Sensitivity to reward and punishment in relation to symptoms of adult ADHD and depression in a non-clinical sample

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Abstract
The present study examined reward and punishment sensitivity using a signal-detection task that gave either equal frequencies of rewards and unequal frequencies of punishments (punishment sensitivity) or unequal frequencies of rewards and equal frequencies of punishments (reward sensitivity). Participants were from a non-clinical population but were screened using scales of adult attention deficit/hyperactive disorder (ADHD) and major depressive disorder (MDD) symptoms. In Experiment 1, participants screened as Adult ADHD displayed significantly higher reward sensitivity than controls, but there were no differences between participants screened as mildly or moderately-or-above depressed and controls. There were no significant differences in punishment sensitivity between Adult ADHD or MDD groups and controls. Experiment 2 modified the task to reduce inherent bias, and scales of reward and punishment sensitivity (BIS/BAS Scales from Carver & White, 1994) were included to compare to the scales of ADHD and MDD. Participants screened with MDD displayed significantly higher reward sensitivity than controls. Their punishment sensitivity was also lower than controls, but this difference was not significant. Participants screened with Adult ADHD displayed higher reward sensitivity, but this difference was not significant. There were no differences between the Adult ADHD participants and controls’ punishment sensitivity. Across both experiments, ADHD and MDD symptoms were correlated, and there was an unexpectedly high numbers of participants screened as Adult ADHD or depressed. Scores on the BIS/BAS scales did not correlate with response bias on the task, and only weakly correlated with ADHD and MDD symptoms. The present study provides some evidence that ADHD and MDD may be related to reward and punishment sensitivity abnormalities; but a clinical sample may be necessary to show strong effects.
Table of Contents

Title Page ................................................................................................................................................................................. i
Acknowledgments ........................................................................................................................................................................ ii
Abstract ................................................................................................................................................................................... iii
Table of Contents ....................................................................................................................................................................... iv
List of Figures ........................................................................................................................................................................... vii
List of Tables ............................................................................................................................................................................. viii
Introduction ............................................................................................................................................................................... 1
  Attention-Deficit Hyperactive Disorder ................................................................................................................................. 2
  Depression .................................................................................................................................................................................. 8
  The Present Study ................................................................................................................................................................... 14
Experiment 1 ............................................................................................................................................................................... 16
  Method ...................................................................................................................................................................................... 16
  Participants ............................................................................................................................................................................... 16
  Apparatus ............................................................................................................................................................................... 16
  Procedure ............................................................................................................................................................................... 17
Results ....................................................................................................................................................................................... 20
  A-ADHD and Depression Scales ........................................................................................................................................... 20
  A-ADHD: Discriminability and Bias ................................................................................................................................... 22
  Depression: Discriminability and Bias ................................................................................................................................. 25
Discussion .................................................................................................................................................................................. 28
  A-ADHD ................................................................................................................................................................................ 29
List of Figures

Figure 1. Experiment 1: PHQ-9 as a function of ASRS ....................................................20
Figure 2. Experiment 1: Discriminability and response bias – A-ADHD Part A...............24
Figure 3. Experiment 1: Discriminability and response bias – A-ADHD Part B ..........25
Figure 4. Experiment 1: Discriminability and response bias – MDD Part A ..............26
Figure 5. Experiment 1: Discriminability and response bias – MDD Part B ............27
Figure 6. Experiment 2: Discriminability and response bias – A-ADHD Part A.........43
Figure 7. Experiment 2: Discriminability and response bias – A-ADHD Part B ..........44
Figure 8. Experiment 2: Discriminability and response bias – MDD Part A .............46
Figure 9. Experiment 2: Discriminability and response bias – MDD Part B .............47
Figure 10. Experiment 2: Correlation between PHQ-9 score and response bias .......48
List of Tables

Table 1. Experiment 1: Demographics of participants in Experiment 1.............................................21
Table 2. Experiment 2: Correlations between ASRS, PHQ-9, and BAS/BIS scales.........................38
Table 3. Experiment 2: Demographics of participants in Experiment 2............................................40
Table 4. Experiment 2: Correlations of the BIS/BAS with discriminability and bias ...............41
People’s behaviour is shaped by its consequences (Skinner, 1936). These consequences mostly take the form of either reward or punishment and respectively increase or decrease the rate of the behaviour that they follow. The same consequence can be a reward or a punishment depending on its context and behaviours can also be contingent on other behaviours acting as reinforcement or punishment. For example, a child may want to play video games but has to clean their room first. This could either lead to the rate of room cleaning increasing, or the rate of playing video games decreasing, depending on which behaviour is a stronger punishment or reinforcement, respectively (Premack, 1959). In this way, behaviours are shaped to provide organisms with currently desired outcomes.

The role of consequences on behaviour has been studied extensively for over a hundred years (e.g., Thorndike, 1911; Skinner, 1938). Behaviourism dominated Psychology in the 20th century, and its current influence has become no less pervasive, but may simply be less obvious (Roediger, 2004). Reward and punishment learning, as well as the basic principle of measurable behaviours, are key aspects of many popular branches and offshoots of psychology today, such as cognitive neuroscience.

Modern disciplines like neuroscience study principles of reinforcement and punishment extensively using techniques such as functional magnetic resonance imaging (fMRI) and electroencephalography (EEG). For example, Thoma, Edel, Suchan, and Bellebaum (2015) investigated reinforcement and punishment sensitivity in adults with Attention-deficit/hyperactivity disorder (ADHD) and compared behavioural results to neurological results such as feedback-related negativity amplitudes (i.e., the strength of brain activity in specific areas). Other studies may use VO2max outputs (using fMRIs) or even structural MRIs and compare structural qualities of brain areas to behavioural responses. While the overt focus of psychological studies has shifted away from behavioural research, it is still widely relied on as a robust, foundational element of psychology (Roediger, 2004).
Behavioural interventions represent a more traditional and applied use of principles of reinforcement and punishment. For example, they are often used to treat ADHD, in particular for training parents to identify and use rewards and punishments effectively (Fabiano, Schatz, Aloe, Chacko, & Chronis-Tuscano, 2015). This provides children with ADHD with ample opportunities to behave well, and promotes these behaviours with rewards. This allows children to add non-disruptive behaviours to their repertoire of behaviours, and thus lowers the chance of disruptive behaviours occurring (Fabiano et al., 2015). Although a wide variety of behavioural interventions use reward and punishment as their basic cornerstones, this assumes a certain normative responsivity to reward and punishment; that is, the treatment would be effective if patients responded to behavioural consequences in a normal fashion. For example, if a child with ADHD was hypersensitive to reward, but hyposensitive to punishment, use of reward would be far more effective than use of punishment.

Taken together, the importance of identifying hyper- or hyposensitivity to reward and punishment in individuals with psychological disorders is clear; it helps tailor effective interventions to an individual’s needs. Furthermore, this knowledge may explain the outcomes of clinical patients in treatment. For example, depressed patients with higher levels of anhedonia (an inability to feel pleasure, related to lower reward sensitivity) have been found to be more resistant to treatment (Vrieze et al., 2013). Therefore, it is important to examine evidence of reward and punishment sensitivity in relation to psychological disorders.

Attention-Deficit Hyperactive Disorder

ADHD is a common neurodevelopmental disorder diagnosed in children (American Psychological Association [APA], 2013). The disorder is identified by symptoms of significant inattentiveness (e.g., unable to listen consistently), hyperactivity and impulsivity (e.g., constantly loaded with energy, unable to remain quiet), or a combination of the two categories (APA, 2013). In this way, ADHD can be categorised into the subgroups of predominantly
inattentive, predominantly hyperactive/impulsive, or a combined subtype, respectively (Luman, Oosterlaan, & Sergeant, 2005). The disorder is quite common, with a prevalence of up to 5% in the general population (APA, 2013). Its causes are thought to be both genetic and environmental, with interactions between these two factors; for example, genetic factors may provide a proclivity for the disorder and environmental factors cause the disorder to surface (APA, 2013; Tripp & Wickens, 2009).

While the disorder is likely caused by genetics and environments, the actual impairments associated with ADHD causing its symptoms are generally thought to be neurobiological, causing impairments in executive function, motivation, and associated areas (Tripp & Wickens, 2009). Furthermore, a robust finding from numerous studies (e.g., Alsop, Furukawa, Sowerby, Jensen, Moffat, & Tripp, 2016; Furukawa, Alsop, Sowerby, Jensen, & Tripp, 2016; Luman et al., 2005; Tripp & Alsop, 1999) is that ADHD is related to impaired processing of rewards and punishments. It has been theorized that some of the functional difficulties (e.g., in academic and social areas) that individuals with ADHD experience may be related to issues with learning from consequences, leading to difficulties with adaptive behaviour (APA, 2013; Tripp & Alsop, 1999).

Some early reports indicated that children with ADHD displayed a diminished sensitivity to both rewards and punishments (e.g., Wender, 1971). This was associated with children being unable to delay gratification (i.e., wait for a larger reward), and being unresponsive to discipline. Furthermore, Barkley (1989) argued that children with ADHD were quick to satiate with reward or punishment, thus they lose their effects more quickly than for children without ADHD. In contrast, other findings have suggested that children with ADHD are in fact excessively sensitive to reward (Douglas, 1989). However, this might arise from increased responding to local (i.e., what is currently rewarding) rather than global (i.e., what is more rewarding overall in the larger scheme of things) frequencies of reward, as well as to
immediate rather than later rewards, even if the later rewards are larger (Luman, Tripp, & Scheres, 2010; Tripp & Alsop, 1999).

Tripp and Alsop’s (1999) study investigated reward sensitivity with a sample of boys with ADHD and matched controls. Participants performed a signal-detection (SD) task in which they had to identify if a cartoon face had a little or big mouth on a given trial. On some trials, correct identifications of the stimulus were rewarded with tokens for which participants could get a prize at the end of the experiment. However, the frequency of rewards assigned to correct identifications of the stimuli were unequal, with an either 1:3 or 3:1 frequency of rewards for correct identification of little or big mouths, respectively (Tripp & Alsop, 1999).

Overall, Tripp and Alsop’s (1999) results showed that both children with ADHD and control children developed a bias towards the more frequently rewarded stimulus, although this bias was somewhat larger (but not significantly so) for the control children (Tripp & Alsop, 1999). However, when performance was examined only on trials after rewards were presented, children with ADHD showed a reduced bias on trials following reward on the lean schedule compared to trials following reward on the rich schedule. This difference was not found in the control group (Tripp & Alsop, 1999). Furthermore, this difference was attenuated when children completed the task while on medication (methylphenidate), but this did not reach statistical significance. Tripp and Alsop (1999) concluded that children with ADHD displayed a higher sensitivity to the local (i.e., what had been rewarding recently) rather than the global (i.e., what had been rewarding overall in all trials) distribution of reward.

In a related study, Alsop et al. (2016) investigated the ability of children with ADHD to adapt to changing reinforcement schedules. Children with or without ADHD completed a SD task where they had to identify if there were more blue or red characters in a field of 100 (Alsop et al., 2016). For the first part of the experiment, the ‘more blue’ alternative was
rewarded four times more often than the ‘more red’ alternative; once 20 rewards had been gained, this contingency was then reversed and the ‘more red’ alternative was rewarded four times more often than the ‘more blue’ contingency. After a further 20 rewards, this schedule was again reversed. Thus, the children had to adjust to an initial schedule, a reversal of this schedule, and a final return to the initial schedule (Alsop et al., 2016). Some children were then also given a final phase of non-reinforcement, in which they received no rewards at all.

Alsop et al.’s (2016) results showed that all children developed an initial bias towards the ‘more blue’ alternative in the first schedule. However, upon reversal of this schedule, children with ADHD had a significantly smaller change in bias to the ‘more red’ alternative than control children. For the last block, the control children’s change in bias was again larger than that of the children with ADHD (Alsop et al., 2016). During the non-reinforcement period, children with ADHD continued to show similar levels of bias, whereas control children shifted their bias to the ‘more red’ alternative.

Alsop et al. (2016) concluded that these results support the idea that children with ADHD do not lack a sensitivity to reward, but rather that their ability to adjust to accommodate changing schedules is impaired. The lack of change in their response bias in response during extinction supports this idea. In contrast, Alsop et al. (2016) interpreted the control children’s reversal in bias to the ‘more red’ alternative as an attempt to try strategies that had been successful in the past when reinforcement schedules had altered, such as during the previous reversals of the reinforcement distributions.

Although children with ADHD have consistently been found to display some difficulty in learning global reinforcement schedules, their responses to punishment have received less attention. Furukawa et al. (2016) investigated the punishment sensitivity of children with ADHD. Children played two games, between which they could freely choose by clicking on
either the game on the left or the game on the right. Each game was arranged to provide reinforcement or punishment, with reinforcement available every 10 seconds on average for both games. In contrast, the left game had a 16% chance of punishment whereas the right game only had a 4% chance of punishment (i.e., a 4:1 punishment ratio).

Furukawa et al. (2016) found that across the first 200 trials of the study (there were at most 300 trials per participant) children without ADHD maintained a steady bias towards the less punished game (the left game) across both blocks of 100 trials. However, although children with ADHD had a similar bias in the first block of 100 trials, their bias continued to increase significantly over the second block, causing a significant group by block interaction. Furukawa et al. (2016) concluded that children with ADHD found punishment more aversive than those without ADHD, causing them to prefer the game with fewer punishers. This also led to more missed opportunities for rewards, lending support to the idea that these differences in response to punishment cause functional impairments in everyday life related to reward and punishment learning.

ADHD is commonly viewed as a childhood developmental disorder, and thus, studies investigating it have predominantly used children as participants (e.g., the studies discussed previously). However, Kessler et al. (2006) report that the prevalence of adult ADHD is about 4.4%, which is only slightly smaller than the prevalence of childhood ADHD in the general population (APA, 2013). The disorder is often seen as a delay in development, which can imply that there is a ‘catch-up’ point where individuals with ADHD reach a normal, but delayed, period of development (Onnink et al., 2014). Alternatively, ADHD has been thought to result from overall neurobiological deficits, which never fully normalise. These deficits may also cause issues in education and therefore compound issues seen in children with ADHD.
There is evidence to support both of these conflicting hypotheses. Several studies have found that brain areas of individuals with ADHD, such as the right globus pallidus, putamen, and the caudate, have deficits in their volume in childhood (Onnink et al., 2014). However, these deficits normalise during adolescence and into adulthood (e.g., Nakao et al., 2011; Castellanos et al., 2002). Furthermore, Shaw et al. (2007) report that development of cortical thickness was simply delayed a few years for children with ADHD. However, these studies did not investigate whether these normalisations of structure correlated to a normalisation of behaviour commonly found in individuals with ADHD.

In contrast, other studies (e.g., Hesslinger et al., 2002; Almeida Montes et al., 2010; Proal et al., 2011) report that adults aged about 30-40 years old who had ADHD as children continue to display deficits in brain structures such as parts of the cortex, caudate, and cortical thickness. However, these studies used fairly small sample sizes, and also did not investigate the behavioural symptoms of ADHD in adults in depth. Taken together, these studies show that the persistence of ADHD into adulthood, at both a structural and a behavioural level, requires further investigation (Onnink et al., 2014).

Although there is relatively little research into the performance of adults with ADHD on tasks measuring reinforcement and punishment sensitivity, Thoma et al. (2015) investigated this issue in an fMRI study. Participants with and without adult ADHD took part in a probabilistic reward learning task. They chose between two stimuli in three pre-arranged pairs which always resulted in either a reward (20 cent monetary gain) or a punishment (10 cent monetary loss). One stimulus in each pair always had a higher chance of being rewarded, while the other had a higher chance of being punished (Thoma et al., 2015). In the three pairs (AB, CD, EF), choosing A, C, and E had higher chances of being rewarded (80%, 70%, 60% chances of reward, respectively). In contrast, choosing B, D, and F had higher chances of receiving punishment (20%, 30%, 40% chances of reward, respectively).
Participants with adult ADHD displayed impaired learning of the 80/20 reward/punishment pair (AB), compared to controls (Thoma et al., 2015). This finding is consistent with reports by Luman et al. (2010) that children with ADHD tend to display impaired performance in response to reinforcement, which indicates that this aspect of ADHD may continue into adulthood. Furthermore, Thoma et al. (2015) reported that participants in the adult ADHD condition performed worse on the transfer phase of the experiment, where the highest and lowest reward frequency stimuli were paired with all other stimuli, and no reward or punishment was given. This indicates that participants struggled with maintaining intrinsic motivation; that is, motivation maintained by themselves rather than external factors such as rewards or punishments. This is also commonly seen in children with ADHD (APA, 2013).

To summarise, the effects of childhood ADHD on reward and punishment sensitivity have been investigated extensively with consistent results (e.g., Tripp & Alsop, 1999; Alsop et al., 2016; Furukawa et al., 2016). However, there is relatively little research looking into if these effects persist or differ into adulthood. Although Thoma et al. (2015) found some evidence of ongoing performance deficits similar to children with ADHD, there is no clear consensus as to the extent to which ADHD carries on into adulthood. Therefore, there is a need for further research in this area.

**Depression**

Major Depressive Disorder (MDD) is one of the most common mental illnesses affecting adults, with a prevalence of about 7% in the general population (APA, 2013). The disorder is characterised by episodes of depressive symptoms, with most sufferers experiencing at least some periods of remission. However, some individuals present with a single onset and no remission of the illness. As such, both the severity of the illness as well as of its symptoms vary from case to case, and can range from minor (but still significant) impairments in functioning to severe, debilitating impairments (APA, 2013). The symptoms of MDD are
generally prototypical of sadness and include feelings of worthlessness, anhedonia (loss of pleasure), as well as other symptoms such as suicidal ideation and hypersomnia or insomnia (APA, 2013).

Like ADHD, MDD is likely caused by a combination of biological risk factors and environmental stressors (APA, 2013; Pizzagalli, 2014). Biological risk factors may include differences in brain pathway activation or dopamine systems, and environmental stressors may include stressful childhood or adolescent experiences, such as abuse (APA, 2013). One consistent indicator of depression is anhedonia: things that may once have been pleasurable or rewarding are no longer so. This symptom is representative of the consistent finding that individuals with MDD display lower responsiveness to rewards (e.g., Henriques, Glowacki, & Davidson, 1994; Henriques & Davidson, 2000; Pizzagalli, Iosifescu, Hallett, Ratner, & Fava, 2008; Pizzagalli, 2014; Vrieze et al., 2013). The severity of this learning impairment has also been linked to the outcome of treatment for depression (Vrieze et al., 2013).

Pizzagalli et al. (2008) investigated reward learning in depressed individuals because prior findings indicated that anhedonia is a significant predictor of depression, as well as a major symptom of the illness (Costello, 1972; Meehl, 1975). In this study, clinically depressed participants and matched controls were exposed to unequal reward frequencies. Their procedure followed the general SD task used by Tripp and Alsop (1999), with participants being asked to identify if a short or a long mouth had appeared on a cartoon face. One of the two options was always rewarded three times as often as the other (Pizzagalli et al., 2008).

Pizzagalli et al. (2008) found a statistically significant difference in overall bias across all trials: depressed participants displayed lower bias in every block, meaning that they did not respond to rewards as much as control participants. Furthermore, depressed subjects had a lower differentiation between the rich and lean stimulus schedules in terms of hit rates. This
means that depressed participants were less likely than controls to select the rich (i.e. more rewarded) stimulus type when a lean (i.e. less rewarded) stimulus was presented. This is representative of a lower bias, as subjects with a high bias are more likely to select a historically more rewarding (or less punishing) stimulus if they are uncertain of the true answer (Pizzagalli et al., 2008). Although depressed subjects did respond to individual rewards (i.e., local reward frequencies), they did not respond as much as control subjects to overall (i.e., global) reward frequencies, as shown by their lower overall bias (Pizzagalli et al., 2008). As discussed above regarding children with ADHD (Tripp & Alsop, 1999), depressed subjects responded to immediate rewards but showed reduced sensitivity to the overall reward frequencies. Taken together, the results indicate that individuals with depression display reduced reward learning.

Vrieze et al. (2013) expanded on this research by investigating if the extent of reward learning reduction in depressed patients predicted outcomes of treatment for their depression. Depressed in-patient and control participants performed the same SD task used by Tripp and Alsop (1999) and Pizzagalli et al. (2008). However, as well as comparing these two groups, results were also compared between depressed patients with high or low anhedonia, and between depressed patients with higher or lower reward learning. Overall, the results supported Pizzagalli et al.’s results (2008). Depressed patients displayed reduced levels of reward learning, again showing lower bias, and participants with high anhedonia displayed lower levels of reward learning than those with low anhedonia (Vrieze et al., 2013). Furthermore, reduced reward learning was a significant predictor of persisting depression after eight weeks of treatment. These results display the robustness of the effect of reduced reward learning in individuals with MDD, as well as its link to anhedonia. Moreover, the study shows that behavioural measures of depressed individuals can serve as a potential indicator of the likelihood of successful treatment (Vrieze et al., 2013).
While these studies clearly show reduced reward learning in depressed patients, the evidence regarding punishment learning has not been as consistent. Henriques et al. (1994) compared learning in response to both rewards and punishments between depressed and non-depressed subjects (grouped by scores on the Beck Depression Inventory). Participants completed an SD task in either a neutral, reward, or punishment condition. Participants could earn money in the reward condition or lose money in the punishment condition by getting trials right or wrong, respectively. Depressed subjects in the reward condition displayed significantly lower response bias than control subjects, which is consistent with Pizzagalli et al.’s (2008) and Vrieze et al.’s (2013) results. In the punishment condition, depressed subjects displayed higher response bias, but this difference was not statistically significant (Henriques et al., 1994). The authors suggested that the difference might have been significant if a larger sample size or a stronger punishment than losing a very small amount of money from a total reward (10 cents in the study) had been used. This difference was consistent with prior hypotheses and findings that depressed individuals experience punishing stimuli as more aversive than non-depressed individuals (e.g., Gable, Reis, & Elliot, 2000).

Elliott et al. (1996) further investigated the effects of punishment on depressed individuals. Their study examined both the general neurological and cognitive deficits of depressed patients, and the effects of punishment on subsequent questions. Depressed participants were impaired in a variety of areas compared to control participants, such as pattern and spatial recognition (Elliott et al., 1996). The authors also investigated the effects of negative feedback, shown by the likelihood of participants getting a problem wrong given that they had failed the previous problem. This was investigated on two tasks, delayed matching-to-sample and Tower of London tests. Compared to control participants, depressed individuals showed a significantly higher chance of getting problems wrong following negative feedback (Elliott et al., 1996).
Elliott et al. (1996) argue that this response to punishment in the form of negative feedback shows that depressed individuals experience negative stimuli more strongly than non-depressed people. Elliott, Sahakian, Herrod, Robbins, and Paykel’s (1997) follow-up study replicated this finding. These results are consistent with Henriques et al.’s (1994) finding that depressed participants had a higher response bias, albeit not statistically significant, in response to punishment than control participants. Taken together, these experiments indicate that depressed individuals may experience punishment more intensely than non-depressed individuals.

Another measure testing responsiveness to reward and punishment is the Iowa Gambling Test (IGT). Must et al. (2006) used the IGT to investigate depressed and non-depressed individuals’ reinforcement and punishment sensitivity, as well as comparing this to measures of executive function. Two sets of decks, ABCD and EFGH, are used in the IGT. Decks AB provide large rewards but also larger, unexpected punishments, whereas decks CD provide smaller rewards but even smaller, unexpected punishments (Must et al., 2006). The reward and punishment allocations are reversed in the EFGH decks: that is, EF provides large punishments but also larger rewards and GH provides small punishments but even smaller rewards. In this way, the two decks investigate if oversensitivity to reward or punishment (compared to the other) drive decisions (Must et al., 2006).

Must et al. (2006) hypothesised that depressed participants would not pick disadvantageous decks in the ABCD set, indicating a normal or hyposensitive reward system, the latter of which had been found in depressed participants in the past (e.g., Pizzagalli et al., 2008; Vrieze et al., 2013). Furthermore, Must et al. (2006) hypothesised that depressed participants would pick disadvantageous decks in the EFGH set, indicating hypersensitivity to punishment, a consistent finding of depressed individuals in past studies. Must et al. (2006) found the opposite; depressed participants picked disadvantageous decks in the ABCD set but
not the EFGH set. Therefore, it appears they displayed hypersensitivity to reward, and no differential effects of punishment sensitivity. These unexpected findings were replicated in a similar study by Cella, Dymond, and Cooper (2010). These findings also contradict those from studies such as Pizzagalli et al. (2008).

However, these results can be interpreted differently. Must, Horvath, Nemeth, and Janka (2013) argue that the depressed participants display impaired reward processing by focusing only on the immediate reinforcement by picking decks AB; but not the overall reinforcement, which would be maximised by picking decks CD. This is similar to the conflicting reinforcement sensitivity findings found in depressed participants as well as in children with ADHD; while they are sensitive to reward in the short-term, they are insensitive to the overall reinforcement contingencies (Pizzagalli et al., 2008; Tripp & Alsop, 1999). However, while this may account for Must et al.’s (2006) unexpected findings regarding reinforcement, it does not account for their finding that depressed participants did not pick disadvantageous decks in the EFGH set. This is unexpected as the finding that depressed individuals are hypersensitive to punishment is fairly well documented (e.g., Elliott et al., 1996; 1997; Henriques et al., 1994).

Taken together, these studies show that depression is linked in some way to reward and punishment sensitivities. The consensus with reward sensitivity appears clear: depressed individuals experience hyposensitivity to reward, this also correlates with their anhedonic symptoms (Pizzagalli et al., 2008; Vrieze et al., 2013). In regards to punishment sensitivity, there is some robustness in the finding that depressed individual experience hypersensitivity to punishment (e.g., Elliott et al., 1996; 1997). However, other studies have produced conflicting results (e.g., Must et al., 2006).
Overall, both ADHD and depression appear to be linked to abnormal reward and punishment sensitivity. Although there have been studies of reward and punishment sensitivity abnormalities in relation to both disorders, there are some gaps and inconsistencies in the literature. For example, the relation of ADHD to reward and punishment sensitivity has not been studied much in adults. Although there is agreement in studies studying reward sensitivity in depression (e.g. Pizzagalli et al., 2008; Vrieze et al., 2013), there are some conflicting results in studies investigating punishment sensitivity in depression (e.g. Elliott et al., 1996; Must et al., 2006). Because of the high comorbidity of ADHD and depression (APA, 2013), a study using one sample, investigating the relation of both disorders to reward and punishment sensitivity, could help to clarify these gaps and inconsistencies.

The Present Study

The present study examined reward and punishment sensitivity in relation to attention-deficit/hyperactivity and depressive symptoms in a non-clinical sample of participants. Past studies such as Tripp and Alsop’s (1999), Alsop et al.’s (2016), and Furukawa et al.’s (2016) have all found abnormal responsiveness to reward and punishment in children with ADHD, but there is a dearth of research investigating this in adults. Although reward and punishment sensitivity has been investigated more thoroughly in adults with depression, there is still disagreement regarding punishment sensitivity in depressed adults in particular, so a measure of depression was also included in the present study to group participants by depressive symptom severity.

Participants completed SD tasks where correct or incorrect identifications of one of two stimuli were sometimes rewarded or punished. Some participants received an equal frequency of rewards and an unequal frequency of punishment for their choices, others received an unequal frequency of rewards and an equal frequency of punishments. The former task gave a measure of punishment sensitivity (i.e., response bias toward the less punished key) and the
latter task gave a measure of reward sensitivity (i.e., response bias toward the more rewarded key). Participants also completed surveys measuring symptoms of ADHD and depression, which were used to group participants.

Based on past studies it was hypothesised that participants with higher attention deficit/hyperactive symptoms would show higher sensitivity to punishment (e.g., Furukawa et al., 2016) and may show lower sensitivity to reward (e.g., Tripp & Alsop, 1999; Alsop et al., 2016). It was also hypothesised that participants with higher depressive symptoms would show higher sensitivity to punishment (e.g., Elliott et al., 1996) and lower sensitivity to reward (e.g., Pizzagalli et al., 2008).
Experiment 1

Method

Participants

The participants were 101 University of Otago first- and second-year Psychology students. Their age range was 17-46 years old (M = 19.98, SD = 3.16), with 79 females and 29 males taking part. Students participated in this study as an optional part of their courses. No medical or psychiatric history was gathered from participants, and measures of depression and ADHD were assessed on the Patient Health Questionnaire – 9 (PHQ-9) and the Adult ADHD Self-Report Scale (ASRS), respectively (from Spitzer, Kroenke, & Williams, 1999 and Kessler et al., 2005). Ethical approval for the study was obtained from the University of Otago Ethics Committee.

Apparatus

The experiments were conducted in University of Otago Psychology computer laboratory rooms. Participants sat with at least one spare computer between each person, and the room was kept quiet in order to minimise distractions. Computer monitors had a screen size of 480x270mm with a resolution of 1680x1050. A Google Forms survey was used to deliver the PHQ-9 and ASRS (see Appendices A and B).

Each computer ran a custom-made signal-detection task. Participants were shown 20x20 grids of 400 red and blue coloured squares on a white background. The grids were 70mm by 70mm, each square was 3mm by 3mm and had a 1mm gap between them. In each trial, the red and blue squares’ positions in the grid were randomly generated, and there was a proportion of 52:48 of either red:blue or blue:red on each trial. There were two response buttons on the screen, positioned below the grid. The left response button was filled red and was the correct response on trials with more red squares than blue squares. The right response button was blue.
and was the correct response on trials with more blue squares than red squares. Both buttons were 40mm by 20mm in size. Above the grid, a counter showed the number of trials remaining on the task.

**Procedure**

Participants were run in small groups of 2 to 5. Each sat at a computer and was given an information sheet (see Appendix C) and consent form (see Appendix D) to read through and sign. If any issues arose during their session, they were asked to let the experimenter know quietly.

Participants completed one of two parts of the experiment. These were Part A (3315, Equal reward/unequal punishment) and Part B (1533, Unequal reward/equal punishment). Both tasks started with the following instructions:

“In this simple computer task, you will see some patterns made up of Red and Blue squares. You must decide whether there are more Red squares or Blue squares. Click ‘Next’ to see an example—“

“If the pattern has more Red squares, then you should click the Red button. If the pattern has more Blue squares, then you should click the Blue button.”

“Most of the time, you will get NO feedback, but sometimes you will be rewarded for maintaining accuracy and you will have 10 trials FEWER to complete the task. Sometimes you will be punished for being inaccurate and you will have 10 trials MORE to complete the task.”

“You start with 500 trials to complete before the task ends. Remember, trials will be added or subtracted to encourage accuracy. If you have any questions, please ask the experimenter.”

Participants then began the experiment by clicking a “Start” button on the screen. Trials began with a dot in the centre of the screen lasting for 500ms. The grid of 400 red and blue
squares then appeared in the centre of the screen, with the coloured response buttons underneath the grid. Participants decided if there were more red squares or blue squares in the grid, and clicked the button of the corresponding colour using the computer mouse.

The stimulus remained for 2000ms, unless a response was made within that period. If the response was made within 2000ms, all elements (the grid of squares and the response buttons) disappeared immediately. If a response had not been made within 2000ms, the stimulus (the grid of squares) disappeared but the response buttons remained until a response was made. Responses produced one of three outcomes. Correct responses were occasionally rewarded; feedback appeared on the screen saying “Correct! 10 fewer trials to complete” and 10 trials were subtracted from the total trials remaining. Incorrect responses were sometimes punished; feedback appeared on the screen saying “Wrong! 10 more trials to complete” and 10 trials were added to the total trials remaining. Other correct or incorrect responses were neither rewarded nor punished, in this case no feedback would appear and 1 trial was subtracted from the total trials remaining. Following either a reward, punishment, or neutral outcome, all elements (stimulus, buttons) would disappear and a black dot appeared in the centre of the screen for 500ms after a one second pause. This dot then disappeared, signalling the start of the next trial.

Each participant completed one of two parts of the experiment (Part A, 3315, and Part B, 1533) with different distributions of rewards and punishers. On Part A, participants were equally likely to be rewarded for correct identification of either more blue or more red stimuli. However, participants were five times more likely to be punished for incorrectly identifying more blue squares than red. On Part B, participants were five times more likely to be rewarded for correctly identifying more blue squares than red, but equally likely to be punished for incorrect identifications of either colour.
Rewards and punishers were allocated using Random-Interval 8-second schedules, using one schedule for rewards and punishers. The program generated random numbers every second to decide if a new reward (or punisher) would be scheduled. A new reward and a new punisher were scheduled every eight seconds on average. If a new reward or punisher was scheduled, the program then allocated the consequence to either the left or right key; this varied depending on which version of the program the participant was completing. Once a reward or punisher was scheduled, timing was paused and only resumed once the reward or punisher was received by the participant.

Once a participant finished the experiment by either reaching zero trials, or after having spent 50 minutes on the task, the following message was displayed on the screen: “Congratulations, you have finished the session. Thank you.” Participants were then asked to fill in the PHQ-9 and ASRS surveys on their computers. Finally, participants were given a debrief sheet (see Appendix E), thanked for their time, and told they were free to leave.
Results

A-ADHD and Depression Scales

Participants completed either Part A (Equal reward/unequal punishment) or Part B (Unequal reward/equal punishment). For each of Part A and B, the ASRS and PHQ-9 scores of each participant were collected and correlated against each other. Figure 1 shows that ASRS and PHQ-9 scores were moderately correlated for both Part A and B ($p < .01$ in both).

![Figure 1. PHQ-9 as a function of ASRS for Part A (left panel) and Part B (right panel).](image)

These scores were used to group participants into either the control or the Adult ADHD (A-ADHD) group, and into the control, mild depression (MILD), or moderate-and-above depression (MOD) groups in each Part. The ASRS’s screening procedure used the first 6 questions of the survey to group participants into the A-ADHD group. If participants had four or more scores of 3 or higher on Questions 1, 2, and 3, and 4 or higher on Questions 4, 5, and 6 (with scores ranging between 1-5, see Appendix B) they were screened as having evidence of Adult ADHD. Participants with a PHQ-9 score of less than 5 formed the control group, participants with scores of 5-9 formed the MILD group, and participants with a PHQ-9 score equal to or higher than 10 formed the MOD group. Table 1 shows the number of participants in each group, their age and the amount of males and females in each group.
Table 1. Demographics of participants in each group.

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Age (SD)</th>
<th>Gender (M/F)</th>
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</thead>
<tbody>
<tr>
<td>Part A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHQ-9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>16</td>
<td>19.9 (1.2)</td>
<td>7/9</td>
</tr>
<tr>
<td>MILD</td>
<td>18</td>
<td>20.1 (2.5)</td>
<td>3/15</td>
</tr>
<tr>
<td>MOD</td>
<td>17</td>
<td>19.2 (1.1)</td>
<td>3/14</td>
</tr>
<tr>
<td>ASRS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>27</td>
<td>19.3 (1.2)</td>
<td>6/21</td>
</tr>
<tr>
<td>A-ADHD</td>
<td>24</td>
<td>19.8 (2.2)</td>
<td>7/17</td>
</tr>
<tr>
<td>Part B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHQ-9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>25</td>
<td>20.9 (5.5)</td>
<td>8/17</td>
</tr>
<tr>
<td>MILD</td>
<td>18</td>
<td>19.8 (1.8)</td>
<td>5/13</td>
</tr>
<tr>
<td>MOD</td>
<td>7</td>
<td>20 (1.9)</td>
<td>3/4</td>
</tr>
<tr>
<td>ASRS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>37</td>
<td>19.8 (1.5)</td>
<td>12/25</td>
</tr>
<tr>
<td>A-ADHD</td>
<td>13</td>
<td>22 (7.4)</td>
<td>4/9</td>
</tr>
</tbody>
</table>

Data Analysis

Participants’ responses to each trial were recorded and converted from left/right (blue/red) into correct left and incorrect left responses (B₁₁ and B₁₂) and correct right and incorrect right (B₂₂ and B₂₁) responses¹. These were grouped into three blocks of 150 for the first 450 trials to examine performance as participants learned the contingencies. In addition, the rewards and punishments obtained on each alternative were recorded. Measures of discriminability (log d) and response bias (log b) were calculated. The former provided a measure of participants’ accuracy and the latter a measure of the effects of the unequal reward and punishment distributions. In this experiment, a bias greater than zero represented a

¹ In Part A; for Part B, 1 and 2 are reversed, corresponding to right and left, respectively
tendency to select the left key over the right key, whereas a bias less than zero represented a
tendency to select the right key over the left key\textsuperscript{2}. The formulae for these measures are:

\[ l_{ogd} = \frac{1}{2} \log \left( \frac{B_{11} \cdot B_{22}}{B_{12} \cdot B_{21}} + 0.5 \right) \]

\[ l_{ogb} = \frac{1}{2} \log \left( \frac{B_{11} \cdot B_{21}}{B_{12} \cdot B_{22}} + 0.5 \right) \]

The data were also inspected for outliers. If any participant had a discriminability of
0.1 or less in any block, the participants’ data across all three blocks were removed (both
discriminability and bias). In Part A, two participants were excluded from the analyses. In Part
B, six participants were excluded from the analyses. In the bias dataset, outliers (any data points
more than two standard deviations from the mean) were also excluded for individual analyses.\textsuperscript{3}

\textbf{A-ADHD: Discriminability and Bias}

All data sets were tested for the assumptions of ANOVA, namely the normality of
distribution, homogeneity of variance, and sphericity. Shapiro-Wilk tests found that the
discriminability during the third block in Part A was non-normally distributed \((p < .05)\). The
assumption of homogeneity of variance was not violated in any of the data sets split by group
and block (all \(p > .05\)). The assumption of sphericity was violated in the bias dataset of Part B
\((p < .05)\).

Repeated measures ANOVA tests were run on the measures of discriminability and
bias individually with block as the within-subjects factor and A-ADHD group as the between-

\textsuperscript{2} In Part A; in Part B bias greater than zero was towards the right key and a bias less than zero was
towards the left key

\textsuperscript{3} Including these outliers did not affect the analyses in any significant way.
subjects factors. Because of the violations of sphericity, Greenhouse-Geisser corrected $p$ values were used.

**Part A (Equal reward/unequal punishment)**

Figure 2 (left panel) shows that mean discriminability slightly increased from Block 1 to 3 ($M = .58, .58, \text{and} .63$) but no main effect of block was found ($F_{1.8,83.8} = 1.53, p = .22$). Although the control group’s discriminability was slightly higher overall than the A-ADHD group’s ($M = .63 \text{ compared to} .56$), there was no main effect of group ($F_{1.47} = 2.59, p = .11$), nor was there a significant block-by-group interaction ($F_{1.8,83.8} = 1.24, p = .29$).

Bias towards the left key (i.e., less punished) was fairly large even in the first block ($M = .37 \text{ and} .33$ for the A-ADHD and control group respectively). Figure 2 (right panel) shows that mean bias increased from Block 1 to 3 ($M = .35, .52, .72$), and there was a significant main effect of block ($F_{1.8,86.5} = 17.94, p < .01$). The control group’s bias was slightly higher overall than the A-ADHD group’s ($M = .57 \text{ compared to} .50$), however, there was no main effect of group ($F_{1.47} = .34, p = .56$), and no significant block-by-group interaction ($F_{1.8,86.5} = .09, p = .90$).
Figure 2. Means and standard error of discriminability (left panel) and response bias (right panel) for control and A-ADHD groups for Part A are plotted across blocks.

**Part B (Unequal reward/equal punishment)**

Mean discriminability increased only slightly from Block 1 to 3 (M = .57, .59, .61 in each block; Figure 3, left panel), and there was no significant main effect of block (F_{2,84} = .88, p = .42). Furthermore, the two group’s overall discriminabilities were similar (M = .59 compared to .60 for control and A-ADHD, respectively) and no main effect of group was found (F_{1,42} = .056, p = .81). There was also no significant block-by-group interaction (F_{2,84} = .015, p = .99).

Figure 3 (right panel) shows the mean response bias for the right key (i.e., more rewarded) for each group. There was a clear difference between the groups, as the A-ADHD group’s scores were higher than the control group’s (M = -.01 compared to -.46), this was supported by a significant main effect of group (F_{1,42} = 5.43, p < .05). As the two groups’ bias levels were moving in opposite directions, no main effect of block was found (F_{1,4,59} = 1.19, p = .30). However, there was a significant block-by-group interaction (F_{1,4,59} = 6.58, p < .01), as
the A-ADHD group’s bias increased while the control group’s decreased (M = -.25, .08, -.13 compared to -.37, -.47, -.55 in each block). Bias was at a strong negative level (i.e., towards the less rewarded key) in the first block (M = -.25 and -.37 for the A-ADHD and control group respectively).

*Figure 3.* Means and standard error of discriminability (left panel) and response bias (right panel) for control and A-ADHD groups for Part B are plotted across blocks.

**Depression: Discriminability and Bias**

Shapiro-Wilk tests showed that no data sets in this condition were non-normally distributed. The assumption of homogeneity of variance was not violated in any of the data sets split by group and block (all $p > .05$). The assumption of sphericity was violated in the bias dataset of Part B when split by depression subscale ($p < .05$). Greenhouse-Geisser corrected $p$ values are provided as a result.

For each Part separately, repeated measures ANOVA tests were run on the measures of discriminability and bias individually with block as the within-subjects factor and depression group (control, MILD, MOD) as the between-subjects factor.
**Part A (Equal reward/unequal punishment)**

Figure 4 (left panel) shows little difference in discriminability across the three groups from the first to the last block (M = .58, .58, .63 in each block), and no significant main effect of block was found (F_{1.8,83.8} = 1.65, p = .20). The three groups had similar mean scores (M = .61, .59, .59, for control, MILD, and MOD groups, respectively), and no main effect of group was found (F_{2,46} = .09, p = .92). There was also no significant group-by-block interaction (F_{3,6,83.8} = .62, p = .64).

The right panel of Figure 4 shows that the mean bias towards the left key (i.e., less punished) increased across blocks (M = .35, .52, and .72) and there was a significant main effect of block (F_{1.8,83.8} = 18.29, p < .01). Even in the first block, all groups had a fairly high bias (M = .30, .46, .30 for the control, MILD, and MOD groups, respectively). No main effect of group was found (F_{2,46} = .64, p = .53), nor was there a significant group-by-block interaction (F_{3,6,83.8} = .61, p = .64).

**Figure 4.** Means and standard error of discriminability (left panel) and response bias (right panel) for control, MILD and MOD groups for Part A are plotted across blocks.
Part B (Unequal reward/equal punishment)

Figure 5 (left panel) shows that the mean discriminability increased slightly across blocks (M = .57, .59, .61, in each block), but there was no main effect of block (F_{2,81.5} = 1.34, p = .27). The MOD group’s discriminability was higher than the other groups’ in the first and third block but not in the second block (M = .72, .61, .76 for MOD, compared to M = .54, .59, .61, and M = .56, .60, .56 for the control and MILD groups, respectively). However, no main effect of group was found (F_{2,41} = 1.86, p = .17), nor was there a significant block-by-group interaction (F_{4,81.5} = 1.96, p = .11).

Figure 5 (right panel) shows that the mean bias towards the right key (i.e., more rewarded) showed little change over the blocks for all groups (M = -.34, -.33, -.38, in each block). Participants’ bias remained, on average, negative for the duration of all three blocks. No significant main effect of block (F_{1,4,55.4} = .15, p = .78) or group (F_{2,41} = .23, p = .80) was found, nor was there a significant block-by-group interaction (F_{2.7,55.4} = .35, p = .77).

Figure 5. Means and standard error of discriminability (left panel) and response bias (right panel) of control, MILD, and MOD groups, for Part B are plotted across blocks.
Discussion

The present experiment investigated sensitivity to reward and punishment in relation to symptoms of Adult ADHD and depression in a non-clinical sample of participants. Reward and punishment sensitivity were measured using a SD task that provided participants with either equal frequencies of rewards and unequal frequencies of punishment for their choices, or unequal frequencies of rewards and equal frequencies of punishments. Participants were grouped by severity of ADHD or depressive symptoms using their responses on the ASRS and PHQ-9 scales.

Participants performed well on the present experiment’s task as they had a hit rate of nearly 80% in the first block. This shows participants engaged with the task and performed it as desired, attending to it rather than selecting alternatives at random. Participants’ response bias towards the better alternative (i.e., less punished key in Part A, more rewarded key in Part B) also increased overall. In Part A, this was seen in all participant groups. This shows that participants responded to the unequal frequency of punishments as desired. However, in Part B, an increase was only found in the A-ADHD group but not its respective control group, nor in any of the depression comparison groups; rather, these groups displayed a relatively unchanging negative response bias (i.e., towards the less rewarded key). This indicates that most participants did not respond to the uneven frequencies of rewards in the task. Indeed, control participants in Part B of the ADHD comparisons decreased in bias (i.e., preferred the less rewarded key), which indicates that something may have blocked learning of consequence frequencies, this is discussed further below.

There was a moderately strong correlation between the scores of participants on the ASRS and the PHQ-9. This is consistent with a high comorbidity of ADHD and MDD in the general population (APA, 2013). Since the participants in the present experiment were University students, it is also consistent with Bray’s (2014) finding that College students with
ADHD often suffer from depression as a result of academic struggles. While the number of participants screened as having MDD and Adult ADHD was greater than expected, this was true for both scales, consistent with the correlation found between the two scales; this will be discussed further in each scale’s section and the General Discussion.

A-ADHD

Part A found no differences between control and A-ADHD participants in punishment sensitivity. This did not support the hypothesis that adults with ADHD would display higher punishment sensitivity, as found in children (e.g., Furukawa et al., 2016). This raises two possibilities. First, adults with ADHD are not abnormally sensitive to punishment compared to the general population. Second, the present experiment failed to detect an effect. Since the extent to which ADHD continues into adulthood is unclear, it is uncertain which of these alternatives may be more likely. This problem will be discussed in further detail in the General Discussion.

Part B of the present experiment found A-ADHD participants displayed significantly higher reinforcement sensitivity than control participants, as shown by higher response bias towards the more rewarded alternative across all blocks. Indeed, control participants failed to develop a response bias towards the more rewarded alternative and instead remained biased towards the less rewarded alternative. These results are inconsistent with Thoma et al.’s (2015) study that found adults with ADHD showed impaired reward learning when differences between reward and punishment frequencies were large. The task used in the present study differed from Thoma et al.’s (2015). In their study, participants chose between two stimuli and received a reward or punishment on every response; one stimulus gave rewards more frequently than punishments, the other stimulus gave punishments more frequently than rewards. However, in the present study, participants were not given rewards and punishments on every response, and their performance impacted the amount of rewards and punishments they
received. Furthermore, the participants in the present study were from a non-clinical sample grouped by the ASRS. In contrast, Thoma et al.’s (2015) participants were all formally diagnosed with ADHD. This was also the case in other past studies examining ADHD and reward sensitivity (e.g., Tripp & Alsop, 1999; Alsop et al., 2016).

These results are also inconsistent with past research indicating that children with ADHD display some hyposensitivity to reward, especially to global frequencies (i.e., overall reinforcement rate) but may display some hypersensitivity to local reward frequencies, that is, what has just been rewarding (e.g., Tripp & Alsop, 1999). It may be that A-ADHD participants responded strongly to local reward frequencies which counteracted the initial bias away from the more rewarding key. This does not account for why control participants did not learn the overall reward frequencies (or why they displayed a decrease in bias over blocks) while A-ADHD participants did.

Thirty-seven of 101 participants screened positive for A-ADHD on the ASRS. Since the prevalence of childhood ADHD in the general population is about 5%, and the prevalence of adult ADHD in the general population is about 4.4%, this is a very high number of participants to screen positively (Kessler et al., 2006; Onnink, 2014). As such, the criteria of the ASRS may have been too liberal and included participants who do not qualify for actual Adult ADHD. However, the ASRS has been found to be a valid scale, with a high concordance rate to professional diagnoses (Kessler et al., 2006). This issue will be discussed in further detail in the General Discussion.

**Depression**

There were no differences in reward or punishment sensitivity between participants in the control, MILD, and MOD groups. This finding is inconsistent with past studies that have found reward hyposensitivity and, less consistently, punishment hypersensitivity in depressed
individuals (e.g., Pizzagalli et al., 2008; Vrieze et al., 2013; Elliott et al., 1996). Unlike these earlier studies, the present experiment did not use a clinical population. Although the depression group cut-offs used in this study have had good success in the past in screening for MDD (e.g., Kroenke et al., 2001), nearly a quarter of the participants in the study were screened as having MDD. While 60 participants were classified as having mild-or-worse depression, 24 were classified as having moderate-or-worse depression. Given that the prevalence of MDD is about 7% in the general population, the number of participants who screened positive for MDD in the present experiment is very high. Similar to the ASRS, the PHQ-9 has been found to have a high sensitivity and specificity (88% for both) for MDD using the moderate depression (10 points or more) cut-off point (Kroenke, Spitzer, & Williams, 2001); this would mean in the present experiment’s sample there was a prevalence of 24%. As such, the criteria of the PHQ-9 may have been too liberal and included false positives of depressed participants in the MILD and MOD groups. The implications of this will also be discussed in more detail in the General Discussion.

Limitations

The present experiment had several clear limitations. First, ADHD and MDD are associated with abnormalities in reward and punishment sensitivity. While there was a moderately strong correlation between participants’ ASRS and PHQ-9 scores, there were still participants who qualified for one group but not the other. In this way, the control group for each analysis may not have represented a proper group with normal reward and punishment sensitivity. Because of this, alternative analyses using a filtered control group were also run. This control group comprised of participants who scored negative for A-ADHD, and had no evidence of depression (i.e., score of less than 5 on the PHQ-9). There were 11 control participants for Part A analyses, and 18 control participants for Part B. Only one instance was affected in a significant way: the main effect of group in the bias analysis of Part B comparing
the control and A-ADHD was not significant using this control group ($F_{1,27} = 2.51, p = .13$). However, the overall means and trend did not change much in this analysis, thus the lack of effect may have been due to the lower sample size.

Second, participants displayed a response bias to the left key (less punished in Part A, less rewarded in Part B) even in their first block of 150 trials. Although this should not have impaired participants' learning of the reward and punishment frequencies in the experiment, it is possible that it affected it to some degree and may have reduced some learning. Bias did strengthen towards the less punished key in Part A of the experiment as expected. However, in Part B, response bias towards the more rewarded key failed to develop. Indeed, with the exception of the A-ADHD group, all participant groups displayed negative average biases (i.e. bias away from the more rewarded key) in every block of the experiment in Part B. Furthermore, the control group’s bias towards the more punished key increased over the course of the experiment. Given the fairly high reward frequency discrepancy between the two keys (1:5), these are unusual findings, especially the finding that bias towards the more punished key increased. Although it is not clear if the inherent bias of the stimuli did affect learning of reward and punishment frequencies, it would be of interest to use stimuli with less inherent response bias to eliminate this possible confound. Experiment 2 addresses this issue.

Last, the scales used in the present experiment may also have presented a limitation. The ASRS and PHQ-9 have been found to be valid scales, with high rates of correct diagnoses (e.g., Kessler et al., 2006; Kroenke et al., 2001). However, the sample of participants in the present experiment had prevalence rates of Adult ADHD and depression (37% and 24%, respectively) well above the estimated normal prevalence rates (around 4.4% and 7%, respectively). This indicates that there were either issues with the sample (i.e., excessively high rates of ADHD and MDD) or the scales (i.e., overly liberal inclusion criteria).
Experiment 2

Experiment 2 addressed some of the limitations found in Experiment 1. First, several pilot procedures using a variety of stimuli and equal reward and equal punishment frequencies were run in order to eliminate any possible effects of the strong inherent bias seen in Experiment 1. Stimuli comprised of horizontal and vertical lines were found to show the least inherent bias of those tested.

Second, although the PHQ-9 and ASRS have shown good validity as screening measures (Kessler et al., 2006; Kroenke et al., 2001), Experiment 1 found an unexpectedly large proportion of participants tested positive for MDD and adult ADHD. It was therefore decided to include other scales to corroborate the PHQ-9 and ASRS. Reward and punishment sensitivity can be measured via direct measures (e.g., a SD task as in Experiment 1) or indirect measures (e.g., psychometric scales). Psychometric scales provide a quick and simple corroboration for direct measures (e.g., the present experiment’s task) as well another way to investigate the effects of depression and adult ADHD symptoms, by correlating the scales against one another. Carver and White (1994) developed the Behavioural Inhibition System/Behavioural Activation System (BIS/BAS) Scales as a quick way to measure punishment and reward sensitivity, respectively. The scales have been used and corroborated extensively in a variety of settings (Carver & White, 1994). For example, they have been used as a way of measuring reward and punishment sensitivity in depression (e.g., Kasch, Rottenberg, Arnow, & Gotlib, 2002), ADHD (e.g., Barnhart & Buelow, 2017; Lie, Zhang, Xiao, & Nie, 2016), and other disorders such as anorexia nervosa (e.g., Harrison, Sternheim, O’Hara, Oldershaw, & Schmidt, 2016). In this way, the BIS/BAS scales are a useful corroborating measure for ADHD and depression because of their past use in research with these disorders.
There is relatively little research comparing individuals’ results on Carver and White’s (1994) scales and behavioural tasks, such as the SD task used in the present experiment and prior studies (e.g., Tripp & Alsop, 1999; Furukawa et al., 2016; Pizzagalli et al., 2008). Carver and White’s (1994) BIS/BAS scales therefore provide an opportunity to compare participants’ depression and ADHD scores to another measure, as well as to corroborate a highly used scale against a well-established behavioural task measuring the same variable.

The hypotheses for Experiment 2 were extensions of those in Experiment 1. It was predicted that participants with higher ADHD symptoms may show lower sensitivity to reward and lower BAS scale scores (e.g., Tripp & Alsop, 1999), but higher sensitivity to punishment and higher BIS scale scores (e.g., Furukawa et al., 2016). Furthermore, it was predicted that participants with higher depressive symptoms would show lower sensitivity to reward and lower BAS scale scores (e.g., Pizzagalli et al., 2008) as well as higher sensitivity to punishment and higher BIS scale scores (e.g., Elliott et al., 1996). Lastly, it was predicted that participants’ levels of response bias for unequal punishment and unequal reward would correlate with their scores on the BIS/BAS scales, respectively.
Method

Participants

There were 118 participants, of which 91 were female and 27 were male. Participants were first- and second-year Psychology students at the University of Otago and ranged in age from 18 to 36 (M = 19.47, SD = 1.8). Students participated as an optional component of their papers. Their medical or psychiatric histories were not gathered, with their responses on the ASRS, PHQ-9, and BIS/BAS scales providing measures of ADHD, depression, and reward/punishment sensitivity, respectively. Ethical approval for the study was obtained from the University of Otago Ethics Committee.

Apparatus

As in Experiment 1, the experiment was run in University of Otago Psychology computer laboratory rooms. Participants sat with at least one spare computer between each person, and the room was kept quiet in order to minimise distractions. Computer monitors had a screen size of 480x270mm with a resolution of 1680x1050. A Google Forms survey was used to present the PHQ-9, ASRS, and BIS/BAS scales (see Appendices A, B, and F) that participants responded to.

Each computer displayed a custom-made signal-detection task in which participants were shown a 16x16 grid of 256 horizontal and vertical lines on a white background. This grid was 92mm by 92mm, each line was 4mm by 1mm (or 1mm by 4mm) and had a 2mm gap between them. On each trial, the horizontal and vertical lines’ positions were randomly generated, and there was a ratio of 53:47 of either horizontal:vertical lines or vertical:horizontal lines. Two response buttons were positioned on the screen below the grid. The left response button read “H –” and was the correct response when there were more horizontal lines than vertical lines. The right response button read “V |” and was the correct response when there
were more vertical lines than horizontal lines. Each button was 47mm by 28mm in size. There was also a counter positioned above the grid showing the number of trials remaining on the task.

**Procedure**

The general procedure was, for the most part, the same as Experiment 1 and only differences will be described below. Participants sat at a computer and were given an information sheet (see Appendix C) and consent form (see Appendix D) to read through and sign. If participants had issues, they were asked to inform the experimenter quietly.

Participants again completed one of two parts of the experiment, Part A (3351, Equal reward/unequal punishment) or Part B (1533, Unequal reward, equal punishment). The instructions given to participants differed slightly due to the new stimuli:

"In this simple computer task, you will see some patterns made up of Vertical lines, |, and Horizontal lines, -. You must decide whether there are more | or -. Click ‘Next’ to see an example –"

"If the pattern has more Horizontal lines, then you should click the H - button. If the pattern has more Vertical lines, then you should click the V | button."

"Most of the time, you will get NO feedback, but sometimes you will be rewarded for maintaining accuracy and you will have 10 trials FEWER to complete the task. Sometimes you will be punished for being inaccurate and you will have 10 trials MORE to complete the task."

"You start with 500 trials to complete before the task ends. Remember, trials will be added or subtracted to encourage accuracy. If you have any questions, please ask the experimenter."

Participants again received different frequencies of rewards and punishers depending on what Part (A or B) they completed. In Part A, participants were equally likely to be rewarded
for correct identification of either more horizontal lines or more vertical lines. However, participants were five times more likely to be punished for incorrectly identifying more horizontal lines than vertical lines. In Part B, participants were five times more likely to be rewarded for identifying more vertical lines than horizontal lines, but equally as likely to be punished for incorrect identification of either more horizontal lines or more vertical lines. The distribution of rewards and punishers was scheduled in the same way as in Experiment 1.

After participants completed their computer task, they were given the questionnaire gathering their age, gender, PHQ-9, ASRS, and BIS/BAS scale responses. Finally, participants received a debrief sheet (see Appendix E), were thanked for participating, and told they were free to leave.
Results

Comparison of Scales

Table 2 shows that there were numerous correlations between the various scales administered in the present experiment. Consistent with the correlation between PHQ-9 and ASRS scores found in Experiment 1 ($r = .43$ and .60 for the two groups), a moderate correlation was also found between participants’ scores on these two scales in the present experiment ($r = .46$ and $r = .45$ for Part A and Part B respectively, both $p < .01$). Participants’ ASRS scores also correlated significantly with the Drive and Fun Seeking subscales of the BAS scale ($r = .31$ and .41, respectively, both $p < .01$), as well as the BAS Total scale ($r = .37$, $p < .01$).

**Table 2. Correlations between ASRS, PHQ-9, and BAS/BIS scales.**

<table>
<thead>
<tr>
<th></th>
<th>PHQ9</th>
<th>BASD</th>
<th>BASFS</th>
<th>BASRR</th>
<th>BIS</th>
<th>BAST</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASRST</td>
<td>.44**</td>
<td>.31**</td>
<td>.41**</td>
<td>.16</td>
<td>-.06</td>
<td>.37**</td>
</tr>
<tr>
<td>PHQ9</td>
<td></td>
<td>-.11</td>
<td>.06</td>
<td>-.23*</td>
<td>.05</td>
<td>-.11</td>
</tr>
<tr>
<td>BASD</td>
<td></td>
<td></td>
<td>.51**</td>
<td>.52**</td>
<td>.05</td>
<td>.85**</td>
</tr>
<tr>
<td>BASFS</td>
<td></td>
<td></td>
<td></td>
<td>.40**</td>
<td>.05</td>
<td>.79**</td>
</tr>
<tr>
<td>BASRR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.22*</td>
<td>.78**</td>
</tr>
<tr>
<td>BIS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.09</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).**

Furthermore, participants’ PHQ-9 scores were significantly negatively correlated with the Reward Responsiveness (BASRR) subscale of the BAS scale ($r = -.23$, $p < .05$), but not any other part of the BIS/BAS scales. Moderate correlations were also found between the subscales of the BAS. Furthermore, and not surprisingly, each of the subscales was strongly
correlated with the total BAS score. Additionally, the BASRR subscale was weakly correlated with the BIS scale ($r = .22$, $p < .05$).

**Data Analysis**

In each trial, participants’ responses were recorded and converted from right/left (vertical/horizontal) responses into correct right ($B_{11}$), incorrect right ($B_{12}$), correct left ($B_{22}$), and incorrect left ($B_{21}$) responses. As in Experiment 1, three blocks of 150 were used for the first 450 trials of each participant to examine their performance. Discriminability ($\log d$) and response bias ($\log b$) were calculated, using the same formulae described in Experiment 1.

If any participant had a discriminability of 0.1 or less in any block of 150 trials, this participant was removed from all analyses. In Part A, nine participants were excluded from the analyses, in Part B, seven participants were excluded from the analyses. Any outliers in the bias dataset (i.e., more than two standard deviations from the mean) were again excluded for a separate analysis. Where this exclusion caused statistically significant differences in analyses, it is reported below.

For categorical comparison of participants, participants were grouped into the ADHD group or control group using the same method as in Experiment 1, as was the grouping of participants into the control, MILD, and MOD depression groups. Table 3 shows the age and gender breakdown of participants in each group.
Table 3. Demographics of participants in Experiment 2.

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Age (SD)</th>
<th>Gender (M/F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part A Control</td>
<td>24</td>
<td>19.2 (.9)</td>
<td>5/19</td>
</tr>
<tr>
<td>PHQ-9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MILD</td>
<td>25</td>
<td>19.1 (.8)</td>
<td>6/19</td>
</tr>
<tr>
<td>MOD</td>
<td>10</td>
<td>18.9 (.7)</td>
<td>1/9</td>
</tr>
<tr>
<td>ASRS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>39</td>
<td>19.5 (1.0)</td>
<td>5/34</td>
</tr>
<tr>
<td>A-ADHD</td>
<td>20</td>
<td>19.2 (.8)</td>
<td>7/13</td>
</tr>
<tr>
<td>Part B Control</td>
<td>25</td>
<td>20.0 (3.5)</td>
<td>5/20</td>
</tr>
<tr>
<td>PHQ-9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MILD</td>
<td>23</td>
<td>19.2 (.7)</td>
<td>8/15</td>
</tr>
<tr>
<td>MOD</td>
<td>11</td>
<td>19.1 (1.4)</td>
<td>2/9</td>
</tr>
<tr>
<td>ASRS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>31</td>
<td>19.9 (3.1)</td>
<td>8/23</td>
</tr>
<tr>
<td>A-ADHD</td>
<td>28</td>
<td>19.1 (1.0)</td>
<td>7/21</td>
</tr>
</tbody>
</table>

**BIS/BAS Scales Correlational Data**

Table 4 shows the correlations between participants’ measures of discriminability and bias taken from the third block of 150 trials and the BIS/BAS subscales. There were no statistically significant correlations with discriminability or bias between any BAS subscales, their combined total, or the BIS subscale. Although these measures of discriminability and response bias are taken from the third block of 150 trials, no statistically significant correlations were found in either the first or second block of 150 trials either.
Table 4. Correlations of the BIS/BAS scales with discriminability and bias from Block 3.

<table>
<thead>
<tr>
<th></th>
<th>3315&lt;sup&gt;a&lt;/sup&gt;</th>
<th>1533&lt;sup&gt;b&lt;/sup&gt;</th>
<th>3351&lt;sup&gt;a&lt;/sup&gt;</th>
<th>1533&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASD</td>
<td>-.10</td>
<td>.17</td>
<td>-.01</td>
<td>-.17</td>
</tr>
<tr>
<td>BASFS</td>
<td>.17</td>
<td>.17</td>
<td>.07</td>
<td>.10</td>
</tr>
<tr>
<td>BASRR</td>
<td>.13</td>
<td>.00</td>
<td>.12</td>
<td>-.20</td>
</tr>
<tr>
<td>BIS</td>
<td>.19</td>
<td>-.00</td>
<td>-.09</td>
<td>-.16</td>
</tr>
<tr>
<td>BAST</td>
<td>.08</td>
<td>.14</td>
<td>.07</td>
<td>-.10</td>
</tr>
</tbody>
</table>

<sup>a</sup> = Even reward, uneven punishment group;  
<sup>b</sup> = Uneven reward; even punishment group.

**A-ADHD: Discriminability and Bias**

All data sets were tested for the assumptions of ANOVA: normality of distribution, homogeneity of variance, and sphericity. The assumption of normality of distribution was violated in several datasets. In Part A, it was violated in the control group’s third block of the bias dataset, as well as the A-ADHD group’s second and third blocks of the bias dataset. For Part B, it was violated in the control group’s second and third blocks of the bias dataset, as well as the A-ADHD group’s second and third blocks in both the discriminability and bias datasets. Also in Part B, the assumption of homogeneity of variance was violated in the second block of the discriminability dataset, as well as the first block of the bias dataset. Furthermore, the assumption of sphericity was violated in both Parts’ bias datasets.

For each Part separately, repeated measures ANOVA tests were run on the measures of discriminability and bias individually with block as the within-subjects factor and A-ADHD
group as the between-subjects factor. Greenhouse-Geisser corrected $p$ values were used because of the violations of sphericity.

**Part A (Equal reward/unequal punishment)**

Figure 6 (left panel) shows that discriminability rose over the three blocks ($M = .35, \ .41, .42$ in each block), and this was supported by a significant main effect of block ($F_{1,9,92.6} = 9.37, p < .01$). The two groups showed similar levels of discriminability over the three blocks ($M = .39$ and .39 for control and A-ADHD groups, respectively) and there was no significant main effect of group ($F_{1,48} = 0, p = .99$) nor a block-by-group interaction ($F_{1,9,92.6} = 1.74, p = .18$).

The right panel of Figure 6 shows participants’ bias towards the less punished key grew steadily over the three blocks ($M = -.06, .08, .19$ in each block). This was supported by a main effect of block ($F_{1,6,74.9} = 12.67, p < .01$). Although A-ADHD participants displayed a higher bias than control participants overall ($M = .15$ compared to .03), no significant main effect of group was found ($F_{1,48} = 1.5, p = .23$). There was also no significant block-by-group interaction ($F_{1,6,74.9} = .06, p = .90$).
Figure 6. Means and standard error of discriminability (left panel) and response bias (right panel) of control and A-ADHD group, for Part A are plotted across blocks.

*Part B (Unequal reward/equal punishment)*

Figure 7 (left panel) shows that participants’ discriminability increased over the three blocks (M = .39, .44, .45 in each block). This was supported by a significant main effect of block ($F_{1,96.5} = 4.47, p < .05$). Although control participants displayed higher discriminability (M = .44 compared to .41), no significant main effect of group was found ($F_{1,50} = .97, p = .33$). Furthermore, there was no significant block-by-group interaction ($F_{1,96.5} = 2.48, p = .09$).

Figure 7 (right panel) shows that participants’ bias towards the more rewarded key increased over time (M = -.11, .03, .08), and there was a significant main effect of block ($F_{1,68.14} = 10.61, p < .01$). The two groups showed similar levels of response bias overall (M = .00 for both groups). No significant main effect of group was found ($F_{1,50} = .02, p = .88$), nor a significant block-by-group interaction effect ($F_{1,68.14} = .53, p = .56$).
Figure 7. Means and standard error of discriminability (left panel) and response bias (right panel) of control and A-ADHD group, for Part B are plotted across blocks.

Correlational Analysis

Participants’ ASRS scores did not significantly correlate with discriminability or response bias in any block.

Depression: Discriminability and Bias

Shapiro-Wilk tests showed that several datasets were non-normally distributed. In Part A, the bias dataset’s second block for the control group and the third block for the MOD group were non-normally distributed. In Part B, the discriminability dataset’s third block for the control and MOD groups, as well as the second block of the bias dataset for the MOD group were non-normally distributed. The assumption of homogeneity of variance was violated in the second and third block of the bias dataset for Part A. It was also violated in the first block of Part B’s discriminability dataset, as well as the second and third blocks of Part B’s bias dataset. The assumption of sphericity was violated in the bias dataset of both parts. Greenhouse-Geisser corrections were used for all \( p \) values as a result.
For each Part separately, repeated measures ANOVA tests were run on the measures of discriminability and bias individually with block as the within-subjects factor and depression group (control, MILD, MOD) as the between-subjects factor.

**Part A (Equal reward/unequal punishment)**

The left panel of Figure 8 shows that participants’ discriminability increased on average across the three groups (M = .35, .41, .43 in each block), this was supported by a significant main effect of block (F1.90.4 = 7.95, p < .01). No main effect of group was found (F2.47 = .64, p = .53), nor was there a significant block-by-group interaction (F3.90.4 = .65, p = .63).

Figure 8 (right panel) shows that participants’ bias toward the less punished key increased over the experiment (M = -.06, .08, .19 in each block), and this increase was statistically significant (F1.6.74.6 = 11.11, p < .01). The control group had higher response bias overall (M = .12, .04, -.08 for control, MILD, MOD, respectively), but no significant main effect of group was found (F2.47 = 1.26, p = .29). The control and MILD groups’ bias levels increased over the three blocks, whereas the MOD group’s bias increased only slightly in the second block (M = -.07, .12, .31 for control; -.02, .09, .18 for MILD; -.16, -.02, -.06 for MOD). However, no block-by-group interaction was found to support these differences (F3.2.74.6 = 1.76, p = .16).
Figure 8. Means and standard error of discriminability (left panel) and response bias (right panel) of control, MILD, and MOD groups, for Part A are plotted across blocks.

**Part B (Unequal reward/equal punishment group)**

Figure 9 (left panel) shows participants’ discriminability increased on average (M = .39, .44, .45) but this increase was not significant (F\(_{1,94}\) = 2.66, \(p = .08\)). The differences between groups’ discriminabilities were negligible and there was no significant main effect of group (F\(_{2,49}\) = .22, \(p = .80\)). There was no significant block-by-group interaction (F\(_{3,8,94}\) = 1.45, \(p = .22\)).

The right panel of Figure 9 shows that participants’ bias for the more rewarded key increased overall (M = -.11, .03, .08 in each block) and there was a significant main effect of block (F\(_{1,7,82}\) = 15.51, \(p < .01\)). Overall, the control group displayed the lowest bias, while the MILD and MOD groups displayed higher biases respectively (M = -.07, -.01, .20, respectively), the main effect of group approached significance (F\(_{2,49}\) = 3.16, \(p = .051\)). A post-hoc Tukey test found the control and MOD group differed significantly from each other (\(p < .05\)), but no other groups. Although the three groups showed similar levels of bias in the first block, the MOD group’s bias increased more than the control group and MILD groups’ over subsequent
blocks (M = -.11, -.05, -.04 for control; -.14, .02, .10 for MILD; -.04, .25, .38 for MOD, in each block). The block-by-group interaction effect approached significance (F_{3.4, 82} = 2.44, p = .06). When outliers were removed from the bias dataset, neither the main effect of group (F_{2, 44} = .09, p = .91) nor the block-by-group interaction effect (F_{3.5, 76.4} = 1.53, p = .21) were near significant.

![Graph](image_url)

Figure 9. Means and standard error of discriminability (left panel) and response bias (right panel) of control, MILD, and MOD groups, for Part B are plotted across blocks.

**Correlational Analysis**

Figure 10 (left panels) shows the correlation between PHQ-9 scores and response bias in Part A, for each block of 150 trials separately, while the right panels show this for Part B. It shows that in Part A, an increase in PHQ-9 scores was correlated with a decrease in response bias. However, this correlation only reached significance in the third block of 150 trials (r = -.29, p < .05). In Part B, an increase in PHQ-9 scores was correlated with an increase in response bias. Figure 10 (right side) shows this correlation was significant in both the second (r = .43, p < .01) and the third (r = .41, p < .01) blocks of the experiment. When outliers more than two
standard deviations from the mean were excluded, no significant correlations between PHQ-9 scores and bias were found in any block in either Part (all $p > .05$).

Figure 10. The left three panels display correlations between participants’ PHQ-9 scores and response bias for the Even reward/uneven punishment condition, while the right show the same for the Uneven reward/even punishment condition. Each graph represents a block of 150.
Discussion

The present experiment again investigated reward and punishment sensitivity in relation to symptoms of ADHD and depression in a non-clinical sample of participants. It used a SD task slightly modified from Experiment 1 to reduce inherent bias towards one stimulus type. Reward and punishment sensitivity were also measured using the BIS/BAS scales developed by Carver and White (1994). These measures were investigated by grouping participants by the severity of their ADHD or depressive symptoms using their responses on the ASRS and PHQ-9 scales.

Participants performed well on the present experiment’s task, displaying hit rates of about 70% in the first block of 150 trials. While this is slightly lower than in Experiment 1, it is still a good performance level and shows that participants attended to the task properly, rather than picking responses at random. Participants’ bias towards the better alternative (i.e., less punished key in Part A, more rewarded key in Part B) increased on average across all groups of the experiment. This shows that overall, participants were sensitive to the unequal contingencies provided to them and learned to respond to the more favourable option.

A moderately strong correlation was again found between the scores of participants on the ASRS and PHQ-9; this is unsurprising because there is a strong comorbidity between ADHD and MDD, even more so in University student populations (APA, 2013; Bray, 2014). Scores on the ASRS were also significantly correlated with scores on the Drive and Fun Seeking subscales of the BAS, which is consistent with the findings that individuals with ADHD are impulsive. These subscales are related to individual reward responsiveness (e.g., Drive subscale: “12. If I see a chance to get something I want I move on it right away”) and impulsivity (e.g., Fun Seeking subscale: “5. I’m always willing to try something new if I think it will be fun”). A weak negative correlation between scores on the ASRS and BAS-Reward Responsiveness was not statistically significant. This trend is, however, consistent with prior
research findings that individuals with ADHD display some hyposensitivity to reward (e.g., Tripp & Alsop, 1999; Thoma et al., 2016). There was also no significant correlation between the ASRS and the BIS subscale. This was unexpected since children with ADHD have also been found to experience punishment as more averse (e.g., Furukawa et al., 2016).

Scores on the BAS-Reward Responsiveness subscale were also significantly negatively correlated with scores on the PHQ-9. This is consistent with findings that depressed individuals display hyposensitivity to reward (e.g., Pizzagalli et al., 2008), but, the correlation was weak ($r = -.23$). Furthermore, no significant correlation was found between scores on the PHQ-9 and the BIS. This was unexpected because the BIS is claimed to measure a system which is hypersensitive in depressed individuals (Carver & White, 1994). Overall, parts of the BIS/BAS scales were only weakly correlated with the ASRS and PHQ-9, which have been found to be valid scales (Kessler et al., 2006; Kroenke et al., 2001). Taken together, this indicates they may not be useful in studying ADHD and MDD.

There was also no significant correlation between any BIS/BAS subscale and discriminability or bias in any block of the present experiment. The present experiment used a type of probabilistic learning task, a well-established method of measuring reward and punishment sensitivity that has been used extensively (e.g., Tripp & Alsop, 1999; Pizzagalli et al., 2008; Vrieze et al., 2013). This lack of correlation is concerning because the scales claim to act as a quick and easy way to measure reward and punishment sensitivity (Carver & White, 1994). It may therefore be prudent to corroborate the scales against other more direct measures of reward and punishment sensitivity to ensure they are performing as intended.

**A-ADHD**

No differences in reward or punishment sensitivity between participants in the control and A-ADHD groups were found in the present experiment. This is inconsistent with prior
findings that children and adults with ADHD display some hyposensitivity to reward (e.g., Tripp & Alsop, 1999; Alsop et al., 2016; Thoma et al., 2016) and hypersensitivity to punishment (e.g., Furukawa et al., 2016). Although Experiment 2’s finding regarding reward sensitivity is inconsistent with the results of Experiment 1, the finding concerning punishment sensitivity is consistent with Experiment 1’s results. This will be discussed in further detail in the General Discussion.

Again, past studies have used clinical samples of formally diagnosed children (or adults) whereas the present sample were only screened for Adult ADHD through the ASRS. Although this scale has been found to have a high concordance with professional diagnoses, an unexpectedly large number of participants in the present experiment were screened with Adult ADHD (40.7%). ADHD is estimated to have a 5% incidence rate in the general population, or a 4.4% incidence rate in adults (APA, 2013; Kessler et al., 2006). In comparison, past studies have found that the prevalence of ADHD can be as high as 20% in University students (e.g., Atwoli, Owiti, Manguro, & Ndambuki, 2011; Shanbhag & Nayak, 2015). This suggests the validity of the ASRS may be lower than previously thought. This will be discussed in relevance to Experiment 1’s findings regarding the ASRS in the General Discussion.

As in Experiment 1, the control groups for the ADHD and depression analyses included participants who screened positive for depression or ADHD, respectively. Because of past research indicating that both disorders are associated with abnormalities in reward and punishment sensitivity, alternative analyses using a filtered control group were run. Again, this control group included participants who had screened negative for Adult ADHD and any signs of depression. Part A analyses had 16 control participants and Part B analyses had 18 control participants. The results of the A-ADHD analyses were not affected in any significant way for either Part A or Part B.
Depression

Although depressed individuals showed a lower sensitivity to punishment than control individuals in Part A, the results showed no significant group or interaction effect. Furthermore, the weak negative correlation between PHQ-9 score and bias towards the less punished key was only significant in the third block of the experiment. Overall, these results were inconsistent with past reports that depressed individuals display hypersensitivity to punishment (e.g., Elliott et al., 1996). They are, however, somewhat consistent with Must et al.’s (2006) finding that depressed people did not differ from controls in punishment measured by the IGT. The present findings are also consistent with Henriques et al.’s (1994) finding a similar trend for punishment hypersensitivity in depressed people. Taken together, the present results do not clarify these conflicting findings.

In Part B, MILD and MOD participants were more sensitive to reward than controls. This was evident from the overall group effect as well as the marginally significant block-by-group interaction which found that MOD participants had a higher rate of increase in bias towards the more rewarded key than controls, but not MILD participants. This effect was supported by correlational data, where there was a moderately strong correlation between PHQ-9 score and bias for the second and third block in Part B. This finding is inconsistent with past studies that have found depressed individuals to display hyposensitivity to reward (e.g., Pizzagalli et al., 2008; Vrieze et al., 2013). However, it is consistent with Must et al.’s (2006) finding that depressed participants displayed reward hypersensitivity on the IGT. Must et al. (2013) explained that this might indicate hypersensitivity to local rather than global reward frequencies. This will be discussed in more detail in the General Discussion.

When participants whose bias was more than two standard deviations from the mean were removed, the effects and correlations found in Part B were not statistically significant. This indicates that a small subgroup of participants with high PHQ-9 scores drove the effects.
in this experiment. Such a small subgroup may have represented clinically depressed participants, which would indicate that repeating the present experiment using a clinical group would lead to strong group differences. This, however, assumes the PHQ-9’s validity. As in Experiment 1, the prevalence of MDD (using the 10-point cut-off in the PHQ-9) was, at 18.6%, far higher than in the general population (7%).

Using a filtered control group did not affect any results in Part A of the depression analyses. Although the trends for Part B’s depression analyses remained the same as described above, several results changed in significance. First, there was a significant block-by-group interaction on discriminability ($F_{4,85.4} = 3.42, p = .01$). Second, as when outliers of the bias dataset were excluded, the marginally significant group effect and block-by-group interaction were no longer significant ($F_{3.5,74.6} = 1.52, p = .21$ and $F_{2,43} = 2.67, p = .08$, respectively). Since the trends did not change in any way, this lack of significance may have been due to smaller sample sizes.

**Limitations**

The limitations of the present experiment will be discussed in the context of Experiment 1 in the General Discussion.
General Discussion

The present study investigated sensitivity to rewards and punishments along two dimensions associated with disorders of high prevalence in the general population – ADHD and depression. The two experiments used psychometric scales to measure these dimensions, and a signal-detection task to measure sensitivity to rewards and punishments. A psychometric scale of reward and punishment sensitivity was also included in Experiment 2. Previous research has found that individuals with ADHD display somewhat lower reinforcement sensitivity and higher punishment sensitivity (e.g., Tripp & Alsop, 1999; Furukawa et al., 2016). Past research has also found that depressed individuals display lower reinforcement sensitivity and higher punishment sensitivity (e.g., Pizzagalli et al., 2008; Elliott et al., 1996).

Participants completed the task in each experiment with good levels of discriminability even in the first block (.57 for Experiment 1, .37 for Experiment 2). This shows that participants attended to the task. Response bias towards the better alternative (i.e., more rewarded or less punished key) increased overall for both experiments. The only exception was in Part B of Experiment 1, where participants’ (except for the A-ADHD group) response bias did not change, remaining at a steady level towards the less rewarded key. Taken together, these data show that, overall, participants engaged with the SD task and responded to its unequal arrangements of rewards and punishments.

Scales

The present study used three scales: the ASRS, the PHQ-9 and the BIS/BAS scales. The ASRS and PHQ-9 measured symptoms of Adult ADHD and MDD, respectively. The BIS/BAS scales were alternative measures of reinforcement and punishment sensitivity, to be compared with the present experiment’s task and to provide a secondary measure related to ADHD and MDD.
Across both experiments, 38.8% of participants screened positively for Adult ADHD on the ASRS. Since the prevalence of Adult ADHD has been estimated at 4.4% (using the ASRS on a general population), this percentage is very high. Past studies, however, have also reported prevalences of 20% and higher in samples of University students (e.g., Atwoli et al., 2011; Shanbhag & Nayak, 2015). These high incidence rates could be due, in part, to some questions in the ASRS relating to common University troubles of finishing projects (e.g., 1. How often do you have trouble wrapping up the final details of a project, once the challenging parts have been done?). That said, the estimates of these previous studies are still not as high as found in the present study. There has been relatively little research directly investigating screening University students with the ASRS. Mixed results have been found; for example, Burlison and Dwyer (2013) report only 4 of 70 students screened for Adult ADHD using the ASRS had reported past ADHD to their University. However, students may not have reported prior diagnoses of ADHD to their University and thereby caused this low concordance rate. In contrast, Gray, Waltering, Mawjee, and Tannock (2014) report the ASRS was useful in looking at symptoms of students previously diagnosed with ADHD. Because this study was limited to already diagnosed students, however, it does not show if the ASRS is useful in screening undiagnosed people.

There was a 20.6% prevalence of MDD in the overall sample of participants (using the ≥10 cut-off recommended by the PHQ-9). Compared to a prevalence of 7% in the general population, again this is a higher number than expected. However, other studies have found the prevalence of depression in University students to be over 20% (e.g., Ibrahim, Kelly, Adams, & Glazebrook, 2013; Sarokhani et al., 2013). The present sample’s incidence rate is similar to these estimates, and therefore adds to the body of literature indicating that high depression rates may be a serious issue in University students. Due to the high comorbidity of depression and ADHD, it also provides support to the possibility that ADHD rates in University students may
be higher than in the general population. This is also supported by Bray's (2014) finding that University students with ADHD often struggle academically and become depressed at high rates.

The ASRS and PHQ-9 were also correlated with one another in both experiments. This is consistent with the high comorbidity found between ADHD and MDD (APA, 2013). Questions on the PHQ-9 investigate extreme levels (i.e., excessively high or low) of activity and troubles with concentrating. These are both common symptoms of ADHD, which may explain why this correlation is consistently high. Furthermore, both scales tap into the common field of generalized anxiety; related symptoms can be, for example, excess energy, fidgetiness, trouble concentrating, and issues with sleeping (APA, 2013). It is therefore possible that the scales correlate highly because their criteria are broad enough to include core symptoms of their disorders, but also less direct symptoms that may be associated with other disorders (e.g., anxiety for the ASRS, anxiety and ADHD for the PHQ-9).

Carver and White's (1994) BIS/BAS scales provided mixed results in the present study. The Fun Seeking subscale of the BAS scale correlated well with total ASRS score, but not PHQ-9 score. This correlation with the ASRS is consistent with ADHD being related to impulsivity (i.e., fun seeking). That there was no correlation between the Fun Seeking subscale and the PHQ-9 was not surprising since depression is not usually related with impulsivity, except for when ADHD is comorbid. The Drive subscale also correlated with total ASRS score but not PHQ-9 score. The correlation with the ASRS is somewhat consistent with past findings of some reward hypersensitivity to individual rewards in children with ADHD (i.e., drive; Tripp & Alsop, 1999). The lack of correlation between the Drive scale and the PHQ-9 is somewhat surprising since MDD is associated with a lack of motivation (i.e., drive). The Reward Responsiveness (RR) subscale correlated with the PHQ-9 but not the ASRS. That there was no correlation between the RR and the ASRS is unexpected because of past findings that
ADHD is related to abnormalities in reward sensitivity (e.g., Tripp & Alsop, 1999; Alsop et al., 2016). The correlation between the RR and the PHQ-9 was expected because of past findings that depressed individuals are hyposensitive to reward (e.g., Pizzagalli et al., 2008; Vrieze et al., 2013).

The BIS scale also did not correlate with the ASRS, or, surprisingly, the PHQ-9. While the BIS was not expected to correlate with the ASRS, it was expected to correlate with the PHQ-9 because the BIS is thought to be hypersensitive in depression and anxiety, and reflect the excessive punishment sensitivity that depressed people feel (Carver & White, 1994; Kasch et al., 2002). Overall, the BIS/BAS scales did not serve as a good corroboration measure to the ASRS and PHQ-9. This may have been due to issues with the ASRS and PHQ-9, as discussed above, rather than the BIS/BAS scales. If the psychometric scales were overly sensitive and inflated symptoms of ADHD and depression, it is possible that they therefore did not correlate well with the BIS/BAS scales.

The BIS (i.e., punishment sensitivity) and BAS-Reward Responsiveness subscales did not correlate with response bias towards the more-rewarded/less-punished key (i.e., reward/punishment sensitivity) in Experiment 2. The lack of correlation between the BIS/BAS subscales and response bias is an unexpected finding because the BIS/BAS scales have been widely used in research. Because such learning tasks are established direct measures of reward and punishment sensitivity, these findings are concerning in terms of the BIS/BAS scales’ validity. This indicates Carver and White’s (1994) scales need more testing against basic tasks to ensure their validity.

**ADHD**

Both experiments found no differences in punishment sensitivity between the A-ADHD and control groups. This finding did not support the present study’s hypothesis that participants
with ADHD would be more sensitive to punishment than controls, and therefore does not support Furukawa et al.’s (2016) study that found punishment hypersensitivity in children with ADHD. However, Furukawa et al.’s (2016) study used children as a sample group, while the present study used adults and this raises two possibilities. First, punishment hypersensitivity might diminish as children develop into adults. A longitudinal study where children with ADHD are tested, then re-tested as adults would clarify if punishment sensitivity abnormalities are present in children with ADHD and if they continue into adulthood. Pairing this longitudinal study with brain imagery at both times may also help to show what brain structures are related to these effects. Second, it is possible that adults with ADHD are hypersensitive to punishment, but the present study failed to detect this hypersensitivity. The present study used both rewards and punishments in its SD task and therefore may have diluted the effects of each consequence. As such, effects of punishment hypersensitivity in adults with ADHD might be easier to detect using an SD task with only occasional punishment for getting questions wrong. Because participants could be discouraged by receiving only punishments and no rewards, the strength and frequency of punishment would have to be carefully controlled. Finally, Furukawa et al. (2016) used a well-diagnosed clinical sample in their comparisons, whereas the present study used a non-clinical sample. Effects of punishment hypersensitivity might be easier to detect using a clinical sample.

In Experiment 1, participants with adult ADHD had higher reward sensitivity than controls. However, there were no differences in reward sensitivity between the A-ADHD group and controls in Experiment 2. This does not support the present study’s hypothesis that participants with adult ADHD would display reward hyposensitivity. Tripp and Alsop (1999) found evidence of local reward hypersensitivity but some evidence of global reward hyposensitivity. Children with ADHD responded strongly to each individual reward, including those from the less rewarded alternative (i.e., their bias moved away from the more rewarded
alternative). In contrast, control children’s bias remained stable (i.e., towards the more rewarded alternative) regardless of which reward was given. It is possible that the reward hypersensitivity in the present study was strong enough to influence reward sensitivity on a global scale. If so, Experiment 1’s results may be consistent with past studies.

Experiment 1’s findings warrant further consideration. Not only did A-ADHD participants show significantly higher response bias than controls, but control participants’ response bias for the more rewarded key decreased as the session progressed, contrary to expectations of general performance on such tasks. Why this happened is unclear; it is possible that control participants were more responsive to the equal frequency of punishers than to the unequal frequency of rewards, therefore only responding to the punishers. Given that there were no differences between controls and A-ADHD participants on punishment sensitivity in both experiments, however, this seems unlikely.

**Depression**

In both experiments, control participants did not differ in punishment sensitivity from the MILD or MOD groups, although in Experiment 2 there was a trend towards punishment hyposensitivity in the MOD group and a significant negative correlation between PHQ-9 scores and response bias in the third block of trials. Overall, the hypothesis that participants with higher depressive symptoms would show higher punishment sensitivity was not supported. It is difficult to assess this result in relation to past research. It differs from research that has found punishment hypersensitivity in depressed people (e.g., Elliott et al., 1996), and research that has found trends of punishment hypersensitivity in depressed people (e.g., Henriques et al., 1994). Henriques et al. (1994) suggested that the effect of punishment hypersensitivity in their participants may have been significant with a larger sample or a stronger punishment. The same may be true for the present experiment; if a larger sample drawn from a clinical rather than a non-clinical population had been used, better results might have been obtained. Alternatively,
the punishers in the present study may have been too weak to detect this abnormal sensitivity. The present results are somewhat consistent with Must et al.'s (2006) finding that depressed participants did not show hypo- or hypersensitivity to punishment on the IGT. It is possible that depressed people only show abnormal sensitivity to punishment to a small degree, which may lead to difficulty in detecting the effect.

Overall, control participants did not differ from MILD or MOD participants in reward sensitivity in Experiment 1. However, in Experiment 2, the MOD group displayed significantly higher reward sensitivity than the control but not the MILD group. There were also significant correlations between PHQ-9 score and response bias towards the more rewarded key in Blocks 2 and 3. The findings are inconsistent with the hypothesis that participants with higher depressive symptoms would show lower reward sensitivity, and with the results of Pizzagalli et al. (2008) and Vrieze et al. (2013). The present study’s task was very similar to Pizzagalli et al.’s (2008) procedure, so it is difficult to explain a result in the opposite direction. It might be that the strength of rewards in the present study was diluted compared to Pizzagalli et al.’s (2008) study. One difference is that the present task punished participants as well as rewarding them, whereas Pizzagalli et al.’s (2008) task only rewarded participants. In their task, every block of 100 trials also included 40 rewards (30 on the better alternative, 10 on the worse alternative); the most rewards any participant received in the present task was 45 in 450 trials. This dilution would not explain why the result was in the opposite direction however.

The present study’s findings are somewhat consistent with Must et al.’s (2006) finding that depressed participants were hypersensitive to rewards on the IGT. However, Must et al. (2013) suggested that their result might reflect a propensity towards individual rewards (rather than overall rewards), which caused participants to pick large rewards and larger punishments rather than small rewards and smaller punishments. Because the IGT tests decision making based on reward compared to punishment, whereas a task like in the present study tests
participants’ overall sensitivity to reward or punishment, this difference might be due to the procedural differences between the tasks.

**Limitations, Implications, and Future Directions**

The present study used a non-clinical sample and investigated their symptoms of ADHD and MDD along a continuum. If the strength of reward and punishment sensitivity abnormalities exist along a continuum, and clinical levels of ADHD and MDD reflect extremes of the continuum (e.g., strong reward hypersensitivity in ADHD), then both a clinical and a non-clinical population should be successful in detecting these effects. Although the correlations between PHQ-9 score and response bias found in Experiment 2 provide some support for reward and punishment sensitivity varying in strength according to symptom severity, the present study may have failed to detect some effects because a non-clinical group was used. A non-clinical sample, such as that in the present study might be less likely to detect differences between the groups because it lacks extremes (i.e., a large number of clinical participants).

The ASRS and PHQ-9 were also presented at the end of the experiments. Participants first completed an attention-demanding SD task which took 30 to 50 minutes to complete and they may have felt restless following such a long period of intense attention. It is possible that they may have overestimated their general inattentiveness and scored higher on the ASRS and PHQ-9 (due to the anxiety-related questions discussed above) than they would have normally. In this way, the prevalence of Adult ADHD and MDD in the sample may have been inflated artificially due to the task used in the present experiment. This possibility could be investigated by presenting the scales to some participants before or after the task and comparing the means and prevalences of the scales and disorders, or by giving the scales both before and after the task and seeing if participants’ scores increased across assessments.
Overall, the present results provide some evidence that ADHD and MDD are related to reward hypersensitivity, and MDD may be related to punishment hyposensitivity. Although neither group consistently displayed these results at a significant level across both experiments and the findings were not always consistent with past research, they still suggest that there are general reward and punishment sensitivity abnormalities in the disorders. These results, and those of previous research, can inform programs working with people with ADHD or MDD that their clients' responses to rewards and punishments are not the same as in the general population. When these consequences are used in an intervention, their effects need to be carefully monitored. For example, assuming the present results are representative of the general case, rewards might be more salient for individuals with ADHD than for people without the disorder. This is also somewhat consistent with past research (e.g., Tripp & Alsop, 1999).

It is less clear if ADHD and MDD are related to punishment sensitivity abnormalities. The present study found no evidence of abnormal punishment sensitivity in participants screened for Adult ADHD, while Furukawa et al. (2016) found punishment hypersensitivity in children with ADHD. Since ADHD is viewed as a neurodevelopmental disorder where there is a period of delay, it is entirely possible that by adulthood, individuals with ADHD respond to punishment normally. This possibility is supported by the results of the present study, and thus supports the idea that overall deficits in children with ADHD can normalise into adulthood. Of course, the present study can provide no evidence concerning whether neurobiological delays seen in ADHD normalise into adulthood.

The present study also found that the prevalence of depression and ADHD appears to be far higher in University students than in the general population. It suggests that students may need easy access to mental health services and that staff at the University should look for symptoms of the disorders and help students with them. Although this is removed from the focus of this thesis, it is nonetheless an important finding and may help to draw attention to the
seriousness of mental health disorders in University students. This finding is also important because many studies use students as participants in general. If this participant pool has high rates of these disorders, it might influence the results in a variety of tasks and studies.

As mentioned above, the present study offers several avenues for further investigation (i.e., using clinical populations of patients with ADHD or MDD, providing only rewards or punishments on the task). Another way to expand this research would be to change the task used. For example, Must et al. (2006) used the IGT to measure reward and punishment sensitivity in depressed patients. This task could also be used to investigate reward and punishment sensitivity in adults with ADHD, as could other tasks shown to measure reward and punishment sensitivity. The results of the tasks could be compared against one another to see if certain tasks find differences between people with a disorder (e.g., ADHD) compared to those without. Furthermore, if groups of the same participants performed a variety of different tasks, their results could be compared more directly than if different groups of participants completed each task.

Overall, the present study found some evidence that ADHD and MDD are related to reward and punishment sensitivity abnormalities. However, these results do not clarify past research or give clear answers regarding reward and punishment abnormalities in adult ADHD. The investigation into these abnormalities therefore remains important.
References


impairment. *Journal of Neurology Neurosurgery and Psychiatry*, 63(1), 74-82. doi:10.1136/jnnp.63.1.74


Appendix A

Patient Health Questionnaire (PHQ-9)

The Patient Health Questionnaire (PHQ-9) - Overview

The PHQ-9 is a multipurpose instrument for screening, diagnosing, monitoring and measuring the severity of depression:
- The PHQ-9 incorporates DSM-IV depression diagnostic criteria with other leading major depressive symptoms into a brief self-report tool.
- The tool rates the frequency of the symptoms which factors into the scoring severity index.
- Question 9 on the PHQ-9 screens for the presence and duration of suicide ideation.
- A follow up, non-scored question on the PHQ-9 screens and assigns weight to the degree to which depressive problems have affected the patient’s level of function.

Clinical Utility
The PHQ-9 is brief and useful in clinical practice. The PHQ-9 is completed by the patient in minutes and is rapidly scored by the clinician. The PHQ-9 can also be administered repeatedly, which can reflect improvement or worsening of depression in response to treatment.

Scoring
See PHQ-9 Scoring on next page.

Psychometric Properties
- The diagnostic validity of the PHQ-9 was established in studies involving 8 primary care and 7 obstetrical clinics.
- PHQ scores ≥ 10 had a sensitivity of 88% and a specificity of 88% for major depression.
- PHQ-9 scores of 5, 10, 15, and 20 represents mild, moderate, moderately severe and severe depression.¹

¹ Koenke K, Spitzer R, Williams W. The PHQ-9: Validity of a brief depression severity measure. JGIM, 2001, 16:506-516
The Patient Health Questionnaire (PHQ-9) Scoring

Use of the PHQ-9 to Make a Tentative Depression Diagnosis:
The clinician should rule out physical causes of depression, normal bereavement and a history of a manic/hypomanic episode

**Step 1: Questions 1 and 2**
Need one or both of the first two questions endorsed as a “2” or a “3”
(2 = “More than half the days” or 3 = “Nearly every day”)

**Step 2: Questions 1 through 9**
Need a total of five or more boxes endorsed within the shaded area of the form to arrive at the total symptom count. (Questions 1-8 must be endorsed as a “2” or a “3”; Question 9 must be endorsed as “1”, “2” or “3”)

**Step 3: Question 10**
This question must be endorsed as “Somewhat difficult” or “Very difficult” or “Extremely difficult”

Use of the PHQ-9 for Treatment Selection and Monitoring

**Step 1**
A depression diagnosis that warrants treatment or a treatment change, needs at least one of the first two questions endorsed as positive (“more than half the days” or “nearly every day”) in the past two weeks. In addition, the tenth question, about difficulty at work or home or getting along with others should be answered at least “somewhat difficult”

**Step 2**
Add the total points for each of the columns 2-4 separately
(Column 1 = Several days; Column 2 = More than half the days; Column 3 = Nearly every day. Add the totals for each of the three columns together. This is the Total Score
The Total Score = the Severity Score

**Step 3**
Review the Severity Score using the following TABLE.

<table>
<thead>
<tr>
<th>PHQ-9 Score</th>
<th>Provisional Diagnosis</th>
<th>Treatment Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-9</td>
<td>Minimal Symptoms*</td>
<td>Support, educate to call if worse, return in one month</td>
</tr>
<tr>
<td>10-14</td>
<td>Minor depression ++</td>
<td>Support, watchful waiting</td>
</tr>
<tr>
<td></td>
<td>Dysthymia*</td>
<td>Antidepressant or psychotherapy</td>
</tr>
<tr>
<td></td>
<td>Major Depression, mild</td>
<td>Antidepressant or psychotherapy</td>
</tr>
<tr>
<td>15-19</td>
<td>Major depression, moderately severe</td>
<td>Antidepressant or psychotherapy</td>
</tr>
<tr>
<td>&gt;20</td>
<td>Major Depression, severe</td>
<td>Antidepressant and psychotherapy (especially if not improved on monotherapy)</td>
</tr>
</tbody>
</table>

* if symptoms present > two years, then probable chronic depression which warrants antidepressants or psychotherapy (ask "on the past 2 years have you felt depressed or sad most days, even if you felt okay sometimes?")
++ If symptoms present > one month or severe functional impairment, consider active treatment
The Patient Health Questionnaire (PHQ-9)

<table>
<thead>
<tr>
<th>Patient Name</th>
<th>Date of Visit</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Over the past 2 weeks, how often have you been bothered by any of the following problems?</th>
<th>Not At all</th>
<th>Several Days</th>
<th>More Than Half the Days</th>
<th>Nearly Every Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Little interest or pleasure in doing things</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2. Feeling down, depressed or hopeless</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3. Trouble falling asleep, staying asleep, or sleeping too much</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4. Feeling tired or having little energy</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5. Poor appetite or overeating</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>6. Feeling bad about yourself - or that you’re a failure or have let yourself or your family down</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>7. Trouble concentrating on things, such as reading the newspaper or watching television</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>8. Moving or speaking so slowly that other people could have noticed. Or, the opposite - being so fidgety or restless that you have been moving around a lot more than usual</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>9. Thoughts that you would be better off dead or of hurting yourself in some way</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Column Totals: _____ + _____ + _____
Add Totals Together: __________

10. If you checked off any problems, how difficult have those problems made it for you to do your work, take care of things at home, or get along with other people?

☐ Not difficult at all  ☐ Somewhat difficult  ☐ Very difficult  ☐ Extremely difficult

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Appendix B

Adult ADHD Self-Report Scale (ASRS)

Adult ADHD Self-Report Scale (ASRS-v1.1) Symptom Checklist

Instructions

The questions on the back page are designed to stimulate dialogue between you and your patients and to help confirm if they may be suffering from the symptoms of attention-deficit/hyperactivity disorder (ADHD).

Description: The Symptom Checklist is an instrument consisting of the eighteen DSM-IV-TR criteria. Six of the eighteen questions were found to be the most predictive of symptoms consistent with ADHD. These six questions are the basis for the ASRS v1.1 Screener and are also Part A of the Symptom Checklist. Part B of the Symptom Checklist contains the remaining twelve questions.

Instructions:

Symptoms

1. Ask the patient to complete both Part A and Part B of the Symptom Checklist by marking an X in the box that most closely represents the frequency of occurrence of each of the symptoms.

2. Score Part A. If four or more marks appear in the darkly shaded boxes within Part A then the patient has symptoms highly consistent with ADHD in adults and further investigation is warranted.

3. The frequency scores on Part B provide additional cues and can serve as further probes into the patient’s symptoms. Pay particular attention to marks appearing in the dark shaded boxes. The frequency-based response is more sensitive with certain questions. No total score or diagnostic likelihood is utilized for the twelve questions. It has been found that the six questions in Part A are the most predictive of the disorder and are best for use as a screening instrument.

Impairments

1. Review the entire Symptom Checklist with your patients and evaluate the level of impairment associated with the symptom.

2. Consider work/school, social and family settings.

3. Symptom frequency is often associated with symptom severity, therefore the Symptom Checklist may also aid in the assessment of impairments. If your patients have frequent symptoms, you may want to ask them to describe how these problems have affected the ability to work, take care of things at home, or get along with other people such as their spouse/significant other.

History

1. Assess the presence of these symptoms or similar symptoms in childhood. Adults who have ADHD need not have been formally diagnosed in childhood. In evaluating a patient’s history, look for evidence of early-appearing and long-standing problems with attention or self-control. Some significant symptoms should have been present in childhood, but full symptomology is not necessary.
### Adult ADHD Self-Report Scale (ASRS-v1.1) Symptom Checklist

<table>
<thead>
<tr>
<th>Patient Name</th>
<th>Today's Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Never</td>
</tr>
</tbody>
</table>

1. How often do you have trouble wrapping up the final details of a project, once the challenging parts have been done?  
2. How often do you have difficulty getting things in order when you have to do a task that requires organization?  
3. How often do you have problems remembering appointments or obligations?  
4. When you have a task that requires a lot of thought, how often do you avoid or delay getting started?  
5. How often do you fidget or squirm with your hands or feet when you have to sit down for a long time?  
6. How often do you feel overly active and compelled to do things, like you were driven by a motor?  
7. How often do you make careless mistakes when you have to work on a boring or difficult project?  
8. How often do you have difficulty keeping your attention when you are doing boring or repetitive work?  
9. How often do you have difficulty concentrating on what people say to you, even when they are speaking to you directly?  
10. How often do you misplace or have difficulty finding things at home or at work?  
11. How often are you distracted by activity or noise around you?  
12. How often do you leave your seat in meetings or other situations in which you are expected to remain seated?  
13. How often do you feel restless or fidgety?  
14. How often do you have difficulty unwinding and relaxing when you have time to yourself?  
15. How often do you find yourself talking too much when you are in social situations?  
16. When you're in a conversation, how often do you find yourself finishing the sentences of the people you are talking to, before they can finish them themselves?  
17. How often do you have difficulty waiting your turn in situations when turn taking is required?  
18. How often do you interrupt others when they are busy?  

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**Part A**

---

**Part B**
The Value of Screening for Adults With ADHD

Research suggests that the symptoms of ADHD can persist into adulthood, having a significant impact on the relationships, careers, and even the personal safety of your patients who may suffer from it. Because this disorder is often misunderstood, many people who have it do not receive appropriate treatment and, as a result, may never reach their full potential. Part of the problem is that it can be difficult to diagnose, particularly in adults.

The Adult ADHD Self-Report Scale (ASRS-v1.1) Symptom Checklist was developed in conjunction with the World Health Organization (WHO), and the Workgroup on Adult ADHD that included the following team of psychiatrists and researchers:

- Lenard Adler, MD
  Associate Professor of Psychiatry and Neurology
  New York University Medical School

- Ronald C. Kessler, PhD
  Professor, Department of Health Care Policy
  Harvard Medical School

- Thomas Spencer, MD
  Associate Professor of Psychiatry
  Harvard Medical School

As a healthcare professional, you can use the ASRS v1.1 as a tool to help screen for ADHD in adult patients. Insights gained through this screening may suggest the need for a more in-depth clinician interview. The questions in the ASRS v1.1 are consistent with DSM-IV criteria and address the manifestations of ADHD symptoms in adults. Content of the questionnaire also reflects the importance that DSM-IV places on symptoms, impairments, and history for a correct diagnosis.

The checklist takes about 5 minutes to complete and can provide information that is critical to supplement the diagnostic process.

References:
APPENDIX C

INFORMATION SHEET FOR PARTICIPANTS

ACCURACY, BIAS, AND PERSONALITY TRAITS
INFORMATION SHEET FOR PARTICIPANTS

Thank you for showing an interest in this project. Please read this information sheet carefully before deciding whether or not to participate. If you decide to participate we thank you. If you decide not to take part there will be no disadvantage to you and we thank you for considering our request.

What is the Aim of the Project?

This study examines the relation between aspects of personality and performance on a discrimination task. This project is being undertaken as part of the requirements for a Masters Thesis.

What Type of Participants are being sought?

First and Second year University of Otago Psychology students will participate in the study. Participants will receive information to complete a post-experiment survey as part of their experimental participation assignment.

What will Participants be Asked to Do?

If you agree to participate in this study, you will be asked to perform a simple discrimination task. There will be a set number of trials in the study; however, the number to do will depend on your accuracy. The study will take about 30-40 minutes to complete.

What Data or Information will be Collected and What Use will be Made of it?

Participants’ performance and their answers to the psychometric scales administered will be recorded. The data collected will be securely stored in such a way that only those listed below will be able to gain access to it. At the end of the project any personal information will be destroyed immediately except that, as required by the University’s research policy, any raw data on
which the results of the project depend will be retained in secure storage for five years, after which it may be destroyed.

The results of the project may be published and will be available in the University of Otago Library (Dunedin, New Zealand) but every attempt will be made to preserve your anonymity.

Can Participants Change their Mind and Withdraw from the Project?

Please be aware that you may decide not to take part or withdraw from the project at any time without any disadvantage to yourself of any kind.

What if Participants have any Questions?

If you have any questions about our project, either now or in the future, please feel free to contact either:-

Darius Paschke
Department of Psychology
pasda696@student.otago.ac.nz

and/or

Brent Alsop
Department of Psychology
balsop@psy.otago.ac.nz

This study has been approved by the Department stated above. If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (ph 03 479-8256). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.
Appendix D

Consent Form for Participants

ACCURACY, BIAS, AND PERSONALITY TRAITS

CONSENT FORM FOR

PARTICIPANTS

I have read the Information Sheet concerning this project and understand what it is about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage.

I know that:

1. My participation in the project is entirely voluntary;

2. I am free to withdraw from the project at any time without any disadvantage;

3. Personal identifying information will be destroyed at the conclusion of the project but any raw data on which the results of the project depend will be retained in secure storage for at least five years;

4. The results of the project may be published and available in the University of Otago Library (Dunedin, New Zealand) but every attempt will be made to preserve my anonymity.

I agree to take part in this project.

.............................................................................
.........................................................
(Signature of participant) (Date)

.............................................................................
.........................................................
(Name of participant)
Appendix E

Debrief Sheet for Participants

Accuracy, Bias, and Personality Traits

Thank you for participating in this study. Here is some information you will need to fill in your survey and receive your experimental participation credit.

This behavioural/operant experiment was of between-subjects design, with one independent and four dependent variables. In the study, participants were either punished or rewarded more often for certain responses. The main experimental question was: Are levels of depression related to abnormal responses to punishment?

If you have any questions, feel free to e-mail me at pasda696@student.otago.ac.nz.
Appendix F

BIS/BAS Scales

BIS/BAS

Each item of this questionnaire is a statement that a person may either agree with or disagree with. For each item, indicate how much you agree or disagree with what the item says. Please respond to all the items; do not leave any blank. Choose only one response to each statement. Please be as accurate and honest as you can be. Respond to each item as if it were the only item. That is, don’t worry about being “consistent” in your responses. Choose from the following four response options:

1 = very true for me
2 = somewhat true for me
3 = somewhat false for me
4 = very false for me

1. A person’s family is the most important thing in life.
2. Even if something bad is about to happen to me, I rarely experience fear or nervousness.
3. I go out of my way to get things I want.
4. When I’m doing well at something I love to keep it.
5. I’m always willing to try something new if I think it will be fun.
6. How I dress is important to me.
7. When I get something I want, I feel excited and energized.
8. Criticism or scolding hurts me quite a bit.
9. When I want something I usually go all-out to get it.
10. I will often do things for no other reason than that they might be fun.
11. It’s hard for me to find the time to do things such as get a haircut.
12. If I see a chance to get something I want I move on it right away.
13. I feel pretty worried or upset when I think or know somebody is angry at me.
14. When I see an opportunity for something I like I get excited right away.
15. I often act on the spur of the moment.
16. If I think something unpleasant is going to happen I usually get pretty “worked up.”
17. I often wonder why people act the way they do.
18. When good things happen to me, it affects me strongly.
19. I feel worried when I think I have done poorly at something important.
20. I crave excitement and new sensations.
21. When I go after something I use a “no holds barred” approach.
22. I have very few fears compared to my friends.
23. It would excite me to win a contest.
24. I worry about making mistakes.
Items other than 2 and 22 are reverse-scored.

BAS Drive: 3, 9, 12, 21
BAS Fun Seeking: 5, 10, 15, 20
BAS Reward Responsiveness: 4, 7, 14, 18, 23

BIS: 2, 8, 13, 16, 19, 22, 24

Items 1, 8, 11, 17, are fillers.

The fact that there are three BAS-related scales and only one BIS-related scale was not planned or theoretically motivated. The factors emerged empirically, from an item set that was intended to capture diverse manifestations of the BAS, according to various theoretical statements. It is likely that a broader sampling of items on the BIS side would also have resulted in more than one scale. I do not encourage combining the BAS scales, however, because they do turn out to focus on different aspects of incentive sensitivity. In particular, Fun Seeking is known to have elements of impulsiveness that are not contained in the other scales.