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ORIGINAL ARTICLE

# Development of communicative abilities in infants with Down syndrome after systematized training in gestural communication

Desarrollo de habilidades comunicativas en lactantes con síndrome de Down posterior a capacitaciones sistematizadas en comunicación gestual

Katherina Linn<sup>a</sup>, Fabiana Sevilla<sup>b,c</sup>, Valeria Cifuentes<sup>b,c</sup>, M. Ignacia Eugenin<sup>d</sup>, Bernardita Río<sup>c,e</sup>, Jaime Cerda<sup>f</sup>, Macarena Lizama<sup>c</sup>

<sup>a</sup>Division of Pediatrics, School of Medicine, Pontificia Universidad Católica de Chile <sup>b</sup>Fonoaudiology <sup>c</sup>UC Down Syndrome Center <sup>d</sup>UC CHRISTUS Health Network <sup>e</sup>Kinesiology <sup>f</sup>Department of Public Health, Pontificia Universidad Católica de Chile

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# Abstract

Introduction: Gestural communication, understood as the use of non-verbal gestures before the word appears, is a strength in children with Down syndrome (DS). Objective: To describe communication development behaviors in children with DS, before and after gestural communication training, based on the "Signs, words and games" workshops of the Baby Signs® program. Subjects and Method: Prospective study of children with DS between 18 and 22 months of cognitive age, who were trained in gestural communication according to the "Baby Signs®" methodology, evaluating communication skills through the MacArthur inventory adapted for children with DS (Communicative Development Inventories, CDI-DS), analyzing the scores before and three months after the intervention. The evaluated items were: Early comprehension, First sentences comprehension, Starting to speak, Vocabulary list, and Decontextualized language use (part 1) and total, early and late gestures (part 2). Results: 21 children completed the workshops, with an average chronological age of 27.5 months and 19.8 months of cognitive age. 29% of the participants increased their scores in sentence comprehension, 62% in vocabulary production with gestures, 33% improved in vocabulary comprehension, 57% lost early gestures, and 43% increased late gestures production. Conclusions: Gestural communication training favors the communication skills development in a group of children with DS, mainly in the initial understanding and gesture production. There is important inter-individual variability, therefore is necessary to consider child to child recommendations.

Keywords:

Down syndrome; gestures; non-verbal communication; communication aids; disability

Correspondence: Macarena Lizama mlizama@med.puc.cl

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# Introduction

Gesture communication is the use of simple nonverbal gestures for the representation of different elements<sup>1,2</sup> and emerges as a bridge before the appearance of the words<sup>3</sup>. It was described in the 1980s, based on observations by psychology doctors Linda Acredolo and Susan Goodwyn, reporting babies using gestures to replace words they could not pronounce. Acredolo and Goodwyn demonstrated that early exposure to gesture communication promotes expressive and comprehensive language development and increases phonetic and syntax tasks<sup>4</sup>. Other studies have shown that the language development through gestures, before the development of speech in typically developing children, promotes parent-child interaction, decreases levels of frustration both in the child and in their parents<sup>5</sup>, allows in the preverbal stage to express emotional states of the child<sup>6</sup>, stimulates cognitive development<sup>1</sup>, and promotes self-regulation<sup>7</sup>.

Children with Down Syndrome (DS) have delayed psychomotor development, cognitive disability of varying degree, and especially delayed language development with a dissociation between receptive and expressive skills, having greater difficulty in expressive communication, including the words absence<sup>8</sup>. Considering the above, social interest and the use of prelinguistic gestures emerge as one of the main opportunities for interaction with the environment<sup>9,10</sup>.

Several authors describe gesture communication as one of the strong points of children with DS<sup>11,12</sup>, where productive vocabulary is comparable to that of typically developing children if gestures are considered<sup>13</sup>. However, to date, there are no data on interventions in the gestural communication development in this population.

The Baby Signs<sup>®</sup> program arises from the research carried out by Acredolo and Goodwyn, as a methodology to teach parents, caregivers, and their children the incorporation of simple gestures that complement communication. This program consists of different modalities, both for families and for instructors in gestural communication, and is based on face-to-face workshops and the use of didactic material, such as cards and songs for teaching and learning gestures.

Considering the before mentioned, the main objective of this study is to describe the communicative development behaviors in children with DS, before and after training in gestural communication, based on the methodology of "Signs, words, and games" of the Baby Signs® program.

#### Subjects and Method

A descriptive prospective study conducted between January and November 2017.

#### Population to intervene

Children between 24 and 30 months of chronological age with a diagnosis of DS were invited to participate. The age range was established arbitrarily by estimating a sample of children between 18 and 22 months of cognitive age. They were called through an open invitation by email, UC Down Syndrome Center social networks, and by the Children with Special Health Care Needs (NANEAS) UC team.

The cognitive age calculation was necessary to be able to apply properly the Communicative Development Inventory (CDI) adapted to the population with DS (CDI-DS), whose results are interpretable according to the mental age of the child and not the chronological one.

The cognitive age range choice of the group to intervene was determined from the estimate of the age at which typically developing children have already acquired the first gestures and are acquiring gestures on a regular basis<sup>14</sup>.

#### Communication evaluation tool

Pre- and post-intervention, the CDI-DS was used. The CDI is a widely used instrument for language assessment in typically developing children and evaluates first words, gestures, and grammar. Its original version has been translated into several languages and validated into Spanish by Jackson-Maldonado<sup>15</sup>. The CDI-DS is the CDI instrument previously validated in Spanish, adapted for children with DS. The adaptation and validation was carried out by Galeote, in Spanish and Spanish-speaking population<sup>16</sup>, where the main adaptations are based on the use of a single inventory covering the age range of 8 to 30 months (the original one separates it into two age groups); the chronological age is not considered, but the developmental age assessed using the Revised Brunet-Lezine Test: Infancy Psychomotor Development Scale or other comparable tests, such as the Bayley Test; and in the evaluation of vocabulary, comprehension, production, and gesticulation of the word are analyzed. The validation performed by Galeote showed a statistically significant correlation in the segments of vocabulary production, receptive vocabulary, and reliability for vocabulary production and comprehension is also described as strong and statistically significant, evaluating test-retest three months apart<sup>16</sup>.

The study consisted of three phases (methodology scheme in Figure 1).

#### Phase 1

Recruitment of interested population. Caregivers who expressed interest in participating whose children met chronological age criteria were invited for assessment and determination of cognitive age. Children with the following characteristic were excluded: a) confirmed diagnosis of untreated epilepsy, untreated bilateral hearing loss (brainstem auditory evoked potentials with waves V higher than 50 dB), or uncorrected visual problems (untreated congenital cataracts); b) previous training in gestural communication with Baby Signs<sup>®</sup> methodology; and c) patient-professional contact history with any of the instructor speech-language pathologists in the study.

#### Phase 2

Target population selection. Those children who met the criteria for participation were assessed using the Bayley III test (17) to determine their cognitive age. The target group for intervention was children with cognitive age between 18 and 22 months. The Bayley III test was performed by three trained professionals who applied the cognitive area, receptive language, and expressive language segments. Cognitive age was calculated according to the Bayley III test cognitive scale score. Participants with cognitive age between 18 and 22 months were invited to participate in the evaluation and training in gestural communication. All the caregivers of the children who were assessed using Bayley III were given an evaluation report, whether or not they were going to participate in Phase 3 of the project.

#### Phase 3

Evaluation and training. Each selected child and their respective significant caregiver were trained and evaluated as follows:

3.1. Initial evaluation: communicative development evaluation of each participant before to start the training, through CDI-DS<sup>18</sup>, authorized by the author for use in research and self-applied by the caregivers<sup>19</sup>.

Table 1 shows the description of the CDI-DS items that were evaluated. For items 1B, 1D, and gestures, the test report gives the results in performance percentiles. For items 1A, 1C and 1E, a descriptive result is provided, calculating the positive responses percentage



**Figure 1.** Chronological outline about phases and methodology of the study.

and comparative tables are arranged for the standard responses percentage according to the cognitive age group (table 1).

It was requested that the form was answered by the caregiver participant in the workshops, before starting the "Workshop for parents" (time 0 = t0), and its result was kept hidden from the speech therapists who taught the workshops. In addition, demographic data, morbid history, number of siblings, age and educational level of both parents, daycare center/kindergarten attendance, and early stimulation program attendance were recorded.

3.2: Training in gestural communication: seven groups were trained, each made up of three to four couples (child-significant caregiver). The training took place between March and August 2017, with a structure according to the "Signs, words and games" methodology of the Baby Signs<sup>®</sup> Program<sup>20</sup>. The significant caregiver was considered to be the father, mother or caregiver who stay with the child for at least 10 hours per week.

The training was seven face-to-face workshops taught by two certified speech-language pathologists as instructors in gestural communication using Baby Signs<sup>®</sup> methodology. The first was a "Workshop for parents" where they were taught the communication basics by gestures, and the next six workshops consisted of a weekly class of 60 minutes, according to the methodology "Signs, words and games" Baby Signs <sup>®</sup>, addressing the following topics: eating, sleeping, dressing, bathing, pets, and the park. Each participant was given four books to work the gestures, a box of gesture cards, a songbook CD, and a CD of each topic with gestural communication information so that they could practice at home.

3.3: Final evaluation: three months after the end of the workshops, the CDI-DS was applied again (final time = ft) through an online platform. To evaluate the responses according to cognitive age, the cognitive age of ft was estimated using a proportional adjustment considering chronological age in t0 and ft and cognitive age in t0 calculated according to Bayley's Test, using the following formula:

# Cognitive age ft = (cognitive age t0 x chronological age ft) / chronological age t0.

At the end of the process, caregivers were asked to

Table 1. Description of	f communicative develo	pment inventory	adapted by	Galeote for	r children with	Down sy	/ndrome (	CDI-SD

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First Words	Definition	Expression of results
A. First signs of understanding: early understanding	It includes a series of questions about words that children usually unders- tand at the beginning of language learning: a) responds to the name; b) responds to the no and c) searches when they call dad or mom	Percentage of affirmative respon- ses according to cognitive age, compared to Galeote's reference
B. Understanding of the first sentences	It includes a series of questions about simple and very familiar phrases that children usually understand at the beginning of learning. Example: "To sleep", "give me a kiss"	Percentile of performance according to cognitive age.
C. Beginning to talk: the beginnings of production	Evaluate how children begin to produce their first words (degree of imi- tation of the phrases and words they hear, names of the objects that are around them) a) Does it imitate words or part of sentences ?, b) name elements do you see?"	Percentage of affirmative respon- ses according to cognitive age, compared to Galeote's reference
D. Vocabulary list*: understands, understands and says, understands and gestures	List of 651 words divided into 21 categories. Evaluating comprehension and production in each one of them a) understands and b) understands and says. It also evaluates the use of gestures to refer to the different items of vocabulary included in the inventory c) understands and gesture	Percentile of performance accor- ding to cognitive age
E. Decontextualized use of language	Evaluates the degree to which children use language to refer to objects, persons or events that are not present, a) events that have occurred in the past, b) in the future, c) production of an object that is absent d) understanding of the object absent and e) absent owner	Percentage of affirmative respon- ses according to cognitive age, compared to Galeote's reference
Gestures	79 gestures and actions divided into 6 categories: (1) first gestures, (2) games with adults and routines, (3) actions with objects, (4) playing to be an adult, (5) imitation of other types of activities of the adults and (6) actions with one object instead	Percentile of performance accor- ding to cognitive age
a. Total gestures	Deictic and symbolic gestures	
b. Early gestures	Deictic and some early communicative gestures: "Give"; "To show"; "In- dicate with index finger"; "Say no with your head"	
c. Late gestures	Symbolic gestures: "comb with the comb"; "Feed the doll"; "Talk with phone with the shoe"	
* A dameta d la concentra da sia		

\*Adapted by Galeote in a single vocabulary list and adding the "understand and gesture" evaluation.

complete a survey of personal satisfaction and perceptions regarding the training, which was based on two open-ended questions: 1. A benefit to the child from participating in the workshops; 2. A benefit to you (the caregiver) from participating in the workshops.

#### Analysis of results

For each child, we compared the results obtained in the CDI-DS before the intervention (t0) and three months after the intervention (ft). The difference between the obtained percentile in ft and the obtained percentile in t0 was called "percentile change".

Positive percentile change corresponded to the increase of more than five percentiles (improvement) after the intervention; without percentile change corresponded to similar results before and after the intervention, with a percentiles delta less than or equal to five; and negative percentile change corresponded to results decrease after the intervention, with a decrease higher than five percentiles.

The satisfaction survey was described as "quotes" from caregiver responses and comments.

#### **Ethical considerations**

Informed consent was requested from the participants' parents and approved by the Research Ethics Committee of the Faculty of Medicine of the Pontifical Catholic University of Chile.

The study was financed by the SOCHIPE 2016 *Semilla* competition.

#### Results

49 children between 22 and 30 months of chronological age participated in the project, who were assessed through the Bayley III Test to determine their cognitive age. Out of these, 15 had a cognitive age of 17 months or less, 30 between 18 and 22 months, and four had a cognitive age older than 22 months. The target group consisted of 24 children with cognitive age between 18 and 22 months (six children with cognitive age could not participate in the training due to the workshop schedule).

The 24 selected children were invited to gestural communication training. A participant was excluded due to not attending to the "Workshop for Parents", a requirement for participating in the training. Out of the 23 participants, 21 completed more than 80% attendance at the workshops.

Out of the 21 children who completed the workshops, and according to the results of the Bayley III Test applied to them, 29% had normal cognitive development, and 71% had a mild developmental delay; no participant had moderate or severe delay. Regarding language, 5% had normal development, 52% mild delay, and 43% moderate language developmental delay.

Out of the total number of participants who completed the workshops, 11/21 (52%) were male, with an average chronological age of 27.5 (SD ± 2.5) months and 19.8 (SD ±1.0) months of cognitive age. Table 2 shows the demographic history of the intervened group.

After the intervention, 29% of the participants had a positive percentile change in the "first sentence comprehension" item of the CDI-DS, 52% had no percentile change, and 19% had a negative percentile change after the intervention. 62% positively changed percentiles in the vocabulary production with gestures, 33% improved percentiles in the vocabulary comprehension, 57% decreased the percentiles in early gestures, and 43% had a positive percentile change in the late gestures production. Only three (14%) children changed their percentile positively in relation to spoken vocabulary production. Table 3 shows the individual percentile performance of the items "Understanding First Phrases", "Vocabulary: Understanding, Producing, and Vocabulary with Gestures", and "Gestures: Totals, Early, and Late" of the CDI-DS, and refers to the individual percentiles delta, highlighting individual performance variation in colors, where red means negative percentile change delta, yellow without percentile change delta, and green positive percentile change delta.

Table 4 shows group results expressed as average percentages of positive responses for items 1A, 1C, and 1E.

In the subjective evaluation, all caregivers reported benefits in relation to training. Table 5 shows the most frequently reported quotes referring to benefits mainly regarding the change in children's communication skills, decreased anxiety, as well as improved communication between parents and children, better ability to understand them, and peace of mind in knowing what they want to express.

#### Discussion

This study shows that training in gestural communication in a systematized way favors the communicative skills development in a group of children with DS, mainly in the language comprehension and in the gestures production at three months of follow-up, demonstrating positive changes in the percentile of development trajectory of communicative skills.

The results describe communicative development characteristics in children with DS, which reveal trends previously described in the literature, such as a higher capacity in comprehension versus expression, which is maintained and even increased after the intervention, supporting what was previously described by Abbeduto, where comprehension would have better development than expression in children with DS<sup>8,21</sup>.

In terms of communication, the results in our series show that there is greater production of total gestures in the lack of late gestures, which increases after the intervention. These results support gestural com-

Table 2.	Demographic	characteristics	of the	participants
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Variable	n (%)
Total participants	21
Male sex	11 (52)
Chronological age in months, average + SD	27.5 ± 2.5
Mental age in months (according to Bayley III), average + SD - 18-19 - 20-21 - 22	19.8 ± 1.0 9 (43) 11 (52) 1 (5)
Comorbidities - Congenital heart disease* - Otorhinolaryngological alterations in treatment <sup>†</sup> - Hypothyroidism in treatment - Others <sup>‡</sup>	9 (43) 3 (14) 3 (14) 8 (38)
Brothers - 0 - ≥ 1	7 (33) 14 (67)
Firstborn	7 (33)
School attendance <sup>§</sup>	14 (67)
Assistance to early stimulation center	17 (81)
Maternal age in years <sup>¥</sup> - < 35 - ≥ 35	2 (10) 19 (90)
Primary carer who participated in workshops - Mother - Father - Other	18 (85) 2 (10) 1 (5)
Mother educational level - Incomplete school - Full school - Advanced technician	0 (0) 1 (5) 20 (95)
Father educational level - Incomplete school - Full school - Advanced technician	1 (5) 0 (0) 18 (85)
Assistance to workshops - > 80% - ≤ 80%	18 (86) 3 (14)

SD: Standard deviation. \* Operated atrial septal defect; Hemodynamically significant persistent ductus arteriosus closed; Operated ventricular autricle channel. <sup>†</sup>Use of ventilation pipes; Narrowing of auditory canal, hearing loss in hearing aid treatment from 6 months of age. <sup>‡</sup>Subglottic stenosis operated; Esophageal stenosis operated; growth hormone deficiency in treatment; Hashimoto's thyroiditis; Myeloproliferative Syndrome; Epilepsy in treatment; Myopia. <sup>§</sup>Sala crib; Kinder garden. <sup>¥</sup>At the time of the birth of your child. munication as a complementary tool for the communicative development of children with DS since it is observed that they use gestures of different complexity even without words production, with the ultimate purpose of communicating<sup>22-24</sup>, which supports what is described by Berglund, who describes that the productive vocabulary of children with DS and typically developing children are comparable if we consider the gestures production<sup>25</sup>. In our study, most intervened children maintain or increase their ability to produce total gestures, but not the words production, where only a small percentage increase in this ability. This could be due to as the gestures disappear, oral production appears, which was not observed in the mental ages of the evaluated children in this study because it is a skill that appears later and because of the short observation period after the intervention.

Galeote et al.<sup>13</sup> evaluated the comprehensive vocabulary development, and the oral and gestural production of 230 children with DS between 8 and 29 months of mental age, where they described a superiority in the vocabulary comprehension over oral production, where the latter was more marked at older mental age. Regarding gestures, Galeote describes a slow increase at younger mental ages, with a stabilization around 20 to 22 months of mental age and a subsequent decrease. These results are similar to those found in our study, in which there are improvements in the items of comprehension over oral production, with an increase in gestural production. The increase in total and late gestures with a decrease in early gestures is noteworthy, in accordance with that described in the literature<sup>8</sup>, where early gestures typically disappear as late gestures increase. Likewise, the literature describes that as the total gestures decrease, there is an increase in the appearance of the words, which probably was not observed in our follow-up time.

The observation of no change in the items "respond to name", "respond to no", "imitate" or "name", is due to that they are skills already acquired in the t0 and are maintained at the end of the process. When comparing our results with the reference percentages of Galeote<sup>18</sup>, the groups have a similar performance in the early comprehension item, however, in the decontextualized language use, there is a performance of our group lower than Galeote's reference, although it improves after the intervention. The differences between Galeote's group and ours could be attributed to selection elements and sample size, as well as to the Spain-Spanish language comprehension, versus Chilean-Spanish that speak parents who answered the CDI-DS.

The results of this series demonstrate a great interindividual variability, that Table 3 shows, which is described not only in children with DS but also in typically developing children.

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	18-19 (	n = 9)	20-21 (r	n = 11)	22-23 (n =		
	% t0 - % tf	% Ref*	% t0 - % tf	% Ref*	% t0 - % tf	% Ref*	
Early comprehensiom							
Respond to the name	100 – 100	100	90.9 – 90.9	100	100 - 100	100	
Answer to the no	88.8 - 100	96	90.9 - 90.9	100	100 - 100	100	
Search when mam/dad calls	100 – 100	92	81.8 - 90.9	96.7	0 - 100	91.3	
Start of production							
Imitate	22.2 - 44.4	52	54.5 – 45.5	70	100 - 100	95.7	
Name	11.1 – 22.2	28	27.3 – 45.5	56.7	0 - 100	47.8	
Descontextualizated use of lenguage							
Past	0 - 22.2	12	9.1 – 9.1	20	100 - 0	34.8	
Future	0 - 11.1	24	18.2 – 18.2	26.7	0 - 100	39.1	
Absent object (production)	11.1 – 22.2	32	27.3 – 45.5	60	100 - 0	60.9	
Absent object (comprention)	33.3 – 66.7	64	54.4 - 72.7	90	100 - 0	95.7	
Absent owner	33.3-22.2	32	36.4 - 27.3	66.7	100- 0	82.6	

Table 4. Average percentage of performance for "Early comprehension", "Beginnings of production" and "Decontextualized use of language", according to cognitive age

The group average of initial percentage (% t0) and the group average final percentage (% tf) according to mental age group are shown: 18 to 19 months, 20 to 21, and 22 months. \*% Ref: percentage of positive responses for these age groups (cognitive age) referenced by Galeote<sup>15</sup>.

Table 5. Main subjective assessments of pa	arents 3 months after the workshops
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Benefit your child got while participating in this workshop	Benefit you got from participating in this workshop
<ul> <li>Socialization</li> <li>Communicative intention</li> <li>Increase of vocabulary</li> <li>Entertainment with the workshops</li> <li>Decrease in aggressive behaviors</li> <li>Emotional bond with other participants</li> <li>Decrease in anxiety</li> </ul>	<ul> <li>Family inclusion</li> <li>Decrease in anxiety</li> <li>Better comunication</li> <li>Understand and address needs</li> <li>Share with other pairs</li> </ul>

It should be noted that a percentage of children reduce their performance in some dimensions, especially in the production and comprehension of vocabulary, which could be determined by the used tool (CDI-DS), which is a self-report answered by parents, that requires observation by them to have a reliable assessment of their children's behavior. In this context, the parents, as they were not familiar with the CDI-DS inventory and had answered it in the first session of the training, answered without intentional observation of their children, but with the representation they had of them, which could generate a bias by overvaluation of the skills<sup>19</sup> that could be inferred especially in some children who have maximum scores in some dimensions at the beginning of the study (participants 5 and 16 in Table 3). On the other hand, the CDI-DS is a long inventory, which requires an extended period of attention (about 60 to 90 minutes), which can lead to a loss of interest in the instrument and a decrease in the veracity of the answers. It is known that vocabulary production in children with DS is usually slower than expected in their remaining cognitive skills, which could develop mostly after 36 months of age<sup>26</sup>, which would require more follow-up to observe the appearance of new words. In the same way, problems are described in intelligible speech, that is to say, a higher frequency of verbal dyspraxia<sup>27</sup>, which can determine difficulty in recognizing the appearance of new words. Additionally, it is described that up to 16% of children with DS may develop autism spectrum disorder and expressive communication impairment<sup>28</sup>. Both conditions could influence the vocabulary development but not in gestures development. Unfortunately, the observation time of our study did not allow us to detect children with dyspraxia or with autism spectrum disorder to attribute the decrease in vocabulary production to these

conditions. Finally, it does not seem that the intervention carried out could produce regression in the skills previously acquired in the studied group, however, the analysis must be done on a case-by-case basis.

Among the study limitations, we consider that although the CDI-DS is the best instrument available in Spanish and validated for children with DS, it is not validated for the Chilean population, which could generate difficulty in understanding by caregivers, with respect to some words of the instrument. This report has a small sample size that only allows describing child by child to generate an individualized impression, rather than group values. Short-term follow-up of participants may have underestimated the impact of the intervention; thus, it would be very interesting to perform a long-term follow-up and determine the impact on word generation in a subgroup of children.

Taking into account the results of our series, we consider that gestural communication training is a complementary and valuable tool for stimulating the development of children with DS. In cases where a greater negative results tendency was obtained, difficulties could be identified in the use of the CDI-DS inventory or social development alteration, which could have interfered with the acquisition of new skills. Considering the limitations of the CDI-DS, it would be appropriate to instruct the caregivers who are going to participate in the training on the aspects that are going to evaluate in the CDI-DS, in order to observe and record them more objectively.

# Conclusions

This is the first Latin American study that describes the response of a group of children with DS to a teaching technique in gestural communication.

The group of children with DS is a heterogeneous one, despite homogenizing them according to their cognitive age, an interindividual variability is observed that does not allow extrapolating the results to groups or to the whole population of children with DS.

Considering that Baby Signs<sup>®</sup>'s "Signs, Words and Games" methodology is a strategy that does not put children at risk, that is low cost and easy for parents to acquire and reproduce it, and taking into account the results showing that some children could benefit from improving their communication skills, the recommendation for training in gestural communication could be a strategy for stimulating complementary communication, always considering the need to make individual and comparative evaluations about themselves, in order to evaluate progress and eventual change in their own developmental trajectory.

There is the need for larger sample size studies, with validated instruments in the Chilean population, and with long-term follow-up of participants to assess the impact on their subsequent development, as well as a comparison of results with typically developing children.

#### **Ethical Responsibilities**

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

**Data confidentiality:** The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

**Rights to privacy and informed consent:** The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is in the possession of the correspondence author.

# **Financial Disclosure**

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# **Conflicts of Interest**

Authors declare no conflict of interest regarding the present study.

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