Psychiatry Research: Neuroimaging 319 (2022) 111424

Contents lists available at ScienceDirect

Psychiatry Research: Neuroimaging

journal homepage: www.elsevier.com/locate/psychresns

Cognitive assessment using ERP in child and adolescent psychiatry: Difficulties and opportunities

Cristina Berchio[a,*], Nadia Micali[a,b,c]

[a] Department of Psychiatry, Faculty of Medicine, University of Geneva, Geneva, Switzerland
[b] Division of Child and Adolescent Psychiatry, Department of Child and Adolescent Health, Geneva University Hospital, Geneva, Switzerland
[c] Great Ormond Street Institute of Child Health, University College London, London, UK

ARTICLE INFO

Keywords:
ERPs recording
Cognitive assessment
Child and adolescent psychiatry

ABSTRACT

Event related potentials (ERPs) represent powerful tools to investigate cognitive functioning in child and adolescent psychiatry. So far, the available body of research has largely focused on advancements in analysis methods, with little attention given to the perspective of assessment. The aim of this brief report is to provide recommendations for cognitive ERPs assessment that can be applied across diagnostic categories in child and adolescent psychiatry research. First, we discuss major issues for ERPs testing using examples from common psychiatric disorders. We conclude by summing up our recommendations for methodological standards and highlighting the potential role of ERPs in the field.

1. Introduction

Event-related potentials (ERPs) represent one of the most widely used tools to study cognitive function in children and adolescents (Bhavnani et al., 2021). A wide variety of neuropsychological tests have been implemented on computer-based models and integrated with ERPs (Ghani et al., 2020; Kutas et al., 2012; Reinvang, 1999; Seer et al., 2016).

ERPs are measured by delivering several times certain category of events, and averaging the signal (Duncan et al., 2009; Luck, 2012). ERPs allow studying the sequence of cognitive processes at high temporal resolution: the early waves (within 100 milliseconds after stimuli onset) are called 'sensory' component, while ERPs generated at later stages reflect higher order information processes (Sur and Sinha, 2009).

The ability to understand, follow instructions, and concentrate are skills required to perform many neuropsychological tests (Howieson, 2019). As such, challenges may be expected for cognitive assessment using ERPs in children and adolescents with atypical development (Brooker et al., 2019).

To date, the body of research relevant to ERPs has largely focused on advancements in electroencephalography (EEG) analysis methods (for a recent review, see (Bridwell et al., 2018)), with little attention given to data collection especially in vulnerable populations. The purpose of this work is to provide recommendations for cognitive ERPs assessment that can be applied across diagnostic categories in child and adolescent psychiatry. This article serves as a 'best practices guide' for researchers interested in applying ERPs methodologies: it is addressed mainly to those not familiar with experimental settings in child and adolescent psychopathology. This article also aims to raise awareness within the community of developers: hardware architects, software developers, computational scientists. The overall objective is to familiarize a wide range of professionals with common methodological issues on data collection, but also with the effectiveness of specific experimental settings.

First, we discuss major obstacles to the use of ERPs as routine assessment, using examples from the most common forms of psychopathology in children and adolescents. We conclude by summing up our recommendations for researchers and highlighting outstanding issues in the field.

2. Challenges related to ERPs assessment in child and adolescent psychiatry

2.1. Anxiety and depressive disorders

Anxiety disorders (AD) and depressive disorders (DD) represent the most common child and adolescent psychiatric disorders (Polanczyk et al., 2015). Median age of onset for separation anxiety disorders and specific phobia is 7 years old, while for social anxiety disorders it is 13

* Corresponding author.
E-mail address: cristina.berchio@unige.ch (C. Berchio).

https://doi.org/10.1016/j.pscychresns.2021.111424
Received 15 June 2021; Received in revised form 28 November 2021; Accepted 29 November 2021
Available online 30 November 2021
0925-4927/

years old (Kessler et al., 2005). DD are usually diagnosed after age of 6 (Bernaras et al., 2019). AD are characterized by cognitive bias towards threat (Abend et al., 2018) and generalized fears (Pittig et al., 2018). Symptoms of DD in youths include low mood, irritability, negative thoughts, reduced motivation and active engagement (Orchard et al., 2017; Watson et al., 2020).

Internalizing symptoms of AD and DD, such as distress during separation; fear of being alone, exposed to unfamiliar people; fears of objects; poor concentration; lack of motivation; and negative bias in processing information may represent challenges for cognitive ERPs assessment.

2.2. Autism spectrum disorders

Autism Spectrum Disorder (ASD) is clinically defined by impairment in communication, social interaction, and stereotypical behavioral (APA, 2013). Early diagnoses occur between 18 and 48 months of age (Jussila et al., 2020). High functioning children with ASD typically have average to above average intelligence and comparable cognitive skills to typically developing children (Lickel et al., 2012), whereas severe forms of ASD are usually characterized by poor cognitive performance (Rommelse et al., 2015). Beyond cognitive functioning, unusual responses to sensory information are also present in ASD (Rogers et al., 2003).

Several features need to be considered to ensure adequate test section and procedure set up, including social/intellectual functioning, very young age, atypical sensory responses (es., tactile/auditory sensitivity), stereotyped movements, and resistance to environmental changes (see, (Kylliäinen et al., 2014; Webb et al., 2015)).

2.3. ADHD

Attention deficit hyperactivity disorder (ADHD) consists of a pattern of inattention and/or hyperactivity–impulsivity (APA, 2013). ADHD is often diagnosed after children start attending school (Evans et al., 2010). Attentional/hyperactivity problems and impulsivity may result in listening difficulties, not following instructions, and making careless mistakes during the execution of tasks (APA, 2013; DuPaul et al., 2014). These children may be easily distracted, easily bored, and struggle to stay seated for long periods of time (Shaughnessy and Waggoner, 2015). Assessment of cognitive ERPs in ADHD is challenging for core symptoms of this disorder, and the requirements of the setting: stay focused for longer periods of time, following instructions, move little as possible.

2.4. Eating disorders

Eating disorders (ED) are mental disorders defined by abnormal eating behaviors (APA, 2013). Child and adolescent ED include anorexia nervosa (AN), bulimia nervosa (BN), binge eating disorder (BED), and avoidant restrictive food intake disorder (ARFID). Low weight and intense fear of becoming fat are characteristics of AN, while BN is characterized by BE episodes and inappropriate compensatory behaviors, and BED by BE episodes in the absence of compensatory behaviors, distress, and presence of several cognitive and behavioral symptoms (APA, 2013). ARFID profiles involve anxiety for eating certain types of food, sensory abnormalities, and lack of interest in foods (Thomas et al., 2017).

Peak age for diagnosis of AN and BN is 15–19 years old (Micali et al., 2013) and childhood for ARFID (Fisher et al., 2014). BED might have a bimodal peak of onset, at young ages and mid-life (Micali et al., 2017).

While AN, BE, and BN are often characterized by weaknesses in specific cognitive domains, such as set shifting (Allen et al., 2013), and cognitive control (Lavagnino et al., 2016), not much is known about the cognitive profile of ARFID.

Medical complications related to malnutrition, such as physical weakness and sense of fatigue, may render testing sessions particularly hard to tolerate, and negatively impact cognitive performance. Impulsivity/distractibility, anxiety, and sensory abnormalities may also cause concomitant problems.

3. Recommendations for researchers

Below, we propose a list of recommendations to guide researchers during implementation stages and data collection. An essential recommendation is to identify tests that are related to critical cognitive areas that can be effectively implemented in combination with ERPs. Critical cognitive areas can be identified based on clinical insights or empirical evidence in neuropsychological research (see for example, on ASD (Charman et al., 2011; Courchesne et al., 2019; Rabiee et al., 2019), AD (Murphy et al., 2018), DD (Jacobs et al., 2008; Vance and Winther, 2021), ADHD (Loyer Carbonneau, Demers, Bigras, and Guay, 2020; Moura et al., 2019), and ED (Basile et al., 2021; Schaumberg et al., 2020). Assembling a cross-functional team would improve the quality of test selection, set-up of procedures (instructions, training practice etc.), and of planning subsequent data analysis.

To minimize the gap between what is known from cognitive research and what is actually feasible, a technical feasibility analysis should be performed. This analysis should ascertain the likelihood of completing the assessment successfully. Critical information to consider includes: affective, social, and cognitive functioning, as well as age, physical symptoms. Stimuli/tasks selection should take into account affective, sensory abnormalities (visual/auditory/tactile), and levels of distractibility.

Emotional intensity has to be carefully evaluated. Phobias have typically been classified as irrational fears of situation, object, or activity (APA, 2013). Typical worries of children are represented by personal harm, medical procedures, separation from parents, environmental threats (Muris et al., 2002). During interaction with a phobic stimulus a combination of avoidance behavior, physiological arousal, and catastrophic thinking may be induced (Davis III, Ollendick, and Öst, 2019). Specific stimuli categories may be expected to induce strong emotional reactions in certain disorders, such as food for ED (Cardi et al., 2019; Thomas et al., 2017), but also to be negatively over-estimated, especially in AD (Bögels and Zigterman, 2000). It may be more difficult determining whether a specific phobia is present in children with ASD or intellectual disability (Davis III et al., 2019), similarly in young children (Brown and Lamb, 2015). Advice from experts in psychopathology or clinicians should be sought to adapt stimuli properties and experimental procedures, and how to safely and ethically apply them. If arousal intensity is judged potentially too high or impossible to estimate, alternative strategies should be planned.

Unusual responses to sensory experiences are characteristics of ASD (Marco et al., 2011), but also of ED, especially ARFID (Galiana-Simal et al., 2017). ERPs cognitive tasks are usually administered using visual or auditory stimuli. To prevent extreme reactions in ASD, specific precautions should be adopted during stimuli and procedure selection: for auditory stimuli high dB intensity should be avoided, as well as moving and flickering light stimuli for visual tasks, skin contact with experimental materials should be carefully evaluated, etc. (see (Kylliäinen et al., 2014; Thomas et al., 2017)).

Distractibility, excessive mental fatigue, boredom, frustration, and lack of motivation may induce poor data quality collection. As a general rule, stimuli/experimental procedures in child and adolescent psychiatry should be selected to be suitable and attractive for the age of participants (Brooker et al., 2019). To deal with symptoms of inattention in ADHD, experiences from the classical cognitive literature, such as introducing novel stimuli to increase orienting responses on computer-based tasks (van Mourik, Oosterlaan, Heslenfeld, Konig, and Sergeant, 2007), or applying contingent reinforcements (Luman et al., 2005) can be helpful. These techniques can also be useful to keep all participants motivated and attentive. However, based on our experience, trying to make the content of a project relevant for participants/families is a key engagement strategy.

A feasibility study should also be planned to decide, not only the feasibility of an idea, but also ensuring a project is operational and feasible. Identified reasons for recruitment difficulties, and poor data quality are methodological aspects that should be carefully estimated.

Although, data quality can be an issue, especially in ASD (Webb et al., 2015), ADHD (Kaiser et al., 2021), and young children (Brooker et al., 2019), excessive fear reactions may have similar effects. Potential data quality issues, either ERPs or behavioral, should be considered when effect sizes and power estimations are calculated.

Based on clinical vulnerabilities and strengths, specific accommodations should be planned. Experimental settings and tasks should be set-up to optimize the child/adolescent functioning.

Whenever stimuli or procedures at high potential level of arousal are used, adequate psychological support should be provided during, and after the procedure of ERPs testing. Furthermore, emotion perceptions and reactions should be monitored during data collection. This can be done using visual analogue scales appropriate for children/adolescents, and specific questionnaires (see, for example (Bringuier et al., 2009)), or collecting other physiological parameters. To reduce anxiety symptoms, participants should be made familiar with the procedures/EEG cap, and testing sessions should be predictable with clear expectations.

For restrictive ED with moderate/severe underweight, multiple breaks should be planned, and time of the day (before/after meals) should be carefully considered.

To handle with ASD symptoms, choice of recording equipment, strategies to reduce novelty of the procedures, accompaniment, and behavioral management techniques should be adopted (see (Webb et al., 2015)).

During ERPs recordings, effective strategies to reduce lack of concentration or distractibility, may consist of giving simple instructions, planning shorter blocks and pauses, and using catch trials to re-address attention. Establishing structure and creating a quiet setting may also help to positively influence self-regulation symptoms.

Accommodations should also take into account patients strengths. These can be defined as intellectual, physical, and cognitive skills, but also interest and motivation. Identifying them should improve quality of ERPs testing. Some children may better understand instructions if they are delivered in a non-verbal way (e.g., visual materials for ASD (Lickel et al., 2012)); others may feel more comfortable with certain tasks (e.g.. logical thinking and emotional reasoning for ADHD (see (Climie and Mastoras, 2015)), or visual attention in AN and BN (Allen et al., 2013).

Before ERPs assessment, children/adolescents should perform a comprehensive assessment. Participants should be assessed in a comprehensive manner: all aspects of development and well-being must be examined, including cognitive, emotional, and physical health, as well as any drug treatments.

Mental health and wellbeing is most often measured using questionnaires, that according to age and level of functioning can be completed by participants, or caregivers, or other professionals.

Tests and questionnaires choices will be determined by clinical features, and inclusion and exclusion study criteria. Knowing as much as possible about fears and exposure may be crucial for younger children, AD, and ASD, and an adequate assessment should be planned. To determine sensory sensitivities in ASD or ED, caregivers/therapists, and older participants should be interviewed. Although, there is no single, easy solution, this evaluation would act as a roadmap, identifying areas of both need and strength for cognitive ERPs assessment.

The distress that participants may experience during the procedure should be minimized. The test setting should be managed by researchers. It is critical to acknowledge and estimate the intensity of reaction that certain stimuli/procedures may induce in certain disorders: in terms of emotions, physical symptoms, and sensorial experience. Selecting appropriate procedures, planning specific accommodations to clinical vulnerabilities and strengths, and performing comprehensive assessments are methodological adjustments that, if properly conducted, should prevent or at least reduce distress of participants and families.

It is also important to emphasize that creating a positive experience for families is also an effective strategy to make research more accessible.

Anyone carrying out the assessment must be well trained in the standardized administration of tests. As is the case in classical neurophysiological assessments, changes in the procedures may introduce systematic errors (Harvey, 2012). Therefore, any method of testing during ERPs data collection should be applied with awareness.

Similarly, researchers should be cautious about simply applying extensions of psychological or clinical methodologies without adequate training. An adequate clinical training will determine the rates of success in interacting with patients and families, and as a consequence in data collection.

Caregivers and participants should be given timely and accurate information. It is good practice to explain the temporal sequence of the whole session in detail, including how the application of the EEG cap will occur. According to age, level of functioning, this can be done using simple words, pictures, or video-clips, allowing them to ask questions and express any possible concerns they may have. To reassure caregivers, they may be invited to observe the assessment from a corner in the testing room, through a one-way mirror, or on a video camera.

4. Conclusion

Employing ERPs and relating them to neuropsychological assessment is a powerful tool to investigate cognitive functioning in child and adolescent psychiatry. The main strengths of this approach are the semi-ecological validity and non-invasiveness, allowing its application in young children for the majority of psychiatric disorders. On the other hand, this also demands clinical expertise, and paradoxically, to date, little attention has been given to methodological aspects of ERPs cognitive assessment, and on consequent development of transversal guidelines for conducting research in child and adolescent psychiatry. High incidence of comorbidity in child and adolescent psychiatry, co-occurrence of similar disorders in parents, and family functioning also have practical implications. Developing methodological standards may also help to validate and refine procedures.

Rapidly evolving advances in technology have the great potential to improve ERPs applications for research in the multi-disciplinary field of child and adolescent psychiatry. Among the exciting developments in technology there are new hardware solutions, such as dry electrodes (Kam et al., 2019) and portable systems (Krigolson et al., 2017; Ogino et al., 2019), but also of sophisticated methodologies of analyses, such as ERPs classification based on single trial (see, (Blankertz et al., 2011; De Lucia and Tzovara, 2015)). However, only with awareness of clinical needs can these methodological improvements become effective and get practical applications for child and adolescent psychiatry.

In the upcoming years, a wave of further advancements in technology is expected, that will certainly mitigate many of the issues mentioned above, such as: technologies allowing cognitive ERPs testing less stressful, and methodologies more effective in reducing/cancelling noise. Once again, this will only be achieved by sharing knowledge from multiple perspectives, and establishing effective dialog between developers and clinical researchers.

Today, clinical applications have been limited to the assessment of biological markers in many psychiatric disorders (Jeste and Nelson, 2009; Kaiser et al., 2020; Mumtaz et al., 2015), and rather little consideration has been given to the development of standards for ERPs cognitive assessment. Further research is absolutely needed in this area to validate existing procedures and to optimize clinical applications in child and adolescent psychiatry.

Declaration of Competing Interest

Dr. Berchio, Prof. Micali disclose any actual or potential conflict of interest including any financial, personal or other relationships with other people or organizations within three years of beginning the work submitted that could inappropriately influence, or be perceived to influence, our work.

Acknowledgements

This work has been supported by the Foundation Gertrude von Meissner (to CB, and NM).

References

Abend, R., de Voogd, L., Salemink, E., Wiers, R.W., Pérez-Edgar, K., Fitzgerald, A., Silverman, W., 2018. Association between attention bias to threat and anxiety symptoms in children and adolescents. Depress. Anxiety 35 (3), 229–238.
Allen, K.L., Byrne, S.M., Hii, H., Van Eekelen, A., Mattes, E., Foster, J., 2013. Neurocognitive functioning in adolescents with eating disorders: a population-based study. Cogn. Neuropsychiatry 18 (5), 355–375.
APA, 2013. Diagnostic and Statistical Manual of Mental Disorders (DSM-5®). Psychiatric Pub, American.
Basile, C., Gigliotti, F., Colaiori, M., Di Santo, F., Terrinoni, A., Ardizzone, I., Sabatello, U., 2021. Comparison of neuropsychological profiles in children and adolescent with anorexia nervosa and avoidant/restrictive food intake disorder (ARFID). Eur. Psychiatry 64 (S1). S351-S352.
Bernaras, E., Jaureguizar, J., Garaigordobil, M., 2019. Child and adolescent depression: a review of theories, evaluation instruments, prevention programs, and treatments. Front. Psychol. 10, 543.
Bhavnani, S., Lockwood Estrin, G., Haartsen, R., Jensen, S.K., Gliga, T., Patel, V., Johnson, M.H., 2021. EEG signatures of cognitive and social development of preschool children–a systematic review. PLoS ONE 23 (4), 687–697.
Blankertz, B., Lemm, S., Treder, M., Haufe, S., Müller, K.-R., 2011. Single-trial analysis and classification of ERP components—A tutorial. Neuroimage 56 (2), 814–825.
Bögels, S.M., Zigterman, D., 2000. Dysfunctional cognitions in children with social phobia, separation anxiety disorder, and generalized anxiety disorder. J. Abnorm. Child Psychol. 28 (2), 205–211.
Bridwell, D.A., Cavanagh, J.F., Collins, A.G., Nunez, M.D., Srinivasan, R., Stober, S., Calhoun, V.D., 2018. Moving beyond ERP components: a selective review of approaches to integrate EEG and behavior. Front. Hum. Neurosci. 12, 106.
Bringuier, S., Dadure, C., Raux, O., Dubois, A., Picot, M.-C., Capdevila, X., 2009. The perioperative validity of the visual analog anxiety scale in children: a discriminant and useful instrument in routine clinical practice to optimize postoperative pain management. Anesth. Analg. 109 (3), 737–744.
Brooker, R.J., Bates, J.E., Buss, K.A., Canen, M.J., Dennis-Tiwary, T.A., Gatzke-Kopp, L. M., Lahat, A., 2019. Conducting event-related potential (ERP) research with young children. J. Psychophysiol. 34 (3), 137–158.
Brown, D.A., Lamb, M.E., 2015. Can children be useful witnesses? It depends how they are questioned. Child Dev. Perspect. 9 (4), 250–255.
Cardi, V., Leppanen, J., Mataix-Cols, D., Campbell, I.C., Treasure, J., 2019. A case series to investigate food-related fear learning and extinction using in vivo food exposure in anorexia nervosa: a clinical application of the inhibitory learning framework. Eur. Eat. Disord. Rev. 27 (2), 173–181. https://doi.org/10.1002/erv.2639.
Charman, T., Jones, C.R., Pickles, A., Simonoff, E., Baird, G., Happé, F., 2011. Defining the cognitive phenotype of autism. Brain Res. 1380, 10–21.
Climie, E.A., Mastoras, S.M., 2015. ADHD in schools: adopting a strengths-based perspective. Can. Psychol./Psychologie Canadienne 56 (3), 295.
Courchesne, V., Girard, D., Jacques, C., Soulières, I., 2019. Assessing intelligence at autism diagnosis: mission impossible? Testability and cognitive profile of autistic preschoolers. J. Autism Dev. Disord. 49 (3), 845–856.
Davis III, T.E., Ollendick, T.H., Öst, L.-G, 2019. One-session treatment of specific phobias in children: recent developments and a systematic review. Annu. Rev. Clin. Psychol. 15, 233–256.
De Lucia, M., Tzovara, A., 2015. Decoding auditory EEG responses in healthy and clinical populations: a comparative study. J. Neurosci. Methods 250, 106–113.
Duncan, C.C., Barry, R.J., Connolly, J.F., Fischer, C., Michie, P.T., Näätänen, R., Van Petten, C., 2009. Event-related potentials in clinical research: guidelines for eliciting, recording, and quantifying mismatch negativity, P300, and N400. Clin. Neurophysiol. 120 (11), 1883–1908. https://doi.org/10.1016/j.clinph.2009.07.045.
DuPaul, G.J., Gormley, M.J., Laracy, S.D., 2014. School-based interventions for elementary school students with ADHD. Child Adolescent Psychiatric Clinics 23 (4), 687–697.
Evans, W.N., Morrill, M.S., Parente, S.T., 2010. Measuring inappropriate medical diagnosis and treatment in survey data: the case of ADHD among school-age children. J. Health Econ. 29 (5), 657–673.
Fisher, M.M., Rosen, D.S., Ornstein, R.M., Mammel, K.A., Katzman, D.K., Rome, E.S., Walsh, B.T., 2014. Characteristics of avoidant/restrictive food intake disorder in children and adolescents: a "new disorder" in DSM-5. J. Adolesc. Health 55 (1), 49–52.
Galiana-Simal, A., Muñoz-Martinez, V., Beato-Fernandez, L., 2017. Connecting eating disorders and sensory processing disorder: a sensory eating disorder hypothesis. Psychopathology 37 (8), 1077–1087.
Ghani, U., Signal, N., Niazi, I., Taylor, D., 2020. ERP based measures of cognitive workload: a review. Neurosci. Biobehav. Rev. 118, 18–26.
Harvey, P.D., 2012. Clinical applications of neuropsychological assessment. Dialogues Clin Neurosci 14 (1), 91–99. https://doi.org/10.31887/DCNS.2012.14.1/pharvey.
Howieson, D., 2019. Current limitations of neuropsychological tests and assessment procedures. Clin. Neuropsychol. 33 (2), 200–208. https://doi.org/10.1080/13854046.2018.1552762.
Jacobs, R.H., Reinecke, M.A., Gollan, J.K., Kane, P., 2008. Empirical evidence of cognitive vulnerability for depression among children and adolescents: a cognitive science and developmental perspective. Clin. Psychol. Rev. 28 (5), 759–782.
Jeste, S.S., Nelson, C.A., 2009. Event related potentials in the understanding of autism spectrum disorders: an analytical review. J. Autism Dev. Disord. 39 (3), 495–510.
Jussila, K., Junttila, M., Kielinen, M., Ebeling, H., Joskitt, L., Moilanen, I., Mattila, M.-L., 2020. Sensory abnormality and quantitative autism traits in children with and without autism spectrum disorder in an epidemiological population. J. Autism Dev. Disord. 50 (1), 180–188.
Kaiser, A., Aggensteiner, P.-.M., Baumeister, S., Holz, N.E., Banaschewski, T., Brandeis, D., 2020. Earlier versus later cognitive event-related potentials (ERPs) in attention-deficit/hyperactivity disorder (ADHD): a meta-analysis. Neurosci. Biobehav. Rev. 112, 117–134.
Kaiser, A., Aggensteiner, P.-.M., Holtmann, M., Fallgatter, A., Romanos, M., Abenova, K., Ethofer, T., 2021. EEG data quality: determinants and impact in a multicenter study of children, adolescents, and adults with attention-deficit/hyperactivity disorder (ADHD). Brain Sci. 11 (2), 214.
Kam, J.W., Griffin, S., Shen, A., Patel, S., Hinrichs, H., Heinze, H.-J., Knight, R.T., 2019. Systematic comparison between a wireless EEG system with dry electrodes and a wired EEG system with wet electrodes. Neuroimage 184, 119–129.
Kessler, R.C., Berglund, P., Demler, O., Jin, R., Merikangas, K.R., Walters, E.E., 2005. Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the national comorbidity survey replication. Arch. Gen. Psychiatry 62 (6), 593–602.
Krigolson, O.E., Williams, C.C., Norton, A., Hassall, C.D., Colino, F.L., 2017. Choosing MUSE: validation of a Low-Cost. Portable EEG System for ERP Research. Front. Neurosci. 11, 109. https://doi.org/10.3389/fnins.2017.00109.
Kutas, M., Kiang, M., Sweeney, K., 2012. Potentials and paradigms: Event-related brain Potentials and Neuropsychology, 1. Wiley-Blackwell.
Kylliäinen, A., Jones, E.J., Gomot, M., Warreyn, P., Falck-Ytter, T., 2014. Practical guidelines for studying young children with autism spectrum disorder in psychophysiological experiments. J. Autism Dev. Disord. 1 (4), 373–386.
Lavagnino, L., Arnone, D., Cao, B., Soares, J.C., Selvaraj, S., 2016. Inhibitory control in obesity and binge eating disorder: a systematic review and meta-analysis of neurocognitive and neuroimaging studies. Neurosci. Biobehav. Rev. 68, 714–726.
Lickel, A., MacLean, W.E., Blakeley-Smith, A., Hepburn, S., 2012. Assessment of the prerequisite skills for cognitive behavioral therapy in children with and without autism spectrum disorders. J. Autism Dev. Disord. 42 (6), 992–1000.
Loyer Carbonneau, M., Demers, M., Bigras, M., Guay, M.-.C., 2020. Meta-analysis of sex differences in ADHD symptoms and associated cognitive deficits. J. Atten. Disord., 1087054720923736
Luck, S.J., 2012. Event-related Potentials, 1. Psychological Association, American.
Luman, M., Oosterlaan, J., Sergeant, J.A., 2005. The impact of reinforcement contingencies on AD/HD: a review and theoretical appraisal. Clin. Psychol. Rev. 25 (2), 183–213.
Marco, E.J., Hinkley, L.B., Hill, S.S., Nagarajan, S.S., 2011. Sensory processing in autism: a review of neurophysiologic findings. Pediatr. Res. 69 (8), 48–54.
Micali, N., Hagberg, K.W., Petersen, I., Treasure, J.L., 2013. The incidence of eating disorders in the UK in 2000–2009: findings from the General Practice Research Database. BMJ Open 3 (5).
Micali, N., Martini, M.G., Thomas, J.J., Eddy, K.T., Kothari, R., Russell, E., Treasure, J., 2017. Lifetime and 12-month prevalence of eating disorders amongst women in mid-life: a population-based study of diagnoses and risk factors. BMC Med. 15 (1), 1–10.
Moura, O., Costa, P., Simões, M.R., 2019. WISC-III cognitive profiles in children with ADHD: specific cognitive impairments and diagnostic utility. J. Gen. Psychol. 146 (3), 258–282.
Mumtaz, W., Malik, A.S., Yasin, M.A.M., Xia, L., Control, 2015. Review on EEG and ERP predictive biomarkers for major depressive disorder. Biomed. Signal Process. 22, 85–98.
Muris, P., Merckelbach, H., Meesters, C., van den Brand, K., 2002. Cognitive development and worry in normal children. Cognit. Ther. Res. 26 (6), 775–787.
Murphy, Y.E., Luke, A., Brennan, E., Francazio, S., Christopher, I., Flessner, C.A., 2018. An investigation of executive functioning in pediatric anxiety. Behav. Modif. 42 (6), 885–913.
Ogino, M., Kanoga, S., Muto, M., Mitsukura, Y., 2019. Analysis of prefrontal single-channel EEG data for portable auditory ERP-based brain–computer interfaces. Front. Hum. Neurosci. 13, 250.
Orchard, F., Pass, L., Marshall, T., Reynolds, S., 2017. Clinical characteristics of adolescents referred for treatment of depressive disorders. Child Adolesc. Ment. Health 22 (2), 61–68.
Pittig, A., Treanor, M., LeBeau, R.T., Craske, M.G., 2018. The role of associative fear and avoidance learning in anxiety disorders: gaps and directions for future research. Neurosci. Biobehav. Rev. 88, 117–140.
Polanczyk, G.V., Salum, G.A., Sugaya, L.S., Caye, A., Rohde, L.A., 2015. Annual research review: a meta-analysis of the worldwide prevalence of mental disorders in children and adolescents. J. Child Psychol. Psychiatry 56 (3), 345–365.
Rabiee, A., Samadi, S.A., Vasaghi-Gharamaleki, B., Hosseini, S., Seyedin, S., Keyhani, M., Ranjbar Kermani, F., 2019. The cognitive profile of people with high-functioning autism spectrum disorders. Behav. Sci. 9 (2), 20.
Reinvang, I., 1999. Cognitive event-related potentials in neuropsychological assessment. Neuropsychol. Rev. 9 (4), 231–248. https://doi.org/10.1023/a:1021638723486.
Rogers, S.J., Hepburn, S., Wehner, E., 2003. Parent reports of sensory symptoms in toddlers with autism and those with other developmental disorders. J. Autism Dev. Disord. 33 (6), 631–642.

Rommelse, N., Langerak, I., Van Der Meer, J., De Bruijn, Y., Staal, W., Oerlemans, A., Buitelaar, J., 2015. Intelligence may moderate the cognitive profile of patients with ASD. PLoS ONE 10 (10), e0138698.

Schaumberg, K., Brosof, L.C., Lloyd, E.C., Yilmaz, Z., Bulik, C.M., Zerwas, S.C., Micali, N., 2020. Prospective associations between childhood neuropsychological profiles and adolescent eating disorders. Eur. Eat. Disord. Rev. 28 (2), 156–169.

Seer, C., Lange, F., Georgiev, D., Jahanshahi, M., Kopp, B., 2016. Event-related potentials and cognition in Parkinson's disease: an integrative review. Neurosci. Biobehav. Rev. 71, 691–714.

Shaughnessy, M.F., Waggoner, C.R., 2015. The educational implications of ADHD: teachers and principals thoughts concerning students with ADHD. Creat. Educ. 6 (02), 215.

Sur, S., Sinha, V.K., 2009. Event-related potential: an overview. Ind. Psychiatry J. 18 (1), 70.

Thomas, J.J., Lawson, E.A., Micali, N., Misra, M., Deckersbach, T., Eddy, K.T., 2017. Avoidant/restrictive food intake disorder: a three-dimensional model of neurobiology with implications for etiology and treatment. Curr. Psychiatry Rep. 19 (8), 1–9.

van Mourik, R., Oosterlaan, J., Heslenfeld, D.J., Konig, C.E., Sergeant, J.A., 2007. When distraction is not distracting: a behavioral and ERP study on distraction in ADHD. Clin. Neurophysiol. 118 (8), 1855–1865.

Vance, A., Winther, J., 2021. Spatial working memory performance in children and adolescents with major depressive disorder and dysthymic disorder. J. Affect. Disord. 278, 470–476.

Watson, R., Harvey, K., McCabe, C., Reynolds, S., 2020. Understanding anhedonia: a qualitative study exploring loss of interest and pleasure in adolescent depression. Eur. Child Adolesc. Psychiatry 29 (4), 489–499.

Webb, S.J., Bernier, R., Henderson, H.A., Johnson, M.H., Jones, E.J., Lerner, M.D., Townsend, J., 2015. Guidelines and best practices for electrophysiological data collection, analysis and reporting in autism. J. Autism Dev. Disord. 45 (2), 425–443.