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Relationships between experimental task and questionnaire measures of reward/punishment sensitivity in attention-deficit/hyperactivity disorder (ADHD): protocol for a scoping review

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ABSTRACT

Introduction One of the purported underlying causal mechanisms of attention deficit hyperactivity disorder (ADHD) is altered motivational processes. Questionnaires have been used to identify the characteristics of reward and punishment sensitivity in individuals with ADHD. However, these questionnaires were initially developed to measure individual traits related to anxiety (inhibitory) and impulsivity (approach) tendencies or differences in pleasure-seeking. These reward and punishment sensitivity questionnaires are useful but might not capture all relevant aspects of altered motivational processes in ADHD. The proposed scoping review aims to: (1) examine which aspects of hypothesised altered reward and punishment sensitivity correspond to constructs measured by existing questionnaires, (2) characterise the relationships between ADHD symptomatology and reward and punishment sensitivity as measured by existing questionnaires and (3) evaluate the consistency between the altered reward and punishment sensitivity as measured by existing questionnaires and experimental task performance.

Methods and analysis Reporting of the scoping review results will adhere to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews and the Joanna Briggs Methodology for Scoping Reviews. Published English-language literature was searched in three electronic databases (PubMed, Web of Science, APA PsycINFO) on 16 November 2023, with no restriction on the year of publication. Two researchers independently screened all identified titles/abstracts before proceeding to full-text review and additional handsearching of relevant studies. A narrative review and conclusions will be presented together with tables summarising the articles reviewed and the results organised by the three aims.

Ethics and dissemination This study reviews existing publications with ethical approval in place. Therefore, ethical approval is not required. Review results will be disseminated through academic conferences and peer-reviewed manuscripts. Scoping review results will also inform future research to measure and identify altered motivational processes in ADHD.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study will review a broad range of questionnaires measuring reinforcement sensitivity, with no restriction on the year of publication.
⇒ This study will include the review of task-based study results when reported together with the questionnaire results.
⇒ This study will include research with clinical and population samples of all ages, with the sample characteristics included in the results.
⇒ The study results will be reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews guidelines.
⇒ This study will only include English-language peer-reviewed studies.

INTRODUCTION

Attention-deficit/hyperactivity disorder (ADHD) is a common neurodevelopmental disorder characterised by three cardinal symptoms, namely: inattention, hyperactivity and impulsivity.[1] The prevalence of ADHD is approximately 7.6% in children and 2.6% in adults,[2 3] with some symptom fluctuation across the lifespan.[3–5] Altered motivational processes have been proposed to account for symptoms of ADHD.[6–9] Behavioural studies have identified altered sensitivity to both reward and punishment in individuals with ADHD.[10] Compared with typically developing peers, children with ADHD have been shown to prefer immediate over delayed reward,[11–13] to show poorer adaptation to changing reinforcement contingencies[14 15] and to demonstrate faster extinction after learning under partial (discontinuous) reinforcement.[16] There have been fewer studies of sensitivity to punishment in those with ADHD,

and the results are mixed. Some studies have shown similar sensitivity to punishment between those with and without ADHD,[17 18] while others report increased sensitivity to punishment among those with ADHD.[19 20]

While most of the evidence on altered motivational processing in ADHD comes from experimental studies, questionnaires assessing sensitivity to reward and punishment have also been used. The only questionnaire developed specifically to assess for altered reward sensitivity is the Quick Delay Questionnaire, designed for use with adults, which assesses feelings/attitudes toward waiting and delayed rewards.[21] Individuals with ADHD report higher levels of delay aversion and delay discounting,[22] compared with their typically developing peers, which is consistent with the available experimental findings.[11 23]

Other reward and punishment sensitivity questionnaires have been developed for other pathological conditions or are based on reinforcement learning theories. Studies using these questionnaires report inconsistent results in terms of reward and punishment sensitivity in ADHD.[24–26] It is unclear whether they are measuring the same motivational constructs as those evaluated in experimental studies. The most commonly used questionnaires on reward and punishment sensitivity[27] were developed based on Gray's reinforcement sensitivity theory (RST).[28] This theory conceptualises reward sensitivity as a biologically based behavioural activation/approach system (BAS), that is, a temperamental trait to seek rewarding stimuli. Punishment sensitivity is thought to relate to the behavioural inhibition system (BIS), that is, an anxiolytic trait to avoid potentially aversive stimuli.[29] An unbalanced BIS/BAS has been linked to increased risks of psychopathology,[30] including ADHD.[31 32] Quay[33] assumed an underactive BIS leads to an inhibition deficit, poor attention and stimulus seeking in ADHD, while other researchers demonstrated that a high or a dysregulated BAS underlies elevated levels of hyperactive and impulsive behaviours.[34–36]

Other questionnaires measure reward anticipation ('wanting') and consumption ('liking') as expressed in behaviour[37] and urges/pleasure seeking.[38] Using a range of questionnaires, researchers have shown a link between excessive, or reduced, reward seeking, anticipation, and consumption and a range of pathological conditions, including addiction,[39 40] eating disorders[41] and anhedonia.[42 43] Links between the constructs measured by these questionnaires and ADHD are unclear. Using the UPPS Impulsive Behaviour Scale,[44 45] which measures levels of urgency, premeditation, perseverance and sensation seeking, some studies have reported greater urgency to obtain rewards in those with ADHD.[46 47] Other measures have been developed to examine anhedonia. Many of these measures examine behaviour or mood symptoms associated with specific disorders (eg, depression) or have items that name specific reward stimuli (eg, social and food).[42 48–50] In a study using the tripartite pleasure inventory, Meinzer *et al*[51] suggested that a reduced capacity to attend to pleasurable stimuli/experiences lead to a disorganised pursuit of rewards in those with ADHD.

A smaller number of questionnaires are available to assess sensitivity to punishment in addition to those developed based on, or elaborated from, the RST. Some of these measures attempted to better differentiate responsiveness to punishment and motivation to avoid punishment,[52] or removed mention of specific aversive stimuli from questionnaire items (eg, the Reward and Punishment Responsivity and Motivation Questionnaire).[52] Using a measure of avoidance of negative outcomes (eg, Acceptance and Action Questionnaire-II) Bond *et al*[53] report that individuals with ADHD show increased avoidance of negative thoughts, feelings and other internal experiences.[54] In children, symptoms of disruptive behaviour disorders may imply reduced responsiveness to punishment, ie, repetitive and persistent patterns of inappropriate behaviour despite negative consequences. One questionnaire (Multidimensional Assessment Profile of Disruptive Behaviour)[55] explicitly measures insensitivity to punishment. In this questionnaire, temper loss, irritability and frustration are also conceptualised as overreactions to aversive stimuli/results or non-reward.[56] However, to our knowledge, the association between this questionnaire and ADHD symptoms has not been explored.

Finally, sensitivity to reward and punishment may relate to perceptions and calculation of benefits and risks. The Domain-Specific Risk Taking scale[57] assesses risk taking, benefit perception and risk perception across multiple domains (health and safety, financial, recreational, social and ethical). Increased risk taking in ADHD has been associated with perception of greater benefits from engaging in risky behaviours[58] and poor decision-making (eg, preferring a risky choice when it results in a suboptimal outcome).[59]

Despite the importance of motivational processes in identifying and describing the characteristics of ADHD, it is unclear whether experimental and questionnaire-based studies evaluate the same aspects of reward and punishment sensitivity or provide consensus. The objective of this study is to review and organise existing literature to help clarify how the concepts of motivational deficits in ADHD have been understood and measured to date. The review will also identify methodological and knowledge gaps in the field. This will allow the generation and testing of new hypotheses regarding altered reward and punishment sensitivity in ADHD.

Review questions

Specifically, this scoping review aims to answer the following questions:

1. Which aspects of hypothesised altered reward and punishment sensitivity in ADHD correspond to the constructs measured by existing questionnaires?

2. What are the relationships between ADHD symptomatology and reward and punishment sensitivity as measured by existing questionnaires?
3. What is the degree of consistency between the experimental and questionnaire findings on reward and punishment sensitivity in ADHD?

By addressing the above questions, this study will identify the overlap and differences in the measurement of reinforcement sensitivity by experimental tasks and questionnaires.

PROTOCOL DESIGN

This review protocol will follow the Joanna Briggs Institute (JBI) Methodology for Scoping Reviews.[60 61] Further, the reporting of this scoping review will be formatted along the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews guidelines (PRISMA-ScR; online supplemental file 1).[62] The iterative review process is being carried out according to the following steps: (1) defining the review objective and questions (completed), (2) creating the search strategies (initial strategies defined, need for additional search being identified), (3) conducting the literature search (initial search completed, handsearching ongoing), (4) selecting studies based on the eligibility criteria, (5) performing data extraction and (6) presentation of results. The eligibility criteria and methods are described below. This protocol will be registered with the Open Science Framework and the progress will be updated.

ELIGIBILITY CRITERIA

Participants

This scoping review will include studies with participants of any age who have a clinical diagnosis of ADHD (all presentation types) or elevated inattention and/or hyperactivity/impulsivity symptoms as reported by parents and teachers in the case of children or adult self-report. The clinical diagnosis may be a diagnosis made by a licensed professional, or by researchers according to the Diagnostic and Statistical Manual of Mental Disorders (DSM) or International Classification of Diseases (ICD) criteria. The degree of elevation in the symptoms of ADHD is as defined by the reviewed manuscript authors (may include above and subthreshold levels of ADHD). The ADHD samples may include individuals with comorbid conditions, or studies may focus on other conditions but include ADHD as a comparison or comorbid conditions. Studies will be included if they report the relationship between ADHD symptoms and reward/punishment sensitivity questionnaire responses or group differences in the questionnaire responses between individuals with and without ADHD. Results will be marked to indicate the evidence for ADHD with or without comorbid conditions. The ADHD samples may be described by other related terms, such as attention deficit disorder (ADD) and hyperkinetic syndrome (see online supplemental appendix 1 for a complete list of terms). Studies focused on non-human participants will not be included.

Concept

This scoping review will focus on the motivational processes in ADHD and will examine questionnaires that measure reward and punishment sensitivity in ADHD and where applicable their relationship to the results of experimental studies. Specifically, this review will include two types of studies: (1) studies that measure and report reward and punishment sensitivity using questionnaires and report their relationship with ADHD diagnosis/symptoms and (2) studies that measure and report reward and punishment sensitivity by both questionnaires and experimental tasks among individuals with an ADHD diagnosis or elevated symptoms. For experimental tasks to be included in the review, they must be designed to measure reward and/or punishment sensitivity.

We define reward as stimuli that increase the likelihood of future occurrence of the behaviour they follow (ie, positive reinforcement), and punishment as stimuli that decrease the likelihood of future occurrence of the behaviour they follow (including both positive and negative punishment). These definitions will be used in evaluating the inclusion of experimental tasks. For questionnaires, broader reward-related and punishment-related concepts will be considered, for example, pleasure, behavioural inhibition/activation and benefit/risk perception (see a complete list of terms considered in online supplemental appendix 1). Inclusion of these constructs is important as one of the aims of the study is to clarify how the concepts of reward and punishment are measured and described in relation to ADHD.

Context

This study's context will be open; all geographical regions/settings, races and genders will be included. However, only English-language articles will be included, which may result in the exclusion of studies from some geographical locations and population groups. Studies conducted in both clinic and community settings will be included. Built-in filters were used to include English-language articles and to exclude systematic reviews and meta-analyses across all databases. The inclusion of human subjects and the publication type were checked using the combination of built-in filters (when available) and manual screening. It is possible that the use of these filters limited the search results.

Types of evidence

The review will consider only full-text articles of primary research published in English in peer-reviewed journals. These include studies with experimental and quasi-experimental designs, analytical observational studies and

descriptive observational studies with quantitative analysis of the reward and punishment sensitivity questionnaires. Systematic reviews, meta-analyses, case reports, commentaries, posters, opinion pieces, editorials, comments, newsletters, letters to the editor with no empirical research, non-human studies and grey literature will be excluded. However, in the Introduction and Discussion sections, this additional literature may be discussed.

METHODS

The expected review period is from 16 November 2023 (completion of initial searches) to January 2024 (estimated completion of data extraction).

Patient and public involvement

None.

Search strategy

The search is conducted across three databases using the search engine Google: PubMed (MEDLINE), Web of Science and APA PsycINFO (Ovid). Using these databases, preliminary searches were carried out to determine keywords, descriptors and Medical Subject Headings (MeSH), for the population (eg, ADD with hyperactivity), measurements (eg, surveys and questionnaires) and concepts (eg, reward sensitivity). The search terms used across the three databases varied slightly given the extent of their coverage of studies and their thesaurus functions. In particular, only certain phrase variations (ie, plural forms) were included in the Web of Science searches, whereas other variations (eg, scaled, scaling) were included in the two other databases. However, care was taken to ensure that the same inclusion and exclusion criteria were applied during the screening process. The asterisk function was used to exclude other related terms for both populations and measurements. All phrases considered are included in the search string with no restriction on the year of publication.

We first built the set of search terms to use in PubMed. We specified the search terms using quotation marks to exclude reordered word combinations and to include abbreviated, older and other terms that were not mapped in thesaurus functions. The term variations were captured using an asterisk where appropriate. The same set of search terms were used in Web of Science, although variations were specified using specific terms, rather than using asterisks. In PsycINFO, given the organisation of the thesaurus is different from PubMed, we repeated the checking of the thesaurus and included additional terms to ensure the consistency with the same set of terms identified by the PubMed MeSH terms. The hierarchies of the terms were considered and used in each database. The identified terms were integrated with the Boolean operators AND and OR for the subject heading and all field searches in all databases. No restriction was placed on the year of publication.

Built-in filters were used to include studies relevant to the research questions. Across all databases, filters were used to include English-language articles and to exclude systematic reviews and meta-analyses. The inclusion of human subjects only studies was managed using the filters in PubMed and PsycINFO and manually for articles identified in the Web of Science, which does not allow for filtering of human studies only. Document types were checked to include only published articles, first using the filters in PubMed (exclude preprints) and Web of Science (include Articles or Early Access) and only manually for articles identified in PsycINFO.

We will find related measurement reports via different databases or sources (eg, Google Scholar) and list all articles citing those papers. Searches from citations in papers that met the criteria will be included. The final scoping review report will include the detailed search strategies from all sources.

Study selection

To check the appropriateness of the search terms and inclusion/exclusion criteria, preliminary searches were conducted using several databases. We then conducted a search on 16 November 2023 using the integrated search strategy with Boolean operators AND and OR, in the three databases as described above, which identified 5180 papers without duplicates. The titles and abstracts are being screened before proceeding to full-text review and additional handsearching of relevant articles referenced in the identified studies via different databases and sources (eg, Google Scholar). We will check these additional papers against the eligibility criteria. We plan to finalise the article selection in December 2023.

All studies identified through the databases and handsearch are grouped and duplicates are removed using Covidence software, a web-based software for managing/streamlining systematic reviews.[63] Using this software, screening of the identified articles is conducted by two independent researchers (MO and NN) according to the eligibility criteria described above, first based on titles and abstracts, prior to preceding to the full-text review. Any conflicts in screening will be resolved through discussion between the two researchers and consultation with the research team (protocol authors). Excluded studies and the reasons for exclusion will be reported. In particular, studies that are not peer-reviewed, do not include reward/punishment sensitivity questionnaires and do not include participants meeting the eligibility criteria will be excluded. Studies that do not report the relationship between ADHD symptoms and reward/punishment sensitivity questionnaire responses or group differences in the questionnaire responses between the ADHD and typically developing or other disordered groups will also be excluded.

Data extraction

Data on the selected studies are extracted by two independent researchers (MO and NN) using a data extraction

form based on the JBI template.[64] The data extraction items include source, eligibility, methods, population characteristics, information on the reward and punishment sensitivity questionnaire(s) (including constructs the questionnaires attempt to measure and how authors define reward and punishment sensitivity), information on the experimental task(s) (if any), results (relationship with ADHD symptoms/diagnosis and experimental task performance) and other relevant information, including conclusions (online supplemental appendix 2). We will use this data collection sheet with ten studies in the first instance and modify the items if necessary. We will report the modifications when reporting the review results. If necessary, the authors of the published papers will be contacted to request missing or additional data.

Presentation of results

All information regarding the selection of papers is presented in a flow chart according to PRISMA-ScR (online supplemental apendix 3). The results of all selected studies will be summarised in tables with descriptive data and in narrative form. We plan to include three results tables. The first table will summarise all studies that meet the eligibility criteria, including the study design, participant number and characteristics, questionnaire(s) used, experimental task(s) used and results. The second table will illustrate which aspects of hypothesised altered reward and punishment sensitivity in ADHD correspond to the constructs measured by existing questionnaires. The third table will characterise the association between the questionnaire results and ADHD symptomatology and experimental task performance, including correlation coefficients when available. The results will be marked to indicate whether they are for children/adolescents (under the age of 18) and adults (over 18),[65] ADHD samples with or without comorbid condition(s), and whether they include clinically diagnosed samples or those with self-reports or other-reports of elevated ADHD symptoms. Any identified differences between the samples will be discussed. Depending on the results, figures may be created to map the concepts of reward and punishment sensitivity as measured by these questionnaires.

Critical Appraisal Skill Programme Checklists will be used to review and report the quality of the study designs and reliability and validity of the results of the selected studies. Limitations of the results will be discussed. These include the exclusion of non-English-language literature and grey (unpublished) literature. This may exclude some studies with culturally under-represented samples and those reporting non-significant results. There may also be other possible terms that are related to reward and punishment sensitivity that we do not use in the search strategy, resulting in missed studies that are relevant to the review questions. The study will focus on the relationship between reward and punishment sensitivity questionnaire responses and ADHD symptomatology but will not allow us to determine if these associations are unique to ADHD or shared by comorbid conditions. The quality and quantity of the studies included will depend on the available literature.

Implications for future research will be discussed based on the relationship between the findings from questionnaire research and hypothesised altered motivational processing as well as experimental task performance. The review will highlight current evidence gaps, as well as the need and appropriateness of additional questionnaire-based and experimental research and a further review, in the context of ADHD motivational processing.

ETHICS AND DISSEMINATION

Since this proposed study is a scoping review, there are no required ethical or safety considerations. The protocol and scoping review will not include members of the general public or patients. The results of the scoping review will be disseminated through publication in peer-reviewed journals and conference presentations.

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Contributors MO, EF and GT contributed to the conception and design of this protocol. MO and NN led the search strategy and pilot data mapping, supported by EF, KDP and GT. MO drafted the manuscript and EF and GT contributed to the revisions. KDP assessed this protocol along with the PRISMA-ScR checklist, which was reviewed by all authors. All authors (MO, EF, NN, KDP and GT) approved the final version of the manuscript for accuracy, completeness and publication.

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Competing interests None declared.

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REFERENCES

1 American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders: DSM-5-TR*. American Psychiatric Association Publishing, 18 March 2022.
2 Salari N, Ghasemi H, Abdoli N, *et al*. The global prevalence of ADHD in children and adolescents: a systematic review and meta-analysis. *Ital J Pediatr* 2023;49:48.

3 Song P, Zha M, Yang Q, *et al*. The prevalence of adult attention-deficit hyperactivity disorder: a global systematic review and meta-analysis. *J Glob Health* 2021;11:04009.
4 Karam RG, Rovaris DL, Breda V, *et al*. Trajectories of attention-deficit/hyperactivity disorder dimensions in adults. *Acta Psychiatr Scand* 2017;136:210–9. 10.1111/acps.12757 Available: https://onlinelibrary.wiley.com/toc/16000447/136/2
5 Kirova A-M, Kelberman C, Storch B, *et al*. Are subsyndromal manifestations of attention deficit hyperactivity disorder morbid in children? A systematic qualitative review of the literature with meta-analysis. *Psychiatry Res* 2019;274:75–90.
6 Barkley RA. Behavioral inhibition, sustained attention, and executive functions: constructing a unifying theory of ADHD. *Psychol Bull* 1997;121:65–94.
7 Luman M, Tripp G, Scheres A. Identifying the neurobiology of altered reinforcement sensitivity in ADHD: a review and research agenda. *Neurosci Biobehav Rev* 2010;34:744–54.
8 Sagvolden T, Johansen EB, Aase H, *et al*. A dynamic developmental theory of attention-deficit/hyperactivity disorder (ADHD) predominantly hyperactive/impulsive and combined subtypes. *Behav Brain Sci* 2005;28:397–419;
9 Tripp G, Wickens JR. Research review: dopamine transfer deficit: a neurobiological theory of altered reinforcement mechanisms in ADHD. *J Child Psychol Psychiatry* 2008;49:691–704.
10 van der Oord S, Tripp G. How to improve behavioral parent and teacher training for children with ADHD: integrating empirical research on learning and motivation into treatment. *Clin Child Fam Psychol Rev* 2020;23:577–604.
11 Marx I, Hacker T, Yu X, *et al*. ADHD and the choice of small immediate over larger delayed rewards: a comparative meta-analysis of performance on simple choice-delay and temporal discounting paradigms. *J Atten Disord* 2021;25:171–87.
12 Sonuga-Barke EJS, Sergeant JA, Nigg J, *et al*. Executive dysfunction and delay aversion in attention deficit hyperactivity disorder: nosologic and diagnostic implications. *Child Adolesc Psychiatr Clin N Am* 2008;17:367–84,
13 Tripp G, Alsop B. Sensitivity to reward delay in children with attention deficit hyperactivity disorder (ADHD). *J Child Psychol Psychiatry* 2001;42:691–8.
14 Alsop B, Furukawa E, Sowerby P, *et al*. Behavioral sensitivity to changing reinforcement contingencies in attention-deficit hyperactivity disorder. *J Child Psychol Psychiatry* 2016;57:947–56.
15 Furukawa E, Shimabukuro S, Alsop B, *et al*. Behavioral sensitivity of Japanese children with and without ADHD to changing reinforcer availability: an experimental study using signal detection methodology. *Behav Brain Funct* 2017;13.
16 Hulsbosch A, Beckers T, De Meyer H, *et al*. Instrumental learning and behavioral persistence in children with attention-deficit/hyperactivity-disorder: does reinforcement frequency matter? *Child Psychology Psychiatry* 2023;64:1631–40. 10.1111/jcpp.13805 Available: https://acamh.onlinelibrary.wiley.com/toc/14697610/64/11
17 Carlson CL, Mann M, Alexander DK. Effects of reward and response cost on the performance and motivation of children with ADHD. *Cognit Ther Res* 2000;24:87–98.
18 Iaboni F, Douglas VI, Baker AG. Effects of reward and response costs on inhibition in ADHD children. *J Abnorm Psychol* 1995;104:232–40.
19 Furukawa E, Alsop B, Shimabukuro S, *et al*. Is increased sensitivity to punishment a common characteristic of attention deficit/hyperactivity disorder? An experimental study of response allocation in Japanese children. *ADHD Atten Def Hyp Disord* 2019;11:433–43.
20 Furukawa E, Alsop B, Sowerby P, *et al*. Evidence for increased behavioral control by punishment in children with attention-deficit hyperactivity disorder. *J Child Psychol Psychiatry* 2017;58:248–57.
21 Clare S, Helps S, Sonuga-Barke EJS. The quick delay questionnaire: a measure of delay aversion and discounting in adults. *Atten Defic Hyperact Disord* 2010;2:43–8.
22 Thorell LB, Sjöwall D, Mies GW, *et al*. Quick delay questionnaire: reliability, validity, and relations to functional impairments in adults with attention-deficit/hyperactivity disorder (ADHD). *Psychol Assess* 2017;29:1261–72.
23 Jackson JNS, MacKillop J. Attention-deficit/hyperactivity disorder and monetary delay discounting: a meta-analysis of case-control studies. *Biol Psychiatry Cogn Neurosci Neuroimaging* 2016;1:316–25.
24 Liu T-L, Su C-H, Lee J-I, *et al*. The reinforcement sensitivity of male adults with attention-deficit/hyperactivity disorder: The association with internet addiction. *Taiwan J Psychiatry* 2019;33:39.
25 Pironti VA, Lai M-C, Müller U, *et al*. Personality traits in adults with attention-deficit hyperactivity disorder and their unaffected first-degree relatives. *BJPsych Open* 2016;2:280–5.
26 Todokoro A, Tanaka SC, Kawakubo Y, *et al*. Deficient neural activity subserving decision-making during reward waiting time in intertemporal choice in adult attention-deficit hyperactivity disorder. *Psychiatry Clin Neurosci* 2018;72:580–90.
27 Torrubia R, Ávila C, Moltó J, *et al*. The Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ) as a measure of Gray's anxiety and impulsivity dimensions. Pers Individ Dif 2001;31:837–62.
28 Gray JA. *The Neuropsychology of Anxiety: An Enquiry into the Functions of the Septo-Hippocampal System*. Clarendon Press/Oxford University Press, 1982.
29 Gray JA. The psychophysiological basis of introversion-extraversion. *Behav Res Ther* 1970;8:249–66.
30 Bijttebier P, Beck I, Claes L, *et al*. Gray's reinforcement sensitivity theory as a framework for research on personality-psychopathology associations. *Clin Psychol Rev* 2009;29:421–30.
31 Luman M, van Meel CS, Oosterlaan J, *et al*. Reward and punishment sensitivity in children with ADHD: validating the Sensitivity to Punishment and Sensitivity to Reward Questionnaire for children (SPSRQ-C). *J Abnorm Child Psychol* 2012;40:145–57.
32 Quay HC. The behavioral reward and inhibition system in childhood behavior disorder. In: Bloomingdale LM, ed. *Attention Deficit Disorder*. 1988: 176–86. Available: https://psycnet.apa.org/fulltext/1988-98066-012.pdf
33 Quay HC. Inhibition and attention deficit hyperactivity disorder. *J Abnorm Child Psychol* 1997;25:7–13.
34 Mitchell JT, Robertson CD, Kimbrel NA, *et al*. An evaluation of behavioral approach in adults with ADHD. *J Psychopathol Behav Assess* 2011;33:430–7.
35 Mitchell JT, Nelson-Gray RO. Attention-deficit/hyperactivity disorder symptoms in adults: relationship to Gray's behavioral approach System. Pers Individ Differ 2006;40:749–60.
36 Nigg JT. Is ADHD a disinhibitory disorder? *Psychol Bull* 2001;127:571–98.
37 Hughes JR, Callas PW, Priest JS, *et al*. Development of a self-report measure of reward sensitivity:a test in current and former smokers. *Nicotine Tob Res* 2017;19:723–8.
38 Watson R, McCabe C, Harvey K, *et al*. Development and validation of a new adolescent self-report scale to measure loss of interest and pleasure: the anhedonia scale for adolescents. *Psychol Assess* 2021;33:201–17.
39 Berridge KC, Robinson TE. Liking, wanting, and the incentive-sensitization theory of addiction. *Am Psychol* 2016;71:670–9.
40 File D, Bőthe B, File B, *et al*. The role of impulsivity and reward deficiency in 'liking' and 'wanting' of potentially problematic behaviors and substance uses. *Front Psychiatry* 2022;13:820836.
41 Vainik U, Eun Han J, Epel ES, *et al*. Rapid assessment of reward-related eating: The RED-X5. *Obesity (Silver Spring)* 2019;27:325–31.
42 Llerena K, Park SG, McCarthy JM, *et al*. The Motivation and Pleasure Scale-Self-Report (MAP-SR): reliability and validity of a self-report measure of negative symptoms. *Compr Psychiatry* 2013;54:568–74.
43 Rizvi SJ, Quilty LC, Sproule BA, *et al*. Development and validation of the Dimensional Anhedonia Rating Scale (DARS) in a community sample and individuals with major depression. *Psychiatry Res* 2015;229:109–19.
44 Whiteside SP, Lynam DR. The five factor model and impulsivity: using a structural model of personality to understand impulsivity. *Personality and Individual Differences* 2001;30:669–89.
45 Whiteside SP, Lynam DR, Miller JD, *et al*. Validation of the UPPS impulsive behaviour scale: a four-factor model of impulsivity. *Eur J Pers* 2005;19:559–74.
46 Lopez R, Dauvilliers Y, Jaussent I, *et al*. A multidimensional approach of impulsivity in adult attention deficit hyperactivity disorder. *Psychiatry Res* 2015;227:290–5.
47 Miller DJ, Derefinko KJ, Lynam DR, *et al*. Impulsivity and attention deficit-hyperactivity disorder: subtype classification using the UPPS impulsive behavior scale. *J Psychopathol Behav Assess* 2010;32:323–32.
48 Chapman LJ, Chapman JP, Raulin ML. Scales for physical and social anhedonia. *J Abnorm Psychol* 1976;85:374–82.
49 Fawcett J, Clark DC, Scheftner WA, *et al*. Assessing anhedonia in psychiatric patients. *Arch Gen Psychiatry* 1983;40:79–84.
50 Snaith RP, Hamilton M, Morley S, *et al*. A scale for the assessment of hedonic tone the Snaith-Hamilton Pleasure Scale. *Br J Psychiatry* 1995;167:99–103.
51 Meinzer MC, Pettit JW, Leventhal AM, *et al*. Explaining the covariance between attention-deficit hyperactivity disorder symptoms and depressive symptoms: the role of hedonic responsivity. *J Clin Psychol* 2012;68:1111–21.
52 Jonker NC, Timmerman ME, de Jong PJ. The reward and punishment responsivity and motivation questionnaire (RPRM-Q): a stimulus-independent self-report measure of reward and punishment sensitivity that differentiates between responsivity and motivation. *Front Psychol* 2022;13:929255.

53 Bond FW, Hayes SC, Baer RA, *et al*. Preliminary psychometric properties of the acceptance and action questionnaire-II: a revised measure of psychological inflexibility and experiential avoidance. *Behav Ther* 2011;42:676–88.
54 Bodalski EA, Abu-Ramadan TM, Hough CE, *et al*. Low standards yet disappointed: ADHD symptoms and experiential avoidance in college students. *Journal of Contextual Behavioral Science* 2023;28:180–4.
55 Nichols SR, Briggs-Gowan MJ, Estabrook R, *et al*. Punishment Insensitivity in early childhood: a developmental, dimensional approach. *J Abnorm Child Psychol* 2015;43:1011–23.
56 Wakschlag LS, Briggs-Gowan MJ, Choi SW, *et al*. Advancing a multidimensional, developmental spectrum approach to preschool disruptive behavior. *J Am Acad Child Adolesc Psychiatry* 2014;53:82–96.
57 Blais AR, Weber EU. A Domain-Specific Risk-Taking (DOSPERT) scale for adult populations. *Judgm Decis Mak* 2006;1:33–47.
58 Shoham R, Sonuga-Barke EJS, Aloni H, *et al*. ADHD-associated risk taking is linked to exaggerated views of the benefits of positive outcomes. *Sci Rep* 2016;6:34833.
59 Dekkers TJ, Agelink van Rentergem JA, Huizenga HM, *et al*. Decision-making deficits in ADHD are not related to risk seeking but to suboptimal decision-making: meta-analytical and novel experimental evidence. *J Atten Disord* 2021;25:486–501.
60 Arksey H, O'Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol 2005;8:19–32.
61 Peters MDJ, Godfrey C, McInerney P, *et al*. Best practice guidance and reporting items for the development of scoping review protocols. *JBI Evid Synth* 2022;20:953–68.
62 Tricco AC, Lillie E, Zarin W, *et al*. PRISMA Extension for Scoping Reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med* 2018;169:467–73.
63 Covidence. *Better Systematic Review Management*. 2020. Available: https://www.covidence.org/
64 Aromataris EMZ, ed. *JBI Manual for Evidence Synthesis*. 2020.
65 Vaghri Z, Zermatten J, Lansdown G. *Article 1: definition of a Child*. In: Vaghri Z, Zermatten J, Lansdown G, eds. *Monitoring State Compliance With the UN Convention on the Rights of the Child*. Cham: Springer International Publishing, 2022: 407–12.

Supplementary appendix 1-1: Search strategy in PubMed

This scoping review's search strategy was based on the following table in PubMed. The first part of each block included Medical Subject Headings (MeSH) terms (1 & 4 & 7). Using All fields, the terms related to MeSH or suited for the scoping review purpose were used to cover the wide range of preliminary research in other parts of each block (2, 5, 8, 9, 10, 11).

Title	The relationships between experimental tasks and questionnaire of reward/punishment sensitivity in attention deficit hyperactivity disorder: protocol for a scoping review
Question	1. Examine which aspects of hypothesized altered reward and punishment sensitivity correspond to constructs measured by existing questionnaires. 2. Characterize the relationships between ADHD symptomatology and reward and punishment sensitivity as measured by existing questionnaires. 3. Evaluate the consistency between the altered reward and punishment sensitivity as measured by existing questionnaires and in experimental tasks.
Database	PubMed
Date	2023/11/16
Searcher	NN/MO

#	Search terms	Items found
Population: People who have diagnosis or tendency of ADHD symptoms		
1	"attention deficit disorder with hyperactivity"[MeSH Terms]	35,139
2	"attention deficit disorder with hyperactivity"[All Fields] OR "adhd"[All Fields] OR "add"[All Fields] OR "attention deficit hyperactivity disorder*"[All Fields] OR "hyperkinetic syndrome"[All Fields] OR "addh"[All Fields] OR "attention deficit disorder*"[All Fields] OR "minimal brain dysfunction"[All Fields]	137,631
Combined sets		
3	**1 OR 2**	137,631
Measurements: Sets of questions to obtain information from participants about a topic of interest.		
4	"surveys and questionnaires"[MeSH Terms] OR "self report"[MeSH Terms] OR "psychometrics"[MeSH Terms]	1,268,156
5	"measurement*"[All Fields] OR "scale*"[All Fields] OR "questionnaire*"[All Fields] OR "survey*"[All Fields] OR "experiment*"[All Fields] OR "task*"[All Fields]	7,015,887
Combined sets		
6	**4 OR 5**	7,424,248
The concepts of measurement: Assessing the reward and punishment sensitivity.		
7	"reinforcement, psychology"[MeSH Terms] OR "punishment"[MeSH Terms] OR "motivation"[MeSH Terms] OR "decision making"[MeSH Terms] OR "pleasure"[MeSH Terms] OR "reinforcement schedule"[MeSH Terms]	458,714
8	"reward sensitivity"[All Fields] OR "punishment sensitivity"[All Fields] OR "sensitivity to reward"[All Fields] OR "sensitivity to punishment"[All Fields] OR "sensitivity to reward and punishment"[All Fields] OR "partial reinforcement"[All Fields] OR "continuous reinforcement"[All Fields] OR "reward responsiveness"[All Fields] OR "reward seeking" [All Fields]	3,692
9	"behavioral inhibition system"[All Fields] OR "behavioral activation system"[All Fields] OR "behavioral approach system"[All Fields] OR "reinforcement sensitivity theory"[All Fields]	611
10	"generalized reward"[All Fields] OR "sensitivity to punishment and sensitivity to reward"[All Fields] OR "fawcett clark pleasure"[All Fields] OR "snaith hamilton pleasure"[All Fields] OR "chapman anhedonia"[All Fields] OR "specific loss of interest and pleasure"[All Fields] OR "temporal experience of pleasure"[All Fields] OR "anticipatory and consummatory interpersonal pleasure"[All Fields] OR "rewarding events"[All Fields] OR "motivation and pleasure"[All Fields] OR "dimensional anhedonia"[All Fields] OR "quick delay"[All Fields]	583
11	"benefit perception"[All Fields] OR "risk perception"[All Fields]	7,817
Combined sets		
12	**7 OR 8 OR 9 OR 10 OR 11**	467,377
13	**3 AND 6 AND 12**	4,387
14	**13 NOT ("systematic review"[Title] OR "meta-analysis"[Title]) AND ((excludepreprints[Filter]) AND (humans[Filter]) AND (english[Filter]))**	2,150

Supplementary appendix 1-2: Search strategy in Web of Science

Based on the search strategy of PubMed, the search terms were decided in Web of Science.

Title	The relationships between experimental tasks and questionnaire of reward/punishment sensitivity in attention deficit hyperactivity disorder: protocol for a scoping review
Question	1. Examine which aspects of hypothesized altered reward and punishment sensitivity correspond to constructs measured by existing questionnaires. 2. Characterize the relationships between ADHD symptomatology and reward and punishment sensitivity as measured by existing questionnaires. 3. Evaluate the consistency between the altered reward and punishment sensitivity as measured by existing questionnaires and in experimental tasks.
Database	Web of Science
Date	2023/11/16
Searcher	NN/MO

#	Search terms	Items found
Population: people who have diagnosis or tendency of ADHD symptoms		
1	(((((((((ALL=("attention deficit disorder with hyperactivity")) OR ALL=("adhd")) OR ALL=("add")) OR ALL=("attention deficit hyperactivity disorder")) OR ALL=("hyperkinetic syndrome")) OR ALL=("adhd")) OR ALL=("attention deficit disorder")) OR ALL=("attention deficit hyperactivity disorders")) OR ALL=("attention deficit disorders")) OR ALL=("minimal brain dysfunction")	200,439
Measurements: Sets of questions to obtain information from participants about a topic of interest.		
2	((((((((((((ALL=("questionnaire")) OR ALL=("questionnaires")) OR ALL=(measurement)) OR ALL=("measurements")) OR ALL=("scale")) OR ALL=("scales")) OR ALL=("self report")) OR ALL=("self-report")) OR ALL=("psychometric")) OR ALL=("psychometrics")) OR ALL=("experiment")) OR ALL=("experiments")) OR ALL=("task")) OR ALL=("tasks")	9,070,465
The concepts of measurement: Assessing the reward and punishment sensitivity.		
3	(((((ALL=("reinforcement")) OR ALL=("punishment")) OR ALL=("motivation")) OR ALL=("decision make")) OR ALL=("decision making")) OR ALL=("pleasure")	782,999
4	(((((((((ALL=("reward sensitivity")) OR ALL=("punishment sensitivity")) OR ALL=("sensitivity to reward")) OR ALL=("sensitivity to punishment")) OR ALL=("sensitivity to reward and punishment")) OR ALL=("partial reinforcement")) OR ALL=("continuous reinforcement")) OR ALL=("reinforcement schedule")) OR ALL=(“reward responsiveness”)) OR ALL=(“reward seeking”)	5,505
5	(((ALL=("behavioral inhibition system")) OR ALL=("behavioral activation system")) OR ALL=("behavioral approach system")) OR ALL=(“reinforcement sensitivity theory”)	1,274
6	((((((((((ALL=("generalized reward")) OR ALL=("sensitivity to punishment and sensitivity to reward")) OR ALL=("fawcett clark pleasure")) OR ALL=("snaith hamilton pleasure")) OR ALL=("chapman anhedonia")) OR ALL=("specific loss of interest and pleasure")) OR ALL=("temporal experience of pleasure")) OR ALL=("anticipatory and consummatory interpersonal pleasure")) OR ALL=("rewarding events")) OR ALL=("motivation and pleasure")) OR ALL=("dimensional anhedonia")) OR ALL=(“quick delay”)	585
7	(ALL=(benefit perception)) OR ALL=(risk perception)	129,440
Combined sets		
8	**3 OR 4 OR 5 OR 6 OR 7**	898,771
9	**1 AND 2 AND 8**	3,184
10	**9 NOT (TI=("systematic review") OR TI=("meta-analysis")) and English (Languages) and Article or Early Access (Document Types)**	2,915

Supplementary appendix 1-3: Search strategy in PsycINFO

Title	The relationships between experimental tasks and questionnaire of reward/punishment sensitivity in attention deficit hyperactivity disorder: protocol for a scoping review
Question	4. Examine which aspects of hypothesized altered reward and punishment sensitivity correspond to constructs measured by existing questionnaires. 5. Characterize the relationships between ADHD symptomatology and reward and punishment sensitivity as measured by existing questionnaires. 6. Evaluate the consistency between the altered reward and punishment sensitivity as measured by existing questionnaires and in experimental tasks.
Database	PsycINFO
Date	2023/11/16
Searcher	NN

#	**Search terms**	**Items found**
Population: People who have diagnosis or tendency of ADHD symptoms		
1	attention deficit disorder with hyperactivity/ or attention deficit disorder/	32,303
2	"attention deficit disorder with hyperactivity" or "attention deficit disorder*" or "attention deficit hyperactivity disorder*" or "add" or "adhd" or "addh" or "hyperkinetic syndrome" or "minimal brain dysfunction"	78,875
Combined sets		
3	**1 or 2**	78,875
Measurements: Sets of questions to obtain information from participants about a topic of interest.		
4	questionnaires/ or surveys/ or measurement/ or psychometrics/ or likert scales/ or rating scales/ or self-report/	194,117
5	"measurement*" or "scale*" or "questionnaire*" or "survey*" or "experiment*" or "task*"	2,240,145
Combined sets		
6	**4 or 5**	2,254,420
The concepts of measurement: Assessing the reward and punishment sensitivity.		
7	reinforcement/ or punishment/ or motivation/ or decision making/ or pleasure/	177,627
8	reward sensitivity/ or reinforcement schedules/ or punishment/	15,507
9	"punishment sensitivity" or "sensitivity to punishment" or "sensitivity to reward and punishment" or "reward responsiveness" or "reward seeking"	2,112
10	behavioral inhibition system/ or behavioral activation system/	902
11	"reinforcement sensitivity theory"	427
12	"generalized reward" or "sensitivity to punishment and sensitivity to reward" or "fawcett clark pleasure" or "snaith hamilton pleasure" or "chapman anhedonia" or "specific loss of interest and pleasure" or "temporal experience of pleasure" or "anticipatory and consummatory interpersonal pleasure" or "rewarding events" or "motivation and pleasure" or "dimensional anhedonia" or "quick delay"	1,519
13	risk perception/	9,241
14	"benefit perception" or "risk perception"	11,333
Combined sets		
15	**7 or 8 or 9 or 10 or 11 or 12 or 13 or 14**	196,284
Combined sets		
16	**3 and 6 and 15**	1,362
17	**(limit 16 to (English and human)) not ("systematic review" or "meta-analysis").ti.**	1,240

Supplementary appendix 2: Draft Data Collection Items

- Source
  - ・Year
  - ・Author
  - ・Title
  - ・Citation Number
- Eligibility
  - ・Reason for inclusion
- Methods
  - ・Design: intervention, experimental task, questionnaire
  - ・Purpose/Study Question
- Population Characteristics
  - ・Age
  - ・Number
  - ・Number of Group
  - ・Sex
  - ・Diagnosis/Symptoms
  - ・Country
  - ・Co-morbidity
  - ・Socio-demographics/Ethnicity/Other
- Measurements for the reinforcement and punishment sensitivity (Outcomes)
  1. Questionnaire
     - ・Name of Measurement
     - ・Developer
     - ・Development Year
     - ・Definition of Measurement
  2. Experimental tasks
     - ・Name of Measurement
     - ・Developer
     - ・Development Year
     - ・Definition of Measurement
- Results
  - ・Outcomes (relationship with ADHD symptoms/diagnosis and experimental task performance)

・Effect size, CI, *p*-values

➢ Others

・Funding

Supplementary appendix 3: PRISMA-ScR

The relationships between experimental tasks and questionnaire of reward/punishment sensitivity in attention deficit hyperactivity disorder: protocol for a scoping review