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ANALYSIS OF THE RELATIONSHIP BETWEEN THE RECOGNITION OF BASIC EMOTIONS AND OTHER NEUROCOGNITIVE FUNCTIONS IN PRIMARY SCHOOL CHILDREN

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Abstract
The capacity for social cognition is an indicator of healthy neurocognitive development in children, as it is related to other intellectual cognitive abilities such as attention, processing speed, and executive functions, necessary for understanding and adapting to the socio-cultural environment. The study aimed to analyze the relationship between the capacity for emotional perception and the development of neurocognitive functions (certain subcomponents of executive function and social cognition) in primary school children. It is an exploratory, descriptive and correlational study in a sample of 214 Argentinean children, to whom a battery of neuropsychological and social cognition tests was applied. The results conclude that there is a relationship between emotion recognition in infancy, with different cognitive variables, such as the ability to recognize the mental state of a person through the reading of TdlM gaze expression ($p = 0.010$), interference control, and Stroop emotion recognition ability ($p = 0.001$), D2 Sustained Attention ($p = 0.006$), cognitive flexibility ($p = 0.002$).
Keywords: Basic Emotion Recognition; Theory of Mind; Interference Control;Selective Attention; Sustained Attention; Cognitive Flexibility.

Resumen
La capacidad de cognición social es un indicador del desarrollo neurocognitivo sano en los niños, pues está relacionado con otras habilidades cognitivas intelectivas como la atención, la velocidad de procesamiento y las funciones ejecutivas, necesarias para la comprensión y adaptación al entorno socio – cultural.El objetivo del estudio consistió en analizar la relación entre la capacidad para la percepción emocional y el desarrollo de las funciones neurocognitivas (determinados subcomponentes de la función ejecutiva y de la cognición social) en niños de escolaridad primaria. Es un estudio de tipo exploratorio, descriptivo y correlacional en una muestra de 214 niños y niñas de nacionalidad argentina, a quienes se aplicó una batería de test neuropsicológicos y de cognición social. Los resultados concluyen que existe una relación entreel reconocimiento de emociones en la infancia (REBI), con distintas variables cognitivas, como la habilidad de reconocer el estado mental de una

persona a través de la lectura de la expresión de la mirada TdlM (p = 0,010), el control de interferencia y la capacidad de reconocimiento de emociones Stroop (p =0,001), la Atención sostenida D2 (p =0,006), la flexibilidad cognitiva (p =0,002).
Palabras clave: Reconocimiento de Emociones Básicas; Teoría de la Mente; Control de la interferencia. Atención selectiva; Atención sostenida; Flexibilidad cognitiva.

INTRODUCTION

The study of social cognition began in the 1990s when, empirically, it was demonstrated that it has a functional relevance as a mediating variable between neurocognition and the level of social functioning. Likewise, new interventions are developed focusing on the different components that make up social cognition, emotional processing, social perception, theory of mind, social schemas, social cognition, and attributional style (Lockwood et al., 2020; Cole & Millett, 2019; Beaudoin & Beauchamp, 2020). The recognition by the scientific community, of the importance of the processes included under the concept of social cognition in the functioning and prognosis of the patient with schizophrenia, must be attributed to the MATRICS project which, in 2003, included social cognition as a differentiated dimension among the seven determinant cognitive domains (Christiani et al., 2019; Subotnik et al., 2020; Vaskinn et al., 2018). From this line of study, social cognition and other cognitive processes have been studied in various mental disorders (Arioli et al., 2018; Burnside et al., 2017; Griffiths et al., 2020).

From a phylogenetic point of view, emotional expressions facilitate the adaptation of human beings to the environment, being some categories universal, which makes them a fundamental strategy in the communication of information that the individual needs for an effective interaction (Angrino, 2011; Brechet, 2017; Kang et al., 2017; Garcia and Tully, 2020). As argued by Damasio (2010) in his book "*In Search of Spinoza*" where he argues that emotions provide a natural means for the brain and mind to assess the inner and surrounding environment of the organism, and to respond accordingly and adaptively". Among other signals, emotional expressions facilitate behavioral adaptation for the transmission of information quickly and accurately, thus enabling survival by behavioral appropriateness to different social interactions (Ekman, 1993, Covic et al., 2019., Ruba and Pollak, 2020).

The progress made in recent years in Cognitive Neuroscience has enabled a better understanding of the structures involved in emotional recognition and expression (López et al., 2020; Alexander et al., 2020). The evolutionary proposal, from the publication of "*The expression of emotions in animals and man*" (Darwin, 2018) has allowed the identification of the basic emotions that make up the set of human expressions, inquiring about the universality of these, their expression and recognition in different cultures (McCoy et al., 2018; Volynets et al., 2019). In addition, the contributions of neurophysiology and, fundamentally, cognitive neuroscience would allow situating emotional recognition as the result of patterns or tendencies of individual regulation that give rise to a predisposition to recognize and express emotions in a particular way and that, in addition, are dependent on the development and their context of occurrence (Herrera et al., 2019; Caffarena et al., 2019).

Several studies have provided knowledge, not only about neurocognition, neurocircuits of emotions, and the acquisition of social cognition but also about their implication in neurodevelopment and their role in mediating social dominance, aggression, affiliation, social bonds, etc. (Ortega et al., 2021; Morandín et al., 2019). The reciprocal influences between the social and biological levels begin in childhood and are evident in all the environments in which the child develops, among them, the school; considering that emotions are at the center of learning (McConnell, 2019; Benavidez & Flores, 2019; Johnson, 2018).

Cognitive neuroscience has shown that stress and constant fear affect the normal functioning of neurological connections in the brain, and hinder the acquisition of new knowledge by cortical inhibition, which affects informational processing, and executive performance of the frontal lobes (Glejzer et al., 2018; Figueroa et al., 2020; Camacho et al., 2020). Several problems that occur in clinical and educational settings are evidenced bya direct affectation of emotional processing and the acquisition of skills related to Social Cognition, even though the tests applied have required adaptations, and present limitations of use in the Castilian language (Valencia et al., 2017; Gordillo et al., 2015; Tortello et al., 2017; Buitrago et al., 2019; Chronaki et al., 2018; Grosbras et al., 2018; Operto et al., 2020; Dodell et al., 2019).

Against this background, the main objective of this study is to analyze the correlation between the capacity for emotional perception and the development of neurocognitive functions (certain subcomponents of

executive function and social cognition) in elementary school children. The study hypothesized whether sensitivity to emotion recognition in third peers correlates with other functions of social cognition (theory of mind), as well as whether sensitivity to emotion recognition in third peers correlates with other functions of intellective cognition: directed attention, sustained attention, inhibitory control, and cognitive flexibility.

METHODOLOGY

Design

The study was defined as a cross-sectional, methodological, descriptive, psychometric, and non-experimental research design.

Participants

A total of 214 Argentine primary school children enrolled in 8 educational establishments, during the period corresponding to the second semester of 2019, from the city of Concordia, participated in the study. Stratified probability sampling was used. For the selection, a mass media call was made to primary school teachers residing in urban areas of the city of Concordia. The teachers who responded to the call were categorized according to the grade in which they worked (1st to 6th grade, drawing lots for two groups per category). In each establishment, the subjects who met the selection criteria were evaluated, which consisted of 1) Being a student in the school year in which the teacher worked, 2) Not having reported a diagnosis of neurological or psychiatric history to the school center, 3) Sign the informed consent of the parents or guardians for the performance of the tests, following international ethical guidelines for biomedical research and experimentation on human beings, and 4) Have Argentine nationality.

Instruments, methods, and procedures

All subjects were administered the Recognition of Basic Emotions as Abilities (REBH) instrument. The Spanish version for children of the Test named Recognition of basic emotions in childhood (REBI-Reconocimiento de emociones básicas en la infancia) by Poenitz and Román (2020) was used. Second, the TdlM Gaze Test (Baron-Cohen et al., 1997) was administered for evaluating the ability to recognize a person's mental state through the reading of gaze expression, based on ToM concepts that consider that healthy subjects candetermine a person's mental state from gaze expression (Roman et al., 2012). The Spanish translation of the TdlM (Baron-Cohen et al., 1997), is freely accessible on the Autism Research Centre website (Eyes Test for Adults) by Autism Research Centre (2021). Third, the *Sally and Anna Test* (Baron-Cohen, 1985) was administered, which consists of seeing if a child can predict the behavior of a person who acts guided by an erroneous belief. Fourth, the assessment of second-order beliefs was applied with the *Ice Cream Maker Test.* This task has a series of representational requirements in its execution since not only the mental states of the actors have to be represented, but also the mental state that the actors have of the mental states of the other actors in the story (Tirapu et al., 2007).

Fifth, the *Stroop Test* was administered. The computerized version of the one standardized by Golden (1975) in the United States was used, which was later standardized in Spain by TEA + Ediciones in 2001 (Golden, 2020). The main objective of this test was to measure the ability to inhibit interference, i.e., the individual's ability to control the interference produced by previously automated and unintentional responses, in favor of other controlled and voluntary responses demanded by the situation.

Sixth, the *D2 Attention Test* (Brickenkamp and Seisdedos, 2002) was administered; it is a time-limited test to measure selective attention and mental concentration. The test can be administered both individually and collectively, the latter being the one used in the research conducted, according to the recommendation in schoolchildren (Lizarazo et al., 2018). For the study, TOT (total effectiveness in the test; CON (concentration index), and TA (Total hits) were considered.

Data analysis

The Matlab R2012a program was used for data analysis and processing (MathWorks, Natick, Massachusetts). Using a customized routine, the files of each subject were read, locating all the data in a single matrix. The techniques used were derived directly from psychometrics: item construction and validation, performance level analysis (response ratio), item discrimination analysis (Pearson item-test correlation), internal consistency analysis (Cronbach's Alpha coefficient), validation through test correlation, population description, and construction of scales employing descriptive statistics.

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RESULTS

Socio-demographic profile

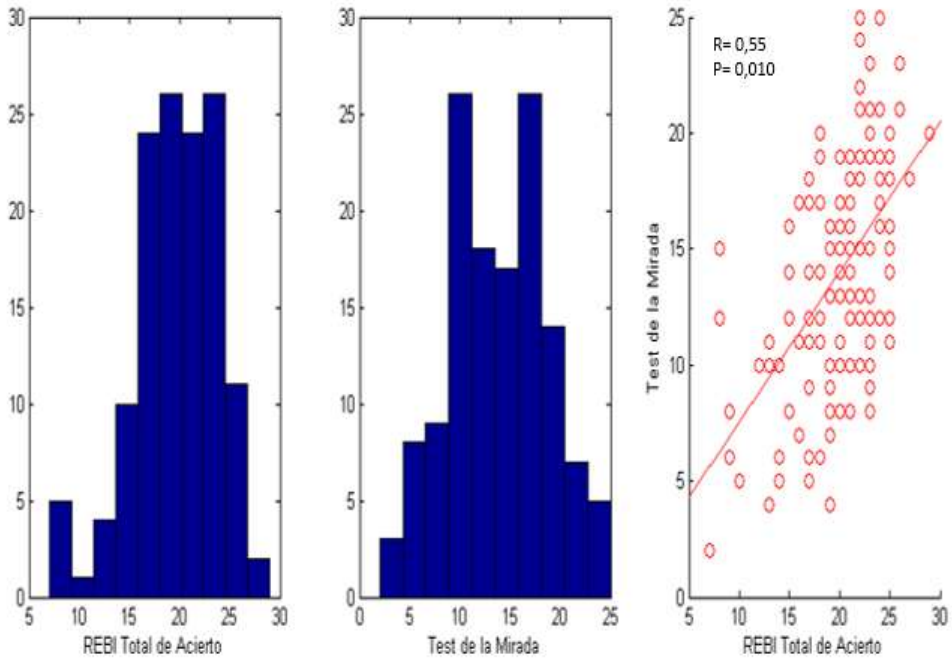
The homogeneous sample consisted of 214 Argentinean children, 118 males, and 96 females, aged between 6 and 12 years. The female participants obtained a significantly higher performance (p=<0.001) in the recognition of mental states with a mean of 15.32 ±4.82 SD, compared to the group of male participants, whose mean performance was 12.77 ±4.77 SD.

Relationship between study variables

REBI/ TdlM test. The subjects who presented a higher number of correct scores in the REBI test presented a better performance in TdlM (r = 0.55; p= 0.010) (Figure 1).

Figure 1

Pearson Correlation Coefficient between REBI[a] and TdlM [b]



REBI[a]: Test of recognition of basic emotions in childhood; TdlMb: Gaze test.*1st Order Beliefs Test. Sally and Anna.*

The total number of correct answers for the REBI Test in subjects who answered correctly was (M:20.41 ±4.04), as opposed to those who answered incorrectly with (M:18.83 ±4.27). Subjects who answered correctly on the First Order Beliefs Test performed better on the REBI Test (p = 0.030).

2nd order beliefs. Ice Cream Maker Test. 69.92% of the subjects evaluated with thesecond-order beliefs test answered incorrectly, while only 30.08% of the participants answered correctly. The mean number of correct answers in the REBI test for the subjects who answered correctly was 20.40 ±4.60, and 19.43 ±4.01 for those who answered incorrectly. No significant differences were observed between both groups of subjects (p = 0.224).

Inhibitory Control

Word reading. There was no significant difference in reading fluency according to gender (p = 0.230). Subjects who presented a higher number of correct scores in the REBI test presented a better performance in word reading (r = 0.43; p = 0.010) (Figure 2).

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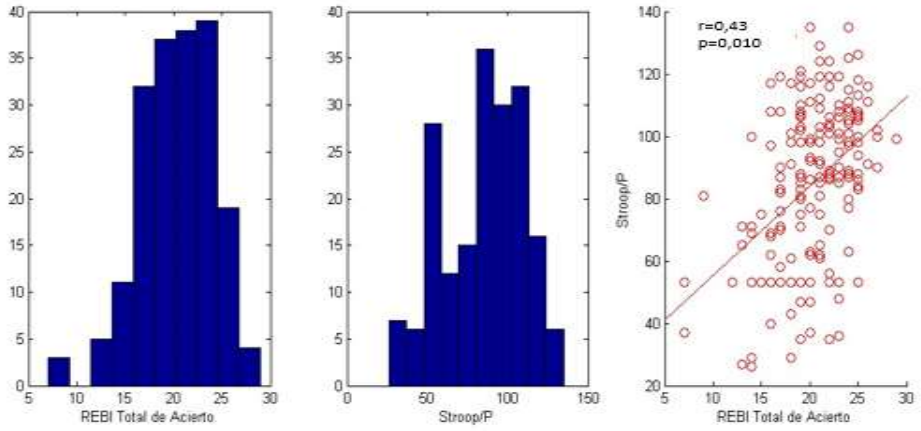
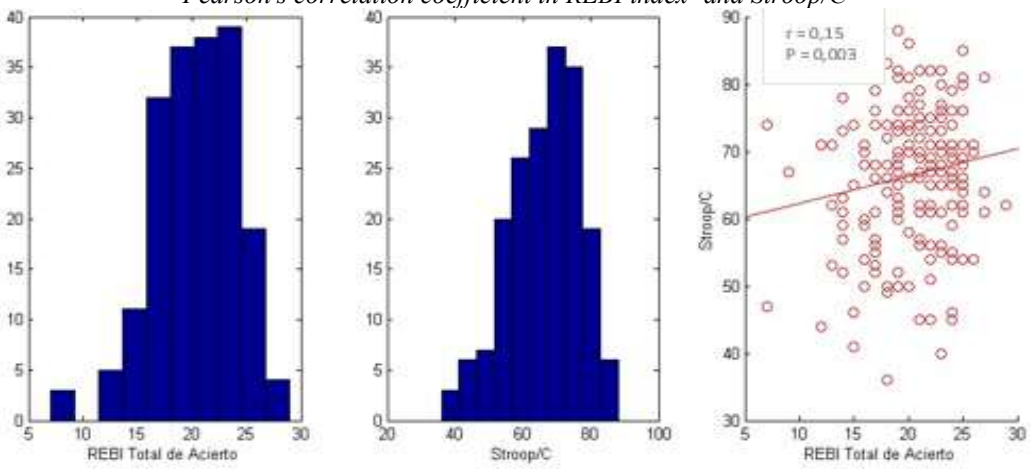
Figure 2
Pearson correlation coefficient in REBI[a] and Stroop/P index.[b]



REBI[a]: Test of Recognition of Basic Emotions in Childhood; Stroop/P[b]: Stroop test word index.

Color recognition. Subjects with a higher number of correct scores in the REBI test had better color recognition in the Stroop/C test (r = 0.15; p = 0.003) (Figure 3).

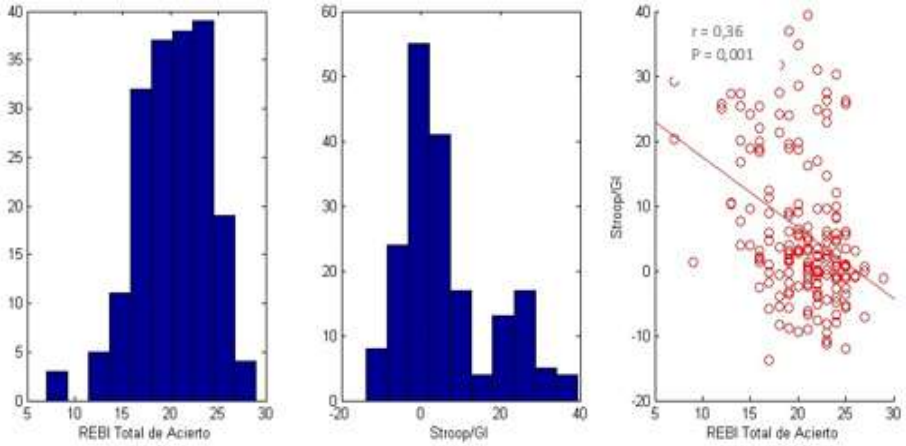
Figure 3
Pearson's correlation coefficient in REBI index[a] and Stroop/C[b]



REBI[a]: Test of recognition of basic emotions in childhood; Stroop/c[b]: Stroop test color index.

Degree of Interference. Subjects with a lower degree of interference showed better REBI than subjects with lower inhibitory control (r= 0.36; p =0.001) (Figure 4).

Figure 4
Pearson correlation coefficient in REBI[a] and Stroop/GI index.[b]

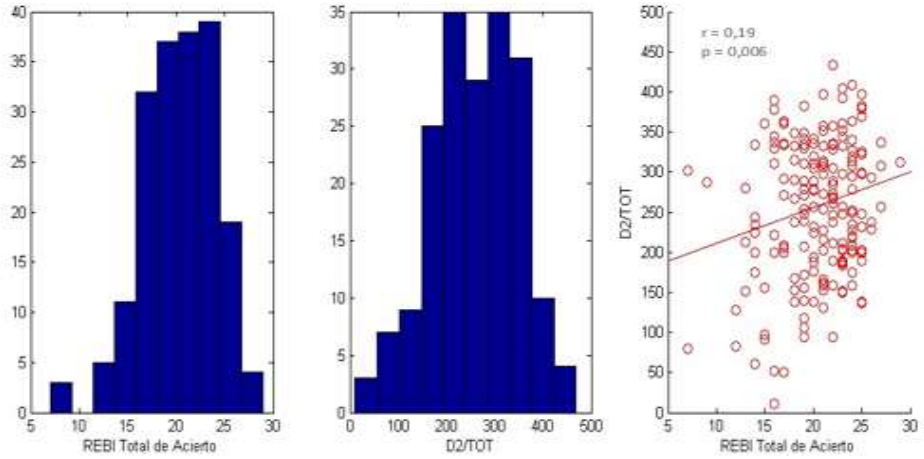


REBI[a]: Test of Recognition of Basic Emotions in Childhood; Stroop/GI[b]: Degree of Interference /Stroop

Attention

Sustained attention. Subjects who presented greater attentional and inhibitory control, with a faster and more precise emission of responses (D2/TOT), showed better REBI than subjects with lower performance in the aforementioned test (r = 0.19; p = 0.006) (Figure 5).

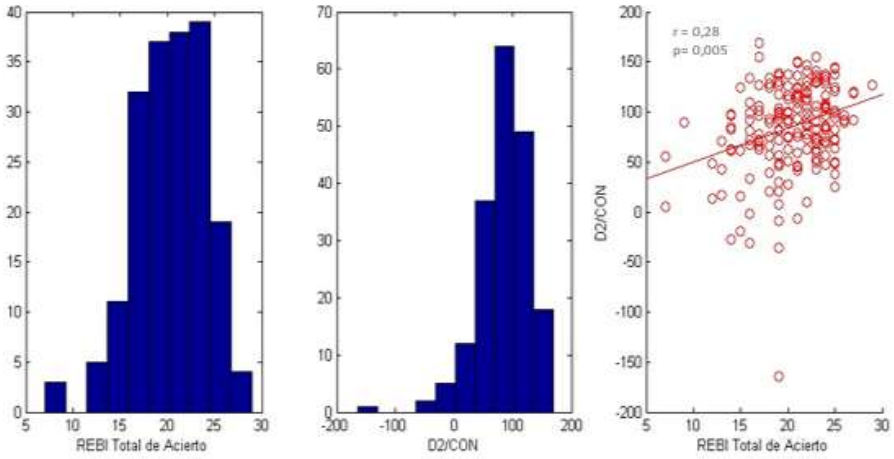
Figure 5
Pearson correlation coefficient in REBI[a] and D2/TOT index[b].



REBI[a]: Test of Recognition of Basic Emotions in Childhood; D2/TOT[b]: total test effectiveness.

Concentration. The subjects who presented a higher level of concentration (D2/CON), understood as a measure of the speed and precision of the performance, showed better REBI than the subjects with lower performance in the aforementioned test (r = 0.28; p = 0.005) (Figure 6).

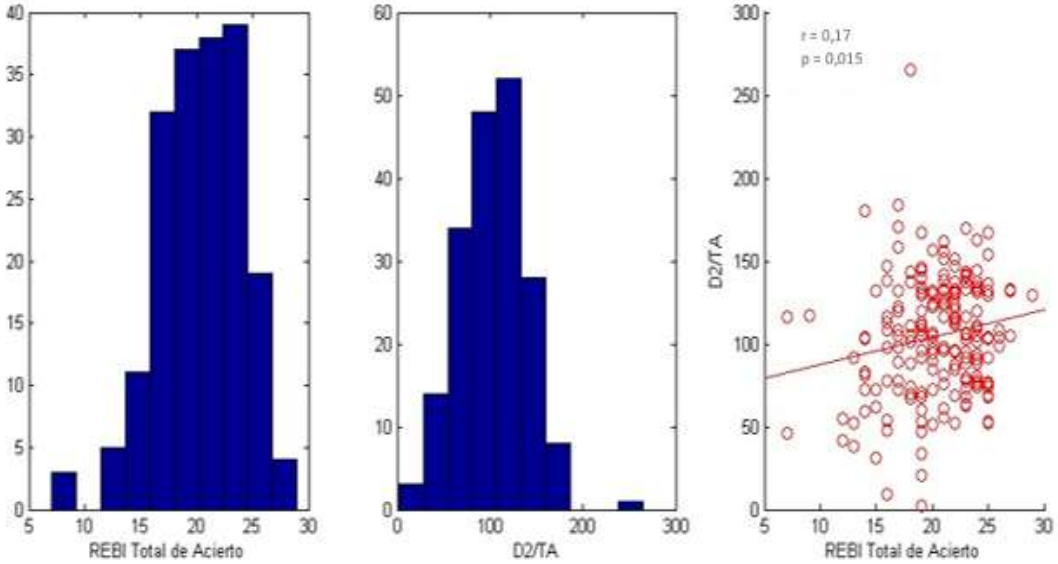
Figure 6
Pearson correlation coefficient in REBI[a] and D2/CON index [b]



REBI[a]: Test of recognition of basic emotions in childhood. D2/CON[b]: Concentration index.

Selective attention. Subjects who presented a better performance in the selective attention measurement test (D2/TA), showed better REBI than subjects with lower performance in the mentioned index (r = 0.17; p = 0.015) (Figure 7).

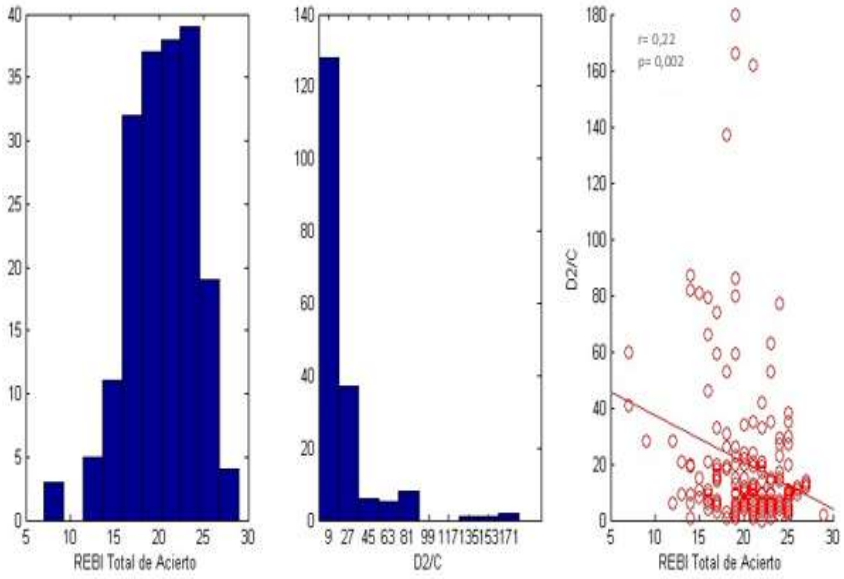
Figure 7
Pearson correlation coefficient in REBI[a] and index D2/TA[b]



REBI[a]: Test of recognition of basic emotions in childhood. D2/TA[b]: Total number of hits.

Cognitive Flexibility. Data on cognitive flexibility were collected through the measurement of Factor C (index of cognitive flexibility composed of the index of visual search, thoroughness, inhibitory control, and processing accuracy). The results obtained indicated, for the sample under study, a mean (M) of 25.91 ± 36.14 SD. No significant difference was observed in categorizing the sample by gender (p =0.100). The data obtained by the subjects in the instance of Cognitive Flexibility in Test D2 and Test REBI show a significant relationship (r = 0.22; p = 0.002). The subjects who presented fewer commission errors showed to have better REBI than the subjects with lower performance in the mentioned index (Figure 8).

Figure 8
Pearson's correlation coefficient in REBI[a] and D2/C index [a]



REBI[a]: Test of recognition of basic emotions in childhood; D2 /C[b]: Factor (index of cognitive flexibility composed of the index of visual search, thoroughness, inhibitory control, and processing accuracy).

DISCUSSION

The results indicate evidence of a positive relationship between better performance in tests measuring neurocognitive functions (ToM, Interference Control, Attention -selective and sustained- and Cognitive Flexibility), and sensitivity in the recognition of basic emotions in third peers in elementary school children. As raised by previous studies (Lockwood et al., 2020; Cole and Millett, 2019; Beaudoin and Beauchamp, 2020), in the present work, when the differentiation between cognitive and emotional is established,it is only an artificial difference. The former is used to refer to information processing and the latter to emotional and affective aspects (Angrino, 2011; Damasio, 2010). The findings allow inferring evidence and congruencies with other studies (Brechet, 2017; Kang et al., 2017; Garcia and Tully, 2020), on the existence of a positive relationship between the ability for Basic Emotion Recognition and better performance in Theory of Mind assessment tests, i.e., children who present difficulties in perceiving, and understanding, the emotions of 3rd peers, show a higher incidence of deficit responses in Gaze Test, and in 1st order beliefs assessment test, than those people with higher levels of Emotional Recognition (Damasio, 2010; Ekman, 1993; Covic et al., 2019; Poenitz and Román, 2020; Tirapu et al., 2007). Along the same lines, previous studies have reported that changes in attention and memory could affect children in the information they obtain from faces during everyday social interactions and, in turn, induce developmental changes in sensitivity to facial expression recognition (Ruba and Pollak, 2020; Lopez et al., 2020; Alexander et al., 2020).

In the research conducted, it became clear that emotions are a fundamental source of information for adequate general cognitive functioning (McCoy et al., 2019; Herrera et al., 2019; McConnel, 2019). The early acquisition shown by children to identify emotions in other children's faces positively predicts their academic performance and other executive skills (Benavidez and Flores, 2019; Johnson, 2018; Glejzer et al., 2019; Figueroa, 2020). Patients with severe central executive system impairment cannot solve these tasks due to difficulties in recording, updating, maintaining, or inhibiting information (Camacho et al., 2020; Valencia et al., 2017), also affecting adequate decision making (Morandín et al., 2019).

CONCLUSION

The results provide new data regarding the evidence of a positive relationship between the capacity for Basic Emotion Recognition and the Control of Interference or inhibition capacity; as well as, between a higher capacity for selective and sustained attention, there will be a higher performance in tasks that require cognitive flexibility.

Conflict of interest
The authors declare that there is no conflict of interest to declare concerning this study and paper.

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