



## ANALYSIS OF GESTURE PRODUCTION IN PORTUGUESE INFANTS WITH AND WITHOUT HEARING IMPAIRMENT

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### **Abstract:**

The aim of this study was to identify and analyze the characteristics of communicative gestures produced by Portuguese infants with and without hearing impairment aged between 8 and 18 months. The participants in this study were 37 infants with normal hearing and 4 infants with hearing impairment. The participants were recruited from kindergartens in the central and southern regions of the country and from a hospital in the central region of Portugal. The results of this study show that as young children grow, they become increasingly confident about the effect of their communicative gestures on adults, and the characteristics of the gestures become more refined or complex; although young children with hearing impairment use communicative gestures in a similar way to their peers, the characteristics of their gesture production differ. The present study emphasizes the importance of characterizing children's gestures in the prelinguistic period, as it allows a better understanding of how the communication process develops and how gestures are used. It is expected that the differences found between different age groups and between children with and without hearing impairment will help Portuguese professionals in more efficient clinical and educational assessment and intervention processes.

**Keywords:** gestures, infants, hearing impairment, pre-linguistic period

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## 1. Introduction

Research into communicative gestures in the pre-linguistic period is of great importance, not only because it provides information about the origin and nature of human communication, but also because its findings are essential for the development of techniques used in the clinical/educational context of language acquisition. Prelinguistic gestures convey and/or support communicative acts that express a range of intentional behaviour in children. These communicative acts are expressed first by gestures, then by gestures and words, and later by increasingly complex combinations of words and gestures until they reach the level of oral language.

There is evidence that the use of gestures in infants predicts the emergence of language skills, namely the emergence of vocabulary (Iverson & Goldin-Meadow, 2005; Rowe, Özçalışkan, & Goldin-Meadow, 2008) and the acquisition of syntactic skills (Özçalışkan & Goldin-Meadow, 2005). Furthermore, it helps to understand how it paves the way for collaborative communication (Liszkowski, Carpenter, & Tomasello, 2007; Tomasello, Carpenter, & Liszkowski, 2007) and how it is used to support the development of communicative functions (Crais, Douglas, & Campbell, 2004; Veena & Bellur, 2015).

Research on the production of children's communicative gestures has mainly focused on their emergence and configuration (type), both in children with and without hearing impairment (Ambrose, 2016; Zaidman-Zait & Dromi, 2007). Fewer studies have explored the characteristics of gesture execution, parameters such as handedness (Cochet & Vauclair, 2010) and hand shape (Capirci et al., 2011). Although there is a similar pattern of gesture development across cultures, culture has been shown to influence the development and use of gestures by both adults (Kita, 2009; Kita & Özyürek, 2003) and children (Iverson et al., 2008; Kwon et al., 2017). The present study identifies and analyses the characteristics of communicative gestures produced by Portuguese infants with and without hearing impairment between the ages of eight and 18 months. Due to the scarcity of studies on this topic, its relevance and pertinence are explained by the lack of national studies on this topic.

## 2. Literature Review

### 2.1 Predictive Effect of Communicative Gestures on Language Development

The literature has pointed to the relationship between the use of communicative gestures and the development of language skills. There is evidence that gestures play a dual role in the process of language development. On the one hand, they are predictors of language proficiency and on the other hand, their use supports communicative-linguistic development. The use of communicative gestures is a predictor of lexical development in two ways: there is a significant relationship between the number of objects a child points to and their understanding of vocabulary in the near future, and the use of gestures indicates which words children will acquire in the near future (e.g. pointing to dog rather

than bone increases the likelihood that the child will acquire the word dog before bone) (Goldin-Meadow, 2009). In fact, between the ages of 14 and 16 months, children use more gestures than words in their communicative acts because they allow them to convey a greater variety of meanings (Özçalışkan & Goldin-Meadow, 2005a), and children who use a greater number of iconic gestures at 19 months have a larger vocabulary at 24 months (Acredolo & Goodwyn, 1988). Furthermore, children who convey a wider range of meanings through communicative gestures at 18 months have larger vocabularies at four years of age (Rowe, Özçalışkan, & Goldin-Meadow, 2008). The authors Sansavini et al. (2011) and Suttora and Salerni (2012) present evidence that gesture is a predictor of greater language skills, especially vocabulary acquisition, which has been supported by several studies.

The predictive value of gestures was also analysed in Portuguese children in the study by Cadime et al. (2017), who measured the effect of gestures on the development of vocabulary comprehension and production in 48 children aged 9 to 15 months using the MacArthur-Bates Communicative Development Inventory (Silva et al., 2017) applied at 9M, 12M and 15M. The authors found that the number of actions and gestures performed at 9M and 12M predicted the number of words understood at 12M and 15M. It is worth noting that the results of this study indicate that word comprehension has no predictive value for the number of actions and gestures produced three months later in development. According to the authors' interpretation, gestures and language seem to share the same neural substrate, and gestures and actions promote the development of representational skills, which are essential for the development of language skills. Gestures also appear to play a predictive role in syntactic development, as the age at which a child produces the pointing gesture associated with a word predicts the age at which they will produce two-sentence sentences, words, it is evidenced that first, the child uses only the pointing gesture, then the same gesture in combination with the word porridge, with the intention of conveying the message I want to eat the biscuit. These bimodal combinations (gesture and word) predict the type of two-word phrase constructions, for example: the combination of producing the word car with the gesture of pointing at the father predicts noun-noun phrases; the combination of producing the word eat with the gesture of pointing at the mother predicts verb-noun phrases (Özçalışkan & Goldin-Meadow, 2005b). It should also be noted that these bimodal combinations used at 12 months of age predict the syntactic complexity of children's oral language at 4 years of age (Rowe & Goldin-Meadow, 2009). Even after they begin to produce two-word utterances, children continue to use gestures in combination with spoken language to convey messages with increasingly complex meanings, and these combinations again precede the emergence of complex utterance structures in spoken language (Özçalışkan & Goldin-Meadow, 2005b; Ozçalışkan & Goldin-Meadow, 2009).

In the early stages of language development, children tend to use only one of the modalities, namely, they use either the word or the gesture (Butcher & Goldin-Meadow, 2000). Later, they use the complementarity of the two modalities to combine meanings (Özçalışkan & Goldin-Meadow, 2005a, 2005b; Rowe & Goldin-Meadow, 2009). The

bimodal use, which is closer to the adult system with the use of gestures, is more integrated around the age of four (McNeill, 1995), although there are still differences at the age of 11 (Dick et al., 2012). Butcher and Goldin-Meadow (2000) suggest that as children's language skills increase, the rate at which they acquire new gestures decreases, as does their frequency of use, but the literature has shown that children continue to use gestures throughout development and that their use and understanding is important to the learning process (Goldin-Meadow, 2011; Novack et al., 2015). There is conflicting evidence in the literature about the increasing use of gestures across development. Results indicate an increase in its use (Sansavini et al., 2011; Silva et al., 2017; Stika et al., 2015) and others a decrease (Iverson, Longobardi, & Caselli, 2003; Iverson, Capirci, & Caselli, 1994; Sequeira, 2016). These differences may be explained by the methodologies used, namely whether the study of gesture was carried out using instruments that analyse gesture repertoires (e.g. MacArthur-Bates Communicative Development Inventory by Viana et al., 2017); Language Use Inventory (LUI)-Portugal by Guimarães & Cruz-Santos, 2020; Early Communication Inventory (ECI)- Portugal by Ferreira, Cruz-Santos, & Almeida, 2019a, 2019b) or whether the data on gesture use were collected in naturalistic contexts. These methodological differences may explain the differences in results, as the former report data on gesture repertoire and the others report data on the frequency of gesture use. It should be noted that the process of transition from the use of gestures to support communicative acts to the use of gestures that accompany oral language in a model closer to that of adults is not yet fully understood, so further studies could provide better explanations of the use of gestures (repertoire, frequency and functions) throughout the life cycle. Thus, the literature suggests three mechanisms underlying the relationship between gesture use and language development: 1) the use of gestures may be an indicator of the development of children's communicative interest and the type of meaning they choose to convey, which will later be revealed in oral language; 2) gestures provide children with a way to participate in communicative interaction before they have a level of language development that supports communicative experiences, or/and; 3) children's gestures induce others' oral language, this possibility being the one that best explains the close relationship between the content of a child's gestures and the content of subsequent language (Hoff, 2014).

Children also use gestures to facilitate and structure their thinking. Rodrigues and Palacios (2007) conducted a study in which they analysed the use of two types of private gestures, namely, gestures that are not directed at the other person, which they called private ostensive gestures (used when planning an activity) and private pointing gestures. They found that the children used them in a self-reflective way to regulate themselves and to help them construct and organize their thinking. In short, communicative gestures play a fundamental role in children's language development and are used in the pre-linguistic period, before oral language emerges. Initially, they enable and support communicative acts in which children express a range of information that is gradually transferred to oral language. Throughout language development,

children maintain the use of gestures in a bimodal system with characteristics similar to the patterns used by adults.

## **2.2 The Use of Communicative Gestures in Children with Atypical Development**

The evidence that the use of gestures is an important indicator for predicting the development of language skills highlights the importance of analysing this indicator in populations with developmental disorders. In contrast to what is known about the development of communicative gestures in typically developing children, what is known about this process is rare in children who are born deaf but are identified early and, therefore have access to assistive listening devices and early intervention. This is a relatively new reality, and most studies are interested in reporting on oral language development, as discussed above. However, the evidence on the impact of gestures on communication and language development in typically developing children highlights the importance of understanding the same process in hearing impairment (Eisenberg et al., 2007). Zaidman-Zait and Dromi (2007) compared the pre-linguistic skills (production of less than 10 words) of children with and without hearing impairment (severe and profound). The children with hearing impairment were born to hearing parents with assistive listening devices and were included in intervention programmes. The results showed that the two groups had a similar pattern of communication. However, although there were no significant differences between the two groups, a qualitative analysis showed that children with hearing impairment used more gestures than typically developing children, especially symbolic gestures. In addition, children with hearing impairment used fewer words and showed less ability to share attention when reading a book than their peers. Although they showed similar skills in episodes of dyadic involvement, their level of performance decreased in episodes of triadic involvement.

Ambrose's (2016) longitudinal study analysed 48 dyads of children with and without hearing impairment (bilateral transmission or sensorineural hearing impairment), aged 14-26 months, with the aim of studying the use of communicative gestures as a form of symbolic communication and mothers' responses to them. The study included mothers with both oral and sign language as their mother tongue. The pattern of communicative gesture use was similar in both groups, both in the frequency of gesture use and in the range of gestures used. Deictic gestures were acquired first, followed by conventional and iconic gestures. However, children without hearing impairment used words more than children with hearing impairment. It should be noted that the children of mothers who used sign language used communicative gestures to communicate on a wider range of topics than the children whose mothers did not use sign language. Regarding the mothers' responses, it was found that the mothers of children with hearing impairment responded less to their children's communicative acts with gestures than the mothers of children without hearing impairment. The results of the two previous studies, which indicate a similar pattern of communicative gesture use in children with and without hearing impairment, are not consistent with the results of Vohr et al.'s (2008) study. Vohr et al. (2008) longitudinally compared the communicative

and linguistic abilities of children with and without hearing impairment (mild to severe) using the MacArthur-Bates Communicative Development Inventory and found significant differences in gesture use and comprehension of words and sentences in children with moderate and severe hearing impairment. Continuing the study (Vohr et al., 2011), they presented the results of the children observed at 18-24 months. They maintained the pattern of lower performance in both gesture and language skills. They also found that children with moderate and severe hearing impairment showed a slower rate of vocabulary acquisition than their peers. While children without hearing impairment maintained an expected rate of acquisition, children with moderate and profound hearing impairment showed a decrease in the rate of acquisition between 12-16 months and 18-24 months. It should be noted that the study by Stika et al. (2015), which included children with and without hearing impairment between the ages of 12 and 18 months, unlike all previous studies, reported similar language development in both groups, as measured by listening comprehension and expressive communication. It can be concluded that the study of gesture in children's development is an integral part of understanding the process of their evolution, especially in the area of developing communication skills. language. The developmental pattern of communicative gesture in children with atypical development highlights the importance of deepening knowledge for clinical applications, both for identifying children at risk and for implementing effective and efficient assessment and intervention processes. Due to the specific nature of the condition of hearing impairment and because of social and political changes, there is little evidence in the field of gesture research to understand how children develop gestures throughout their development.

### **3. Material and Methods**

#### **3.1 Participants**

This study comprised 41 participants, divided into two groups: Group A (20 girls and 17 boys without hearing impairment, mean age = 14.2 months, age range: 8-18 months) and Group B (three girls and one boy with severe/profound hearing loss, mean age = 16.7 months, age range: 15-18 months). Group A (GA) participants were recruited in seven kindergartens located in the central and southern regions of Portugal (Coimbra, Leiria and Lisbon districts), and Group B (GB) participants were recruited in a hospital in the central region of Portugal (Coimbra district). All parents had normal hearing, and all children showed a typical development profile (except children of GB in Hearing/Language and Speech/Language subscales) after applying the Schedule of Growing Skills II (Portuguese version). Three children of GB had cochlear implants, one had a conventional hearing aid, and all had speech and language therapy intervention.

#### **3.2 Procedures**

Data were collected with the use of the Assessment Tool: Gestures and Communicative Functions – 8 to 18 months (ATGCF) (developed by Lima and Cruz-Santos, 2012), which

consists of eight tasks performed during children/parent interaction. The classification of the gestures in this study is the following: deictic (used to point at objects, people, and locations in the immediate surroundings so that the meanings they convey are context-bounded), conventional (whose forms and meanings are culturally determined or conventionalized), iconic (when they depict actions or attributes of concrete or abstract referents), and other hand and body actions (produced while the children were involved in the communicative act, but without matching the properties considered to define the other three types of gestures).

The interactions were video recorded with three high-definition cameras, placed in different positions so that it was possible to capture the child, the parent and both simultaneously.

Participants of GA were included in three age groups: age range 8-9 months (n=10), 10-12 months (n=10) and 13-18 months (n=17).

### **3.3 Coding Procedures**

The gestures selected for the coding process were manual gestures and movements of other parts of the body involved in the communicative act, in which there was no manipulation of objects.

McNeill's (1995) proposal was adapted for the coding process of each identified gesture, and the following parameters were considered: the preparation phase (the moment before the stroke, when the gesture's articulators are activated, when they leave the relaxed position); the stroke (the motion of the articulator, considering its properties of path, configuration, and meaning); and the retraction phase (the moment when the articulators resume the relaxed position). McNeill's (1995) proposal was also adapted for coding the gesture form, handedness (right hand, or left hand or both hands), location (the position of the stroke in the quadrant of the head or body), and hand-shape (described according to the configurations of the Portuguese Sign Language). Based on the properties of Gesture Production in Portuguese Toddlers 151 of these parameters and on the context of use, the gestures were classified as deictic, conventional, iconic, and hand and body actions. ELAN software (version 4.9.1) was used to code gestures.

### **3.4 Coding Reliability**

The primary experimenter (Observer A) coded all the videotapes collected through the application of the ATGF. Two external observers (Observer A and Observer C) were trained in the coding procedures established for this study and were responsible for coding 10% of the videotapes. Interrater reliability between Observer A and Observer B was strong in coding decision of gesture (Cohen's Kappa of .93) and communicative functions (Cohen's Kappa of .82). Interrater reliability between Observer A and Observer C was substantial in coding decision of gesture (Cohen's Kappa of .79) and communicative functions (Cohen's Kappa of .76).

#### 4. Results and Discussion

Data related to the use of gestures in the three age groups of GA are shown in figure 1, with an increased use of gestures between 8-9 and 10-12 months of age.

**Table 1:** Gesture use in GA and GB

	GA			GB
	8-9M	10-12M	13-18M	13-18M
Gesture use	45.5%	63.9%	60.5%	60%

Legend: M = Months; % = Percentage.

This trend does not occur in children between 13-18 months, where, on the contrary, there is a slight decrease. The decrease in this age group is concomitant with the increase in the use of other communicative forms, more precisely, a more proficient use of words.

Inferential statistics using the Chi-square test were used to test whether hearing status was associated with the use of gestures in children in the locutionary period. The values found do not show statistically significant differences ( $\chi^2 = .038$ ;  $p = 0.845$ ), concluding that the frequency of gesture use is similar in children with hearing impairment and typically developing children.

Figure 2 shows the results for the type of gestures used by children of all age groups of GA, and children of GB. Younger children more frequently performed conventional gestures. The trend is for these types of gestures to increase along with the age of the group. Most of the 8-9 months' old children performed conventional gestures (like moving their body and/or hands, meaning 'dancing' or 'clapping'). At 10-12 and 13-18 months' children produced a more varied range of conventional gestures, such as head-nods (meaning affirmation and agreement), head-shakes (meaning negation and rejection), thumbs-up (positive meaning), or index finger vertically placed in front of their lips (meaning hush/silence).

**Table 2:** Gesture types according to age groups of GA and GB

	GA			GB
	8-9M	10-12M	13-18M	13-18M
Deictic gesture	4.20%	42.5%	37.5%	32.5%
Conventional gesture	12.6%	42.3%	46.5%	48.8%
Iconic gesture	0.00%	3.6%	8.7%	12.0%
Other gesture	83.2%	11.7%	7.2%	6.7%

Legend: M = Months; % = Percentage.

Data suggest a considerable increase in deictic gestures in children aged between 8-9 and 10-12 months and a tendency for these gestures to decrease at the age of 13-18 months, while there is a simultaneous increase in iconic gestures.

At 8-9 months, children did not produce iconic gestures. Moreover, children of all age groups used these types of gestures less frequently. This also applies to children with hearing impairment, who also performed fewer iconic gestures than other types of



gestures. The difference was that they used conventional gestures more frequently and deictic gestures less frequently than their peers in the same age group did.

The high frequency of other hand and body actions at the age of 8-9 months is due to the quantity of these actions performed in ritualized games with the parent(s) (e.g. children songs), of actions performed without accuracy and thus difficult to code, and of actions like grasping and shaking arms and hands to express appreciation or displeasure.

The use of different types of gestures (deictic, conventional, iconic and other gestures) between the groups was analysed using inferential statistics through the chi-square test. The values are statistically significant ( $\chi^2 = 15.52$ ;  $p = .001$ ), indicating that there are differences in the way children with hearing impairment and typically developing children use the types of gestures in their communicative acts.

Concerning the location of gestures, namely, the place of their execution in gesture space, the results obtained for all age groups show a trend to perform gestures in the torso quadrant (see Figure 3). As children develop and use more types of gestures, they tend to explore other regions of the body and produce gestures in the head area and head gestures.

**Figure 3:** Gesture location according to age in GA and GB

		GA			GB
		8-9M	10-12M	13-18M	13-18M
Localization	Head	1.7%	8.6%	16.8%	10.2%
	Torso	98.3%	91.4%	83.2%	89.8%

**Legend:** M = Months; % = Percentage

Gestures produced in the head area or head gestures were mostly conventional (e.g. nodding to agree and shaking head to reject refuse), and some iconic gestures (e.g. open hand at the top of the head to depict 'chicken' or two open hands on each side of the top of the head to depict 'rabbit').

Compared with their peers, children with hearing impairment produced more gestures in the torso quadrant and fewer in the head area.

As regards the shape of manual gestures (see Figure 4), data show that there is a preference for the open hand.

Furthermore, throughout the age groups, the tendency is to perform gestures with more precision and varied hand shapes. There is also a decrease in the quantity of the hand shapes coded as 'other' hand shapes.

The comparison between children with and without hearing impairment demonstrates that, although the two groups display a higher frequency of both open hand and index pointing, in the GB group there is a lower percentage of these two hand shapes and a higher percentage of other hand shapes.

**Figure 4: Hand shapes according to age in GA and GB**

		GA			GB
		8-9M	10-12M	13-18M	13-18M
Hand Shapes	Open Hand	81.3%	40.4%	50.1%	46.7%
	Close Hand	6.3%	3.4%	1.9%	7.4%
	Shell	0.0%	0.0%	0.2%	1.2%
	Claw	0.0%	0.2%	0.5%	2.3%
	Indicator	0.0%	43.8%	43.3%	37.4%
	Beak	0.0%	1.9%	0.7%	0.4%
	Others	12.5%	10.3%	3.3%	4.7%

**Legend:** M = Months; % = Percentage.

The results presented in Figure 5 show that children at 10-12 and 13-18 months (in both groups) tend to use their right hand to produce manual gestures.

Although the frequency of use of the left and right hand is very similar in 8-9 months' children, there is a tendency to perform gestures with both hands.

**Figure 5: Handedness according to age in GA e GB**

	GA			GB
	8-9M	10-12M	13-18M	13-18M
Right hand	17.9%	71.8%	53.6%	68.1%
Left hand	18.8%	9.8%	22.8%	13.2%
Both hands	61.6%	18.4%	23.6%	18.7%

**Legend:** M = Months; % = Percentage.

Confirming the results of the GA indicating that age, i.e. a higher level of development, is associated with the preferential use of one of the hands (see 2.1.5.3), the inferential analysis using the chi-squared test shows a statistically significant association ( $\chi^2 = 18.27$ ;  $p < .001$ ) between the characterisation of the use of the hands to make gestures and the groups, with children with hearing impairment tending to use one hand more than both hands compared to typically developing children.

**Figure 6: Mean time duration (milliseconds) of gesture phases according to age in GA and GB**

	Age group	Phases of unit gesture	Mean	n	SD
GA	8-9M	Preparation	0:00:00.39	105	0:00:00.29
		Stroke	0:00:02.23	111	0:00:02.10
		Retraction	0:00:00.40	82	0:00:00.20
	10-12M	Preparation	0:00:00.51	454	0:00:00.26
		Stroke	0:00:01.69	465	0:00:01.34
		Retraction	0:00:00.50	382	0:00:00.30
	13-18M	Preparation	0:00:00.48	863	0:00:00.25
		Stroke	0:00:01.80	877	0:00:01.46
		Retraction	0:00:00.49	732	0:00:00.29
GB	13-18M	Preparation	0:00:00.49	251	0:00:00.31
		Stroke	0:00:03.24	257	0:00:04.36
		Retraction	0:00:00.55	206	0:00:00.30

**Legend:** M = Months; M = Mean; SD = Standard Deviation.

As shown in Figure 6, similar time averages were observed for the execution of the preparation and retraction phases in all age groups of GA and GB children. However, there is a difference in the mean time of execution of the stroke phase, in which meaning is expressed. The mean time is longer in children at 8-9 months than in older children.

The data suggest that younger children tend to perform longer-lasting gestures in the stroke phase by insisting on movement (e.g. performing more repeated movements) to ensure that the meaning of the gesture is being understood by their parents.

In contrast, older children are more confident that their interlocutor will understand the meanings of their gestures, and therefore, they do not emphasize their content with repeated movements. They perform single movements with shorter duration. This suggests that throughout their development, children become more confident about their parents' ability to interpret their gestures, so they come to rely on the conversational commitment established in communicative acts.

The mean time duration of the stroke phase of children with hearing impairment is substantially higher when compared to that of their peers. The data indicate that children with hearing impairment need more time to guarantee adults' conversational commitment and do not demonstrate confidence in adults' ability to understand the gestures they are performing. Thus, they perform gestures with repeated movements and phases with post-stroke holds that increase the duration of stroke phases.

Based on the inferential statistics using the Mann-Whitney test, it can be seen that there are statistically significant differences in the mean duration of the gestural unit ( $U = 191,026.0$ ;  $p < .001$ ) and the strike phase ( $U = 149,419.5$ ;  $p < .001$ ) between the two groups, indicating that the mean duration of the gestural unit, and more specifically the strike phase, is related to the presence or absence of hearing impairment in the participants.

It should be noted that the pattern of longer duration of the strike phase was also observed when comparing the GA age groups (see 2.1.6.1), suggesting that children with hearing impairment also have a lower sensitivity to the conversational commitment of the interlocutor during communicative acts. The results suggest that children with hearing impairment actually need to increase the strength of the message, regardless of the movement used, compared to typically developing children, which supports the interpretation regarding the longer duration of the strike phase in GB.

The results of this study show that as toddlers grow, they become increasingly confident about the effect of their communicative gestures on adults, and the characteristics of the gestures become more refined or complex; although toddlers with hearing impairment use communicative gestures in a similar way to their peers, the characteristics of their gesture production differ.

There was a spike in gesture use in children aged 10-12 months, but as language skills improved at 13-18 months, the frequency of gesture use decreased, confirming the findings of Sequeira (2016), Guimarães and Cruz-Santos (2020), and Ferreira, Cruz-Santos, and Almeida (2024). However, within this age range, children tend to use a wider range of hand shapes, different locations of gesture execution and different gesture types.

In terms of gesture type, conventional gestures were used most frequently by younger children, followed by deictic gestures and iconic gestures. Our results confirm the findings of Sequeira (2016) regarding the sequence of gesture acquisition in Portuguese children. Other studies have shown that deictic gestures are the first type of gesture to appear in the repertoire of prelinguistic children (Ambrose 2016). These differences can be explained by the cultural influence on gesture use or by methodological reasons, since some studies only observe the use of representational and deictic gestures and do not include conventional gestures in their analyses. Our results also show that children with hearing impairment use more iconic gestures than their peers, but fewer deictic gestures. As they use fewer words than their peers, they probably need to increase the use of iconic gestures to convey more complex meanings. Conventional gestures were used in communicative acts to maintain interaction with the adult. Deictic gestures were used to communicate elements of the context. Within this interactional context, the opportunity and need to express meanings of a more symbolic nature was created, encouraging the use of iconic gestures. Thus, the results suggest that more diversified forms of gesture are accompanied by the challenge of more complex meanings across the different age groups. On the one hand, there is greater variation in the location of gesture execution, and on the other, 13-18 month-olds showed a greater ability to use a wider range of hand shapes than 8-9 month-olds (who mostly used the open hand shape). This interpretation is supported by the analysis of the data from the children with hearing impairment, which showed more frequent use of iconic gestures and a greater variety of hand shapes. Working with older children (4 to 10 years), Capirci et al. (2011) also found that as the range of hand shapes increased, the use of previously used shapes decreased. In addition, the authors suggested that the development and use of gestures increases children's ability to explore the expressive capacity of gestures by considering their semiotic properties, meaning and function in utterance production.

The data show a decrease in the duration of the stroke phase in older children. These children use single movements with shorter stroke phases as they seem to be more confident in the ability of adults to understand their gestures and to establish and maintain conversational engagement in communicative acts. Children with hearing impairment produced gestures with a stroke phase duration that was significantly longer than that of their peers and even that of 8-9-month-old children. The difference in phase duration and in the use of deictic gestures suggests that these children have a different pattern of collaborative communication compared to children without hearing impairment.

The results of the present study emphasize the importance of characterizing children's gestures in the prelinguistic period, as they allow for a better understanding of how the communication process develops and how gestures are used. It is expected that the differences found between different age groups and between children with and without hearing impairment will help Portuguese professionals in more efficient clinical and educational assessment and intervention processes.

## **5. Recommendations**

To date, there is very little data available in Portugal on the pre-linguistic development of infants, so professionals working with children at this stage of development must rely on international scientific evidence for their work. Only recently have some studies been conducted on the use of gestures by Portuguese children (Cadime et al., 2017; Guimarães, 2016; Guimarães & Cruz-Santos, 2020; Lima & Cruz-Santos, 2017; Sequeira, 2016; Silva et al., 2017). Due to the existence of cultural diversity in the use of some gestures, the study of prelinguistic gestures of Portuguese children needs more research. The present time is crucial for this type of research; due to the efforts of the Portuguese health system to follow international guidelines in new-borns and infant hearing screening programmes, there is a new generation of hearing-impaired children who have been diagnosed early and can benefit from auditory rehabilitation and early intervention.

## **6. Conclusion**

The present study highlights the importance of characterising children's gestures in the pre-linguistic period, as it allows for a better understanding of how the communication process develops and how gestures are used. Furthermore, it contributes with relevant findings that demonstrate the importance of the use of communicative gestures, emphasising the importance of using them as an indicator in assessment and intervention processes with children and further research in this area. It is expected that the differences found between different age groups and between children with and without hearing impairment will help Portuguese health and educational professionals in more efficient clinical and educational assessment and intervention processes.

## **Acknowledgements**

This work was financially supported by Portuguese national funds through the FCT (Foundation for Science and Technology) within the framework of the CIEC (Research Center on Child Studies of the University of Minho) projects under the references UIDB/00317/2020 and 161 UIDP/00317/2020. Also, this work was funded by Portuguese national funds provided by FCT (Foundation for Science and Technology) (UI/05704/2020). The authors would like to thank the families and professionals who provided all of the support for the study.

## **Conflict of Interest Statement**

The authors declare no conflicts of interest.

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