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# Multiple exemplar instruction and integration of listening and speaking behaviors with substantive-adjective syntactic units in children with ANSD and CI

## *Ensino por múltiplos exemplares e integração de comportamentos de ouvinte e falante com unidades sintáticas substantivo-adjetivo em crianças com DENA e IC*

**Keywords**

Hearing Loss
Cochlear Implant
Teaching
Verbal Learning
Rehabilitation

## ABSTRACT

**Purpose:** To verify the effect of the multiple exemplar instruction at the acquisition and integration of listening and speaking behaviors, with substantives and substantive-adjective combinations, in children with Auditory Neuropathy Spectrum Disorder (ANSD) and cochlear implant (CI). **Methods:** Participants were two children with ANSD that were users of CI. We adopted dictated stimulus and pictures that corresponded to words (substantive) and substantive-adjective syntactic units. The study was arranged in teaching steps that were intercalated with listening and speaking behaviors probes, with all stimuli. The multiple exemplar instruction presented oral imitation (echoic), auditory recognition (listening) and pictures naming (touch) tasks, on a rotating way; the substantives were taught first and, after that, the substantive-adjective combinations. **Results:** In the pre-test, the participants showed variability and discrepancy in the correct responses percentages of listening and speaking. All achieved firstly 100% correct responses in the listening task and the speaking performances were close to listening after the teaching. All extended substantive learning to substantive-adjective syntactic units. **Conclusion:** Children with ANSD and CI can learn and integrate listening and speaking behaviors by multiple exemplar instruction, from words to syntactic units.

**Descritores**

Deficiência Auditiva
Implante Coclear
Ensino
Aprendizagem Verbal
Reabilitação

## RESUMO

**Objetivo:** Verificar o efeito do ensino por múltiplos exemplares na aquisição e integração dos comportamentos de ouvinte e falante, com substantivos e combinações substantivo-adjetivo, em crianças com Desordem do Espectro da Neuropatia Auditiva (DENA) e implante coclear (IC). **Método:** Participaram duas crianças com DENA que usavam IC. Foram adotados estímulos ditados e figuras que correspondiam a palavras (substantivo) e unidades sintáticas substantivo+adjetivo. O estudo foi organizado em passos de ensino que foram intercalados por avaliações dos comportamentos de ouvinte e falante, com todos os estímulos. O ensino por múltiplos exemplares apresentou tarefas de imitação oral (ecoico), reconhecimento auditivo (ouvinte) e nomeação de figuras (tato) de maneira rotativa; os substantivos foram ensinados primeiro e, em seguida, as combinações substantivo-adjetivo. **Resultados:** No pré-teste, os participantes mostraram variabilidade e discrepância nas porcentagens de acertos de ouvinte e de falante. Todos alcançaram primeiro 100% de acertos nas tarefas de ouvinte e os desempenhos de falante ficaram próximos aos de ouvinte após o ensino. Todos estenderam a aprendizagem dos substantivos para as unidades sintáticas substantivo-adjetivo. **Conclusão:** Crianças com DENA e IC podem aprender e integrar comportamentos de ouvinte e de falante por meio do ensino por múltiplos exemplares, de palavras a unidades sintáticas.

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## INTRODUCTION

Language covers a complex set of abilities that can be classified as receptive and expressive[1]. These abilities can be functionally described as listening and speaking behaviors, as they occur under some conditions and produce consequences. To act as listener and as speaker are distinct verbal abilities, established by different teaching conditions and, therefore, are initially independent[2,3]. The speech sound processing starts even before the birth and the deprivation of access to speech sounds at the first years of life compromises the typical development of the oral language[1], affecting the global development and life quality[4].

In the comprehensive framework of hearing losses, the Auditory Neuropathy Spectrum Disorder (ANSD) is characterized by the function of the preserved outer hair cells; however, the afferent neural transmission has been altered. This alteration generates a neural dyssynchrony and significantly affects the speech perception and comprehension, mainly in the presence of noise[5] and, as a result, the speech production[6]. The clinical characteristics of children with ANSD are very peculiar and, specifically in relation to oral language, and it was not identified a performance standard or requested personal attention at intervention[7]. Children with ANSD diagnostic that do not have gains with a hearing aid for amplification of sounds might obtain benefits by means of cochlear implant (CI)[5], biomedical device that integrates external and internal components (surgically implanted), and electrically stimulates the auditory nerve fibers, providing an auditory sensation. In the cases of ANSD, this device can minimize auditory dyssynchrony, once it partially replaces the functions of the hearing sensorial cells and directly stimulates the auditory nerve[6]. The neural synchrony improvement by means of CI can deeply contribute to the learning of the listening and speaking abilities of children with ANSD[8].

One important ability to listen is the auditory recognition observed when visual stimuli are conditionally selected to the auditory stimuli presentation; also called listening response based on selection[9]. In the scope of this work, the speaker's ability involve the oral production in specific situations and the interest fell over the naming ability and over oral imitation, that can be respectively called touch and echoic[2,9]. The naming occurs in situations when the non-verbal stimuli (e.g. an object or a picture) are presented and the person reacts orally, naming the stimuli. The relation between the oral production and the non-verbal stimuli is arbitrary and stipulated by the oral community[2,9]. The oral imitation occurs when an auditory stimulus is presented and the person orally reproduces, in a way that there is a point-to-point correspondence with the previous stimuli[2,9].

To Stemmer[10], previous learning on the listener behavior would be a necessary condition to the learning of the speaker's abilities, being the listener's abilities transferred to the speaker's. In this proposition, adequately behave in face of the word (even if the object is not present) means that the individual has become a competent listener of the word. It can involve the capacity of producing and recombining the linguistic components that were previously learned. The child could initially to responding to the expressions as a whole (e.g. eattheporridge, eatthefruit, eatthesoup) and later, start separating the words, understanding each element (e.g. eat the soup).

Recent researches have investigated relations between the abilities of listener and speaker and under which conditions the interdependence of these repertoires occurs for different populations, such as listener children[11] and with hearing loss[12]. In general, these studies have exposed the participants to teaching of listening tasks based on selection (by the *matching-to-sample* procedure) and, after that, evaluated the naming of these pictures. At the listener's tasks, a dictated word was presented as sample and three pictures as comparison and the participant selected the picture (comparison stimuli) that was arbitrarily related to the auditory sample. The results in the different studies suggest that learning listener's behaviors was not condition for the naming to occur, even in the conditions where the echoic was accurately issued in the pre-tests[11]. On the other hand, other studies have demonstrated the biderectional relation between the listener's and speaker's behavior[13], including children with hearing loss and CI[14].

To identify functional relations among environmental variables and verbal actions can provide useful tools for planning teaching strategies and integrating the verbal abilities of children with CI. Among the conditions that can promote and integrate the listener and speaker's abilities is the teaching by multiple exemplars[9].

The teaching by multiple exemplars (*Multiple Exemplar Instruction,* MEI) is a structure recognized by its efficiency on establishing and integrating listener and speaker's repertoires, mainly in populations with a little or none oral verbal repertoire. Teaching by MEI is structured by the rotation of one or more speaker's tasks (for example, to ask for items or name pictures) with the listener's tasks (such as listening response based on selection). On considering the different stimuli controls on listening (dictated word) and speaking (need of an item when requested and of a picture when naming), it is verified that MEI can provide the stimuli shared control, before independent, during the consecutive tasks. Teaching by MEI has been efficient to promote new verbal repertoire in populations with minimum verbal repertoire, mainly in people with Autism Spectrum Disorder[15]. MEI potential has also been explored at the integration between listener and speaker's repertoire of children with neurosensory hearing loss[14] and with ANSD[16] that use CI. A current issue is to verify if, on integrating the listener and speaker's repertoires this can have any effect over the dyssynchrony, which is peculiar to ANSD.

Pereira et al.[14] evaluated if the teaching structured by MEI would be a condition to establish and integrate speaker's repertoire (name pictures and echo words) and listener's in three children (between eight and twelve years old) with pre-lingual neurosensory hearing loss and CI users. The results had a lot of variability and suggested that MEI effects at the integration of speaker and listener's repertoire of this population should be better explored and outlined.

Rique et al.[16] verified the effects of teaching by MEI at the establishment and integration of listener and speaker's behaviors (name pictures and echo words) in a child of six years and nine

months old, with ANSD and CI. Three sets of simple words were adopted (with consonant-vowel syllabic structure) and the teaching of each set was made in a staggered way, and the other sets successively evaluated. The teaching involved the rotation of tasks such as tact, echoic and listening response based on selection; the teaching was repeated until the performances of listener, echoic and tact were well established. The listener's repertoire was established at first and the number of expositions to teaching until learning this repertoire was superior to the one found in the former study[14]; however, those did not present ANSD. The teaching by MEI favored the repertoire integration of listener and speaker for this participant.

These findings are preliminary and have suggested MEI teaching potential to establish and integrate listening and speaking behavior in children with neurosensory hearing loss and with ANSD, and that use CI. Considering that children with ANSD and CI rehabilitation configures a challenge and that Rique et al. [16] study was of a single participant, this study aims at verifying if MEI teaching would promote listener and speaker's behavior learning and integration with substantives, replicating the results of the former study with a bigger sample. The present study has also expanded the linguistic stimuli of isolated words (substantives, such as seal) to syntactic combinations of two terms (substantive-adjective, such as blue seal). This way, this study aimed at verifying if the effects of MEI teaching would be similar when used these syntactic units.

## METHODS

### Participants

Participated a boy (Dado) and a girl (Flor), both with six years old, that attended regular municipal schools in Bauru; Dado was at the last year of childhood education and Flor at the first year of Elementary School I. The participants presented Auditory Neuropathy Spectrum Disorder (ANSD), used cochlear implant (CI) and received audiological service follow-up (Cochlear Implant Service) and rehabilitation (Educacional Center for the Hering Impaired)" of the Hospital for Rehabilitation of Craniofacial Anomalies (Hospital de Reabilitação de Anomalias Craniofaciais, HRAC), Bauru, São Paulo. Flor sequentially received bilateral CI; the first one was inserted in the left ear at three years and three months old and the contralateral at four years and six months old. Dado recently received unilateral CI, with five months use at the time of the study; he returned to HRAC one year and four months after starting the research, for the follow up on CI performance, and demonstrated trend levels very similar between the programs.

The project was approved by the Research Ethics Committee on Human Beings (CEPSH) of the Universidade Estadual Paulista – campus Bauru and the Hospital for Rehabilitation of Craniofacial Anomalies (HRCA) (CAAE 52237315.8.0000.5398). The participants entered in the study after their responsible ones expressly authorized their participation by means of the Informed Consent Form (ICF) and the children agreed by means of the Informed Assent Form (IAF).

The participants were individually evaluated and characterized in cognition by the Columbia Scale of Intellectual Maturity[17] and in receptive language by the *Peabody Picture Vocabulary Test* (PPVT-4R)[18]. At Columbia, Flor presented intellectual maturity index below the expected for her age (stanine 3) and Dado above the average for his age (stanine 9). In vocabulary auditory recognition, both presented performance similar and lower to the expected for the age (Flor – 3 years; Dado – 2 years and 11 months).

The Hearing Categories (Cat Hear) and Language (CatLang)* were checked in the participants' record. Flor could differentiate dictated words in closed set (category 3 of hearing) and could communicate with sentences of four and five words (category 4 of language). The participant Dado was able to detect speech sounds (category 1 of hearing) and spoke isolated words (category 2 of language). Table 1 presents the participants' characterization.

### Tools, materials, environment and stimuli

Standardized tests on cognition and on receptive language were adopted to characterize the participants. Columbia Scale of Intellectual Maturity[17] evaluated the cognition and consisted in presenting cards with a series of pictures and the participant pointed which picture was different from the others; the results were obtained in stanine from 0 to 9 and characterized the categorization repertoire. *Peabody Picture Vocabulary Test* (PPVT-4R) – 4th Edition[18] evaluated the receptive language; the participant pointed the picture corresponding to the spoken word by the evaluator within a closed set of four pictures distributed in a matrix (2x2); assessed the ability of recognizing spoken words and produced measures from the reference of the chronological age.

For data collection, were used a *notebook* HP® with *PowerPoint Microsoft Office*® installed and attached sound boxes. The responses of stimuli selection and speech production of the participants were registered by means of a compact camcorder *Sony Handycam* HDR-CX440 brand. The tasks were exhibited by means of *PowerPoint*®, in consecutive slide format; when the task had auditory stimuli, the slide automatically enabled the audio to be reproduced in the sound box. The participants chose gifts such as pens, play dough, adhesives, colorful paper, balloons and candies as reinforcers to keep the task engagement. The sessions were individual and were performed, now at the facilities of the clinic-school of a public university of the countryside of Sao Paulo, now at the residence of one of the participants for the responsible one's convenience. The researcher guaranteed that the collection environments were adequate and with little noise.

The study adopted two sets of substantives and of substantive+adjective syntactic units as linguistic stimuli. The substantives were simple (set 1: doll, ball, house; set 2: car, wolf and cow). The combinations substantive+adjective were formed by the previous substantives added by adjectives designating

* These categories are attributed by means of evaluations and mainly include the scales *Infant-Toddler Meaningful Auditory Integration Scale* (ITMAIS) and *Meaningful Use of Speech Scale* (MUSS). The hearing categories vary from 1 to 6. The Language categories vary from 1 to 5.

**Table 1.** Participants characterization per age (in years), time of listening with cochlear implant (in years and months), device laterality (Lateral. CI), school year, hearing category (Cat. Hear.), language category (Cat. Lang.) and Columbia score (in stanine) and of PPVT (in equivalent age)

| Name | Age (years) | Time of listening with CI (years and months) | Lateral. CI | School year | Cat. Hear. | Cat. Lang. | Columbia (stanine) | PPVT (equivalent age) |
|---|---|---|---|---|---|---|---|---|
| Flor | 6 | LE:3y RE:1y9m | Bilateral | Pre II | LE:3 RE: 3 | 4 | 3 | 3 |
| Dado | 6 | LE:5 m | Unilateral | 1st year ES. I | LE:1 | 2 | 9 | 2y11m |

**Legend:** y: years; m: months; CI: cochlear implant; RE: right ear; LE: left ear; ES. I: Elementary School I

colors (set 1: pink, brown, yellow; set 2: red, green and blue). These combinations were arranged by means of matrixes[19] with three substantives displayed on the columns and three adjectives on the lines (matrix 3x3), and that produced nine substantive+adjective syntactic combinations at the intersection of the components of the lines and columns. The diagonal combinations of the matrix were directly taught and the others were only tested to verify the recombination among the terms taught. The stimuli and the way they were arranged in the matrixes are represented on Figure 1.

The auditory stimuli were recorded with a female voice. The visual stimuli were pictures; when they related only to the nouns, pictures in black and white were presented and, when they represented substantive+adjective combinations, the pictures were filled with specific colors.

### Tasks

The tasks were organized in discrete trials[9], each one made up of instructions, presentation of stimuli arrangement, response opportunity (selection of stimuli or of vocalization), differential consequence for correct and error responses (only at teaching) and one interval between the trials. The time for responding was of five seconds approximately and the interval between the end of one attempt and the instruction for the next task was of two seconds. The study planned tasks for listener and speaker.

The listener's task (or listening response based on selection) consisted on the instruction "Point" followed by the simultaneous presentation of an auditory stimuli that worked as sample and of the three pictures from which one should be chosen conditionally to the sample (stimuli-comparison). The participant's task was to point the picture that "*goes with*" the auditory sample. The presentation of the auditory stimuli and the position of the pictures were at random at the consecutive trials, avoiding choices based on stimuli position.

The speaker's tasks were of echoic and tact. At the echoic task, the instruction "Listen and repeat" was followed by the auditory stimuli to be repeated, and the participant should vocalize what he had just heard (in other words, the response should be topographically identical to the previous auditory stimuli). At the tact tasks, the instruction "What is this?" was simultaneously presented with a picture and the participant should orally name the picture in the way stipulated by the verbal community.

### Design

The study adopted the multiple probe design. These probes intersperse each step of the teaching and served to evaluate the maintenance of the listener and speaker's behavior learned at each step. Still, they permitted to verify the learning effects of the verbal relations with substantives (Step 1) over the learning of verbal relations involving substantive+adjective combinations (Step 2)[20].

### General procedure

The study was organized in teaching steps (units and steps) and probes (that interspersed the steps of the teaching). The Chart 1 presents the step organization and quantity of trials in each step.

### First probe

Before teaching, the participants were evaluated in listener's tasks (listening response based on selection) and in speaker's (echoic and tact) for each one of the six substantives and of the six substantive+adjective combinations taught of the Units 1 and 2. Considering that each step involved three stimuli and that the study had four steps, the probes totaled 36 trials (Chart 1). The tasks were distributed in blocks that randomized the tasks presentation.

### Teaching

The teaching was organized in two units and each unit was composed by Step 1 (substantive) and Step 2 (substantive+adjective). Each teaching step was composed by blocks with six tasks of each verbal relation, for each one of the three stimuli; then, one block presented six echoic tasks, six of listening response based on selection and six of tact for the first stimuli, and so consecutively for the second and third stimuli. These trials were structured by MEI.

MEI teaching block presented linguistic stimuli (substantive or substantive+adjective) in a rotation way, so that it was conducted a sequence of tasks with one stimulus, followed by the same sequence with another stimulus and so on. This sequence was used for all the stimuli and consisted of echoic trials, followed by listening response based on selection and, finally, by the tact. One example of MEI teaching block would be orally imitate /doll/, followed by pointing to the picture of a doll when it was heard the auditory sample /doll/ and after that name /doll/ facing the respective picture. Following the block,

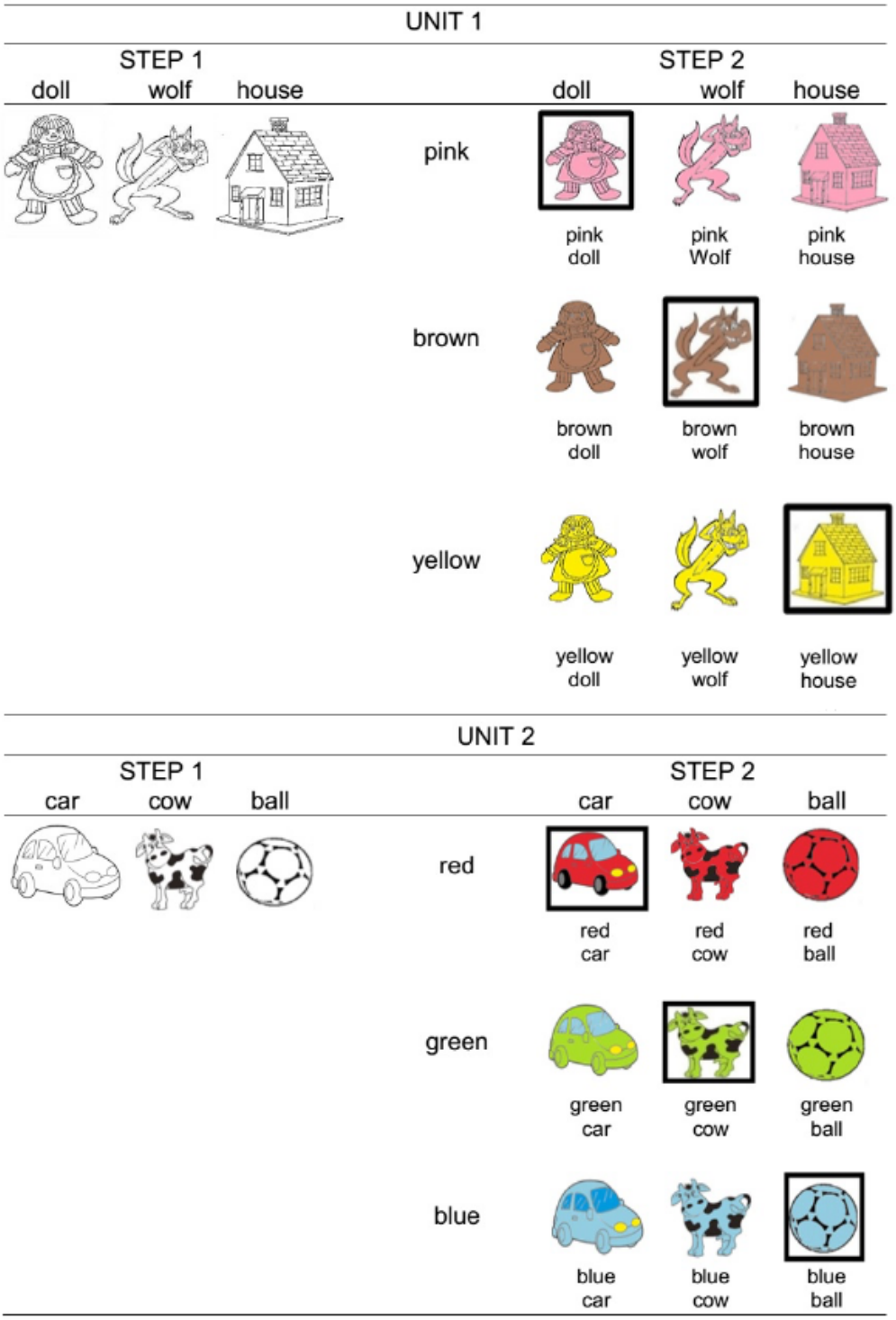


**Figure 1.** Steps stimuli of the Teaching Units 1 and 2. The pictures with borders indicate the combinations substantive+adjective that were directly taught at Step 2

it would be requested the oral imitation of /house/, after the selection of a house picture when listen /house/ dictated and, after that, name /house/ facing the referred picture. Finally, the same tasks sequence (echoic, listening response based on selection and tact) would be applied to "wolf" stimuli.

The trials for the second and third stimuli were added in a sequence according to the same MEI structure[15], totalizing 54 teaching trials (Chart 1). All teaching steps were organized this way.

During the teaching, the errors and correct responses were followed by differential consequences. After the correct responses, the participant was offered adhesives, small gifts and praises; and corrections ware presented after errors. The corrections at the listening based on selection tasks were dictated tips

**Chart 1.** Steps, stimuli, tasks and number of trials at Units 1 and 2

| Unit | Step | Stimuli | Task | Number of trials | | | Total |
|---|---|---|---|---|---|---|---|
| | | | | [Substantive] of Teaching | [Substantive]+ [Adjective] of Teaching | [Substantive]+ [Adjective] Recombined | |
| | Pre-test | All | Echoic | 6 | 6 | - | 36 |
| | | | Listener | 6 | 6 | - | |
| | | | tact | 6 | 6 | - | |
| Unit 1 | Teaching Step 1 | Wolf | Echoic, Listener and tact | 18 | - | - | 54 |
| | | House | Echoic, Listener and tact | 18 | - | - | |
| | | Doll | Echoic, Listener and tact | 18 | - | - | |
| | Probe | All | Echoic, Listener and tact | 18 | 18 | - | 36 |
| | Teaching Step 2 | Brown wolf | Echoic, Listener and tact | - | 18 | - | 54 |
| | | Yellow house | Echoic, Listener and tact | - | 18 | - | |
| | | Pink doll | Echoic, Listener and tact | - | 18 | - | |
| | Probe | All | Echoic, Listener and Touching | 18 | 18 | 36 | 72 |
| Unit 2 | Teaching Step 1 | Car | Echoic, Listener and tact | 18 | - | - | 54 |
| | | Cow | Echoic, Listener and tact | 18 | - | - | |
| | | Ball | Echoic, Listener and tact | 18 | - | - | |
| | Probe | All | Echoic, Listener and tact | 18 | 18 | 36 | 72 |
| | Teaching Step 2 | Red car | Echoic, Listener and tact | - | 18 | - | 54 |
| | | Green cow | Echoic, Listener and tact | - | 18 | - | |
| | | Blue ball | Echoic, Listener and tact | - | 18 | - | |
| | Probe | All | Echoic, Listener and tact | 18 | 18 | 36 | 72 |

"No, it isn't!" followed by the instruction "Point _____", signalizing a new opportunity to change the choice stimuli, in the same trial. At echoic tasks, the correction consisted on the repetition of the auditory sample and again the instruction "Listen and repeat". When the participant incorrectly named the picture, the researcher offered a, echoic prompt, that is, spoke the correct name of the picture. In all correction cases, only the first response was accounted. The criteria to go ahead to the next step were based in performance (reach, at least, 90% of the correct listening responses, tact and echoic) or stability (if the percentage of correct listening responses, tact and echoic did not vary for three consecutive sessions).

**Probes between teaching steps**

The probes evaluated the participants' performance in listening based on selection, tact and echoic with all stimuli taught at Units 1 and 2, with blocks identical to the first probe. After teaching Step 2 of Unit 1, were added probes of the verbal relations for the combinations between substantive-adjective that were not directly taught. Then, from 36 trials, the probes started to have 72 trials (Chart 1). These probes aimed to evaluate if the teaching of substantive-adjective syntactic combinations referring to the matrix diagonal (that is, the taught combinations at Step 2) would promote performances of listener and speaker involving the substantive-adjective combinations that refer to the other cells of the Step 2 matrixes (see Figure 1).

**Dependent variables**

The listener performance (listening based on selection) and of speaker (echoic and tact) were the dependent variables on the study. The discrepancy between the performances of listener and speaker can be observed by means of the difference at the correct responses percentage at the tasks of listening based on selection, echoic and tact.

**Data analysis procedure**

The performance at the listening based on selection tasks was calculated in correct response percentages per block (of teaching or of probe). At the tasks that required oral production (in the presence of picture and a auditory stimuli), were performed the speech transcription from the video recordings and verified the point-to-point correspondence between the transcribed words by the observers and the target words. The speech accuracy measure was calculated with the ratio between correctly produced phonemes by the total quantity of target stimuli phonemes and, later, converted into correct response percentage.

## RESULTS

The two participants finished the study. Flor concluded all the steps in 20 sessions and Dado in 41 sessions. Figure 2 summarizes the correct response percentages at the initial and final probes, of listener and speaker (echoic and tact), with substantives (Step 1) and substantive-adjective syntactic units (Step 2), of Units 1 and 2. On the left side of the picture are presented the performances with teaching stimuli and on the right side with recombination stimuli.

According to Figure 2, the participants presented percentages of correct responses different at the tasks of listeners, echoic and tact during the initial probe and, after the teaching, these performances were closer to both substantives (Step 1) and with the combinations substantive-adjective (Step 2). This

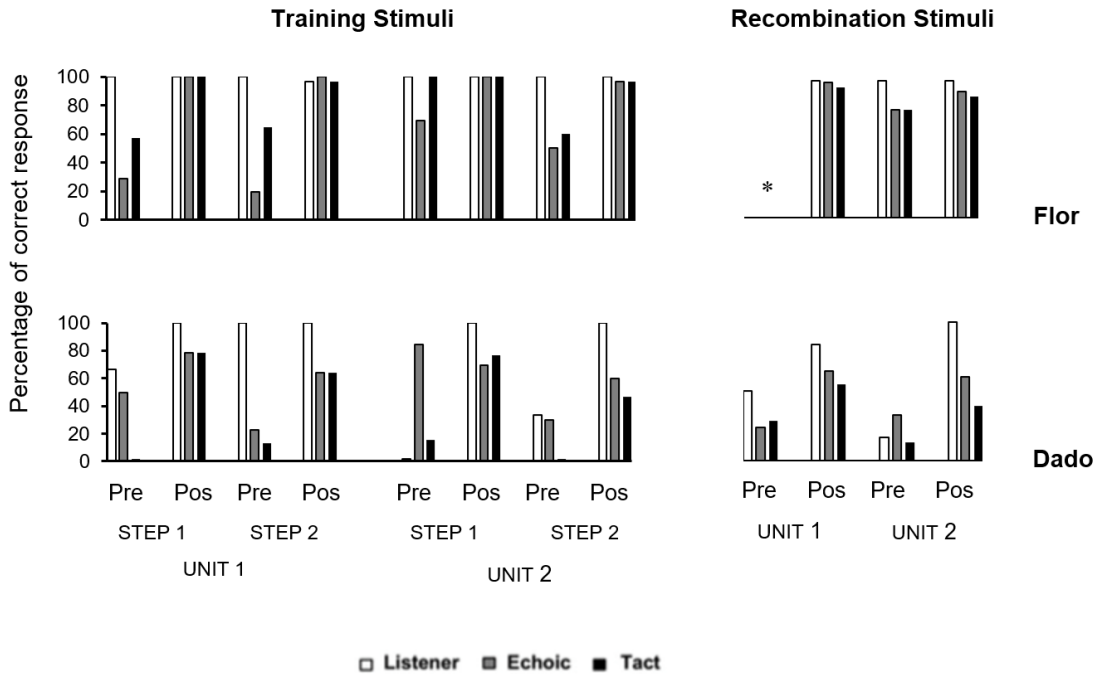


**Figure 2.** General performance of the participants at the tasks of listener, echoic and tact before and after the teaching by multiple exemplar (MEI). Teaching stimuli on the left and of recombination on the right. The pretest data for the relationships indicate with asterisk (*) were not obtained for Flor

result suggests a better integration between these repertoires of listening and speaking that were initially discrepant. After MEI teaching, Flor obtained performances above 90% of correct responses in listener and speaker, with the substantives and substantive-adjective of the two units. Dado, on the other hand, reached accuracy only at the listen tasks with the teaching stimuli; yet the speaking performances (mainly tact), that were lower to 15% of correct responses at the initial probe, had an increase to over 60% of correct responses.

This trend of the listening and speaking performances was similar to the recombination stimuli (substantive-adjective combinations not directly taught). As mentioned at the procedure, the pre-test data for these relations were not obtained by Flor (indicated with asterisk on Figure 2) and, at the final probe, were observed percentages higher to 95% of correct responses at the tasks of listener and speaker with the recombined stimuli of Unit 1. At Unit 2, Flor had accuracy at the tasks of listener at the initial probe and increased the correct response percentages in speaker, changing from approximately 78% to above 88% of correct responses in echoic and tact. Dado presented less than 50% of correct responses at the initial probe at the three tasks with recombined stimuli of the two units and, after the teaching, increased to above 54% of correct responses in listener, tact and echoic in these units. The listening response based on selection presented higher percentage of correct responses with the recombined stimuli of the two units; 83% with the ones of Unit 1 and 100% of correct responses with the ones of Unit 2.

During the tact, echoic and listener teaching, at MEI teaching structure, in Unit 1, Flor needed four expositions to the teaching blocks to reach the criteria with substantives (Step 1) and six teaching sessions for the substantive-adjective combinations (Step 2). In Unit 2, were necessary three sessions to reach the criteria with the substantives (Step 1) and seven with substantive-adjective (Step 2); it is noted that Flor requested more expositions to teaching of Step 2 of the two units, that is, when the stimuli had more components (substantives and adjectives). Flor presented overlapping of correct response percentages on tact, echoic and listener and got 100% of correct responses at the last teaching session for the three tasks, suggesting some integration between the behaviors of listener and speaker.

Dado needed more expositions to the first teaching, so that were conducted 14 expositions to the teaching block to reach the criteria with substantives (Step 1 of Unit 1) and seven expositions with the combinations substantive-adjective (Step 2 of Unit 1). At Unit 2, he had nine expositions to the teaching blocks with substantives (Step 1) and 11 with substantive-adjective (Step 2). This higher quantity of expositions to teaching with the syntactic units (Step 2) also occurred to Flor, although it has demonstrated lower variation during the teaching with stimuli of Unit 2. Dado increased the correct response percentages at the tasks of tact and echoic, obtaining between 60% and 80% of correct responses, and reached 100% of correct responses at the listener tasks; the performances of speaker were integrated, but did not reach the levels of repertoire of the listener. The listener's behavior was the first to be acquired by the two participants.

Figure 3 presents the performances of the participants at the probes. The upper part of this picture presents Flor's performances and the lower, Dado's. For each participant, there are two graphs, the upper with stimuli of Unit 1 and the lower graph with stimuli of Unit 2. The open dots represent the performances with stimuli of Step 1 (substantives) and the closed dots represent with stimuli of Step 2 (substantive-adjective). The listening response based

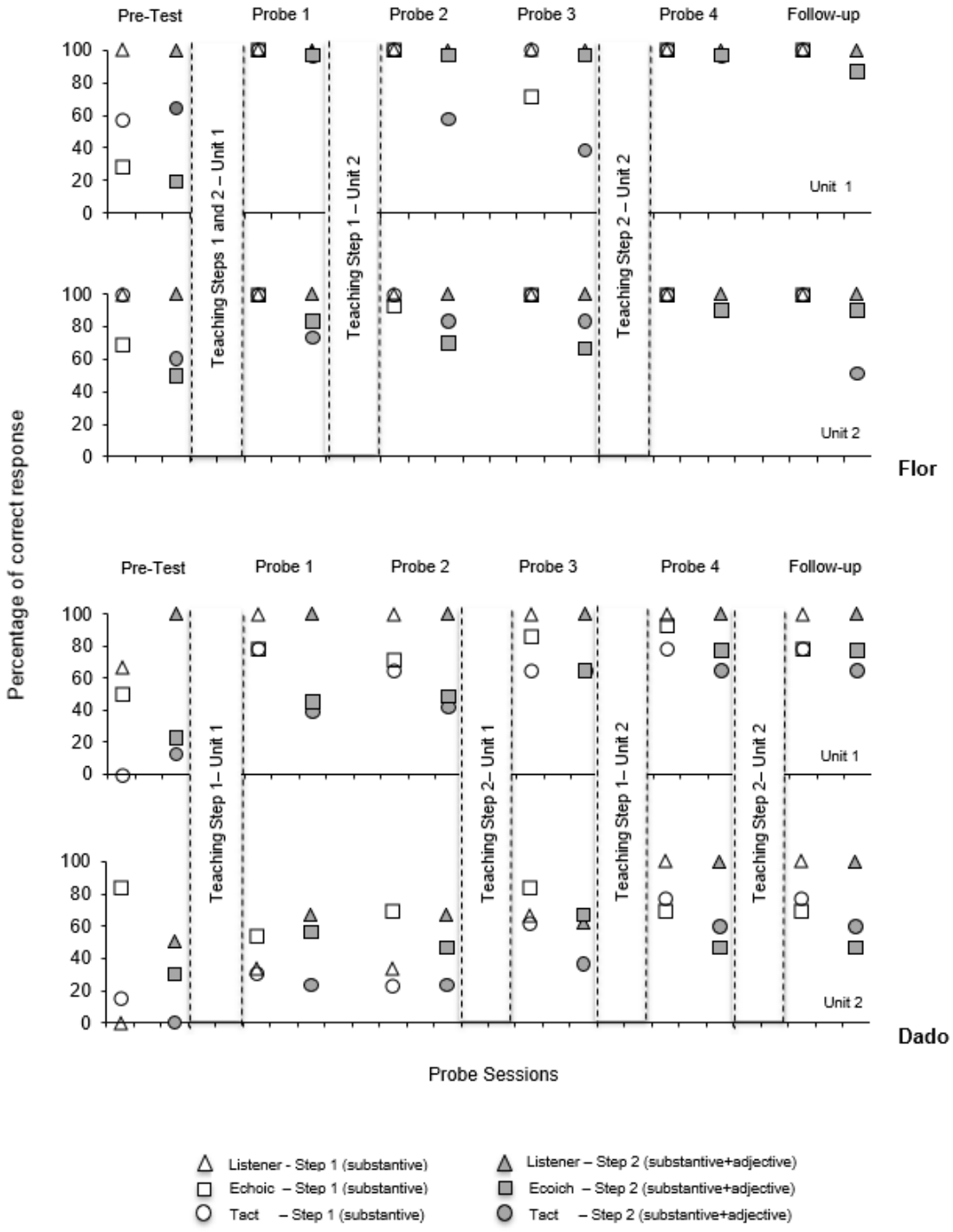


**Figure 3.** Participants' performance at the tasks of listener, echoic and tact during the teaching probes

on selection is indicated by triangles, the tact by circles and the echoic by squares.

According to Figure 3, the participants presented correct response percentages different at the tasks of tact, echoic and listener during the first probe. After MEI teaching steps, the participants increased the correct response percentages at the tasks of listener, tact and echoic, significantly reducing the difference between the performances of listener and speaker; in some cases, accurate performances were observed and one total overlapping of the correct response percentages in listener and speaker.

Flor reached 100% of correct responses at the listen tasks based on selection, 60% of correct responses (approximately) at echoic and 20% of correct responses at tact during the initial probe. These results suggest that the fact that she heard words or syntactic units do not guarantee the accuracy at echoic (with the same auditory stimuli) and neither at tact (with the corresponding pictures). This discrepancy between the performances of

listener and speaker was similar with stimuli of Units 1 and 2. After the teaching of Steps 1 and 2 of Unit 1, Flor presented behaviors of listening and speaking with the same correct response percentage, around 100% (Probe 1, upper panel) for the stimuli of this unit. The teaching of Unit 1 interfered in the performances of Unit 2 and the participant increased the correct response percentages in speaker's tasks (Test 1, lower panel), however, the overlapping of the performances in listener, tact and echoic at Unit 2 occurred only after the teaching of Step 2. Flor had a decrease at the correct response percentage at the follow up, but the performances of listener and speaker kept upper if compared to the initial probe.

Dado also presented different correct response percentages at the tasks of listener and speaker during the initial probe. The echoic performance was superior to 60% of correct responses at Unit 1, while the correct response percentages in listener and tact were low, mainly with substantive-adjective combinations of the two units (lower to 30% of correct responses). After teaching with substantives (Step 1) of Unit 1, Dado increased the correct response percentage of listener and tact, that stayed close to the correct response percentage of echoic (probe 1, white dots). This result replicates with substantive-adjective combinations of Unit 1 and the correct response percentage of listener and tact got closer to echoic (probe 3) after the teaching of Step 2 of this unit. The teaching of Unit 1 also interfered over the performance with stimuli of Unit 2. The accurate performance (100% of correct responses) at the tasks of listener occurred after the teaching of Steps 1 (probe 4) and 2 (probe 5) of Unit 2, while the tact and echoic percentage started to be similar after the teaching of these steps (around 70% of correct responses). These performances were kept in follow-up, at higher levels to the ones observed at the baseline.

## DISCUSSION

The objective of this study was to verify the effects of MEI *(Multiple Exemplar Instruction)* teaching on the learning and integration of listener and speaker's behavior, in children with ANSD and CI. The results showed that the participants' percentages of correct responses in listener, tact and echoic increased after MEI teaching and became more similar (and, in some cases, overlapped) among themselves, highlighting the integration between listening and speaking.

These results demonstrate the efficiency of MEI to integrate and reduce the discrepancy between the repertoires of listener and speaker, and converge with previous studies with different populations, such as people with Autism Spectrum Disorder[9], children with neurosensory hearing loss and CI[14] and with ANSD and CI[16]. These results are also consistent with the ones observed in an Audiology research that adopted the same design of a single-case and of multiple probles[20].

The present study adds to the literature that adopted the MEI in children with CI, either with neurosensory hearing loss or with ANSD[14,16]. Particularly, this study replicated the findings of a case study[16] with two children with ANSD and CI. Furthermore this research has not simply replicated, but also extended these findings to larger linguistic units, from isolated words (substantives) to syntactic combinations of two terms (substantive-adjective).

Several researches have investigated ways to promote the learning of listening and speaking with units larger than words, in children with CI[21,22]. Some studies have established these verbal abilities with sentences by means of equivalence based instruction (between stimuli dictated, textual and pictures)[23], while others systematically taught listener's tasks with echoic[21]. In this scope, this study has contributed with the line of research on identifying MEI as a way of teaching to promote and integrate the listening and the speaking with larger units of the language in children with CI. In this direction, future researches could extend these findings and verify the effects of MEI teaching when adopted sentences of three or more terms. In special, the present study comes closer to Golfeto and Souza[21] that taught two children with neurosensory hearing loss and CI to behave as listener (that is, to point at video scenes conditionally to the dictated sentences) and echo them, this way improving the tact of the video scenes. Although there are differences between the present study and the one of Golfeto and de Souza[21] (such as participants' diagnosis, teaching procedures and linguistic unit extension), these results can, together, enlarge the research possibilities and intervention with children with ANSD and CI.

In general, the participants of the present study established the listener behavior first, while the speaker's performance (tact and echoic) increased and was refined at the consecutive exposure to teaching. Such results replicated Pereira et al.[14] and Rique et al.[16]. These results are also according to the Audiology study that demonstrated that children with CI learn first the listener's abilities and the speaker's abilities are acquired later[24].

In the present study, were necessary many repetitions to the teaching blocks for the participants achieve the criteria of correct responses or get closer to it, what initially contrasts with literature. In Pereira et al.[14], there was a lower number of teaching exposure until reaching the correct responses criteria and a synthesis of researches revealed that children with neurosensory hearing loss and CI present few repetitions to teaching blocks to learn listener's behaviors, such as to relate pictures to dictated stimuli[25]. However, this high quantity of repetitions to the teaching blocks was also found in the study case with ANSD and CI[6] and suggests some hypothesis. The participants' performance in both studies can indicate a behavioral evidence of auditory dyssynchrony caused by ANSD and confirms the findings of the Audiology about the difficulties on the acquisition and maintenance of listen abilities, what turns the auditory rehabilitation of this public a challenge[5,6]. On the other hand, some procedure adjustments can be adopted at MEI teaching viewing at minimizing the auditory dyssynchrony and the discrepancy between the listening and speaking behaviors (measured by the correct response percentages quite distinct for the same words). These are issues that can be explored in future studies.

The variability at the performances of listener and speaker was observed in the present study, both with the same participant (intra-subject) and between participants (inter-subjects). The inter-participant variability can be identified in this study from the performances that were unstable along consecutive

teaching sessions and that did not keep stable between two consecutive sessions, what replicates the results found in the case study of Rique et al.[16]. The variability results between participants, in the present study, is similar to the ones found in studies of other centers[8] and suggest that the variability between children with ANSD and CI is recurrent in relation to the learning rhythm, to the number of repetitions and to order of acquisition of the speaker's behavior (tact and echoic).

The participants of the present study presented similar characteristics (such as age and ANSD diagnostic), however distinct regarding the time of CI use and the auditory and language categories. Dado has used CI for five months, detected speech sounds (1 of listen) and spoke isolated words (2 of language), while Flor had more than three years of CI use, recognized words in closed set (3 of listen) and constructed short sentences (4 of language). This difference in CI time of using and in the previous hearing and language categories could predict intervention success[5,8], supposing it is more effective for Flor than for Dado. However, the present study showed that these children with ANSD and CI learned and integrated the listener and speaker tasks, by MEI, regardless the short time of CI use and the variability presented[6].

One variable that could be intervenient and was not controlled in the present study was the fact that Dado, for having recent CI, performed follow up of the device and went through potential adjustments of electrode intensity and frequency in his CI. However, the trend levels were very similar in the two maps during the period of data collection. Then, Dado's listening and speaking results are functionally related to the exposition to the teaching procedures. These results suggest that MEI can be adopted as teaching strategy, even when there is little hearing experience. The generality of these results should be investigated.

During the initial evaluation, the participants of this study presented distinct percentages of correct responses between the speaker's behavior (tact and echoic) and the listener's (listening based on selection). These results are one more evidence, among many reported in literature, of the functional independence between the repertoire of listener and speaker in different populations, such as typical listener children[11], with Down Syndrome[3], with intellectual disability and with neurosensory hearing loss and CI[26].

The present study demonstrated that the discrepancy between the listener and speaker performances was reduced after MEI teaching, in children with ANSD and CI. These findings aggregate a wider literature that demonstrates the effects of teaching conditions over the integration between verbal repertoire and the acquisition of tact accuracy in children with CI, from words to longer units of the language. Some studies showed that teaching based on equivalence relations[23] could promote the integration of verbal abilities and accurate tact, from words[27] up to sentences[22]. These children initially had a controlled speech by textual stimuli (reading) and, after the teaching, this accurate speech started to occur also in response to the picture (tact) due to the control extension of the textual stimuli for the picture. In another research line, studies have taught listener and speaker behavior, in an isolated or rotation way (by MEI teaching), to integrate verbal repertoire and improve children's tact with CI, for both words[14,16] and sentences[21].

MEI teaching route, adopted in the present study, can have its clinical potential explored[28], viewing at decreasing the intra-individual variability at learning and speaker and listener repertoire integration of children with ANSD and CI. Investigations of strategies and interventions[6,29] with this public can derive in teaching technologies, as well as maximize the gains at auditory rehabilitation when combined with factors that favor the language acquisition of this population, such as the age of implantation and time of CI use. Thus, the biomedical technological potential can be aggregated to the behavioral technology potential, following the proposal of the behavioral audiometry proposal[30].

Some limitations of the present study can be adjusted in future researches, such as the generality of MEI effects over the integration of listener and speaker repertoire of this population, by means of replications with a bigger sample of participants. The variability intra-subject can be better controlled by repeated measures before the intervention (for example, three consecutive pre-tests), as suggest the single-case experimental design. This systematic monitoring of the baseline will permit to identify if and which would be the stability level during the pre-test (in case it exists) and, consequently, to estimate in a more accurate way, the effects of teaching at the variability reduction in children with ANSD and CI. Another research possibility would be to return to the proposal of Pereira et al.[14] and of other studies about MEI[15] and extend them to participants with ANSD and CI. These studies could perform MEI teaching and the integration between speaker and listener behaviors with a set of stimuli and, after that, to verify if only the behavioral teaching of the listener behavior would guarantee the emergency of the speaker's behavior with new stimuli.

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## Authors contributions

*AMBM participated on the study elaboration, performed data collection, analysis and interpretation and wrote the article; ACMAV participated on the study idealization and orientation, performed data analysis and interpretation and wrote the article; AJN participated on the study idealization and co-orientation, performed data analysis and interpretation and wrote the article; LTNS and ALMM participated on the study co-orientation, supplied technical-scientific support, performed speech language evaluation of the participants, performed data analysis and interpretation and wrote the article.*