Psicothema

Psicothema 2022, Vol. 34, No. 2, 259-265
doi: 10.7334/psicothema2021.405

ISSN 0214 - 9915 CODEN PSOTEG

www.psicothema.com

Article

Neurocognitive Functioning in Adolescents at Risk for Mental Health Problems

Rebeca Aritio-Solana[1], Eduardo Fonseca-Pedrero[1], Alicia Pérez-Albéniz[1], Oliver Mason[2], and Javier Ortuño-Sierra[1]

[1] Universidad de La Rioja and [2] Surrey University

Abstract

Background: The main goal of the study was to assess the neurocognitive performance in adolescents at high psychometric risk for mental health problems. **Method:** A sample of 48 participants at high risk for mental disorders and an age-gender matched healthy comparison group of 48 adolescents were identified from a community-derived sample of 1,509 adolescents. The Strengths and Difficulties Questionnaire problems and the University of Pennsylvania Computerized Neuropsychological Test Battery for children (included 14 tasks assessing five neurobehavioral domains: executive functions, episodic memory, complex cognition, social cognition, and sensorimotor speed) were used. **Results:** Relative to healthy comparison participants, individuals at high risk showed significant impairments across almost all neurocognitive domains (executive functions, episodic memory, complex cognition, social cognition, and sensorimotor speed). **Conclusions:** These findings demonstrate that neurocognitive impairments can be shown in adolescents at high psychometric risk for mental health problems before the onset of more severe psychological problems.

Keywords: Mental health, adolescents, cognitive performance, emotional problems.

Resumen

Funcionamiento Neurocognitivo en Adolescentes con Riesgo de Trastornos Mentales. **Antecedentes:** el objetivo principal del estudio fue evaluar el funcionamiento neurocognitivo en adolescentes con alto riesgo psicométrico de presentar problemas de salud mental. **Método:** se seleccionó una muestra de 48 participantes con alto riesgo de trastornos mentales y un grupo de comparación de 48 adolescentes emparejados por edad y género a partir de la muestra total de 1.509 adolescentes. Se administró el Cuestionario de Capacidades y Dificultades y la Batería Neurocognitiva Computerizada de la Universidad de Pensilvania para población infantil y adolescente (incluidas 14 tareas que evalúan cinco dominios neurocognitivos: funciones ejecutivas, memoria episódica, cognición compleja, cognición social y velocidad sensoriomotora). **Resultados:** en relación con el grupo de comparación, los participantes de alto riesgo mostraron diferencias significativas en casi todos los dominios neurocognitivos. **Conclusiones:** estos hallazgos demuestran que diferentes alteraciones neurocognitivas pueden manifestarse en adolescentes con alto riesgo psicométrico de presentar problemas de salud mental antes de la aparición de dificultades psicológicas más graves.

Palabras clave: salud mental, adolescentes, funcionamiento neurocognitivo, problemas emocionales.

Mental health problems in children and adolescents range from 10 to 20% of the population (Dray et al., 2017; Polanczyk et al., 2015). Moreover, these symptoms seem to persist and potentially could become more severe with age (McGrath et al., 2016). It is well known, for instance, that adolescents with depression are more likely to have depression when adults, and are more likely to show antisocial behaviors as adults (Agerup et al., 2015). Thus, and considering the negative consequences associated with mental disorders, public health systems are devoting more and more resources to the prevention, detection, and intervention of these problems and related phenomena (Fonseca-Pedrero, Pérez-Álvarez et al., 2021).

The identification of specific correlates for emotional and behavioural problems during adolescence and prior to transitioning to clinically severe problems, may help us to elucidate risks and protective factors, as well as etiological mechanisms and developmental pathways that mitigate, delay or even prevent the onset of clinical outcomes (Polanczyk et al., 2018). Thus, studies including phenotypically characterized samples of children and adolescents before they have developed mental health problems are still needed in order to incorporate different measures, including genetic, brain, psychological, and neurobehavioural markers as well as social and cultural factors that may help us to articulate prophylactic and more effective interventions (Calkins et al., 2015; Fonseca-Pedrero, 2021). In particular, adolescence is a key period of human development in which neurodevelopmental changes take place (Spear, 2013). Neurodevelopmental changes in the brain (e.g., pre-frontal cortex) are related to the development of executive functions (EFs) (e.g., decision-making, organization, impulse control, and planning for the future) and the emotional system, allowing the refinement of cognitive, social, and emotional skills (Blakemore & Robbins, 2012).

Previous studies have shown the close relation between neurocognitive functioning and mental problems in children and teenagers (Blanken et al., 2017; Caspi et al., 2020; Hobson et al., 2011). For instance, Hobson et al. (2011) found that EFs were associated

Received: September 9, 2021 • Accepted: November 15, 2021
Corresponding author: Rebeca Aritio-Solana
Departamento de Ciencias de la Educación
Universidad de La Rioja
26002 Logroño (Spain)
e-mail: rebeca.aritio@unirioja.es

with the occurrence of internalizing and externalizing problems. It is believed that neurocognitive impairments may be implicated in the onset of mental illness (Fusar-Poli et al., 2012; Mewton et al., 2017). For example, deficits in neurocognition were related according to Schoemaker et al. (2012) to an increase in disruptive behaviour and more externalizing problems in general. In addition, children with attentional deficit hyperactivity disorder children (ADHD) revealed problems in inhibition (K. Schoemaker et al., 2014). Similar results have been found in psychotic disorders (Fonseca-Pedrero, Debbané et al., 2021). For instance, those youths who endorse psychotic symptoms are neurocognitively delayed across the age range (Gur et al., 2014) and had reduced accuracy and slower speed scores across neurocognitive domains (Calkins et al., 2014).

Neurocognitive factors like working memory have been proposed to play an important role in processing information and decision-making which may lead to impairments in social functioning (McQuade et al., 2013). Different studies show that there are different neurocognitive profiles linked to internalizing and externalizing symptoms. Thus, more externalizing symptoms were related to a decrease in attention and executive domains, whereas difficulties in verbal fluency and memory were associated with internalizing symptoms (Blanken et al., 2017). Also, Merikangas et al. (2017) found, in a large community-based family study, that participants with mood disorders showed poorer social cognition and complex cognition, though directionality is as always difficult to ascertain. Therefore, the study of neurocognitive performance in adolescents at risk for mental health problems is relevant in order to transcend symptom-based classifications and incorporate phenotypic biomarkers for integration with psychological problems.

Considering this background, evaluation combining traditional assessment of mental health problems with neurocognition may help to create developmental pathways of cognitive development in internalizing and externalizing problems (Gur et al., 2014). The study of brain-behavior phenotypes in different developmental stages can contribute to detecting life course characteristics related to psychological vulnerability and so provide tools for staging and intervention (Moore et al., 2017). Nonetheless, rigorous neuropsychological investigations spanning adolescent mental health are limited, and neurobehabioural markers have not been thoroughly examined. To date, few studies have investigated a broad cognitive profile in individuals with emotional and behavioural problems. Thus, the main goal of this study was to characterize the neurocognitive phenotype of adolescents at risk for mental health problems by comparing them with low risk-healthy adolescents. Considering previous literature, we hypothesized that adolescents at psychometric risk would show a wide range of deficits across neurocognitive domains compared to those adolescents at low-risk. Deficits in executive functions and social cognition domains were also expected to be higher in those adolescents at risk for mental health problems.

Method

Participants

Stratified random cluster sampling was conducted at the classroom level, in an approximate population of 15,000 students. Different public and concerted Educational Centers of Compulsory Secondary Education and Vocational Training, in addition to different socio-economic levels were considered. In order to create the different layers, the geographical zone and the educational stage were considered. The initial sample was composed of N = 1881 participants. Those students with a score higher than 3 in the Oviedo Infrequency Scale (Fonseca-Pedrero et al., 2009) (n = 104), older than 19 years (n = 170), or that did not finished the rest (n = 76) were eliminated. Thus, the sample was composed of 1509 students, 667 males (44.3%) from 34 educational centers and 98 classrooms. The mean age was 16.5 years (SD = 1.36), with age ranging from 14 to 19 years. The age distribution was as follows: 14 years (n = 200; 13.3%), 15 years (n = 313; 20.8%), 16 years (n = 381; 25.3%), 17 years (n = 365; 24.2%), 18 years (n = 174; 11.6%), and 19 years (n = 73; 4.8%).

With the aim to compare at high-risk and low-risk adolescents, two different groups were established. For the psychometric risk group, attending to previous research (Fonseca-Pedrero et al., 2017) a SDQ Total difficulties' score higher than 20 points was considered as indicator of inclusion criterion. Participants who reported a diagnosis of past or present mental health disorders were deleted from the study. A total of 67 adolescents were selected attending to this criterion. With the aim to minimize the influence of outliers, z-scores lower than -3 and higher than 3 of the computerized neurocognitive battery were eliminated from the sample. Thus, a sample of n = 48 (24 males), with a mean age of 16.2 years old (SD = 1.20) were included in the high-risk group. In order to stablish an equivalent comparison group, participants from the control individuals were randomly selected attending to gender and age parameters of the risk group. The sample of the comparison group was comprised of n = 48 (24 males), with a mean age of 16.1 years old (SD = 1.19).

Instruments

The Penn Computerized Neurocognitive Battery (CNB) (Gur et al., 2010, 2012). The CNB is a single computerized battery that combines tests from multiples batteries, which is one of its main strengths. The CNB was developed with the aim to attend to large-scale genomics studies. With the aim to administer the CNB, a system developed at University of Pennsylvania (U.S) was employed. The CNB takes about one hour to be completed and includes 14 different tasks that assess five different domains including executive functions (abstraction and mental flexibility, attention, working memory), episodic memory (words, faces, and shapes), complex cognition (verbal reasoning, non-verbal reasoning, and spatial processing), social cognition (emotion identification, emotion intensity differentiation, and age differentiation), and sensorimotor speed (motor, sensorimotor).

The following specific task were used: Penn Conditional Exclusion Test, The Penn Continuous Performance Test, and Letter N-back test were used to assess executive functions. The Penn Word Memory Test, the Penn Face Memory Test, and the Visual Object Learning Test were used to analyze memory. The Children's version of the Penn Verbal Reasoning Test, Penn Matrix Reasoning Test, and the Penn Line Orientation Test were used to assess complex cognition. The Penn Emotion Identification Test, Penn Emotion Differentiation Test, and the Penn Age Differentiation Test were used to analyze social cognition domain. The CNB is composed of different neurobehavioural indicators and different tasks that are prepared to assure the relation between measures in these task and brain systems in children. Moreover, previous studies have shown adequate psychometric properties (Gur et al., 2012). Aside of those tests developed to only measure speed, the other test includes measures of accuracy and speed.

Instructions and vocabulary for verbal stimuli were simplified from the adult CNB. The Motor Praxis task and Finger Tapping Test were evaluated in sensorimotor domain.

The following platform was used: https://penncnp.med.upenn.edu/webcnp.pl. According to previous works (Gur et al., 2012; Moore et al., 2015) the web based platform for the CNB was established with Perl CGI, HTML, a mySQL database and the Apache web server; tests were developed by means of Adobe Flash®. Using this platform ant tests, the scores are generated automatically.

Adaptation of the battery into Spanish was performed using a back translation procedure in accordance with international guidelines for translation of psychological measures (Muñiz et al., 2013). A panel of experts translated the American English original version of the CBN adolescent version into Spanish. Then, another bilingual researcher, familiar with American culture, translated this version into English. A third panel of researchers compared the two English versions (original and translated). All process were supported by the Brain Behavior Laboratory, Department of Psychiatry, University of Pennsylvania Perelman School of Medicine, Philadelphia (U.S).

The Strengths and Difficulties Questionnaire (SDQ) (Goodman, 1997). The SDQ self-reported form, was developed with the intention to measure emotional and behavioural problems. A total of 25 items, distributed in five subscales composed the SDQ. The different subscales are: Emotional symptoms, Conduct problems, Hyperactivity, Peer problems, and Prosocial behaviour. The SDQ items are presented in a three-option Likert response format (Not True = 0, Somewhat True = 1, Certainly True = 2). Consequently, the score on each subscale goes from 0 to 10 points. The sum of the difficulties subscales (all of them besides the Prosocial behaviour) display the Total difficulties score. The Spanish version (www.sdqinfo.org) of the instrument, validated in previous studies (Ortuño-Sierra et al., 2015) was used.

The Oviedo Infrequency Scale (INF-OV) (Fonseca-Pedrero et al., 2009). The INF-OV is an instrument developed to determine participants responding in a dishonest manner. The INF-OV contains a total of 12 items with a 5-point Likert- scale format (1 = Completely Disagree; 5 = Completely Agree). The guidelines for test construction were attended to develop the instrument. An example of items of the INF-OV is: “I know someone that wears glasses”. Those students that reveal three or more incorrect responses are eliminated from the sample. This measuring instrument has been administrated in previous works (Fonseca-Pedrero et al., 2009).

Procedure

The research was approved by the Department of Education of the Government of La Rioja and the Ethical Committee of Clinical Research of La Rioja (CEICLAR). Administration took place under the supervision of the researchers.

The CNB and self-reports were administered by assessors trained in a standard protocol. Thus, those CNB tasks requiring a greater cognitive effort (e.g. Matrix reasoning) were either preceded or followed either by a break, or a test involving motor speed (e.g., finger tapping). The CNB order and some other conditions created to prevent fatigue and frustration were followed attending to Gur et al. (Gur et al., 2012) recommendations and participants were offered breaks every 20 minutes approximately. Both measures were administered collectively, in groups of 10 to 30 students, during normal school hours and in a classroom specially prepared for this purpose. Participant were informed about the voluntary nature of the study and no incentive was provided for participation. Parents or legal guardians gave informed consent for participants under 18 years old.

Data analyses

For the present study, raw scores for accuracy and speed for each test were calculated and converted then z-transformed to their standard equivalents attending to means and standard deviations for the entire sample. In order to facilitate interpretation and to make it consistent, higher z-scores always reflect better performance (*i.e*., higher accuracy and shorter responses correspond to higher z-scores). As so, response time z-scores were multiplied by -1, so that slower response time is reflected in lower z-scores.

Descriptive statistics for accuracy, speed, and efficiency measures of the five neurobehavioural domains of the CNB were calculated attending to the risk and no-risk mental health status. Second, a MANCOVA was performed taking the four neurocognitive domains (Executive Function, Memory, Complex Cognition, Social Cognition, and sensorimotor in the case of speed) as the dependant variables and the two groups derived from the SDQ scores (high-risk VS. low-risk) as the fixed factor. For the analysis, gender and age were controlled as covariates that could affect the results. Partial eta squared (*partial* η^2) was employed as an effect-size estimate. SPSS 22.0 was used for data analyses (IBM Corp Released, 2013).

Results

Descriptive statistics for the neurocognitive domains

A total of 96 participants from the community-derived sample of adolescents (n= 1509) were selected as high-risk (n = 48) and low-risk (n = 48) attending to the SDQ Total difficulties scores (20 points). Descriptive statistics for all the *z*-scores in the neurobehavioural functions attending to accuracy, speed, and efficiency are shown in Table 1.

Table 1
Descriptive statistics for the total sample, the low-risk, and high-risk groups (low and high risk for health mental problems)

	Group					
	Low Risk		High Risk		Total	
Neurobehavioural Domain	M	SD	M	SD	M	SD
Accuracy						
Executive Function	1.06	0.93	0.09	1.32	0.58	1.24
Episodic Memory	1.12	1.28	-0.05	1.99	0.53	1.76
Complex Cognition	1.19	1.41	-0.90	2.28	0.14	2.16
Social Cognition	0.62	1.06	-0.03	2.27	0.29	1.79
Speed Domains						
Executive Function	0.63	1.71	-0.40	1.37	0.12	1.62
Episodic Memory	1.66	1.88	-0.68	1.99	0.49	2.25
Complex Cognition	0.98	1.67	-1.22	1.30	-0.12	1.85
Social Cognition	1.45	1.92	-1.14	1.52	0.16	2.16
Sensorimotor	0.11	1.02	-0.08	1.04	0.02	1.03
Efficiency						
Executive Function	1.69	1.62	-0.31	1.68	0.69	1.92
Episodic Memory	2.78	2.12	-0.73	2.85	1.03	3.06
Complex Cognition	2.17	2.52	-2.12	3.01	0.02	3.50
Social Cognition	2.07	2.16	-1.16	3.04	0.45	3.08

Accuracy performance across neurocognitive domains by groups

After controlling for the effects of the participant's gender and age, results of the MANCOVA with the accuracy scores of neurocognitive domains as dependent variables and the two groups (at-risk vs. low-risk) as fixed factor, showed a main effect for group ($\lambda = 0.706$, $F_{(4,89,000)} = 9.268$, $p \leq 0.001$, *partial* $\eta^2 = 0.294$) (see Table 2). The ANOVAs revealed statistically significant differences by group in Executive Function ($F_{(1,92)} = 17.349$, $p \leq 0.001$, *partial* $\eta^2 = 0.159$), Episodic Memory ($F_{(1,92)} = 32.906$, $p \leq 0.001$, *partial* $\eta^2 = 0.112$), Complex Cognition ($F_{(1,92)} = 29.498$, $p \leq 0.001$, *partial* $\eta^2 = 0.243$), but not for Social Cognition domain ($F_{(1,92)} = 3.392$, $p \geq 0.05$, *partial* $\eta^2 = 0.036$). The effect sizes found were large. Youths at high mental risk showed a significant decrease in performance accuracy across these neurocognitive domains compared to those at low-risk.

Speed performance across neurocognitive domains by groups

The MANCOVA on speed scores showed a main effect for group ($\lambda = 0.502$, $F_{(5, 88,000)} = 17.493$, $p \leq 0.001$, *partial* $\eta^2 = 0.498$). As shown in Table 3, the ANOVAs indicated that participants speed scores in the five different domains differed significantly according to the group in Executive Function ($F_{(1,92)} = 10.934$, $p \leq 0.001$, *partial* $\eta^2 = 0.106$), Episodic Memory ($F_{(1,92)} = 35.107$, $p \leq 0.001$, *partial* $\eta^2 = 0.276$), Complex Cognition ($F_{(1,92)} = 51.395$, $p \leq 0.001$, *partial* $\eta^2 = 0.358$), and Social Cognition domains ($F_{(1,92)} = 53.017$, $p \leq 0.001$, *partial* $\eta^2 = 0.366$). Large effect size were found. However, no statistically significant differences were found for Sensorimotor domain ($F_{(1,92)} = 0.804$, $p \geq 0.05$, *partial* $\eta^2 = 0.009$).

Table 2
Accuracy neurocognitive performance scores by group (low and high risk for mental health problems)

	Group					
	Low Risk		High Risk		p	partial η^2
Neurobehavioural Domain	**M**	**SD**	**M**	**SD**		
Executive Function	1.059	0.164	0.092	0.164	< 0.001	0.159
Episodic Memory	1.118	0.243	-0.054	0.243	< 0.001	0.112
Complex Cognition	1.179	0.270	-0.892	0.270	< 0.001	0.243
Social Cognition	0.616	0.246	-0.026	0.246	≥ 0.05	0.036

Table 3
Speed neurocognitive performance scores by group (low and high risk for mental health problems)

	Group					
	Low Risk		High Risk		p	partial η^2
Neurobehavioural Domain	**M**	**SD**	**M**	**SD**		
Executive Function	0.961	0.230	-0.529	0.23	< 0.001	0.106
Episodic Memory	3.195	0.242	-0.909	0.242	< 0.001	0.276
Complex Cognition	1.534	0.231	-1.286	0.231	< 0.001	0.358
Social Cognition	1.848	0.245	-1.201	0.245	< 0.001	0.366
Sensorimotor	0.372	0.220	0.026	0.220	≥ 0.05	0.009

Youths at-risk showed a significant decrease in speed performance (slower time) across these neurocognitive domains compared to low-risk group.

Efficiency performance across neurocognitive domains by groups

When attending to the efficiency (means values of accuracy and speed scores) in the four domains, the MANCOVA scores showed a main effect for group ($\lambda = 0.485$, $F_{(4,89,000)} = 23.599$, $p \leq 0.001$, *partial* $\eta^2 = 0.515$). Results from the ANOVAs can be seen in Table 4. As can be seen, adolescents of both groups differed significantly in efficiency performance scores in Executive Function ($F_{(1,92)} = 34.758$, $p < 0.001$, *partial* $\eta^2 = 0.274$), Episodic Memory ($F_{(1,92)} = 46.126$, $p < 0.001$, *partial* $\eta^2 = 0.334$), Complex Cognition ($F_{(1,92)} = 57.792$, $p < 0.001$, *partial* $\eta^2 = 0.386$), and Social Cognition domains ($F_{(1,92)} = 35.952$, $p < 0.001$, *partial* $\eta^2 = 0.281$). Large effect size were also found. Individuals at-risk showed a significant decrease in efficient scores across these neurocognitive domains compared to low-risk group.

Discussion

To date we still have limited knowledge of the neurocognitive performance correlates of adolescents at psychometric high risk for mental health problems. In order to address this gap of knowledge, we set out to assess the neurocognitive performance in adolescents at high and low risk for mental health problems. The present work, to the best of our knowledge, is one of the first studies analysing the association bewtween neurobehavioral functioning and mental health problems in a community derived sample of adolescents from the general population. Results found in the present study have demonstrated that adolescents at risk of mental health problems, measured by means of the SDQ Total difficulties scores, performed significantly lower in accuracy, speed, and efficiency than those with low risk of mental health problems in five neurobehavioural functions (e.g., Executive Functions, Episodic Memory, Complex Cognition, Social Cognition, and Sensorimotor Speed), with the exception of accuracy for Social Cognition and Sensorimotor speed.

Results as to the accuracy performance in four different domains indicated that at risk adolescents had a lower performance on all the domains besides Social Cognition. These results are somehow similar to those found in previous studies. For instance, the study of Merikangas et al. (2017) indicated that people with mood disorders had worst social cognition and complex cognition. Similarly, Blanken et al. (2017) found worst performance on neurocognitive

Table 4
Efficiency neurocognitive performance scores by group (low and high risk for mental health problems)

	Group					
	Low Risk		High Risk		p	partial η^2
Neurobehavioural Domain	**M**	**SD**	**M**	**SD**		
Executive Function	1.692	0.240	-0.31	0.24	< 0.001	0.274
Episodic Memory	2.774	0.364	-0.721	0.364	< 0.001	0.334
Complex Cognition	2.161	0.398	-2.113	0.398	< 0.001	0.386
Social Cognition	2.066	0.381	-1.161	0.381	< 0.001	0.281

task in children both with internalizing and externalizing problems. However, the study of Blanken et al. (2017) found no statistically significant differences in executive functions and episodic memory. The results found in our study revealed that adolescents at risk for mental health problems did not differ, compared to those at low risk, on social cognition when accuracy was tested. It maybe that aspects like executive functioning or complex cognition have a bigger impact on mental health that social cognition, although significant differences were found on social cognition both in speed and efficiency performance. Previous research indicated the key role of social cognition in predicting mental health problems (Cotter, 2018; Santamaría-García et al., 2020), so further research should analyzed the results found in the present study.

Analyses of variance for speed performance revealed that adolescents at risk were slower on all the neurobehavioural functions compared to non-risk adolescents. Specifically, adolescents showed lower scores on all the domains except Sensorimotor. Previous research has been variable in this regard: For example, the work of Merikangas et al. (2017) found no relation between mood disorders in speed of neurocognitive performance.

With regards to efficiency, significant differences were found between the high risk and low-risk groups on all the neurobehavioural functions. To date, few studies have reported data about efficiency impairments and its relationship with mental health problems. However, global deficits in executive functions have been found to be linked with externalizing symptoms (Loge et al., 1990). According to Blanken et al. (2017), children with internalizing symptoms are more likely to show impairments in verbal fluency and memory while those with externalizing symptoms show deficits in attention/executive functioning domains. The present study reveals that individuals and high-risk have a lower performance on all the domains when efficiency is tested. The differences found in this study are consistent with the idea of a lower ability to internally regulate behaviour and inhibit disruptive conduct in those children and adolescents with general neurocognitive deficits (K. Schoemaker et al., 2014).

A significant percentage of children and adolescents present mental health difficulties throughout their life, often with long term health and personal, academic, familiar, social and economic impacts (Drabick & Kendall, 2010). In addition, adolescence sees specific neurocognitive changes that allow the refinement of neurocognitive skills but may also be related to an increase in the vulnerability to certain mental health problems (Blakemore & Robbins, 2012; Spear, 2013). Overall our findings are consistent with the idea that a range of disruptions in emotional and behavioral areas of development are frequently accompanied by impairments in other areas, such as neurocognitive domains, and indicating possibly a common underlying neurodevelopmental disorder (Basten et al., 2013). Our results are consistent with findings that mental health problems are closely linked to neurocognitive functioning both in children and teenagers (Blanken et al., 2017; Hobson et al., 2011), after, during and before to transition to clinical outcome. These findings offer the possibility to detect cognitive endophenotypes in order to understand etiological mechanisms, develop prevention and early detection strategies, and therapeutic targets in mental health field (Gottesman & Gould, 2003). Endophenotypic measures of specific cognitive domains combined with reliable information of mental difficulties can help us to better understand the prognosis of these problems and are a useful and relevant starting point for researchers, clinicians and professionals of education in order to stablish targets for treatment interventions.

Results of the present study should be understood in light of the following limitations. First, the cross-sectional nature of the study precludes the interpretation of the neurocognitive performance. Thus, it is not possible to stablish whether differences in neurobehavioural assessment precede or postdate the onset of mental difficulties. It is not known, for example, whether our sample contained individuals with diagnosed or undiagnosed neurodevelopmental disorders. Future longitudinal follow-up studies could expand the understanding and correlation of neurocognitive functions and mental health problems. Second, to detect individuals at high risk for mental health problems the SDQ were used as proxy indicator. Although this measure has been proved to be a useful screening tool, the inclusion of other measures, including interviews and hetero-informant measures may help to further determine participants at risk of mental health problems. Finally, no previous information were collected about family history of mental disorders.

Notwithstanding these limitations, results found in the present study show specific and relevant relations between mental health problems and neurocognitive impairment during adolescence. By comparing risk and non-risk groups of adolescents, the present study provides information that contributes to a deeper understanding of the underlying aetiology of mental health problems in a relevant stage of the development. Future studies could continue the study of phenotypic measures of cognitive domains with specific mental health problems and combine these measures with neuroimaging, genomic, contextual factors, and clinical evaluation. All these may help to characterize the different developmental pathways that explain typical and non-typical development.

Acknowledgements

This research was funded by the "Beca Leonardo a Investigadores y Creadores Culturales 2020 de la Fundación BBVA".

References

Agerup, T., Lydersen, S., Wallander, J., & Sund, A. M. (2015). Associations Between Parental Attachment and Course of Depression Between Adolescence and Young Adulthood. *Child Psychiatry and Human Development*, *46*(4), 632-642. https://doi.org/10.1007/s10578-014-0506-y

Basten, M. M. G. J., Althoff, R. R., Tiemeier, H., Jaddoe, V. W. V., Hofman, A., Hudziak, J. J., Verhulst, F. C., & van der Ende, J. (2013). The Dysregulation Profile in Young Children: Empirically Defined Classes in the Generation R Study. *Journal of the American Academy of Child & Adolescent Psychiatry*, *52*(8), 841-850.e2. https://doi.org/10.1016/j.jaac.2013.05.007

Blakemore, S.-J., & Robbins, T. W. (2012). Decision-making in the adolescent brain. *Nature Neuroscience*, *15*(9), 1184-1191. https://doi.org/10.1038/nn.3177

Blanken, L. M. E., White, T., Mous, S. E., Basten, M., Muetzel, R. L., Jaddoe, V. W. V., Wals, M., van der Ende, J., Verhulst, F. C., & Tiemeier, H. (2017). Cognitive functioning in children with internalising, externalising and dysregulation problems: A population-based study. *European Child & Adolescent Psychiatry*, *26*(4), 445-456. https://doi.org/10.1007/s00787-016-0903-9

Calkins, M. E., Merikangas, K. R., Moore, T. M., Burstein, M., Behr, M. A., Satterthwaite, T. D., Ruparel, K., Wolf, D. H., Roalf, D. R., Mentch, F. D., Qiu, H., Chiavacci, R., Connolly, J. J., Sleiman, P. M. A., Gur, R. C., Hakonarson, H., & Gur, R. E. (2015). The Philadelphia Neurodevelopmental Cohort: Constructing a deep phenotyping collaborative. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *56*(12), 1356-1369. https://doi.org/10.1111/jcpp.12416

Caspi, A., Houts, R. M., Ambler, A., Danese, A., Elliott, M. L., Hariri, A., Harrington, H. L., Hogan, S., Poulton, R., Ramrakha, S., Rasmussen, L. J. H., Reuben, A., Richmond-Rakerd, L., Sugden, K., Wertz, J., Williams, B. S., & Moffitt, T. E. (2020). Longitudinal Assessment of Mental Health Disorders and Comorbidities Across 4 Decades Among Participants in the Dunedin Birth Cohort Study. *JAMA Network Open*, *3*(4), e203221. https://doi.org/10.1001/JAMANETWORKOPEN.2020.3221

Cotter, J. (2018). Social cognitive dysfunction as a clinical marker: A systematic review of meta-analyses across 30 clinical conditions. *Neuroscience Biobehavioral Review*, *84*, 92-99.

Drabick, D. A. G., & Kendall, P. C. (2010). Developmental Psychopathology and the Diagnosis of Mental Health Problems among Youth. *Clinical Psychology: A Publication of the Division of Clinical Psychology of the American Psychological Association*, *17*(4), 272-280. https://doi.org/10.1111/j.1468-2850.2010.01219.x

Dray, J., Bowman, J., Campbell, E., Freund, M., Wolfenden, L., Hodder, R. K., McElwaine, K., Tremain, D., Bartlem, K., Bailey, J., Small, T., Palazzi, K., Oldmeadow, C., & Wiggers, J. (2017). Systematic Review of Universal Resilience-Focused Interventions Targeting Child and Adolescent Mental Health in the School Setting. *Journal of the American Academy of Child & Adolescent Psychiatry*, *56*(10), 813-824. https://doi.org/10.1016/j.jaac.2017.07.780

Fonseca-Pedrero, E. (2021). *Manual de tratamientos psicológicos Infancia y adolescencia* [Manual of psychological treatments Childhood and adolescence]. Pirámide.

Fonseca-Pedrero, E., Debbané, M., Rodríguez-Testal, J. F., Cohen, A. S., Docherty, A. R., & Ortuño-Sierra, J. (2021). Schizotypy: The way ahead. *Psicothema*, *33*(1), 16-27 https://doi.org/10.7334/psicothema2019.285

Fonseca-Pedrero, E., Inchausti, F., Pérez-Gutiérrez, L., Aritio Solana, R., Ortuño-Sierra, J., Sánchez-García, M. Á., Lucas-Molina, B., Domínguez, C., Foncea, D., Espinosa, V., Gorría, A., Urbiola-Merina, E., Fernández, M., Merina Díaz, C., Gutiérrez, C., Aures, M., Campos, M. S., Domínguez-Garrido, E., & Pérez de Albéniz Iturriaga, A. (2017). Suicidal ideation in a community-derived sample of Spanish adolescents. *Revista de Psiquiatria y Salud Mental*, *11*(2), 76-85. https://doi.org/10.1016/j.rpsm.2017.07.004

Fonseca-Pedrero, E., Paino-Piñeiro, M., Lemos-Giráldez, S., Villazón-García, U., & Muñiz, J. (2009). Validation of the Schizotypal Personality Questionnaire-Brief Form in adolescents. *Schizophrenia Research*, *111*(1-3), 53-60. https://doi.org/10.1016/j.schres.2009.03.006

Fonseca-Pedrero, E., Pérez-Álvarez, M., Al-Halabí, S., Inchausti, F., López-Navarro, E. R., Muñiz, J., Lucas-Molina, B., Pérez-Albéniz, A., Baños Rivera, R., Cano-Vindel, A., Gimeno-Peón, A., Prado-Abril, J., González-Menéndez, A., Valero, A. V, Priede, A., González-Blanch, C., Ruiz-Rodríguez, P., Moriana, J. A., Gómez, L. E., … Montoya-Castilla, I. (2021). Empirically supported psychological treatments for children and adolescents: State of the art. *Psicothema*, *33*(3), 386-398. https://doi.org/10.7334/PSICOTHEMA2021.56

Fusar-Poli, P., Deste, G., Smieskova, R., Barlati, S., Yung, A. R., Howes, O., Stieglitz, R.-D., Vita, A., McGuire, P., & Borgwardt, S. (2012). Cognitive Functioning in Prodromal Psychosis. *Archives of General Psychiatry*, *69*(6), 562-571. https://doi.org/10.1001/archgenpsychiatry.2011.1592

Gottesman, I. I., & Gould, T. D. (2003). The Endophenotype Concept in Psychiatry: Etymology and Strategic Intentions. *American Journal of Psychiatry*, *160*(4), 636-645. https://doi.org/10.1176/appi.ajp.160.4.636

Gur, R. C., Calkins, M. E., Satterthwaite, T. D., Ruparel, K., Bilker, W. B., Moore, T. M., Savitt, A. P., Hakonarson, H., & Gur, R. E. (2014). Neurocognitive Growth Charting in Psychosis Spectrum Youths. *JAMA Psychiatry*, *71*(4), 366. https://doi.org/10.1001/jamapsychiatry.2013.4190

Gur, R. C., Richard, J., Calkins, M. E., Chiavacci, R., Hansen, J. A., Bilker, W. B., Loughead, J., Connolly, J. J., Qiu, H., Mentch, F. D., Abou-Sleiman, P. M., Hakonarson, H., & Gur, R. E. (2012). Age group and sex differences in performance on a computerized neurocognitive battery in children age 8-21. *Neuropsychology*, *26*(2), 251-265. https://doi.org/10.1037/A0026712

Gur, R. C., Richard, J., Hughett, P., Calkins, M. E., Macy, L., Bilker, W. B., Brensinger, C., & Gur, R. E. (2010). A cognitive neuroscience-based computerized battery for efficient measurement of individual differences: Standardization and initial construct validation. *Journal of Neuroscience Methods*, *187*(2), 254-262. https://doi.org/10.1016/j.jneumeth.2009.11.017

Hobson, C. W., Scott, S., & Rubia, K. (2011). Investigation of cool and hot executive function in ODD/CD independently of ADHD. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *52*(10), 1035-1043. https://doi.org/10.1111/j.1469-7610.2011.02454.x

IBM Corp Released (2013). *IBM SPSS Statistics for Windows, Version 22.0*. IBM Corp.

Loge, D. V., Staton, R. D., & Beatty, W. W. (1990). Performance of Children with ADHD on Tests Sensitive to Frontal Lobe Dysfunction. *Journal of the American Academy of Child & Adolescent Psychiatry*, *29*(4), 540-545. https://doi.org/10.1097/00004583-199007000-00006

McGrath, J. J., Saha, S., Al-Hamzawi, A. O., Alonso, J., Andrade, L., Borges, G., Bromet, E. J., Browne, M. O., Bruffaerts, R., Caldas De Almeida, J. M., Fayyad, J., Florescu, S., De Girolamo, G., Gureje, O., Hu, C., De Jonge, P., Kovess-Masfety, V., Lepine, J. P., Lim, C. C. W., … Kessler, R. C. (2016). Age of onset and lifetime projected risk of psychotic experiences: Cross-national data from the world mental health survey. *Schizophrenia Bulletin*, *42*(4), 933-941. https://doi.org/10.1093/schbul/sbw011

McQuade, J. D., Murray-Close, D., Shoulberg, E. K., & Hoza, B. (2013). Working memory and social functioning in children. *Journal of Experimental Child Psychology*, *115*(3), 422-435. https://doi.org/10.1016/j.jecp.2013.03.002

Merikangas, A. K., Cui, L., Calkins, M. E., Moore, T. M., Gur, R. C., Gur, R. E., & Merikangas, K. R. (2017). Neurocognitive performance as an endophenotype for mood disorder subgroups. *Journal of Affective Disorders*, *215*, 163-171. https://doi.org/10.1016/j.jad.2017.03.021

Mewton, L., Hodge, A., Gates, N., Visontay, R., & Teesson, M. (2017). The Brain Games study: protocol for a randomised controlled trial of computerised cognitive training for preventing mental illness in adolescents with high-risk personality styles. *BMJ Open*, *7*(9), e017721. https://doi.org/10.1136/bmjopen-2017-017721

Moore, T. M., Gur, R. C., Thomas, M. L., Brown, G. G., Nock, M. K., Savitt, A. P., Keilp, J. G., Heeringa, S., Ursano, R. J., & Stein, M. B. (2017). Development, Administration, and Structural Validity of a Brief, Computerized Neurocognitive Battery. *Assessment*, 107319111668982. https://doi.org/10.1177/1073191116689820

Moore, T. M., Reise, S. P., Gur, R. E., Hakonarson, H., & Gur, R. C. (2015). Psychometric properties of the Penn Computerized Neurocognitive Battery. *Neuropsychology*, *29*(2), 235-246. https://doi.org/10.1037/neu0000093

Muñiz, J., Elosua, P., & Hambleton, R. K. (2013). Directrices para la traducción y adaptación de los tests: segunda edición [International Test Commission Guidelines for test translation and adaptation: Second edition]. *Psicothema*, *25*(2), 151-157. https://doi.org/10.7334/psicothema2013.24

Ortuño-Sierra, J., Fonseca-Pedrero, E., Paino, M., Sastre I Riba, S., & Muñiz, J. (2015). Screening mental health problems during adolescence: Psychometric properties of the Spanish version of the strengths and difficulties Questionnaire. *Journal of Adolescence*, *38*(2), 49-56. https://doi.org/10.1016/j.adolescence.2014.11.001

Polanczyk, G. V., Fatori, D., & Matijasevich, A. (2018). Integrating child and adolescent psychiatry and the field of early childhood development. *European Child & Adolescent Psychiatry*, *27*(2), 137-138. https://doi.org/10.1007/s00787-018-1131-2

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. *Journal of Child Psychology and Psychiatry*, *56*, 345-365.

Santamaría-García, H., Baez, S., Gómez, C., Rodríguez-Villagra, O., Huepe, D., Portela, M., Reyes, P., Klahr, J., Matallana, D., & Ibanez, A. (2020). The role of social cognition skills and social determinants of health in predicting symptoms of mental illness. *Translational Psychiatry, 10*(1), 1-13. https://doi.org/10.1038/s41398-020-0852-4

Schoemaker, K., Bunte, T., Espy, K. A., Deković, M., & Matthys, W. (2014). Executive functions in preschool children with ADHD and DBD: An 18-month longitudinal study. *Developmental Neuropsychology*, *39*(4), 302-315. https://doi.org/10.1080/87565641.2014.911875

Schoemaker, M. M., Niemeijer, A. S., Flapper, B. C. T., & Smits-Engelsman, B. C. M. (2012). Validity and reliability of the Movement Assessment Battery for Children-2 Checklist for children with and without motor impairments. *Developmental Medicine and Child Neurology*, *54*(4), 368-375. https://doi.org/10.1111/j.1469-8749.2012.04226.x

Spear, L. P. (2013). Adolescent neurodevelopment. *The Journal of Adolescent Health: Official Publication of the Society for Adolescent Medicine*, *52*(2 Suppl 2), S7-13. https://doi.org/10.1016/j.jadohealth.2012.05.006