will be introduced into the anti-saccade cost index of attentional control by variance in basic speed to execute ocular-motor movement (Myles, Grafton, Clarke, & MacLeod, 2019). Conversely, in probe-based assessment methods noise will be introduced by variance in the time taken to perceptually discriminate a probe's identity, and by variance in basic speed to execute a finger pressing response. These alternative sources of noise will differentially impact on the capacity of eye movement and probe discrimination latency measures to sensitive index participants' attentional control ability. Nonetheless, the relative ease and cost-effectiveness with which the probe-based adaptation of the anti-saccade task can be deployed, without the need for specialised equipment to assess eye movement, renders this approach of considerable potential value to researchers wishing to investigate individual differences in attentional control. Consequently, probe-based adaptations of the anti-saccade paradigm have been increasingly adopted by researchers.

Recognising the potential utility and efficiency of anti-saccade assessment procedures that do not use eye movement recording, some researchers have directly compared measures yielded by eye movement recording with measures yielded by recording of manual responses (Brett & Machado, 2017). Brett and Machado observed that, though statistically significant, the association between anti-saccade cost indices yielded by saccade latencies and manual response latencies was small (r = .238). This finding was consistent with the proposal that anti-saccade cost reflects both attentional processes and inhibitory control processes. Importantly however, the method adopted by Brett and Machado (2017) for assessing performance via manual responses did not require participants to execute eye movements in order to manually respond to discriminate the identity of probes on each trial, but rather required participants to simply indicate the direction that they would move their gaze in order to execute a correct prosaccade or anti-saccade. Given that researchers have identified processes of attentional goal identification and execution provide independent contributions to anti-saccade performance (Myles et al., 2019), it possible that the association observed between manual responses and eye movements by Brett and Machado (2017) does not reflect the strength of the association that would be observed if the manual response task necessitated eye movements in a manner similar to the traditional anti-saccade task.

However, no study has yet investigated the degree to which probe-based adaptations of the anti-saccade paradigm reflect the same variation in attentional control that is revealed by the traditional anti-saccade task. Contrasting these two assessment approaches will serve to determine the validity of the assumption that these methods assess the same variation in attentional control.

The purpose of the present study is to examine whether the index of attentional control yielded by a probe-based adaptation of the anti-saccade task converges with the index of attentional control provided by the traditional anti-saccade task, and whether these alternative measures have comparable levels of psychometric reliability. To do so, the present study will require individuals to complete both tasks, and an index of anti-saccade cost will be computed from each. One task will index anti-saccade cost by computing the degree to which the latency to execute an instructed eye movement directed away from an abrupt onset stimulus is slower than the latency to execute an instructed eye movement directed toward this abrupt onset stimulus. The other task will index anti-saccade cost by computing the degree to which participants are slower to discriminate the identity of a probe presented distally from an abrupt onset stimulus when instructed to attend away from this stimulus, than to discriminate the identity of a probe presented proximally to an abrupt onset stimulus when they are instructed to attend towards this stimulus. Analyses will determine the degree to which the anti-saccade cost indices provided by each task converge in their assessment of individual differences in attention control. Further analyses will compare the internal consistency of these two anti-saccade cost indices, and their reliability over time.

Methods

Participants

Ninety-two participants will be recruited through advertisement to the cohort of undergraduate psychology students at The University of Western Australia. All recruited participants will be between the ages of 18 and 30 years and have normal vision or corrected-to-normal vision. The Human Research Ethics Committee of the University of Western Australia has approved the methods that will be employed in research protocol and all participants will provide informed consent.

Power analysis

Power analyses were computed using the R package 'pwr' (Champely, 2018; R Development Core Team, 2018). A power analysis was conducted to determine the number of participants required to provide 90% power ($1 - \beta = 0.90$), with a one-tailed test of statistical significance set at $p < .05$, to detect a correlation of at least $r = .30$. This effect size is smaller than $r = .50$, commonly considered to represent a minimum acceptable level of convergent validity (Carlson & Herdman, 2012). Thus, this effect size was considered to reflect the smallest correlation of interest for the purpose of determining whether the two tasks converged enough to be considered equivalent measures of attentional control. This power analyses revealed a minimum sample size of 92 participants would be required.

Materials

Apparatus. All tasks will be developed using Experiment Builder 2.2.61 (SR Research Ltd, Mississauga, Canada). The task will be run on a desktop PC and presented on a widescreen 24-inch monitor at a resolution of 1920 x1080 pixels. Participants' head movements will be stabilised with a chinrest mounted at a 60 cm viewing distance from the monitor screen. Participants' eye movements will be recorded using a desk-mounted SR Research EyeLink 1000 that records monocular gaze at 1000Hz with 0.25˚ accuracy and 0.01˚ spatial resolution. Eye movements will be recorded using pupil centre corneal reflection standardised via a nine-point calibration procedure. A standard QWERTY keyboard with USB connection will be used to collect manual responses from participants.

Attentional control assessment tasks. Two tasks will be deployed. The parameters of each task will be closely matched, but the critical differences in their design will reflect the assessment of either eye movement, or probe discrimination latency, to compute an anti-saccade cost index believed to reflect attentional control. The design parameters common to both tasks will be described first, followed in turn by a description of parameters unique to each task. A schematic representation of the two tasks is presented in Figure 1.

Design parameters common to both tasks. In both tasks, trials will be presented upon a black background. Each trial will commence with the presentation of a white fixation cross in the centre of the computer screen. A gaze contingency algorithm will be implemented such that the trial would not proceed from this point until a fixation is detected at the location of the cross, otherwise the cross will remain on the screen until an appropriate fixation was detected. Once gaze is directed to the fixation cross, the cross will remain on screen for 1000 ms, 1500 ms, or 2000 ms with equal frequency. Upon offset of this fixation cross a solid white oval shaped stimulus (H = 63 mm, W = 35 mm) will be abruptly presented on screen for 600 ms. The stimulus will be presented 130 mm to the left, or 130 mm to the right, of the fixation point with equal frequency. This distance results in 12 degrees of visual angle between the central fixation point and the stimulus at a viewing distance of 60 cm. This eccentricity value falls within the range of eccentricity values commonly used by other investigators assessing the anti-saccade effect, which have varied from 8 to 20 degrees of visual angle (Ansari et al., 2008; Berggren, Hutton, & Derakshan, 2011; Brett & Machado, 2017; Chen, Clarke, Watson, MacLeod, & Guastella, 2014; Derakshan, Ansari, et al., 2009; Derakshan, Salt, & Koster, 2009; Manoach, 2004; Manoach et al., 2002). Previous research has demonstrated adopted eccentricity capable of detecting anti-saccade slowing effects

(Cornwell, Mueller, Kaplan, Grillon, & Ernst, 2012; Myles et al., 2019). At the onset of the abrupt stimulus participants will be required to execute the instructed attentional response.

Trials in each task will be presented in two conditions. In one condition, labelled the anti-saccade condition, participants will be instructed to “look” at the opposite side of the screen to the stimulus as soon as it is presented. In the other condition, labelled the prosaccade condition, participants will be instructed to “look” at the stimulus as soon as it is presented.

Each task will present 96 trials experiment critical, across eight blocks of 12 trials each. Four blocks will present trials in the anti-saccade condition and four blocks will present trials in the prosaccade condition. The order of the trial blocks will be counterbalanced across participants such that participants will start with anti-saccade or prosaccade condition of each task with equal frequency. Each block will be preceded by instructions informing the participant of the required action for trials in the upcoming block.

In each task, the index of attentional control will be the *anti-saccade cost index*. This index will be computed by subtracting the mean latency to correctly respond on trials in the prosaccade condition, from the mean latency to correctly respond on trials in the anti-saccade condition. Thus, for each task higher scores on this index will represent greater slowing to correctly respond in the anti-saccade compared to the prosaccade condition, and so will reflect poorer attentional control.

Eye movement latency assessment task. The eye movement latency assessment task reflects the traditional eye movement approach to the anti-saccade paradigm. Thus, this task will assess the degree to which participants are slower to execute required saccadic movements in the anti-saccade condition as compared to the prosaccade condition.

Across trials in the anti-saccade condition participants will be required to execute a saccadic eye movement away from the abrupt onset stimulus as soon as it is presented, to the opposite screen region. Instructions for these trials will inform participants to “immediately look at the opposite side of the screen” when the stimulus is presented. Across trials in the prosaccade condition participants will be required to execute a saccadic eye movement towards the abrupt onset stimulus as soon as the stimulus is presented. Instructions for these trials will inform participants to “immediately look at shape” when the stimulus is presented.

During both types of trials, a saccade-contingency procedure will detect the conclusion of an eye movement response in the correct direction. Upon detection the stimulus will remain on the screen for 500ms, after which the screen will be cleared. A 500ms inter-trial interval precede the commencement of the next trial.

For trials delivered in each condition the latency and accuracy of saccadic responses will be recorded by the experiment software for later analysis. Response latencies will be determined by measuring the initiation latency, in milliseconds, of participants’ first saccade eye movement executed after the appearance of the abrupt onset stimulus. A saccade will be defined as an eye movement that exceed a 30˚s-1 velocity threshold and 8000˚s-2 acceleration threshold, are greater than 3˚ in amplitude, and are directed within 45˚ from the horizontal plane of the initial fixation location. Saccades will be excluded from analysis if they reflected an eye movement to an incorrect location. Remaining saccades will be excluded if they were initiated earlier than 80 ms following the appearance of the abrupt onset stimulus. Finally, remaining saccades will be excluded if their initiation latency falls beyond 2.58 standard deviations above the mean of the participant’s initiation latencies within each trial condition.

Probe discrimination latency assessment task. The probe discrimination latency assessment task reflects an adaptation to the anti-saccade paradigm that does not measure eye movement. The probe discrimination latency assessment task will assess the degree to which participants are slower to discriminate the identity of visual target probes presented distally to the abrupt onset stimulus in the anti-saccade condition, than to discriminate the identity of visual target probes presented proximally to this abrupt onset stimulus in the prosaccade condition.

Across trials in the anti-saccade condition, participants will be required to discriminate the identity of a small target probe presented in the opposite screen location to the abrupt onset stimulus. Instructions for these trials will inform participants to "immediately look at the opposite side of the screen and identify the direction the arrow is pointing" when the stimulus is presented. Across trials in the prosaccade condition, participants will be required to discriminate the identity of a small target probe presented in the same screen location as the abrupt onset stimulus. Instructions for these trials will inform participants to "immediately look at the shape and identify the direction the arrow is pointing" when the stimulus is presented.

Probes will be a small arrow 5 mm in length that will be oriented either to point upwards or downwards with equal frequency. Participants will be required to discriminate the orientation of the target probe by pressing the associated arrow key on the computer's keyboard. Upon executing the probe discrimination response the screen will be cleared, and the next trial will commence after a 500 ms delay[1].

[1] On the basis of published data from studies employing similar probe-based and eye-movement based methodological approaches, it appears that performing manual response typically takes around 250ms longer than performing the saccadic response (Ansari et al., 2008; Derakshan, Ansari, et al., 2009). This means that

For trials in each condition the latency and accuracy of responses will be recorded by the experiment software for later analysis. Response latencies will be operationalised as the temporal interval between the probe appearance and the execution of participants' probe discrimination response on the keyboard (in milliseconds). Individual probe discrimination latencies will be excluded from analysis if they reflect an incorrect discrimination response. Remaining discrimination latencies will be excluded if they were occurred at a latency beyond 2.58 standard deviations below, or above, the mean of the participant's discrimination latencies within each trial condition[Error! Bookmark not defined.].

Procedure

All procedures necessary to conduct this research have been approved by the Human Research Ethics Committee at the University of Western Australia. Prior to recruitment, participants will be briefed that the study seeks to examine patterns of visual information processing across different attention assessment conditions and will be provided an information sheet that informs them of the requirements involved in participation.

The experiment session will comprise two consecutive phases. In the first phase participants will provide written consent and basic demographic information. Next, participants will be seated with their head placed in the chin rest. Testing will take place in two phases. In phase 1, participants will complete each task in an order that will be counterbalanced across participants, such that half of participants will complete each task first. All participants will then be given a ten-minute break. Then, in phase 2, they will again

blocks of trials in the probe discrimination latency task will last approximately 3 seconds longer than blocks in the eye-movement latency assessment task.

complete each task in the same alternating order. The completion of both tasks in phase 1 and phase 2 will allow for an examination of the test-retest reliability of these two alternative assessments of attentional control.

In each phase participants will be provided with task instructions verbally by the experimenter, and by text presented on screen. Before starting experiment critical trials, participants will complete a practice version of each assessment task. Each practice task will comprise one block of trials each for the prosaccade and anti-saccade conditions. At this point, in the case that a participant is unable to comprehend the requirements of the tasks, or unable to register a recordable gaze signal during the initial gaze calibration procedure, the experiment session will be discontinued and the participant's data will be excluded from any analysis.

The length of the experiment session is anticipated to be less than 60 minutes. The experimenter will monitor participants' performance and eye movements from a second computer. Once both phases of the experiment session are concluded the experimenter will verbally debrief participants concerning the aim of the experiment and participants will be provided this information in writing.

Data Analysis Plan

Participant Exclusion Criteria

Participants will be excluded from statistical analyses if they do not complete the entire study protocol. As the primary focus of the study is to compare indices of task performance across the two tasks, a list-wise exclusion method will exclude remaining participants if they demonstrate a response error rate on either task that is more than 2.58 standard deviations below the mean accuracy rate for that task across all participants, or if they yield a number of valid trials that is less than 2.58 standard deviations below the mean number of valid trials yielded by participants.

Statistical Analyses

The objectives of the statistical analyses will be to determine whether there is convergence between the anti-saccade cost indices yielded by each task, and to compare the respective reliability of these two indices. The convergence between the anti-saccade cost indices yielded by each task will be determined by examining the *observed* correlation of anti-saccade cost indices yielded by each task, as well as estimating the '*true*' correlation of the indices by accounting for the estimated internal consistency of each task. The reliability of these tasks will be determined by examining the internal consistency of anti-saccade cost indices yielded by each task and the constancy of anti-saccade cost indices yielded by each task over each phase of the experimental session. Statistical significance will be determined using an alpha criterion of $p < .05$.

Descriptive statistics. Descriptive statistics, including the means, standard deviations, and proportions as relevant, will be reported for participant demographic characteristics and measures of response latency and accuracy recorded under the anti-saccade and prosaccade trial conditions for each task conducted in each phase of the experiment session.

Assessment of internal consistency of each anti-saccade cost index. A measure of internal consistency will be computed for each assessment task, using a Monte Carlo re-sampled split-half correlation approach. This approach splits each participant's trial data into two randomly selected halves before computing the anti-saccade cost index for each half. The approach then computes the Pearson correlation coefficient between these indices across all participants, including the Spearman-Brown formula adjustment. This process is repeated across 5000 randomly selected split-half trial combinations. The measure of internal consistency is then determined by computing the mean and 95% confidence interval of the distribution of correlations coefficients observed across the split-half trial combinations. Thus, for each task a higher mean estimate and narrower 95% confidence interval reflects a greater level of internal consistency.

Assessment of test-retest reliability of each anti-saccade cost index. A measure of test-retest reliability will be computed for each assessment task. This measure will be derived by computing the Pearson correlation coefficient between anti-saccade cost indices yielded by participants from each task in the first and second phases of the experiment session. Thus, for each task, relatively greater correlation coefficients will reflect relatively greater test-retest reliability of the resulting anti-saccade cost index.

Assessment of convergence of individual differences in anti-saccade cost indices. Convergence between the anti-saccade cost indices yielded by the eye movement latency assessment task and the probe discrimination latency assessment task will be computed for each phase of the experiment session. Importantly, this will determine whether anti-saccade cost index yielded by the probe discrimination latency assessment task plausibly reflects the same individual difference in attentional control as is measured by the anti-saccade cost index yielded by conventional eye movement latency assessment task.

Convergent validity will be examined using a Pearson correlation coefficient between anti-saccade cost indices yielded by each task within each phase of the experiment session. The Pearson correlation coefficient will reveal the degree to which the anti-saccade cost indices yielded by the eye movement and probe discrimination assessment tasks are associated across participants.

Importantly, the observed correlation between measures yielded by tasks that are not completely internally consistent may underestimate the *true* correlation between the underlying constructs assessed by these measures (for review, see Goodwin & Leech, 2006). Correcting for imperfect internal consistency of the tasks employed in the present study will allow for an estimation of the degree to which the two tasks index the same underlying individual difference. Thus, analyses will also compute and report correlation coefficients between anti-saccade cost indices yielded by each task, in each phase of the experiment session, after statistical correction that accounts for the imperfect internal consistency of these tasks.

Timeline for completion

This study will commence as soon as Stage 1 approval is granted by the Quarterly Journal of Experimental Psychology. The University of Western Australia's School of Psychological Science regularly conducts undergraduate student cohort participant recruitment waves in the periods of March to June and August to November of each year. Each wave consistently recruits over 900 students who consent to invitations to participate in research studies conducted by the School of Psychological Science across the wave period. It is anticipated that participant testing for the current study will be completed within one of these wave periods, subject to the date of receiving Stage 1 approval.

References

Ansari, T. L., & Derakshan, N. (2010). Anxiety impairs inhibitory control but not volitional action control. *Cognition & Emotion*, *24*(2), 241–254. https://doi.org/10.1080/02699930903381531

Ansari, T. L., Derakshan, N., & Richards, A. (2008). Effects of anxiety on task switching: Evidence from the mixed antisaccade task. *Cognitive, Affective, & Behavioral Neuroscience*, *8*(3), 229–238. https://doi.org/10.3758/CABN.8.3.229

Basanovic, J., Notebaert, L., Clarke, P. J. F., MacLeod, C., Jawinski, P., & Chen, N. T. M. (2018). Inhibitory attentional control in anxiety: Manipulating cognitive load in an antisaccade task. *PLOS ONE*, *13*(10), e0205720. https://doi.org/10.1371/journal.pone.0205720

Basanovic, J., Notebaert, L., Grafton, B., Hirsch, C. R., & Clarke, P. J. F. (2017). Attentional control predicts change in bias in response to attentional bias modification. *Behaviour Research and Therapy*, (September). https://doi.org/10.1016/j.brat.2017.09.002

Berggren, N., Hutton, S. B., & Derakshan, N. (2011). The effects of self-report cognitive failures and cognitive load on antisaccade performance. *Frontiers in Psychology*, *2*(OCT), 1–5. https://doi.org/10.3389/fpsyg.2011.00280

Brett, C. H. R., & Machado, L. (2017). Manual versus saccadic assessment of cognitive inhibition and switching in young and older adults. *Psychological Assessment*, *29*(11), 1420–1425. https://doi.org/10.1037/pas0000453

Calkins, M. E., Curtis, C. E., Iacono, W. G., & Grove, W. M. (2004). Antisaccade performance is impaired in medically and psychiatrically healthy biological relatives of schizophrenia patients. *Schizophrenia Research*, *71*(1), 167–178. https://doi.org/10.1016/j.schres.2003.12.005

Carlson, K. D., & Herdman, A. O. (2012). Understanding the impact of convergent validity on research results. *Organizational Research Methods*, *15*(1), 17–32. https://doi.org/10.1177/1094428110392383

Champely, S. (2018). pwr: Basic Functions for Power Analysis. Retrieved from https://cran.r-project.org/package=pwr

Chen, N. T. M., Clarke, P. J. F., Watson, T. L., MacLeod, C., & Guastella, A. J. (2014). Biased saccadic responses to emotional stimuli in anxiety: An antisaccade study. *PLoS ONE*, *9*(2). https://doi.org/10.1371/journal.pone.0086474

Cornwell, B. R., Mueller, S. C., Kaplan, R., Grillon, C., & Ernst, M. (2012). Anxiety, a benefit and detriment to cognition: Behavioral and magnetoencephalographic evidence from a mixed-saccade task. *Brain and Cognition*, *78*(3), 257–267. https://doi.org/10.1016/j.bandc.2012.01.002

Currie, J., Ramsden, B., Mcarthur, C., & Maruff, P. (1991). Validation of a Clinical Antisaccadic Eye Movement Test in the Assessment of Dementia. *Archives of Neurology*, *48*(6), 644–648. https://doi.org/10.1001/archneur.1991.00530180102024

De Lissnyder, E., Koster, E. H. W., Goubert, L., Onraedt, T., Vanderhasselt, M. A., & De Raedt, R. (2012). Cognitive control moderates the association between stress and rumination. *Journal of Behavior Therapy and Experimental Psychiatry*, *43*(1), 519–525. https://doi.org/10.1016/j.jbtep.2011.07.004

Derakshan, N., Ansari, T. L., Hansard, M., Shoker, L., & Eysenck, M. W. (2009). Anxiety, inhibition, efficiency, and effectiveness: An investigation using the Antisaccade task. *Experimental Psychology*, *56*(1), 48–55. https://doi.org/10.1027/1618-3169.56.1.48

Derakshan, N., Salt, M., & Koster, E. H. W. (2009). Attentional control in dysphoria: An investigation using the antisaccade task. *Biological Psychology*, *80*(2), 251–255. https://doi.org/10.1016/j.biopsycho.2008.09.005

Friedman, N. P., & Miyake, A. (2004). The Relations Among Inhibition and Interference Control Functions: A Latent-Variable Analysis. *Journal of Experimental Psychology: General*, *133*(1), 101–135. https://doi.org/10.1037/0096-3445.133.1.101

Fukushima, J., Fukushima, K., Chiba, T., Tanaka, S., Yamashita, I., & Kato, M. (1988). Disturbances of voluntary control of saccadic eye movements in schizophrenic patients. *Biological Psychiatry*, *23*(7), 670–677. https://doi.org/10.1016/0006-3223(88)90050-9

Goodwin, L. D., & Leech, N. L. (2006). Understanding correlation: Factors that affect the size of r. *Journal of Experimental Education*, *74*(3), 249–266. https://doi.org/10.3200/JEXE.74.3.249-266

Guitton, D., Buchtel, H. A., & Douglas, R. M. (1985). Frontal lobe lesions in man cause difficulties in suppressing reflexive glances and in generating goal-directed saccades. *Experimental Brain Research*, *58*(3), 455–472. https://doi.org/10.1007/BF00235863

Hallett, P. E. (1978). Primary and secondary saccades to goals defined by instructions. *Vision Research*, *18*(10), 1279–1296. https://doi.org/10.1016/0042-6989(78)90218-3

Hutton, S. B. (2008). Cognitive control of saccadic eye movements. *Brain and Cognition*, *68*(3), 327–340. https://doi.org/10.1016/j.bandc.2008.08.021

Hutton, S. B., & Ettinger, U. (2006). The antisaccade task as a research tool in psychopathology: A critical review. *Psychophysiology*, *43*(3), 302–313. https://doi.org/10.1111/j.1469-8986.2006.00403.x

Jazbec, S., McClure, E., Hardin, M., Pine, D. S., & Ernst, M. (2005). Cognitive control under contingencies in anxious and depressed adolescents: an antisaccade task. *Biological Psychiatry*, *58*(8), 632–639. https://doi.org/10.1016/j.biopsych.2005.04.010

Kane, M. J., Bleckley, M. K., Conway, A. R. A., & Engle, R. W. (2001). A controlled-attention view of working-memory capacity. *Journal of Experimental Psychology: General*, *130*(2), 169–183. https://doi.org/10.1037//0096-3445.130.2.169

Kitagawa, M., Fukushima, J., & Tashiro, K. (1994). Relationship between antisaccades and the clinical symptoms in Parkinson’s disease. *Neurology*, *44*(12), 2285–2285. https://doi.org/10.1212/WNL.44.12.2285

Klapetek, A., Jonikaitis, D., & Deubel, H. (2016). Attention allocation before antisaccades. *Journal of Vision*, *16*(1), 11. https://doi.org/10.1167/16.1.11

Manoach, D. S. (2004). Deficient saccadic inhibition in Asperger’s disorder and the social-emotional processing disorder. *Journal of Neurology, Neurosurgery & Psychiatry*, *75*(12), 1719–1726. https://doi.org/10.1136/jnnp.2003.025981

Manoach, D. S., Lindgren, K. A., Cherkasova, M. V., Goff, D. C., Halpern, E. F., Intriligator, J., & Barton, J. J. S. (2002). Schizophrenic subjects show deficient inhibition but intact task switching on saccadic tasks. *Biological Psychiatry*, *51*(10), 816–826. https://doi.org/10.1016/S0006-3223(01)01356-7

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The Unity and Diversity of Executive Functions and Their Contributions to Complex “Frontal Lobe” Tasks: A Latent Variable Analysis. *Cognitive Psychology*, *41*(1), 49–100. https://doi.org/10.1006/cogp.1999.0734

Myles, O., Grafton, B., Clarke, P., & MacLeod, C. (2019). GIVE me your attention: Differentiating goal identification and goal execution components of the anti-saccade effect. *PLOS ONE*, *14*(9), e0222710. https://doi.org/10.1371/journal.pone.0222710

Pierrot-Deseilligny, C. (1994). Saccade and Smooth-Pursuit Impairment after Cerebral Hemispheric Lesions. *European Neurology*, *34*(3), 121–134. https://doi.org/10.1159/000117025

R Development Core Team. (2018). R: A Language and Environment for Statistical Computing. *R Foundation for Statistical Computing Vienna Austria*, *0*, {ISBN} 3-900051-07-0. https://doi.org/10.1038/sj.hdy.6800737

Remington, R. W. (1980). Attention and saccadic eye movements. *Journal of Experimental Psychology: Human Perception and Performance*, *6*(4), 726–744. https://doi.org/10.1037/0096-1523.6.4.726

Remington, R. W., Johnston, J. C., & Yantis, S. (1992). Involuntary attentional capture by abrupt onsets. *Perception & Psychophysics*, *51*(3), 279–290. https://doi.org/10.3758/BF03212254

Shepherd, M., Findlay, J. M., & Hockey, R. J. (1986). The relationship between eye movements and spatial attention. *The Quarterly Journal of Experimental Psychology Section A*, *38*(3), 475–491. https://doi.org/10.1080/14640748608401609

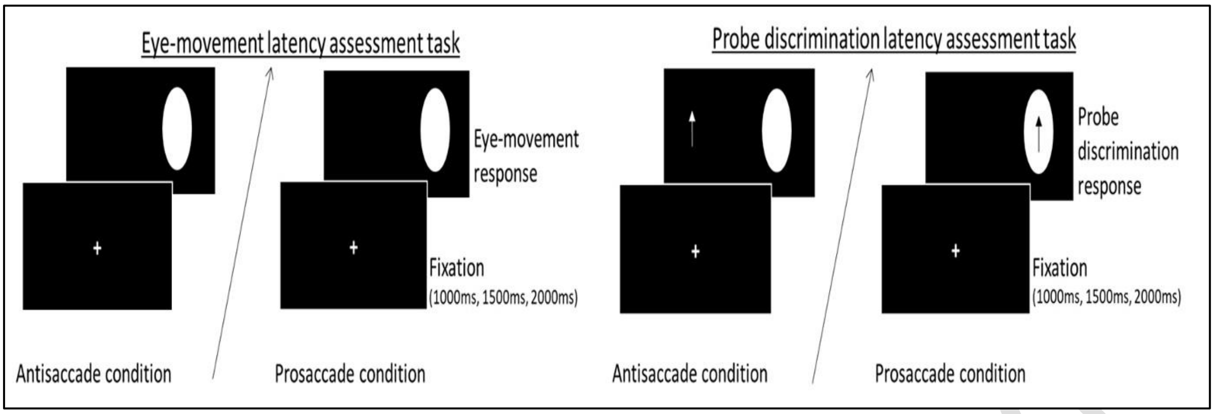
Smyrnis, N., Evdokimidis, I., Stefanis, N. C., Avramopoulos, D., Constantinidis, T. S., Stavropoulos, A., & Stefanis, C. N. (2003). Antisaccade performance of 1,273 men: effects of schizotypy, anxiety, and depression. *Journal of Abnormal Psychology*, *112*(3), 403–414. https://doi.org/10.1037/0021-843X.112.3.403

Unsworth, N., Spillers, G. J., Brewer, G. A., & McMillan, B. (2011). Attention control and the antisaccade task: A response time distribution analysis. *Acta Psychologica*, *137*(1), 90–100. https://doi.org/10.1016/j.actpsy.2011.03.004

Vidailhet, M., Rivaud, S., Gouider-khouja, N., Pillon, B., Bonnet, A., Gaymard, B., … Pierrot-deseilligny, C. (1994). Eye Movements in Parkinsonian Syndromes. *Annals of Neurology*, 420–426.

Wright, C. A., Dobson, K. S., & Sears, C. R. (2014). Does a high working memory capacity attenuate the negative impact of trait anxiety on attentional control? Evidence from the antisaccade task. *Journal of Cognitive Psychology*, *26*(4), 400–412. https://doi.org/10.1080/20445911.2014.901331

Figure 1



Schematic example of trials in each antisaccade task, under each trial condition. Objects in figure not to scale.