

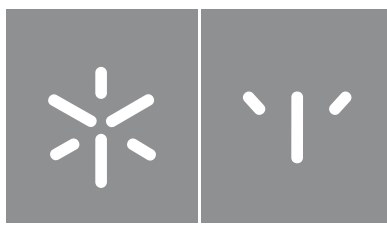


**Universidade do Minho**  
Escola de Psicologia

Ana Catarina Ferreira Pereira

**Children and Adolescents: Empathy and the  
Processing of Intransitive and Pantomime  
Gestures**





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Gestures**

Dissertação de Mestrado  
Mestrado Integrado em Psicologia

Trabalho efetuado sob a orientação da  
**Professora Doutora Adriana Sampaio**  
e da  
**Professora Doutora Angela Bartolo**

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*"There is freedom waiting for you, on the breezes of the sky. And you ask, "what if I fall?". Oh, but my darling, what if you fly?"* - Erin Hanson

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## **STATEMENT OF INTEGRITY**

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Universidade do Minho, 04/06/2020

Assinatura: Ana Catarina Ferreira Pereira

## Crianças e Adolescentes: Empatia e o Processamento dos Gestos Intransitivos e Pantomímicos

### RESUMO

Os gestos são uma forma de comunicação não verbal que podem ser divididos em gestos com (intransitivos, transitivos e pantomímicos) ou sem significado, tendo um papel importante na interação social. Enquanto gestos pantomímicos implicam a representação do uso de um objeto, gestos intransitivos não envolvem o uso de objetos, sendo caracterizados por serem comunicativos, expressivos ou simbólicos. Em relação a estes gestos, existe uma dimensão ainda pouco investigada, - os gestos pró-sociais - que podem induzir um comportamento pró-social e exigem capacidades socio-comunicativas como a empatia. Neste estudo, 30 indivíduos (6 crianças e 24 adolescentes) participaram voluntariamente, com o objetivo de investigar como é que os gestos, realizados na direção e longe do corpo, são desempenhados e reconhecidos durante a infância e a adolescência. Adicionalmente, também se investigou o papel da empatia no reconhecimento dos diferentes tipos de gestos, ao longo do desenvolvimento. Para o efeito, os participantes responderam a algumas medidas de avaliação social e cognitiva, assim como, a uma tarefa experimental, onde avaliavam se o gesto observado tinha ou não significado. Os resultados mostram que os gestos são melhor desempenhados e reconhecidos pelos participantes mais velhos, sugerindo uma maior relevância dos gestos pró-sociais, uma vez que estes se encontram mais fortemente associados com a idade. Níveis mais elevados de empatia encontraram-se positivamente associados com a performance dos gestos intransitivos e o reconhecimento dos gestos pantomímicos, apenas em crianças. Relativamente à direção dos gestos, não foram encontradas diferenças significativas entre os grupos. As descobertas deste estudo revelam-se importantes para um maior entendimento relativamente ao processo de desenvolvimento dos gestos como uma importante fonte de comunicação e o papel da empatia neste processo.

*Palavras-chave:* gestos, empatia, gestos pró-sociais, gestos intransitivos, gestos pantomímicos, comportamento pró-social, infância, adolescência

## Children and Adolescents: Empathy and The Processing of Intransitive and Pantomime Gestures

### **ABSTRACT**

Gestures are a form of nonverbal communication that can be distinguished into meaningful (intransitive, transitive and pantomimes) and meaningless and have an important role in social interaction. While pantomime gestures imply the representation of the use of an object, intransitive gestures do not involve the use of objects and are characterized by being communicative, expressive or symbolic. Regarding these gestures, there is a dimension that is still poorly investigated - the prosocial gestures that can induce a prosocial behavior and require sociocommunicative abilities as empathy. In this study, 30 individuals (6 children and 24 adolescents) participated voluntarily, with the aim of investigating how gestures performed toward or away from the body are performed and recognized during childhood and adolescence. Additionally, the role of empathy in the recognition of different types of gestures was also investigated throughout development. To this end, the participants responded to some social and cognitive assessment measures, as well as to an experimental task, in which they evaluated whether the observed gesture was meaningful or not. The results show that gestures are better performed and recognized by older subjects and point out to the relevance of prosocial gestures, since they are more strongly associated with age. Higher levels of empathy were positively associated with the performance of intransitive gestures and the recognition of pantomime gestures, only in children. Regarding the direction of gestures, no significant differences were found between groups. The findings of this study can be important for a greater understanding on gestures development, highlighting the role of empathy in this process.

*Keywords:* gestures, empathy, prosocial gestures, intransitive gestures, pantomime gestures, prosocial behavior, childhood, adolescence



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**ABBREVIATIONS AND ACRONYMS**

- ANOVA – Analysis of Variance
- ASD- Autism Spectrum Disorder
- fMRI- Functional Magnetic Resonance Imaging
- M - Mean
- SD - Standard Deviation

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### INTRODUCTION

It is widely acknowledged that communication is an essential part of people's daily life. It can be defined as a bidirectional and social process in which people share messages, ideas, and feelings, that can have an impact on their behavior (Silva, Brasil, Guimarães, Savonitti, & Silva, 2000). Literature discerns two different and possible means of communication: verbal (e.g. language) and non-verbal (e.g. gestures, posture, facial expressions, etc.) that can be produced alone or in combination.

Specifically, as a form of nonverbal communication, gestures have an important role in the social exchange, as they contribute to the emerging and the preservation of social interactions (Duarte et al., 2014). According to the literature, gestures can be distinguished into meaningless and meaningful. Meaningless gestures do not carry any semantic information (e.g. “put the fist under the chin”; Bartolo & Stieglitz Ham, 2016), whereas meaningful gestures, besides having a significance for the observer and the agent, are discern into object-related and non-object related actions. Object-related actions include transitive gestures, i.e. when the gesture is performed to show the actual use of an object; and pantomime which consists in the mime of the object use (e.g. “combing oneself; Bartolo et al., 2019) (Bartolo, Cubelli, DellaSala, & Drei, 2003). Finally, we have also intransitive gestures that do not imply the use of objects, are communicative, expressive or symbolic (e.g. “waving goodbye”) and culturally related (Bartolo & Stieglitz Ham, 2016).

Intransitive gestures are typically used for nonverbal social communication. Thus, in merit to these gestures, it is possible to consider another dimension that is still poorly investigated, that is, the prosocial gestures. These gestures can induce a prosocial behavior, or in other words, they can elicit a helping behavior in the observer. For example, the gesture “I am hungry”, performed by placing the hand over the belly, does not only inform the observer of the personal feeling of the individual performing the action, as it would be the case for other intransitive gestures (e.g. “I am thinking”), but can also induce in the observer a helping behavior as providing something to eat. In other words, prosocial gestures can induce a premeditated and voluntary action that may be beneficial for another person (Eisenberg & Miller, 1987). The relevance of these gestures for socio-communicative behaviors stands out since, according to Godman, Nagatso, and Salmela (2014), one of the most peculiar and distinct features of sociability held by humans is the prosocial behavior, which tends to increase with age (Fabes, Carlo,

Kupanoff, & Laible, 1999) and is essential for the development of healthy social relationships (Figueira, 2017).

In accordance, several studies have investigated which brain regions are involved in social gesture processing and highlighted the role of social cognition brain areas associated with expressive gestures. Gallagher and Frith (2004) found dissociable neural pathways for the recognition of different types of intransitive gestures: expressive gestures (i.e. gestures performed to express inner feeling states) (e.g. “I am thinking”) and instrumental gestures (i.e. gestures performed to change the immediate behavior of another person) (e.g. “Come here”). Indeed, they found that while expressive gestures activated brain regions related with the theory of mind processing, also known as “social brain” (i.e. the right superior temporal sulcus; anterior paracingulate cortex [BA 9/32]; the amygdala and the temporal poles), instrumental gestures triggered brain regions linked to language and motor imitation (i.e. the left inferior frontal cortex [BA 44] and the left middle frontal cortex [BA 6/8]) (Gallagher & Frith, 2004). Likewise, other studies have documented that the observation of these communicative gestures activates specific social cognition brain-related areas (e.g. the temporoparietal junction; insula; Pereira, 2018).

Recently, Fourie, Palser, Pokorny, Neff, and Rivera (2020) investigated how functional pantomimes (e.g. “driving”) and communicative gestures (e.g. “waving”) were processed and performed by typically developing children and adolescents and in Autism Spectrum Disorder (ASD). Their results showed that typically developing individuals exhibited a positive correlation between age and the ability to process and perform these gestures. In other words, the older the subject, the better the gestures were executed and understood. Also, they observed that the subjects who showed greater social and communicative skills were better producing and processing the gestures, suggesting that impairments at the level of gestures can be associated with a greater social deficit and poorer social outcomes in both groups (Fourie et al., 2020).

Childhood and adolescence are two critical periods of development with important changes taking place, as the continuous maturation and alteration of brain structures and networks occur (Huttenlocher, Courten, Garey, & Van der Loos, 1982). For instance, the “social brain”, known for its role in mediating a set of different social-related skills, as empathy, is indispensable for successful interpersonal interactions (Misra, 2014), are susceptible to continue to develop and mature during adolescence (Blakemore, 2012). In

particular, empathy can be defined as the capacity of individuals to understand others' perspectives or feelings and to share their internal emotional states or conditions (Yoo, Feng, & Day, 2013). Increased empathy skills have been described in females (Mestre, Samper, Frías, & Tur, 2009), tends to emerge during early childhood and to improve during the period of adolescence (Yoo, Feng, & Day, 2013), having an impact in the development of the prosocial behavior (McMahon, Wernsman, & Parnes, 2006). Some authors propose that empathy can be responsible for the way people employ the sense of their own body (i.e., embodiment; Longo et al., 2008) during gestures comprehension (Jospe, Flöel, & Lavidor, 2017). Still, little is known about the possible effect that empathy can have in gestures recognition and production. In this sense, and considering the relevance of these two periods of development and the impact that gestures and empathy can have in communication and in the establishment of social relationships (McMahon et al., 2006; Fourie et al., 2020), the current study aims to understand gestures processing during childhood and adolescence and to explore the role of empathy in the processing of intransitive and pantomime gestures.

Finally, it has been reported that depending on gesture direction, i.e. toward the body (e.g. "I'm thinking") or away from the body (e.g. "Stop"), gestures may convey a message with different social meanings (Bartolo et al., 2019). Bartolo and colleagues (2019) analyzed the physiological responses (e.g. pupil dilation and heart rate variability [HRV]) in a group of healthy individuals during the observation of gestures performed by an actress with a neutral facial expression. The gestures used as stimuli were meaningless, pantomimes and intransitive and were carried out toward or away from the body. Interestingly, individuals showed greater pupil dilation during the observation of pantomimes and intransitive gestures performed toward the body, suggesting that these gestures convey social and emotional information regarding the inner state of the agent. Regarding the comparison of intransitive gestures performed toward vs away from the body, the authors also showed that intransitive gestures performed away from the body produced a larger vagal suppression (HRV). This result has been interpreted as a sign of a change of the homeostasis that occurs while observing these gestures, as they elicit a motor response (e.g., the gesture of waving requires a reaction from the observer). This distinction is coherent with the results achieved in a functional magnetic resonance imaging (fMRI) study in which expressive/inner (executed toward the body) and instrumental gestures (away from the body) engaged different brain regions (Gallagher

& Frith, 2004). Therefore, we will also explore in this study the different direction of gestures in the groups under study.

Considering these evidences, in this study we investigated how gestures performed toward or away from the body are performed and recognized during childhood and adolescence. Additionally, we also explored the role of empathy in the recognition of different types of gestures. In particular, we predict that the recognition of gestures performed toward the body (mainly the prosocial gestures), in comparison to the gestures executed away from the body, will show a positive correlation with age and empathy scores, as these gestures are more prone to transmit social and emotional information (Bartolo et al., 2019). Also, we expect that older and more empathic subjects will be better in the recognition and production of pantomime and intransitive gestures, in accordance with other studies (Fourie et al., 2020).

## **METHOD**

### **Participants**

Thirty typically developing children and adolescents, ranging from 7 to 18 years old ( $M_{AGE} = 13.43$  years,  $SD = 3.22$ ) took part in this study. Since the study involved the collaboration of participants with ages under 18 we asked for the permission of parents or careers, via email, by sending them an informed consent to be signed and sent, holding the purpose of explaining the aims, the pertinence and the tasks that would be required for the study.

All the participants were Portuguese native speakers, 16 were female (53.3%), and two were left-handed (6.7%). Also, considering that adolescence is defined as the period of development that occurs between the ages of 10 and 19 (WHO, 2006), 6 children (20.0%) and 24 adolescents (80.0%), participated in this study.

### **Measures**

Previous studies showed that pantomimes rely on executive control and mental imagery (Bartolo et al., 2003; Buxbaum, Kyle, & Menon, 2005) while intransitive gestures rely on social cognition (Bartolo & Stieglitz Ham, 2016). Considering this, the current study follows the protocol of a broader study of the University of Lille, which comprises specific cognitive assessments, as explained below.

### **Cognitive and Social Assessment**

In order to assess verbal and executive control abilities (Shao, Janse, Visser, & Meyer, 2014) we used the Phonemic Fluency Subtest from the Verbal Fluency Tests (Cavaco et al., 2013). This measure comprised three trials of one minute each, where the participants had to produce orally as many words as possible beginning with the letters M, R and P. Nevertheless, whenever the subject produced a word starting with a capital letter (e.g. names of persons or places) or with the same root (*“produzir”*, tr. “produce” and *“produção”*, tr. “production”), the response was excluded. The total score was obtained by summing the words pronounced in each one of the three trials.

Motor imagery (i.e. “the mental simulation of a voluntary movement”; Decety & Michel, 1989) was also evaluated through an adaptation of the paradigm proposed by Decety and Michel (1989). According to the model of these authors, the mental performance of a multifaceted movement like writing involves similar processes to the ones required to actually execute that same movement. Thus, this paradigm comprised two different tasks. In the first task, after the researcher had pronounced orally three sentences, one at a time, (i.e. *“Eu sou português”*, tr. “I am Portuguese”; *“Eu sou português e vivo em Portugal”*, tr. “I am Portuguese and I live in Portugal” and *“Eu sou português e vivo em Portugal com a minha família”*, tr. “I am Portuguese and I live in Portugal with my family”), the participants were asked to write down in a piece of paper these same sentences. After this, the researcher, once again, read the sentences one by one and subjects were requested to only imagine themselves writing each sentence. The time required to complete both tasks was recorded and considered for the analysis of data.

To assess empathy, we used the Empathy Index for Children and Adolescents (Bryant, 1982). This measure included a set of 22 sentences (e.g. *“As pessoas que se beijam e abraçam em público são tolas”*, tr. “People who kiss and hug in public are silly”) that the subjects had to read carefully and respond in a Likert Scale, ranging from 1 (*“Discordo totalmente”*, tr. “Strongly Disagree” ) to 5 (*“Concordo Totalmente”*, tr. “Strongly Agree”). The degree of agreement with half of the sentences was from 1 to 5 and inverted for the remaining ones. The final score was obtained by summing the result of each item and the higher the score, the higher the empathy index (Urbano, 2008; Figueira, 2017; Oliveira, 2017).

### Gestures Assessment

The performance of pantomime and intransitive gestures was evaluated by using a gesture protocol adapted to the Portuguese population (Viana, 2015). This protocol can be applied through three possible modalities (i.e. verbal, verbal with description and visual). For the current study, only the visual condition was used. To evaluate pantomime gestures production, seven line-drawing pictures depicting different situations in which the use of an object was required, were presented one at a time (one training item and six test items). Then, the participants were asked to mime the object required for each situation (e.g. “scissors”) (see Figure 1A). Intransitive gestures production was assessed by showing seven different scenarios (one training item and six test items) one at a time and participants were asked to execute the gesture that the person of the picture would do (e.g. “Stop”) (see Figure 1B). For each item performed the participant was given a score of 1 if the gesture was executed correctly and a score of 0 otherwise.

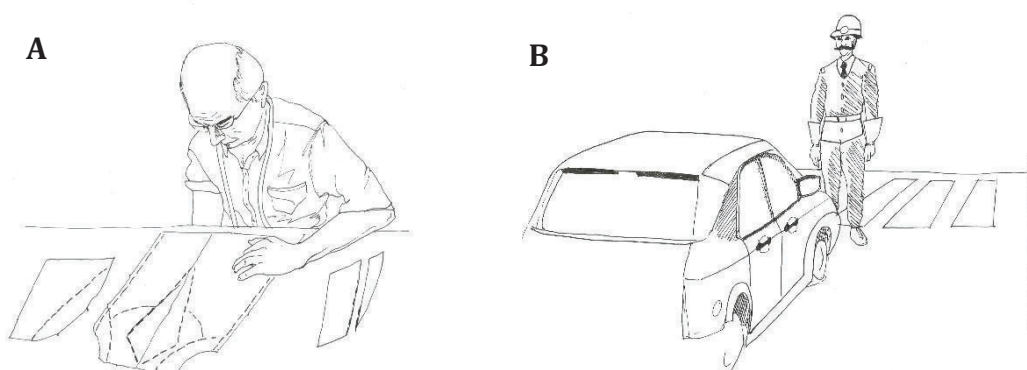


Figure 1. Examples of one item used for pantomimes gestures (A) and intransitive gestures (B) assessment.

### Experimental Task - Gestures Processing

For the present study, we presented participants with 96 silent gesture-videos (48 gestures performed with the right and the left hand, thus  $48 \times 2 = 96$  gesture-videos) performed by an actress who kept a neutral facial expression while executing meaningful (i.e. 24 intransitive and 24 pantomime gestures; half of them were gestures toward and half away from the body) and meaningless gestures (i.e., 24 toward and 24 away from the body) (Pereira, 2018). Among the 6 intransitive gestures performed toward the body, 3 of them were expressive gestures and the remaining 3 prosocial gestures (see Figure 2). Each video, with a duration of 4 seconds, appeared on a randomized order, one by one, on



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an online questionnaire where participants had to press play to watch and after that, answer to each one, by choosing between two possible options - yes or no, as will be following explained in the procedure.

### **Procedure**

First, we asked for the permission of parents or careers, via email, by sending them an informed consent to be signed and sent, holding the purpose of explaining the aims, the pertinence and the tasks that would be required for the study. After the consent of parents or caregivers, the researcher contacted the participants' through their respective phone number and scheduled a day and time to meet, through the platform Zoom. First, the phonemic fluency subtest, motor imagery task and gestures assessment were administered. To this end, it was asked to each participant to be comfortably seated in the quietest place possible of their respective homes in front of a computer and to have a pen and paper nearby. The order of each assessment was counterbalanced across participants.

Next, we sent a link by email to participants' to give them access to the online questionnaire performed on the Qualtrics platform ([www.qualtrics.com](http://www.qualtrics.com)), where their respective responses were recorded. After answering some sociodemographic questions, the participants read the instructions and cleared up possible doubts that they could have regarding the gestures task that would follow. In this part of the questionnaire, the participants were asked to pay attention to a set of videos of an actress performing either a meaningful or a meaningless gesture, that would appear on the screen of their computers. After pressing play and watching each video, the participants had to decide if the gesture they saw was meaningful, by answering yes or no in the questionnaire. Finally, they answered the Empathy Index for Children and Adolescents (Bryant, 1982) that would appear at the end.

The researcher was always present, through video, while participants answered to the questionnaire. All data were collected in a single session that had a duration between 30 minutes to 45 minutes. The videos were counterbalanced and randomized across participants.

## EMPATHY, INTRANSITIVE AND PANTOMIME GESTURES

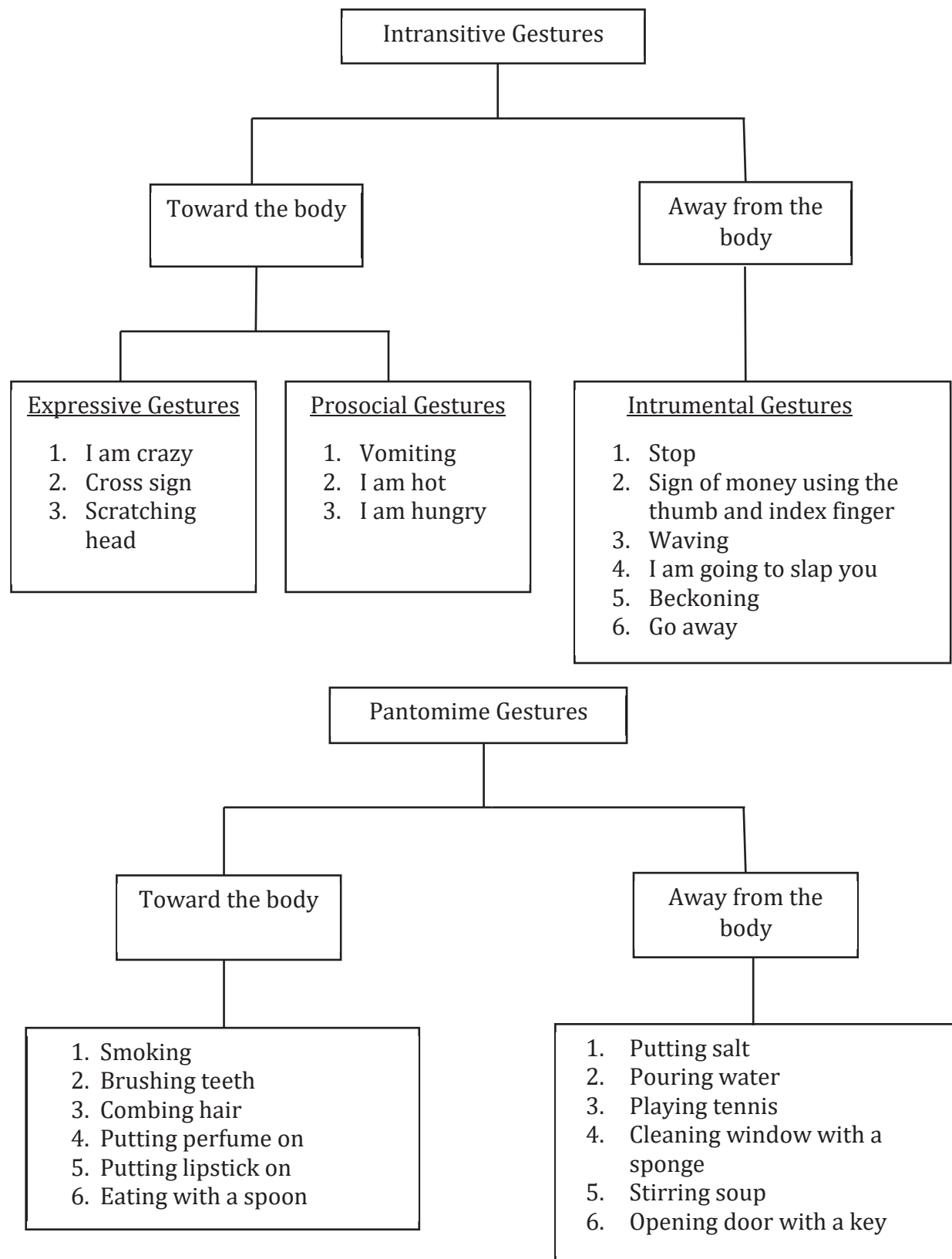


Figure 2. Scheme with intransitive and pantomime gestures used as stimuli in the study.

### Data Analysis

First, we analyzed the normality of data using Kolmogorov–Smirnov tests. Since the data of motor imagery task and social assessment didn't follow a normal distribution, we explored possible outliers with boxplots (Field, 2018), and, of the original sample, two participants were considered outliers. Therefore, they were removed from the final analysis and only 28 participants (6 children and 22 adolescents) ranging from 7 to 18 years old ( $M_{AGE} = 13.57$  years,  $SD = 3.29$ ) were analyzed in this study.

The data of this study was analyzed through the software *Statistical Package for the Social Science* (SPSS), Version 26.0. Descriptive analyzes were carried out to characterize the sample of the study, the gestures accuracy and the social and cognitive assessments for both populations. Posteriorly, and since the data followed a non-normal distribution, we employed non-parametric analyses, more specifically, the test Mann-Whitney for independent groups comparison and the Wilcoxon test when we compare the data within each group (paired samples). Correlations of Pearson were used to investigate the associations between the variables under study, namely, empathy, age of participants and gestures performance and recognition. Also, Chi-Square correlations were used to explore the association between gender and empathy scores. Finally, Friedman's test was applied to analyze the accuracy of pantomime and intransitive gestures either performed toward or away from the body.

## RESULTS

### Cognitive and Social Assessment

Participants scored, in general, above the normal range ( $10 \pm 3$  words) in Phonemic Fluency Skills ( $M = 21.64$ ,  $SD = 9.75$ ) with children ( $M = 11.33$  words,  $SD = 3.72$ ) performance being lower than adolescents ( $M = 24.45$  words,  $SD = 8.00$ ),  $U = 7.00$ ,  $p < .001$ ,  $r = .63$ . In Motor Imagery Task, the difference between the time the subjects took to write and to imagine writing the sentences was, on average, 81.37s ( $SD = 77.77$ s) for children and 16.73s ( $SD = 13.30$ s) for adolescents. Despite the discrepancy observed in both groups, this difference was not significant,  $U = 18.00$ ,  $p = .007$ ,  $r = .51$ . Concerning social assessment, there were no group differences, as levels of empathy scored by children ( $M = 94.17$ ,  $SD = 5.71$ ) did not differ from those observed in the group of adolescents ( $M = 87.18$ ,  $SD = 7.90$ ),  $U = 32.00$ ,  $p = .056$ ,  $r = .36$ , in the Empathy Index for Children and Adolescents (Bryant, 1982).

### Gestures Performance

Adolescents showed a higher proportion of correct responses (Figure 3) (filled dots,  $M = .92$ ,  $SD = .08$ ) than children (empty dots,  $M = .72$ ,  $SD = .05$ ),  $U = 5.50$ ,  $p = .001$ ,  $r = .66$ , for either intransitive,  $U = 4.00$ ,  $p < .001$ ,  $r = .70$ , and pantomime gestures,  $U = 25.50$ ,  $p = .014$ ,  $r = .46$ . In particular, the higher accuracy difference was observed in the category of intransitive gestures (children:  $M = .67$ ,  $SD = .07$ ; adolescents  $M = .92$ ,  $SD = .10$ ), in comparison to the category of pantomimes (children:  $M = .79$ ,  $SD = .12$ ; adolescents:  $M = .92$ ,  $SD = .11$ ).

Additionally, for children the accuracy for intransitive ( $M = .70$ ,  $SD = .07$ ) was not significantly different from pantomime ( $M = .78$ ,  $SD = .12$ ),  $Z = -1.49$ ,  $p = 0.14$ ,  $r = .61$ , and the same was observed in the group of adolescents: intransitive ( $M = .92$ ,  $SD = .10$ ) and pantomime gestures ( $M = .92$ ,  $SD = .11$ ).

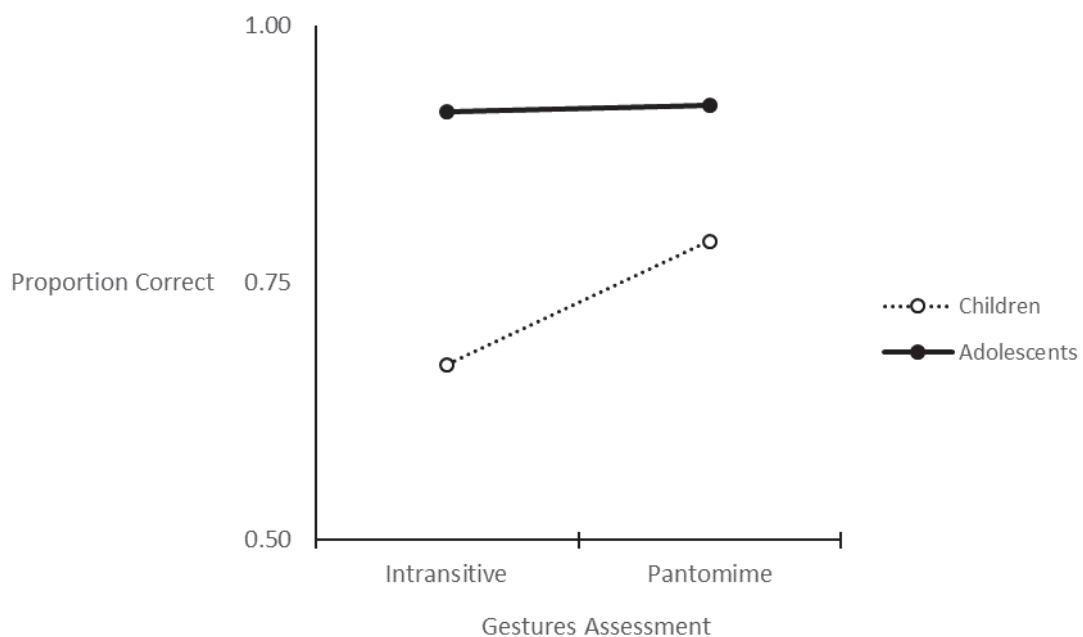


Figure 3. Mean proportion for correct production of pantomime and intransitive gestures. The filled dots refer to the adolescents' group and the empty dots refer to the children group.

### Gestures Processing

Regarding the experimental gestures task (Figure 4), we first carried out a within-group analysis. In children (empty dots), there were no differences in accuracy for meaningful (pantomime more intransitive) ( $M = .84$ ,  $SD = .14$ ) and meaningless gestures

## EMPATHY, INTRANSITIVE AND PANTOMIME GESTURES

( $M = .91$ ,  $SD = .06$ ),  $Z = -.84$ ,  $p = .400$ ,  $r = .34$ . The same was observed in adolescents' group (filled dots), as the proportion of correct responses for meaningful ( $M = .93$ ,  $SD = .07$ ) was similar to meaningless gestures ( $M = .93$ ,  $SD = .07$ ). Specifically, considering the categories of meaningful gestures, we observed that while adolescents showed a significant difference between intransitive ( $M = .95$ ,  $SD = .07$ ) and pantomime gestures accuracy ( $M = .90$ ,  $SD = .10$ ),  $Z = -2.26$ ,  $p = .024$ ,  $r = .48$ , the same didn't applied in children group (intransitive:  $M = .88$ ,  $SD = .12$ , pantomime:  $M = .80$ ,  $SD = .22$ ), as no differences were observed between categories,  $Z = -1.08$ ,  $p = .279$ ,  $r = .44$ . Finally, there were no group difference regarding the accuracy of pantomime,  $U = 50.00$ ,  $p = .362$ ,  $r = .17$ , and intransitive gestures,  $U = 40.50$ ,  $p = .120$ ,  $r = .29$ .

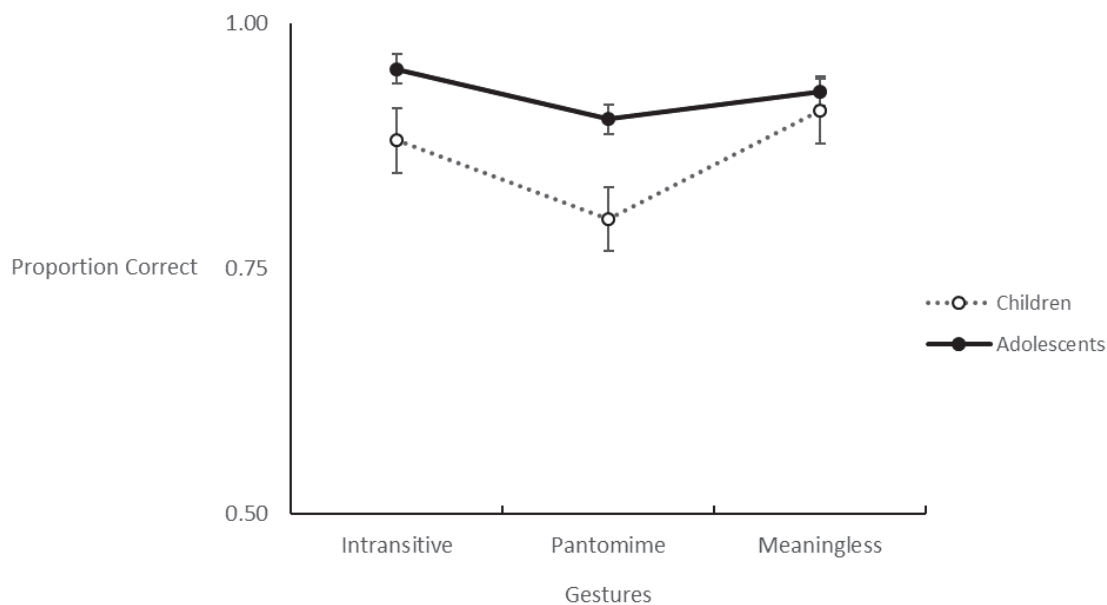


Figure 4. Mean proportion (with error bars) for correct recognition of intransitive, pantomime and meaningless gestures. The filled dots refer to the adolescents' group and the empty dots refer to the children group.

When we consider the direction, away or toward the body, of pantomime and intransitive gestures (Figure 5), there were no differences in these categories within children group (empty dots),  $\chi^2(3) = 2.11$ ,  $p = .549$ . On the other hand, within adolescents group (filled dots), we observed a significant difference between gestures away or toward the body,  $\chi^2(3) = 9.18$ ,  $p = .027$ . To perform comparisons between the different conditions of gestures (type x direction) we used Wilcoxon tests with Bonferroni correction applied, resulting in a more exigent significance level of  $p < .008$ . According to

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Martins (2011) this correction is applied when we try to discovered where those differences can be found, in order to avoid the occurrence of a type I error (i.e., differences were found when in fact they don't exist; Field, 2018). However, no significant differences were observed: intransitive toward vs intransitive away,  $Z = -1.49$ ,  $p = .136$ ,  $r = .32$ , intransitive toward vs pantomime toward,  $Z = -1.46$ ,  $p = .145$ ,  $r = .31$ , intransitive toward vs pantomime away,  $Z = -.87$ ,  $p = .383$ ,  $r = .19$ , intransitive away vs pantomime toward,  $Z = -2.57$ ,  $p = .010$ ,  $r = .55$ , intransitive away vs pantomime away,  $Z = -1.98$ ,  $p = .048$ ,  $r = .42$ , and pantomime toward vs pantomime away,  $Z = -.89$ ,  $p = .376$ ,  $r = .19$ .

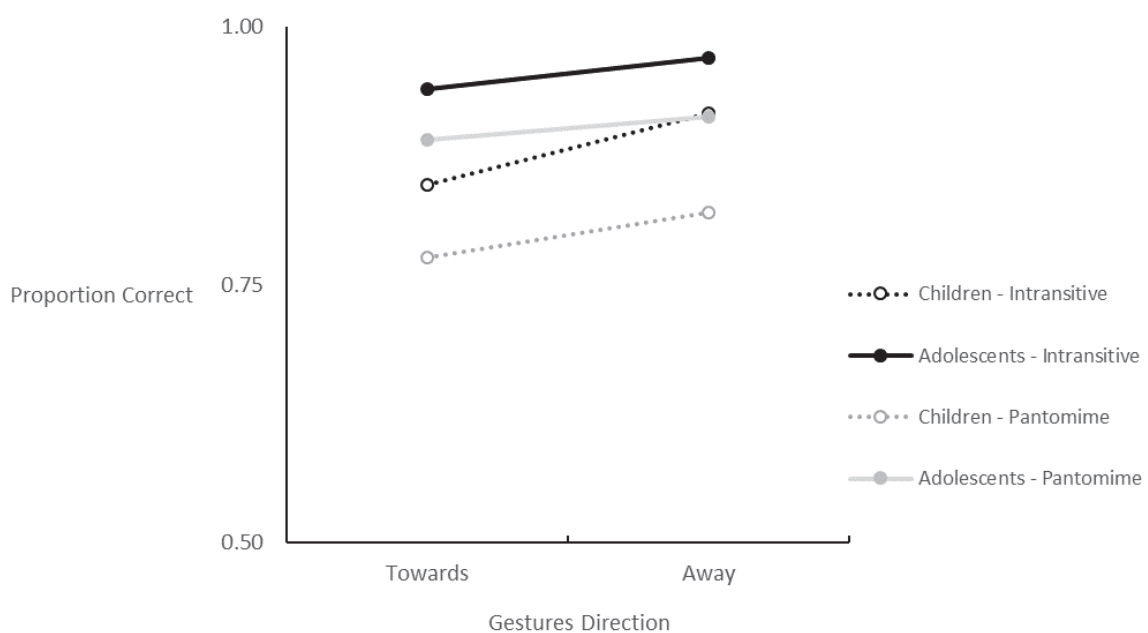


Figure 5. Mean proportion for correct recognition of intransitive and pantomime gestures performed toward and away from the body. The filled dots refer to the adolescents' group and the empty dots refer to the children group.

Finally, regarding the different dimensions of intransitive gestures (Figure 6), no difference was observed between groups in the accuracy of prosocial,  $U = 46.50$ ,  $p = .202$ ,  $r = .24$ , and instrumental gestures,  $U = 57.50$ ,  $p = .549$ ,  $r = .11$ , but groups differed in the accuracy of expressive gestures,  $U = 47.00$ ,  $p = .048$ ,  $r = .37$ . Considering each group separately, we observed that adolescents (filled dots) differed in the accuracy of prosocial and expressive gestures,  $Z = -2.45$ ,  $p = .014$ ,  $r = .52$ , and prosocial and instrumental gestures,  $Z = -2.08$ ,  $p = .037$ ,  $r = .44$ . This difference can be due to the higher accuracy for

either expressive ( $M = .99$ ,  $SD = .07$ ) and instrumental gestures ( $M = .97$ ,  $SD = .06$ ), when compared to prosocial gestures ( $M = .89$ ,  $SD = .16$ ). For children (empty dots), no differences were observed between prosocial ( $M = .81$ ,  $SD = .16$ ), expressive ( $M = .89$ ,  $SD = .20$ ) and instrumental gestures ( $M = .94$ ,  $SD = .09$ ).

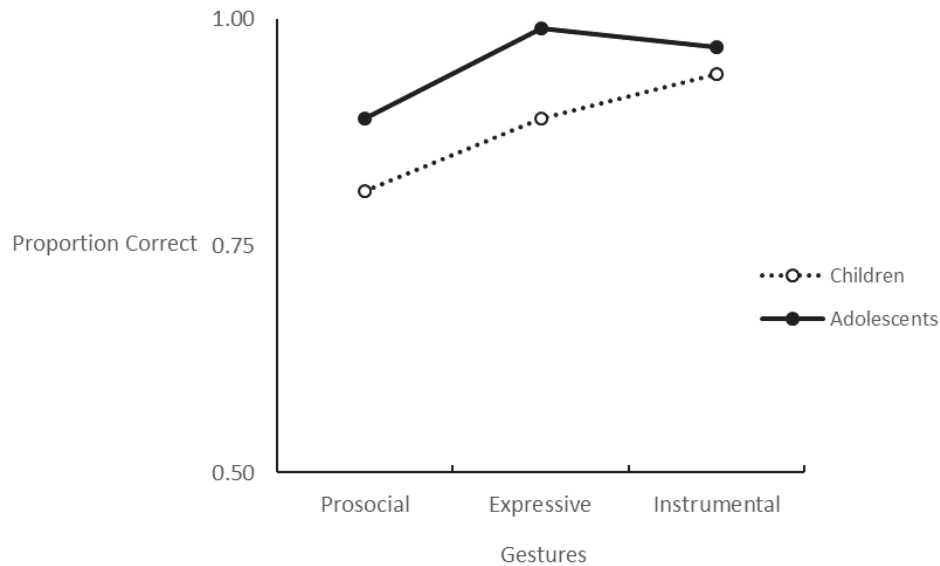


Figure 6. Mean proportion for correct recognition of prosocial, expressive and instrumental gestures. The filled dots refer to the adolescents' group and the empty dots refer to the children group.

### Gestures and Age

In this study, we wanted to explore the correlation between age and gestures performance and processing to analyze possible changes acrossing the different development periods. Since this study comprised a large age range of participants (divided into two non-homogenous groups), we considered all the sample to examine these relationships.

We observed that performance in both type of gestures (pantomimes and intransitive) was positively and significantly correlated, with the age of participants  $r = .71$ ,  $p < .001$ , being observed when each category was considered individually (pantomime:  $r = .52$ ,  $p = .005$ ; intransitive:  $r = .70$ ,  $p < .001$ ). The same was observed for the processing of gestures (intransitive:  $r = .43$ ,  $p = .023$ , pantomime:  $r = .39$ ,  $p = .040$ ).

As far as the direction of gestures are concerned, a positive and significant correlation between the age of participants was observed, in particular, with intransitive gestures

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performed toward the body,  $r = .41$ ,  $p = .029$ , and pantomimes performed away from the body,  $r = .38$ ,  $p = .049$ .

Lastly, regarding the different categories of intransitive gestures, we found a positive and significant correlation with the age of participants

### **Gestures and Empathy**

For gestures performance, we did not observe any association between empathy scores with overall accuracy,  $r = -.21$ ,  $p = .282$ , intransitive:  $r = -.29$ ,  $p = .128$ ; or pantomime:  $r = -.05$ ,  $p = .785$ . However, when we analyzed this association with a within-group approach, we evinced that children empathy levels were positively and significantly correlated with intransitive gestures,  $r = .95$ ,  $p = .003$ , but not with pantomimes,  $r = -.23$ ,  $p = .660$ . No associations between empathy and the performance of intransitive,  $r = -.24$ ,  $p = .273$ , or pantomime gestures,  $r = -.13$ ,  $p = .579$ , were observed in the adolescent group.

Regarding gestures task processing, no significant correlation was found between empathy score levels and overall gestures' accuracy,  $r = -.09$ ,  $p = .634$ . When considering each group, we observed that in children, empathy was positively and strongly correlated with recognition of pantomime gestures,  $r = .94$ ,  $p = .005$ , but no with intransitive,  $r = .32$ ,  $p = .537$ . For adolescents, no significant association was observed between empathy scores and intransitive,  $r = -.14$ ,  $p = .549$ , or pantomime gestures,  $r = .10$ ,  $p = .644$ . In relation to the direction of gestures, a positive correlation between empathy scores and pantomime gestures performed toward,  $r = .85$ ,  $p = .034$ , and away from the body,  $r = .98$ ,  $p = .001$ , was observed in the children group whereas no association emerged in the adolescent group.

Finally, no significant correlations were observed between empathy and prosocial, expressive and instrumental gestures.

## **DISCUSSION**

The present study aimed to understand how intransitive and pantomime gestures performed toward and away from the body and a particular type of intransitive gestures (prosocial gestures) are processed by typically developing children and adolescents. Prosocial gestures hold the capability to produce a prosocial behavior, relevant in the establishment of healthy social relationships (Figueira, 2017) which are pivotal in these developmental periods. In accordance, we additionally investigated if different levels of empathy would have an influence in the processing and performance of gestures, mainly



at the level of prosocial gestures, considering its role in the development of prosocial behavior (McMahon, Wernsman, & Parnes, 2006).

In line with our predictions, adolescents performed more accurately than children for both intransitive and pantomime gestures, but showed, in particular, a higher accuracy for the execution of intransitive gestures (see also Mozaz et al., 2002). These gestures are communicative and are linked to social cognition (Gallagher & Frith, 2004; Pereira, 2018) which involves a set of diverse abilities (e.g., the theory of mind, recognition of different emotions, empathy) (Baksh, Abrahams, Auyeung, & MacPherson, 2018) that tend to develop with age (Yoo, Feng, & Day, 2013). Hence, the results observed at the level of the performance of intransitive gestures could be explained by the ongoing development of the different social skills that are maturing in adolescence.

Regarding the experimental gestures task, and considering separately each group, we also observed higher accuracy for the recognition of intransitive gestures, when compared to pantomime gestures, but only in adolescents, which was in line with our expected results and other studies (see also Mozaz et al., 2002). Once again, these results appear to support the link between intransitive gestures and social skills, that undergo development during adolescence. Then, and according to previous studies suggesting that the direction of gestures can carry messages with different social meanings, having an impact on the physiological responses of individuals (Bartolo et al., 2019), we decided to investigate further the direction of these meaningful gestures. Our results show no differences regarding gestures performed toward and away from the body, in both children or adolescents, contrary to our initial prediction. Bartolo and colleagues (2019) included in their study adult participants which are different from our study, suggesting that it is likely that children and adolescents may be less sensitive to the different social messages and meanings that gestures convey according to their direction (see Bartolo et al., 2019). However, further studies are needed to confirm this explanation at younger ages, as the ones used in this study.

Considering the main objectives of this dissertation and that prosocial gestures are related to intransitive gestures, we analyzed differently the accuracy of intransitive gestures performed toward, that included the prosocial and expressive gestures, and away from the body (i.e. instrumental), in both groups separately. Whereas in the children group no significant difference emerged between prosocial, expressive and instrumental gestures, we observed that in adolescents expressive and instrumental gestures were

better recognized than prosocial gestures. These results are also in accordance with our data comparing both groups, as they differed only in the accuracy of expressive gestures, with adolescents recognizing more accurately these gestures than children. This suggests that the ability to process efficiently prosocial gestures might be still under development, while expressive gestures (i.e., more related to theory of mind abilities), and instrumental gestures (associated with language skills), can be in advantage in terms of a faster improvement during adolescence. However, in the absence of evidence on gestures processing development in the literature, more studies are needed to explore this hypothetical explanation.

Furthermore, we discovered a positive association between age with performance and processing of pantomimes and intransitive gestures (Fourie et al., 2020). The direction of meaningful gestures was also explored. A significant and positive correlation was found, specifically for intransitive prosocial gestures and pantomimes performed away from the body. As already reported by some authors (see Bartolo et al., 2019), intransitive gestures have the capacity to transmit social and emotional information to individuals, when they are performed toward the body (e.g., expressive and prosocial gestures). Specifically, in what concerns prosocial gestures, they do not only convey this specific information but are also known for being capable of producing prosocial behaviors. Hence, these results appear to support that both intransitive and pantomimes are developmentally-based and improve with age (Fourie et al., 2020). On the other hand, the pantomime gestures performed away from the body convey messages related to the function of different tools (Bartolo et al., 2019) and involve processes responsible for motor and visuospatial imagery (Ruotolo et. al., 2020). Performance of motor imagery tasks also improves with age (Munroe-Chandler et al., 2007). Therefore, the current results could be justified by improvements observed across age at the level of motor imagery, recognized for being correlated with pantomime gestures (Ruotolo et. al., 2020).

Previous literature reported that empathy can have an important role during gestures comprehension (Jospe, Flöel, & Lavidor, 2017). A recent study discovered that individuals with greater social skills, like empathy, are better performing gestures (Fourie et al., 2020). We observed that an increase in the level of empathy in children was associated, especially, with a better performance of intransitive gestures. These results support the idea that intransitive gestures performance and social skills are linked, particularly in children.

Nevertheless, these findings were not similar to the ones observed in the gestures processing task, as the accuracy of pantomime gestures was higher in more empathic children. Some authors showed that pantomimes were correlated with the performance of the theory of mind tasks in preschooler children (Suddendorf, Fletecher-Flinn, & Johnston, 1999). In this sense, our results support the assumption that during this development period, pantomime gestures could rely more on specific social skills, like the theory of mind, on younger subjects. Also, the lack of a significant correlation with empathy for adolescents seems to follow some authors, who defended that as individuals get older, the relation between social skills and other variables can also become more stable (Underwood & Moore, 1982). Hence, our results suggest that the association between empathy and gestures recognition appears to be more notorious in childhood, being more stabilized in older ages justifying why no significant or strong associations emerged for this group. Although, in the absence of complementary information, this explanation directs to the need of conducting more investigations regarding the role of empathy over the recognition of gestures.

It is also important to consider the difference in gestures performance and gesture recognition abilities. In the performance task, individuals had to interpret a set of different scenarios to produce a gesture (i.e., a higher-order motor response; Walther, Vanbellinghen, Müri, Strik, & Bohlhalter, 2013), appropriate to each context presented. For the recognition task, participants had to observe videos of an actress, without any facial expression, performing different types of gestures, and simply answer if the gesture had any meaning or not to them. Considering this, the different nature of each task could be associated with differences in both gesture tasks.

Finally, we also studied if empathy scores were related with the direction of gestures, as previous studies have been showing that gestures performed toward the body convey social and emotional information regarding the inner feeling state of the agent (Bartolo et al., 2019). In the group of adolescents, once again, no significant correlations were found regarding empathy levels. Although, more empathic children recognize better pantomime but not intransitive gestures (towards and away). The significant and positive correlation found for pantomime toward the body is consistent with previous evidence suggesting that these gestures are known for transmitting social information in relation to the inner state of the person performing the action (Bartolo et al., 2019). On the contrary, pantomimes performed away from the body only transmit information regarding the

function of tools (Bartolo et al., 2019). Taking into consideration the results regarding pantomime gestures and the lack of correlation with intransitive gestures, known for being linked to social cognition (Gallagher & Frith, 2004), maybe can be explained by the ongoing development of social abilities (i.e., empathy) that are still occurring during childhood, not being fully mature yet (Blakemore, 2012).

As they grow, humans change the way they process social interactions (Walbrin, Mihai, Landsiedel, & Koldewyn, 2020). According to Walbrin et al. (2020), the neural responses to social interactions are under development during the period of adolescence not being completely mature in younger children. In this line, we showed that gestures, considered as a non-verbal source essential for daily communication and important in social interaction, undergo development. Thus, the relevance of the current study stands out considering the recent discoveries made by some authors, who found out that higher social deficits and poorer social outcomes in typical developing children and adolescents, can be in part explained by impairments present in gestures performance and/or their respective recognition (Fourie et al., 2020).

In conclusion, our results suggest that both the performance and recognition of intransitive and pantomime gestures tend to get better with age. Also, inside the big category of intransitive, the dimension of prosocial gestures showed the most significant correlation with age indicating the relevance of studying further the recognition and processing of these gestures throughout development. Concerning empathy, significant results were found only for the children group and appear to indicate that, during childhood, this social skill can be more relevant in guiding gestures recognition and performance. In this sense, these findings contributed for a greater understanding about the important role empathy can hold throughout development.

Despite this, the results for the direction of gestures may be due to the non-homogenous sample obtained for this study or to the little number of each type of stimuli used, especially for prosocial gestures that only involved a very little number of videos (6 stimuli). It should not go unnoticed that for this study we carried out a diversity of comparisons within and between groups, with a non-homogenous sample. So, we don't know if some differences didn't emerge due to the presence of a type II error (i.e., no differences were found when in fact they could exist) (Field, 2018). Likewise, given the outbreak, the conditions in which the experiment occurred could not be completely controlled: if participants watched the video more than one time or until the end could

not be detected by the researchers. In this sense, we suggest that future studies should take into consideration not only the accuracy but also the reaction times regarding each gesture with a presential task, as well as a more homogenous sample with a bigger number of participants. Moreover, the number of stimuli to be included in each category of gestures should be improved.

Lastly, it is known that children typically resort to different hand gestures (e.g. pointing) with the purpose of express their needs and desires before they are able to do it with the verbal language (Clements & Chawarska, 2012). Considering this, gestures can represent some of the first predictors of important neurodevelopmental disorders that display socio-communication impairments, as is the case of the Autism Spectrum Disorder (ASD), having a significant role in the earlier identification of this disorder (Silverman, Bennetto, Campana, & Tanenhaus, 2010; Clements & Chawarska, 2012). In this light, not only the early diagnosis of ASD has been recognized as crucial to a subsequent successful intervention in these individuals (Gizonno et al., 2015) but also two periods of development appear to arise in terms of relevance in order to accomplish such thing, that is, childhood and adolescence. Hence, it would also be interesting to conduct a study with children and adolescents who follow a typical development and compared them to the ones with ASD since the results could be important for the development of intervention programs with the goal to help individuals to improve important social skills, indispensable for communication and social relationships.

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APPENDIX



Comissão de Ética para a Saúde

Data: 25-09-2015

Nossa referência: CESHB 034/2015

Outra referência:

Relator: Juan R. Garcia

**Parecer emitido em reunião plenária de 12 de Maio 2015**

Nos termos dos N° 1 e 6 do Artigo 16° da Lei N° 21/2014, de 16 de Abril, a Comissão de Ética para a Saúde do Hospital de Braga (CESHB) em relação ao estudo "**Gestos Intransitivos e Cognições Sociais em Vítimas de AVC**", de que é investigadora principal Johanna Andrea Rodrigues Viana, aluna do Mestrado Integrado em Psicologia da Universidade do Minho; e orientadora a Profª. Dra. Adriana Sampaio, e decorrerá no Serviço de Medicina Interna da instituição, emite o seguinte parecer:

O estudo visa avaliar os mecanismos neurocognitivos envolvidos na produção de gestos intransitivos e mímicos em 20 pacientes com AVC pelo menos três meses antes, sem outra patologia neurológica ou psiquiátrica, e níveis normais de compreensão verbal. Inclui a avaliação de uma coorte de 20 participantes saudáveis.

a) O estudo é pertinente: e todos os participantes irão usufruir de sessões de avaliação neuropsicológica, podendo ser encaminhados para outras especialidades de acordo com as necessidades.

c) Metodologia científica: estudo observacional, transversal e analítico, tipo caso-control. Serão utilizados diversos testes psicológicos de compreensão verbal, de atenção, de funcionamento executivo e cognições sociais e vídeo-espaciais. A avaliação de gestos será gravada em vídeo. Além disso, cada participante irá realizar um Ressonância Magnética.

b) Não riscos a mencionar.

d) O investigador principal e dos restantes membros da equipa são aptos para o estudo;

e) O Serviço de Medicina reúne condições materiais e humanas necessárias à realização do estudo clínico;



## Comissão de Ética para a Saúde

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- f) Não está prevista qualquer retribuição ou compensação eventuais dos investigadores e dos participantes;
  - g) As modalidades de recrutamento dos participantes é adequada. Não consta do projeto cálculo de poder amostral.
  - h) Não existem situações de conflito de interesses por parte do promotor ou investigador envolvidos no estudo clínico;
  - i) Não está contemplado o acompanhamento clínico dos participantes, após a conclusão do estudo;
  - j) Está adequadamente prevista a obtenção de consentimento informado. Os dados serão anonimizados mediante código a atribuir aos testes e ressonâncias magnéticas, só conhecidos pelas investigadoras. As gravações em vídeo serão destruídas no final do projeto. A divulgação do estudo nunca será para dados individuais, mas para o conjunto dos dados.
  - k) Os custos serão suportados pelo Centro de Investigação em Psicologia da Universidade do Minho.

Pela Comissão de Ética do Hospital de Braga não há objeções éticas no presente projeto.

O Presidente

A handwritten signature in black ink, appearing to read "Juan R Garcia", written over a horizontal line.

Dr. Juan R Garcia.