TRAIT IMPULSIVITY AND OCULOMOTOR INHIBITION

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Abstract: Trait impulsivity is multi-dimensional in nature. Researchers are beginning to explore how these dimensions of impulsivity relate to inhibitory control. When using behavioural tasks, some studies have found inhibitory control deficits in people with high levels of impulsivity. Comparatively, little is known about the relationship between oculomotor inhibition and trait impulsivity in healthy participants. The aim of this study was to determine the relationship between trait impulsivity and oculomotor inhibition. Using a sample of 80 participants, impulsivity was measured via two self-report questionnaires; oculomotor inhibition was measured with antisaccades. In general there was no relationship between impulsivity and antisaccade errors. Although, those with low scores on the BIS attentional scale made more antisaccade errors than those with high scores. Neither antisaccade nor prosaccade latencies correlated with impulsivity. These findings suggest oculomotor inhibition is not impaired in individuals with trait impulsivity.

Key words: impulsivity, oculomotor, inhibition, antisaccade, prosaccade

Introduction

Impulsivity is often described as a tendency to act without adequate thought. It is a personality trait which plays a vital role in behaviour and is commonly prevalent in several psychiatric disorders including; Attention-Deficit/Hyperactivity Disorder (ADHD), Borderline Personality Disorder (BPD) and substance use disorders (see Moeller Barratt, Dougherty, Schmitz, & Swann, 2001 for review). Although there has been considerable disagreement concerning the definition of impulsivity, there is growing consensus that impulsivity is multi-faceted in nature (Dickman, 1990; Patton, Stanford, & Barratt, 1995; Whiteside & Lynam, 2001). Patton et al. (1995) proposed a multi-dimensional model of impulsivity. The authors suggested that impulsivity consists of three factors; 1) attentional impulsivity (lack of focus on the task in hand), 2) motor impulsivity (a tendency to act without delay), 3) non-planning impulsivity (lack of planning). However, in recent years impulsivity has been suggested to comprise four dimensions. Whiteside and Lynam (2001) argue that impulsivity comprises four factors; 1) negative urgency (the tendency to act rashly when experiencing negative emotions), 2) lack of premeditation (the tendency to act without deliberation), 3) lack of perseverance (the tendency to give up when activities become difficult or boring), 4) sensation seeking (the tendency to seek out activities involving an element of risk or thrill). Multi-dimensional approaches argue that an impulsive

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behaviour may be realised through several personality pathways.

A key characteristic of impulsivity is a deficit in the suppression of prepotent motor responses – a lack of inhibitory control (Chamberlain & Sahakian, 2007). According to Nigg (2000), an important component of inhibitory control is 'executive inhibition' which is the deliberate suppression of immediate motor behaviour in the service of a long-term goal in working memory. Within this component Nigg postulates four processes; 1) interference control, 2) cognitive inhibition, 3) behavioural inhibition, 4) oculomotor inhibition. Oculomotor inhibition requires withholding a prepotent response and stopping a reflexive eye movement.

A growing body of literature has explored the relationship between trait impulsivity and inhibitory control in healthy participants using various interference control paradigms e.g. Stroop task (Raz, Shapiro, Fan, & Posner, 2002), cognitive inhibition paradigms e.g. negative priming (Visser, Das-Smaal, & Kwakman, 1996), and behavioural inhibition paradigms e.g. continuous performance test (Swann, Bjork, Moeller, & Dougherty 2002), Stop signal task (Avila & Parcet, 2001; Logan, Schachar, & Tannock, 1997; Marsh, Dougherty, Mathias, Moeller, & Hicks, 2002). Comparatively little research has investigated the relationship between impulsivity and inhibitory control in healthy participants using oculomotor paradigms. Roberts, Filmore, and Milich (2011) investigated the relationship between impulsivity and manual and oculomotor inhibition in healthy adults and adults with ADHD. Oculomotor inhibition was measured using a visual stopping task and a delayed ocular response task (DORT). In the DORT, participants were asked to first focus on a white central fixation cross, after a short while, a white circle (target) briefly appeared for 100 ms to the left or right of the fixation point. The fixation point then remained on the screen for a random interval and participants were to withhold any saccade to the target. Following this interval, the central fixation point disappeared and the display was blank for 1000 ms. Participants were told to execute a saccade to the location of the target stimulus as quickly as possible upon the disappearance of the fixation point. The authors found that specific domains of impulsivity were related to oculomotor inhibition but not manual inhibition in adults with ADHD. Moreover, there was no relationship between impulsivity and oculomotor or manual inhibition in healthy adults. These results suggest that oculomotor inhibition is more closely related to impulsivity than manual inhibition. This may be due to differences in task characteristics (i.e. eye movement vs. button press). Roberts et al. (2011) argue that the oculomotor tasks they used were more reflexive in nature than the manual tasks they used, suggesting a difference in response prepotency.

Another oculomotor paradigm that is arguably more suitable for exploring potential links between impulsivity and inhibitory control is the antisaccade task (Hallett, 1978). In the antisaccade task participants are required to make an eye movement to the mirror image location of a sudden onset target. Although the concept of making an antisaccade sounds fairly simple, the highly pre-potent response of looking towards a sudden onset target makes the execution of a successful antisaccade difficult (see Hutton, 2008 for review). The task provides a powerful tool with which to investigate the cognitive processes underlying inhibitory control.

To date, only a few papers have investigated the relationship between trait impulsivity and antisaccade performance in healthy participants. Spinella (2004) examined the relationship between impulsivity (as measured by the Barratt Impulsiveness Scale (BIS-11), Patton et al., 1995) and potential neurobehavioural correlates of this trait, including the antisaccade task. He wanted to see if prefrontal sensitive measures (such as the antisaccade task) would correlate with impulsivity, as there is converging evidence that impulse control is associated with prefrontal functioning (Mega & Cummings 1994), as is antisaccade performance (Everling & Fischer, 1998; Hutton, 2008). Spinella found a positive correlation between impulsivity and antisaccade errors, thus, higher BIS scores were associated with more antisaccade errors. Specifically, antisaccade errors correlated with total BIS scores [BIS(t), the motor scale (BIS(m) and the attention scale (BIS(a)]. These results provide support for the shared overlap in neural circuitry between impulsivity and antisaccade performance. In a more recent paper, Jacob et al. (2010) compared females with Borderline Personality Disorder (BPD) and matched controls on a Stroop task, stop signal task and an antisaccade task. Self-report measures of impulsivity (UPPS Impulsivity scale, Whiteside & Lynam, 2001; I7, Eysenck, Pearson, Easting, & Allsopp, 1985; BIS-11, Patton et al., 1995) were completed too. The authors found that although patients with BPD scored higher on the measures of impulsivity, there were no differences in terms of errors on any of the tasks. However antisaccade errors correlated with the lack of premeditation scale of the UPPS questionnaire and separately with the non-planning scale of the BIS-11. In other words, higher impulsivity scores were associated with an increase in antisaccade errors (poorer inhibition). The results from this paper corroborate Spinella (2004) to the extent that certain domains of impulsivity correlate with antisaccade error rate in healthy populations. However, the inconsistency in which measures associate with antisaccade performance between the two studies could be due to methodological issues relating to the instructions of the antisaccade task. As both Spinella (2004) and Jacob et al. (2010) fail to report the exact antisaccade task instructions they used, it is possible that different wording was used, or that speed was emphasised over accuracy, for example. The wording of antisaccade task instructions is critical as previous research has found that simply altering the task instructions given to participants can significantly impact on antisaccade performance in healthy participants (Taylor & Hutton, 2009). Another criticism of both studies is that only antisaccade errors were reported. Numerous articles report correct antisaccade latencies, and this metric of performance is important because it represents the decision-making process of making the correct saccade (Hutton, 2008). Correct antisaccade latencies may be useful in quantifying inhibitory control in participants with impulsivity, thus this measure will be used in the current study.

The main aim of the current study was to determine the relationship between trait impulsivity and oculomotor inhibition in a sample of healthy participants. Specifically, I wanted to know if impulsivity would relate to the ability to inhibit a prepotent eye movement response. To address this question, impulsivity was measured via two self-report questionnaires and oculomotor inhibition was measured using an antisaccade task.

Previous studies that have investigated the relationship between impulsivity and antisaccade performance have either used BIS-11 and/or UPPS to measure impulsivity (Jacob et al., 2010; Spinella, 2004). In the present paper, BIS-11 was also used to measure impulsivity, as well as a recent revised version of the UPPS (UPPSP, see Cyders & Smith, 2007). It is noteworthy that the aforementioned studies only tested a small number of participants and used a limited number of antisaccade trials (25, Spinella, 2004), or failed to report how many trials were used (Jacob et al., 2010). Given that eye movement data is often disrupted by obscure eye blinks, it is essential that participants complete a significant proportion of trials, in order to counteract this problem. Therefore the present study sought to overcome this by testing an increased number of participants and included an increased proportion of antisaccade trials. Similarly, these previous studies used two goal locations, making it quite easy for participants to plan saccades to the correct locations. To avoid this, I included four goal locations in the study.

Investigating the relationship between impulsivity and inhibitory control in healthy participants is important because it could extend the range of personality measures that have been found to influence antisaccade performance in healthy participants, such as schizotypy and extraversion (Holahan & O'Driscoll, 2005; Nguyen, Mattingly, & Abel, 2008). I made separate predictions about antisaccade error rates and latencies. In line with Spinella (2004) and Jacob et al. (2010), it was predicted that impulsivity would relate to antisaccade performance. Specifically, impulsivity as measured by BIS and UPPSP would positively correlate with antisaccade errors. Previous research has found no relationship between other personality measures and correct antisaccade latencies (Ettinger et al., 2005; Gooding, 1999; Nguyen et al., 2008; Taylor & Hutton, 2007). Based on previous findings, impulsivity will not correlate with correct antisaccade latencies.

Method

Participants

Eighty participants (40 female) from Bournemouth University took part. Ages ranged from 18-47 ($M = 27.06$, $SD = 5.96$). Participants had normal to corrected normal vision and were naïve to the purpose of the study. The study was approved by the departmental ethics committee.

Impulsivity Measures

Barrett Impulsiveness Scale

The Barrett Impulsiveness scale (Patton et al., 1985) (BIS) is a 30 item questionnaire that measures impulsivity through items related to things such as extraversion and sensation seeking. For example, (I act on impulse), or (I often have extraneous thoughts when thinking). Participants responded on a 4-point scale as rarely/never, occasionally, often, or almost always/always. Scoring was calculated as a 1 for rarely/never through to 4 for almost always/always, with total scores ranging from 30-120. Higher scores are associated with a greater level of impulsivity. The BIS can be divided into 3 subscales; Attentional impulsivity (BISa), Motor impulsivity (BISm) and Non-planning impulsivity (BISn). In the current study, an overall score was obtained (BISt) and scores for each separate subscale. The BIS shows high internal consistency (between 0.79 and 0.83 in different groups) (Patton et al., 1995).

UPPSP Impulsive Behaviour Scale

The UPPSP (Cyders & Smith, 2007) is a 59-item questionnaire that measures impulsivity through five distinct personality dimensions, including negative urgency, lack of premeditation, lack of perseverance, sensation seeking and positive urgency. For example, items include: (I would like to learn to fly an airplane), or (I have trouble controlling my impulses). Participants responded on a 4-point scale as either agree strongly, agree somewhat, disagree somewhat, or disagree strongly. Scoring was calculated as 1 for agree strongly through to 4 for disagree strongly. Scores can range from 59-236. Higher scores are associated with greater levels of impulsivity. The Cronbach's alphas of the five scales in the present study are as follows: Negative Urgency (.84) Lack of Perseverance (.82), Lack of Premeditation (.84), Sensation Seeking (.85) and Positive Urgency (.92).

Oculomotor Measures

Prosaccade Task

A prosaccade task was included as a control for the antisaccade task. The task itself measures a participants' ability to reflexively saccade to a suddenly appearing target in their peripheral field. Therefore the task is less volitional and more stimulus-driven in nature compared to the antisaccade task and would not require the use of any inhibitory mechanisms. On each trial, the display comprised a black background, containing one red circle (0.25 degs in diameter), located in the centre of the screen. Participants were instructed to look at the central circle. After a random interval (between 800-1200 ms), this central stimulus disappeared from the screen and following a 200 msec gap, was replaced by a target stimulus (also a red circle with the same diameter as the central stimulus), which appeared at one of four positions on the horizontal axis (+/- 7.5, or 15 degs). The target stimulus was displayed for a variable time; 1500-2750 ms. Participants were asked to look at the suddenly appearing target stimulus as quickly and as accurately as possible.

Antisaccade Task

The stimuli used were identical to those used in the prosaccade task. For antisaccade trials, participants were told to look to the mirror image location of the suddenly appearing target stimulus as quickly and as accurately as possible.

Procedure

The testing session began with the participant providing consent and demographic information. Subsequently, half of the participants completed the eye movement tasks (prosaccade and antisaccade) followed by the impulsivity measures (BIS and UPPS-P) and the other half completed the questionnaires first then the eye movement tasks. Participants performed 20 practice trials (10 prosaccade, 10 antisaccade) and 128 experimental trials (64 prosaccade, 64 antisaccade). Each set of trials was preceded by a calibration procedure, during which participants focused their eye gaze on 9 separate targets in a 3 x 3 grid. After testing finished, participants were debriefed.

Eye Movement & Data Analysis

For the prosaccade task, we recorded number of prosaccade errors and correct prosaccade latency. A prosaccade error was defined as a trial in which a saccade was made to the opposite direction of the target stimulus, even if this was corrected with a saccade towards the target. Correct prosaccade latency was measured as the difference in milliseconds between target onset and onset of a saccade made towards the target. For the antisaccade task, we recorded number of antisaccade errors and correct antisaccade latency. An antisaccade error was defined as a trial in which a saccade was made to the target only, or prior to a saccade made to the goal location (mirror image location of target). Correct antisaccade latency was measured as the difference in milliseconds between the target onset and the onset of a saccade made to the opposite hemifield (without any intervening erroneous saccade). Trials were excluded from analysis if, a) the eye was not within 40 pixels (approximately 1 degree of visual angle) of the central fixation point at the time of target appearance; b) no saccade was made within the trial duration; c) the primary saccade was obscured by blinks, d) the primary saccade was made < 60 msec after target onset, e) the primary saccade was made > 500 msec after target onset. These criteria resulted in less than 7% of trials being excluded.

Eye movements were recorded using an Eyelink 1000 eye tracker (www.sr-research.com) with a temporal resolution of 1 ms, a spatial resolution of 0.25° and sample rate of 1000 Hz. The system uses infrared video-based technology to simultaneously track the eyes and head position composition. Only the position of the right eye was tracked.

Eye movement recordings were visualized and quantified off-line using Data Viewer software (SR-Research, Ontario). Saccade onset time was defined as the first of a series of three data points for which the instantaneous velocity exceeded 30%/s. Similarly, the end point of the movement was defined as the first of three data points following saccade onset for which the instantaneous velocity fell below 30%/s. Two-tailed partial correlations were conducted for trait measures and eye movement metrics. Bonferroni correction was calculated as 0.05/3 multiple comparisons for the BIS analysis and 0.05/5 comparisons for the UPPSP analysis.

Results

First, the data was assessed for normality using a series of Kolmogorov-Smirnov tests. With the exception of the BIS(t) and the UPPSP-pe scales, all other scales and saccade metrics distributions did not deviate from normality (all *p's* > .05). Second, to assess normality further, skewness of the distribution of the data was analysed (Field, 2013). With the exception of UPPSP-pe scale, all other scales and saccade metrics' distributions were neither positively nor negatively skewed (*p's* > .05). Therefore, we selected a parametric test for analysis. Average scores and standard deviations (see Table 1) were in line with those of the original BIS-11 paper (Patton et al., 1995).

As previous research has indicated potential gender differences in self-report measures of impulsivity and on impulsive task performance (see Cross, Copping, & Campbell, 2011 for review), I included gender in the analysis. Pearson partial correlations when con-

Table 1 *Descriptive statistics of impulsivity scales and saccade metrics*

	Mean	*SD*	Min-Max
BIS(t)	68.19	9.74	43-98
BIS(a)	17.68	3.96	11-31
BIS(m)	24.89	3.89	17-36
BIS(np)	25.62	4.85	15-37
UPPSP-t	140.16	25.46	119
UPPSP-n	29.45	7.57	17-48
UPPSP-pr	24.55	5.24	15-40
UPPSP-pe	20.40	4.50	13-33
UPPSP-ss	37.55	7.58	19-48
UPPSP-p	28.20	10.38	14-55
Pro-Lat	181.03	46.26	71.26-251.52
Anti-Lat	256.99	68.85	198.26-344.87
Anti-err	18.22	12.57	0-51

Note. BIS(t) = Total BIS score; BIS(a) = attentional scale; BIS(m) = motor scale; BIS(np) = non-planning scale; UPPSP-t = Total UPPSP score; UPPSP-n = negative urgency scale; UPPSP-pr = lack of premeditation scale; UPPSP-pe = lack of perseverance scale; UPPSP-ss = sensation seeking scale; UPPSP-p = positive urgency scale; PS-lat = prosaccade latencies; AS-lat = antisaccade latencies; AS-err = antisaccade errors

trolling for gender, were analysed to establish the relationship among trait impulsivity scores, and prosaccade latencies and antisaccade errors and latencies (see Table 2). Prosaccade errors were not included in analysis as very few were made overall <1.5%. The first analysis compared the scores of the scales of the Barratt impulsivity scale (BIS) with antisaccade errors. High scores on the attentional scale [BIS(a)] were associated with fewer antisaccade errors ($r = -.275, p < .05$). This result remained significant after a Bonferroni correction. There were no significant correlations between the other scales of the BIS and antisaccade errors. The second analysis compared the scores of the scales of the UPPSP with antisaccade errors. A significant correlation was found between

Table 2 *Partial Correlation r values among BIS and UPPS-P scales of impulsivity and oculomotor performance when controlling for gender (N = 80)*

	BIS(t)	BIS(a)	BIS(m)	BIS(np)	UPPSP-t	UPPSP-n	UPPSP-pr	UPPSP-pe	UPPSP-ss	UPPSP-p	PS-Lat	AS-Lat	AS-err
BIS(t)		.771**	.744**	.780**	.833**	.537**	.757**	.650**	.351*	.730**	.193	.068	.168
BIS(a)			.445**	.373**	.769**	.502**	.576**	.615**	.351*	.706**	.055	.086	**-.275***
BIS(m)				.326**	.721**	.474**	.669**	.437**	.404**	.602**	.190	.046	-.082
BIS(np)					.712**	.446**	.743**	.646**	.197	.622**	.241	.028	-.047
UPPSP-t						.698**	.746**	.661**	.508**	.909**	.050	-.050	-.236
UPPSP-n							.275	.459**	-.028	.666**	.162	.085	**-.344***
UPPSP-pr								.519**	.464**	.561**	-.031	-.133	-.063
UPPSP-pe									.024	.574**	-.065	-.071	-.121
UPPSP-ss										.290	-.141	-.148	.089
UPPSP-p											.149	.026	-.293
PS-Lat												.808**	.025
AS-Lat													-.052
AS-err													

Note. BIS(t) = Total BIS score; BIS(a) = attentional scale; BIS(m) = motor scale; BIS(np) = non-planning scale; UPPSP-t = Total UPPSP score; UPPSP-n = negative urgency scale; UPPSP-pr = lack of premeditation scale; UPPSP-pe = lack of perseverance scale; UPPSP-ss = sensation seeking scale; UPPSP-p = positive urgency scale; PS-lat = prosaccade latencies; AS-lat = antisaccade latencies; AS-err = antisaccade errors.
* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

UPPSP-n scores and antisaccade errors, as those who scored lower on this scale were those who made more antisaccade errors (*r* = -.344, $p < .05$). This result failed to remain significant after a Bonferroni correction, however, the bootstrapped confidence intervals did not cross zero, suggesting there is a genuine correlation in the population (Field, 2013). There were no significant correlations between the other scales of the UPPSP and antisaccade errors.

No relationship between impulsivity and antisaccade latencies was found, suggesting that although those with high impulsivity scores on BIS(a) and UPPSP-n made less antisaccade errors than those with low impulsivity scores**,** they did not have slower latencies. Therefore, the significant correlation found between BIS(a) and antisaccade errors was not due to a speed/accuracy trade off ($r < .087$). Similarly, there were no correlations between impulsivity scores and prosaccade latencies confirming that the relationship between impulsivity and antisaccade errors is not due to a general deficit in eye movement performance, i.e. impaired prosaccade latencies (*r's* < .242). Taken together, these findings refute our hypothesis that high trait impulsivity in healthy participants is related to impaired antisaccade error rate and more broadly deficits in oculomotor inhibition.

Discussion

The present study in general has demonstrated no relationship between trait impulsivity and oculomotor inhibition. However, contrary to our expectations, we found that those who scored high on a certain self-report scale of impulsivity were those who actually made fewer Inhibitory errors than those who scored lower on these scales. Participants scoring at the higher end of the attentional scale of the Barratt Impulsiveness Scale (BISa) made fewer antisaccade errors compared to participants who scored towards the lower end of the scale. This finding opposes previous studies which have observed a positive relationship between impulsivity and antisaccade errors (Jacob et al., 2010; Spinella, 2004), but supports one study which found no positive relationship between impulsivity and oculomotor inhibition using different tasks (Roberts et al., 2011). Jacob et al. (2010) asked a group of female participants with borderline personality disorder (BPD) and a group of female controls to complete antisaccades. They found that participants who scored high on the UPPS-P lack of premeditation scale and the non-planning scale of the BIS made more antisaccade errors than those who scored low on these scales. However, data from both patients and controls were used in these correlations; therefore, the relationship between impulsivity and impaired antisaccade performance may have been due to the increased number of antisaccade errors made by the patients with BPD. Furthermore, the authors only tested female participants, which may have biased the correlations they found. However, in the current study we controlled for any potential effect of gender and still found a negative relationship between certain dimensions of impulsivity and antisaccade error rate.

Another possibility for the disparity in the direction of the relationship between impulsivity scores and antisaccade errors in our study compared to prior studies is due to differences in sample size. Both Jacob et al. (2010) and Spinella (2004) used small sample sizes (30 and 45, respectively) in their analyses suggesting their correlations may not have been stable. A correlation is expected to be stable with a sample size of 80-150 (Schönbrodt & Perugini, 2013). Similarly, as previous studies used very few antisaccade trials, we cannot be sure that a reliable measure of antisaccade performance was taken in their studies.

As expected, antisaccade latencies were unrelated to trait impulsivity. Firstly, this finding is in line with previous research that has shown no relationship between antisaccade latencies and other personality traits (Ettinger et al., 2005; Nguyen et al., 2008). Secondly, the lack of relationship between impulsivity and antisaccade latencies in the present study confirms that the association between the BIS(a) and the UPPS-P negative urgency with antisaccade errors was not due to a speed/accuracy trade off. Prosaccade latencies were also unrelated to impulsivity scores, which ruled out the possibility of any general eye movement behaviour differences between high and low impulsive participants.

Some of our findings are in line with past research in that there was no relationship between antisaccade errors and the BIS(np) scale (Spinella, 2004) nor between antisaccade errors and the BIS(m) scale, UPPS-P lack of perseverance and sensation seeking scales (Jacob et al., 2010). One reason why some impulsivity scales failed to correlate with antisaccade performance is that the scales measure impulsivity over time, whereas laboratory impulsivity tasks may measure in the moment behaviour that may not be observable to the individual (Cyders & Coskunpinar, 2011). These findings affirm that only certain dimensions of the trait relate to oculomotor inhibition.

The findings from the present study have indicated in general no relationship between trait impulsivity and antisaccade performance; although a certain facet of trait impulsivity was negatively related to antisaccade performance and oculomotor inhibition. Moreover, after controlling for gender prosaccade latency had no bearing on the antisaccade results. The relation of the higher number of inaccurate antisaccades with the lower scores on the Impulsiveness scale gives a new perspective on the impact of the given personality characteristics affecting human oculomotor activity. Future work would be wise to include additional eye movement tasks, to ascertain if the reported negative relationship extends to other measures of oculomotor inhibition.

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