Case Report

https://doi.org/10.1590/2317-6431-2020-2427

Audiology Communication Research
ISSN 2317-6431

Use of software for speech therapy with deaf children

Utilização de software para terapia fonoaudiológica com crianças surdas

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ABSTRACT

From the perspective of working on the improving the speech of deaf children, the speech therapy action, when seeking new tools beffitting the current technological scenario, can use technological applications to help its interventions with deaf children, because digital games, besides stimulating visual perception, favors interactive moments as phases of the learning process. The present study aimed to analyze therapeutic strategies mediated by the use of software in the rehabilitation of vocal and articulatory speech skills of deaf children using cochlear implants. It is a case study of three deaf children was carried out through the survey of medical records; evaluation of the voice and articulation and acoustic analysis of the vocal productions of the vowels [a], [i], [u], and of the occlusive sounds [p], [b]; and application of the digital game VoxTraining to improve vocal and speech aspects performed in five therapeutic sessions. It was observed that all children were diagnosed with hearing los and early rehabilitation. The children are also in the process of acquiring the Brazilian Sign Language as their mother tongue and presents vocal and articulatory speech alterations. The results suggest that the participants were interested in the software due to the request for repetition of the games by the children, and this fact contributed to a better understanding of the vocal and articulatory exercise to be performed due to the contribution of visual feedback. It was concluded that bilingual work with deaf children using digital games facilitates therapy and improves voice quality and speech.

Keywords: Cochlear implantation; Deafness; Language Therapy; Voice; Software

RESUMO

Na perspectiva de se trabalhar o aprimoramento da fala de crianças com surdez, a atuação fonoaudiológica busca novas ferramentas condizentes com o cenário tecnológico atual, utilizando-se de aplicativos tecnológicos no auxílio de suas intervenções, pois os jogos digitais, além de estimular a percepção visual, favorecem momentos interativos como etapas do processo de aprendizagem. O presente estudo se propôs a analisar estratégias terapêuticas mediadas pelo uso de *software* na reabilitação das habilidades vocais e articulatórias de fala de crianças com surdez, usuárias de implante coclear. Tratou-se de pesquisa do tipo estudo de caso com três crianças, realizada por meio do levantamento de prontuário; avaliação da voz e da articulação e análise acústica das produções vocais das vogais [a], [i] e [u] e dos sons oclusivos [p] e [b]; aplicação do jogo digital *VoxTraining* para aprimoramento de aspectos vocais e de fala, realizada em cinco sessões terapêuticas. Observou-se que todas as crianças tiveram diagnóstico de perda auditiva e início de reabilitação tardios, estavam em fase de aquisição da Língua Brasileira de Sinais como língua materna e apresentavam alterações vocais e articulatórias. Os resultados sugerem que os participantes se interessaram pelo *software* devido às solicitações de repetição dos jogos e estes contribuíram para melhor entendimento sobre o exercício vocal e articulatório realizado, devido ao estímulo do *feedback* visual. Conclui-se que o trabalho com crianças surdas utilizando jogos digitais facilitam a terapia e proporcionam melhora na qualidade da voz e da fala.

Palavras-chave: Implante coclear; Surdez; Terapia da Linguagem; Voz; *Software*

Study carried out at Universidade Estadual de Campinas – Unicamp – Campinas (SP), Brasil.
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Conflict of interests: No.
Authors' contribution: PVD developed the theoretical/practical research for her dissertation, from which she drew elements for the creation of this article; MCMPL and ACC were, respectively, advisor and co-advisor, assisting in the development and revision of the article in an intellectually important way.
Funding: bolsa concedida pela Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) - Código de Financiamento 001
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Received: April 27, 2020; Accepted: June 27, 2021

INTRODUCTION

Hearing loss in children is considered one of the main factors that cause delay or disorder in oral language acquisition. Even though it is not possible to predict with certainty the impact of this loss on a child's oral language development, the type and degree of the loss, as well as the age of onset and duration of the problem are factors that greatly influence the repercussions in their global development[(1)].

Currently, most children with profound sensorineural hearing loss are initially referred for the adaptation of hearing aids and, if amplification is not sufficient for oral language acquisition, these children are referred for cochlear implants (CI). Thus, the speech therapy work with them is based on auditory stimulation.

The auditory-linguistic sophistication achieved by most children undergoing CI placement demonstrates the speed with which language mastery is reached. However, in individuals with deafness, the impediment to maintain an adequate auditory feedback, even with the use of CI, leads to the appearance of specific vocal characteristics that exceed the alterations at the glottic level[(2)], with the appearance of difficulties in the combinatorial performance of speech sounds, as well as in the development of vocal, respiratory and articulatory control[(3)].

The most common findings in the literature about the characteristics of oral production of individuals with deafness mention the following difficulties: high values of fundamental frequency, therefore, more acute pitch; variability of speech resonance parameters; presence of roughness, breathiness and tension; instability of phonatory control, which is essential for vocal balance and alteration of suprasegmental characteristics, such as articulation and intelligibility[(3)].

In view of the aforementioned characteristics, speech therapy, seeking new tools consistent with the current technological scenario, will be able to use various resources to improve the speech of deaf children. The applicability of digital games as a therapeutic resource provides a sense of purpose, since games incorporate rules and therefore command strategic thinking by inserting a feedback system that motivates users to achieve their goals. Such mediation helps with attention and decision making, among others numerous features[(4)].

Thus, this study aimed to analyze therapeutic strategies mediated by the use of software in the rehabilitation of vocal and articulatory speech skills of deaf children, users of cochlear implants.

PRESENTATION OF CLINICAL CASES

This research was approved by the Research Ethics Committee (REC) of the Faculty of Medical Sciences, State University of Campinas – Unicamp, under protocol number CAEE 85020418.3.0000.5404. After acceptance, the parents signed the Informed Consent Form and the participants signed a consent form for the research, since they were older than 5 years old.

Three deaf children, users of cochlear implants, inserted in the services of the Center for Studies and Research in Rehabilitation "Prof. Dr. Gabriel Porto" (CEPRE), without pathology associated with hearing loss, two girls and one boy. Since this is a case study, variables such as age at diagnosis of hearing loss, etiology of the loss, mode of communication with the family, age at implantation and length of speech therapy were considered in the analysis. All participants received the same therapy with a technological focus. A fictitious name was used for each child: Renata, Cláudio and Marta.

CEPRE, referenced here, is based on the bilingual theoretical current and works in the assistance of users with deafness in all age groups. The programs are developed to offer psychological support and social service to parents/caregivers and enhance the child's communication possibilities through oral language, with speech therapy and exposure to Brazilian Sign Language (Libras) with deaf instructors, in addition to educational support, with individual and group activities.

Voice and speech assessment was performed at two different times, in all research participants. The first was applied before the beginning of the therapeutic procedure and served as a basis for observing the voice and articulation characteristics presented by the children (pre-test). The second assessment was performed at the end of the therapeutic procedure and compared with the initial assessment (post-test).

Speech and voice samples were recorded in an acoustically treated environment, captured by a Shure SM-58 microphone and recorded using the Praat software[1], installed on a Dell Desktop computer, using the sampling frequency of 44.1 kHz. At this time, video recordings were made for clinical archive and analysis for pre- and post-treatment comparison. The videos were recorded using a Cannon Power Shot A3100 IS camera.

To carry out this step, the following tasks were used: a) word repetition tasks: use of the two-syllable word recognition index, phonetically balanced; b) isolated emission of each sound: emission of vowels [a], [i] and [u] and occlusive sounds [p] and [b]. The participant was required to emit at least twice the sounds requested by the therapist. Whenever necessary, synesthetic cues were provided for the closest production of sound; c) performance of the Maximum Phonation Time (MPT)**:** sustaining the vowels [a], [i] and [u] as long as possible. The MPT analysis followed the criteria proposed by a previous study[(5)], and it was expected to vary between six and seven seconds for the children in this study.

For the acoustic analysis of the voice and speech assessment data, the Praat software was also used. In the acoustic analysis of vowels [a], [i] and [u], the frequencies of the first two formants were observed, and the production of vowels occurs through the free passage of air, therefore, they are more subject to changes caused by prosodic/articulatory conditions[(6)]. The values of the first formant (F1) are directly related to the height of the linguomandibular system and the values of the second formant (F2) are related to the anteroposterior movement of the tongue [(6)]. Thus, these parameters provided important information for the articulatory understanding of production. To calculate the formants of the isolated vowel, the analysis was performed by recording the MPT of each vowel, selecting its stable point.

Regarding the acoustic analysis of plosive sounds [p] and [b], the delimitation of an interval of interest was considered for the study of voicing, named VOT (Voice Onset Time), which can occur between the onset of transient noise and the beginning of the vowel that follows it – positive VOT –, or between the beginning of the transient noise and the end of the vowel that precedes it – negative VOT[(6)]. Such values can explain the time of onset of vocal fold vibration and inform

[1] Software developed by Paul Boersma and David Weenink, Institute of Phonetic Sciences in Amsterdam, available free of charge at www.praat.org.

on supraglottal pressure and on the joint; the latter can provide clues about the correct production of the vocalization of sounds [p] and [b], as well as their moments of exchange in speech.

For the acoustic analysis of vowels, the following spectrogram configurations were used: view range (Hz) from 0 to 4000 Hz with window length (s) of 0.005 s. For formant configurations, the maximum formant (Hz) at 5000 Hz was used.

Individual therapies began in March 2019, totaling ten therapeutic sessions; however, the sounds mentioned above were used in only five of them. Each speech therapy session lasted 45 minutes and the application of the digital game was included in the initial or final 15 minutes.

The interventions were carried out in a therapeutic room provided by the institution, with headphones Headphone Headset High Tone and HS302 Newlink microphone for use in the game. At all times, videos were recorded with a Cannon Power Shot A3100 IS camera, for clinical archive and analysis for pre- and post-treatment comparison.

The therapy with digital games focused on the development of the phonation time of the vowels [a], [i], [u]; improved articulation of occlusive sounds [p], [b]; development of the fine coordination of breathing and articulation necessary for speech. The digital game entitled VoxTraining was applied, consisting of a set of eleven vocal exercise games, with the objective of stimulating, conditioning and training the aspects of voice and speech, improving the production and control of various vocal parameters[2**], such as: a) vocal intensity: intensity control was worked in the strong-weak dimension and two games were used: the airplane game and the balloon game; b) vocal frequency: frequency control was worked in the low-high dimension with the seagull game; c) rhythm and vocal attack: the shooter game was used for the simultaneous work of rhythm and vocal attack; d) maximum phonation time: the astronaut game was used to increase MPT.

The data found were computerized for further acoustic and qualitative analysis. This analysis was descriptive, outlining a group profile, aiming to relate the development of speech skills with the use of the specific software.

The three children participating in the study were between 6 and 7 years of old and the diagnosis of deafness was completed between 1 year and 1 year and 6 months of age. The time elapsed in speech therapy, since the detection of such loss, varied among the research participants: the child Renata has participated in speech therapy for a year and a half, Cláudio for three years and Marta for two and a half years. Regarding the use of technological devices, two of the children had been using the personal sound amplification device (PSAD) for more than three years and were between 3 and 4 years old when they underwent CI placement. Thus, the auditory pathway was stimulated from the beginning of the therapy sessions and not from the prosthesis itself. Furthermore, the children's guardian are in the process of acquiring Libras and that their communication with their families is guided by Libras, gestures and vocalizations.

The summary of the goals and games used in each therapeutic session and their respective settings are presented in Table 1.

The phases that needed settings by frequency were the most difficult to be played by the children. The summary of each therapeutic session of all children in the study and their respective results are shown in Chart 1.

Acoustic analysis

The tabulated data from the pre-test and post-test comparison of the MPT and the first two formants of the isolated emissions of vowels [a], [i] and [u], in all analyzed subjects, are shown in Table 2, the table of the vowel spaces, in Figure 1, using the JT[3***] statistical analysis method, and the comparison of the VOT values of [p] and [b] of all participants, in Table 3.

DISCUSSION

Based on the characteristics of the study participants, we observed that both the age of deafness diagnosis and the beginning of speech therapy contradicted what is proposed in the literature, despite being a recurrent situation in the Brazilian scenario.

The Care Guidelines for Neonatal Hearing Screening of the Ministry of Health establish that it is desirable to identify babies with hearing loss before 3 months of age[7], which was only observed in one of the children in this research, since the others were identified with hearing loss after the 12 months of age, therefore, past the age of early identification.

Regarding the beginning of the speech therapy work with the children, only one started when she was 4 years old. The literature shows that the diagnosis process should be completed at 3 months and speech therapy started at 6 months of life [7], which shows a worrying situation of delay in our reality. A study that sought to assess the medical records and conduct interviews with the mothers of 22 children with congenital deafness found that the age of these children - when they were included in an educational and/or therapeutic care program for the deaf population - varied with minimum values of 2 years of age, maximum of 6 years and average of 3.5 years[8], values that confirm the data of this research.

The late beginning of speech therapy in the three cases in this study is justified. One of the children was born in a city whose maternity hospital lacked the neonatal hearing screening service and, therefore, the entire process of diagnosis was delayed; in the case of the two children who were born in the city of Campinas, they underwent the newborn hearing screening test, but diagnosis was delayed due to social problems or/and the delay in performing the cochlear implant. In general, a possible common cause among all participants is analyzed, that is, the existence of a discontinuity in the care network for deaf people and the social reality that permeates them. This data is cited in a study that observed facets of a medium complexity hearing health care service, in which several problems were found, such as: not all individuals had access to the service; shortage of places for therapeutic care and continuation in the care network; fragmented service and focused on the hearing impairment; social inequalities are little considered at the time of prosthetization, which interfere in the effectiveness of the care provided, when considering issues such as precarious housing

[2] **Information taken from CTS Informática's sales location. Available at: https://www.ctsinformatica.com.br/fonoaudiologia/voz/voxtraining-exercicios-vocais.

[3] ***Jacobson NS, Truax P. Clinical significance: A statistical approach to defining meaningful change in psychotherapy research. Journal of Consulting and Clinical Psychology. 1991; 59(1):12-19.

Chart 1. Summary of therapeutic sessions and their respective results

SESSIONS	RENATA'S ANSWERS	CLAUDIO'S ANSWERS	MARTHA'S ANSWERS
1- Train MPT [a], [i] and [u]	Weak production of vowels [i] and [u] MPT - Changed	Vowels - Appropriate MPT - Changed	Vowels - Appropriate MPT - Improvement
2- Train MPT of vowels [a], [i], [u]	Vowels - Appropriate MPT - Difficulties due to phase	Vowels - Appropriate MPT - Difficulties due to phase	Vowels - Appropriate MPT - Better, but with difficulties due to the phase
3- Productions [p] and [b]	[p] - Improved production [b] - Difficulties in production	[p] - Improved production [b] - Achieved with support	[p] - Achieved with support [b] - Achieved with support
4- Productions [p] and [b]	[p] - Appropriate production [b] - Achieved only with support	[p] - Appropriate production [b] - Improved production	[p] - Improved production [b] - Improved production
5- Production and intensity of vowels [a], [i], [u]	[a] and [i] - Appropriate production [u] - Slightly altered production	[a] and [i] - Appropriate production [u] - Slightly altered production	Vowels - Appropriate production [u] - Slightly altered production

Subtitle: Appropriate production = final moment of therapy in which the subject was able to adequately perform the necessary articulation; Improvement in production = end of therapy in which the child evolved in relation to the beginning; Production difficulties = not much improvement was observed during therapy

Table 1. Summary of the goals and games used in each therapy session, and the respective settings used in each session

	Therapeutic objective	Game used	Configuration used
Session 1	MPT of vowels [a], [i] and [u]	Astronaut game	F0 min: 200 Hz; F0 max: 550 Hz
Session 2	MPT of vowels [a], [i] and [u]	Astronaut game	F0 min: 200 Hz; F0 max: 550 Hz
Session 3	Sound production [p] and [b]	Seagull game	F0 min: 180 Hz; F0 max: 260 Hz
Session 4	Sound production [p] and [b]	Seagull game; shooter game	- F0 min: 180 Hz; F0 max: 260 Hz (Seagull game) - Int min: 50 dB; Int max: 100 dB (Shooter Game)
Session 5	Production and intensity of vowels [a], [i], [u]	Baloon game Astronaut game	- Int min: 50 dB; Int max: 100 dB (Balloon game) - F0 min: 250 Hz; F0 max: 500 Hz (Astronaut game)

Subtitle: MPT = Maximum Phonation Time; Hz = Hertz; F0 = fundamental frequency; Int= Intensity; min=minimum; max=maximum; dB = decibels

Table 2. Pre- and post-test comparison of the Maximum Phonation Time and the values of the first two formants of vowel emissions [a], [i] and [u] in all research participants

	PRE-TEST			POST-TEST		
Renata		**MPT**			**MPT**	
	[a]	**[i]**	**[u]**	**[a]**	**[i]**	**[u]**
	5.38 s	9.0 s	5.5 s	10.8 s	7.3 s	10 s
		FORMANTS			**FORMANTS**	
	[a]	**[i]**	**[u]**	**[a]**	**[i]**	**[u]**
	F1: 1059 Hz F2: 1766 Hz	F1: 365 Hz F2: 1958 Hz	F1: 327 Hz F2: 1232 Hz	F1: 972 Hz F2: 1251 Hz	F1: 341 Hz F2: 2309 Hz	F1: 378 Hz F2: 961 Hz
Cláudio		**MPT**			**MPT**	
	[a]	**[i]**	**[u]**	**[a]**	**[i]**	**[u]**
	8.6 s	10 s	9.2 s	15.6 s	7 s	10.3 s
		FORMANTS			**FORMANTS**	
	[a]	**[i]**	**[u]**	**[a]**	**[i]**	**[u]**
	F1: 1030 Hz F2: 1859 Hz	F1: 352 Hz F2: 1032 Hz	F1: 502 Hz F2: 843 Hz	F1: 1138 Hz F2: 1814 Hz	F1: 345 Hz F2: 1826 Hz	F1: 402 Hz F2: 1018 Hz
Marta		**MPT**			**MPT**	
	[a]	**[i]**	**[u]**	**[a]**	**[i]**	**[u]**
	4.8 s	6.1 s	5.9 s	11.6 s	15 s	12 s
		FORMANTS			**FORMANTS**	
	[a]	**[i]**	**[u]**	**[a]**	**[i]**	**[u]**
	F1: 1215 Hz F2: 2143 Hz	F1: 366 Hz F2: 2322 Hz	F1: 335 Hz F2: 1214 Hz	F1: 691 Hz F2: 1176 Hz	F1: 357 Hz F2: 2828 Hz	F1: 451 Hz F2: 809 Hz

Subtitle: MPT= Maximum Phonation Time; F1= First formant; F2= Second formant; s= seconds; Hz= Hertz

and lack of financial resources or education to understand the stimulation of language for the continuity of treatment[9].

Like in other studies, the age of the cochlear implant of the children in this study ranged between 3 and 4 years old. An investigation that analyzed 60 implanted children showed that 56 individuals received the implant under the age of 5 years, an age equivalent – for most of the individuals – to the time of auditory sensory deprivation[10].

Table 3. Pre- and post-test comparison of Voice Onset Time of [p] and [b] in all analyzed subjects (in milliseconds)

	PRE-TEST				POST-TEST			
Renata	VOT [p]				VOT [p]			
	R1	**R2**	**P1**	**P2**	**R1**	**R2**	**P1**	**P2**
	8	14	5	14	18	15	16	17
	VOT [b]				VOT [b]			
	R1	**R2**	**P1**	**P2**	**R1**	**R2**	**P1**	**P2**
	-67	*(-44)*	...	18*	*(-125)*	-95	14*	-115
Cláudio	VOT [p]				VOT [p]			
	R1	**R2**	**P1**	**P2**	**R1**	**R2**	**P1**	**P2**
	9	15	14	10	12	...	17	15
	VOT [b]				VOT [b]			
	R1	**R2**	**P1**	**P2**	**R1**	**R2**	**P1**	**P2**
	-70	-56	I	8*	-100	-79	19*	I
Marta	VOT [p]				VOT [p]			
	R1	**R2**	**P1**	**P2**	**R1**	**R2**	**P1**	**P2**
	16	15	10	12	17	18	12	17
	VOT [b]				VOT [b]			
	R1	**R2**	**P1**	**P2**	**R1**	**R2**	**P1**	**P2**
	-66	-40	14*	I	-47	-64	13*	19*

*Replaced by [p]

Subtitle: VOT = Voice Onset Time; R1= First repetition of the sound; R2 = Second repetition of the sound; P1 [p] = Repetition of the word [Pilha]; P1 [b] = Repetition of the word [Bicho]; P2 [p] = Repetition of the word [Pula]; P2 [b] = Repetition of the word [Bolo]; I = Unintelligible; ... = There were no other repetitions; *(No.)* = Participant started production before the therapist finished her/his speech

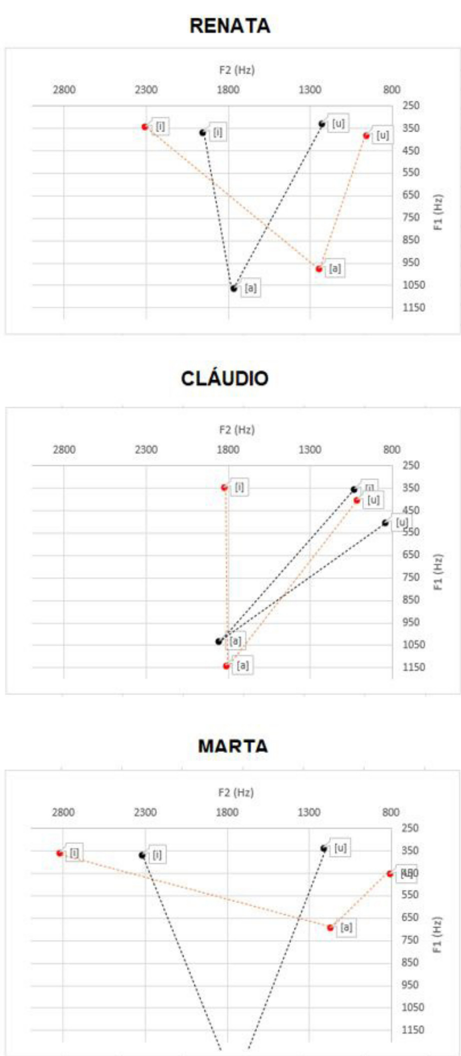

Figure 1. Acoustic space in vowels [a], [i] and [u] in the three research participants
Subtitle: Pre-test (black line); Post-test (red line)

Regarding the MPT in vowels – except for the vowel [i] in participants Renata and Cláudio – there was an increase between the pre-test and post-test, which allowed us to state that there was maintenance of new values during the therapeutic process. Therefore, the procedure can be considered effective.

According to a research that sought to perform vocal training – through computer games with deaf people aged 12 to 17 years –, the MPT values of vowel [a] were 7.88 seconds (s) in the pre-test to 13.97 seconds in the post-test; for the vowel [i], the values were 8.33 s and 12.48 s, and for the vowel [u], the values were 9.21 s in the pre-test and 11.78 s in the post-test(11). Since the criteria for the analysis of the MPT are based on the values calculated according to the individual's age(5), the values found in the previous study were similar to the data from the present research, in which all individuals presented MPT values greater than their own age.

The activities related to the use of Voice Onset Time (VOT) with plosives showed an evolution in the production of [p] and [b], both in terms of syllable and word. Regarding the values themselves, in a study that sought to analyze VOT values of Brazilian Portuguese plosives in speakers with preserved hearing and in individuals with deafness, mean values of [p] of 11 ms and of [b] of -77 ms were found for individuals without deafness(12). Deaf participants, in turn, obtained values of 13 ms for [p], and 12 ms for [b](12), that is, [b] was performed as [p].

Considering such values for individuals with deafness, similar values for [p] ranged between 8 ms and 16 ms in the pre-test; in the post-test, values of [p] ranged between 12 ms and 19 ms, values that showed evolution and that are within the normal range. Regarding the values of [b] in the pre-test, there were changes from [b] to [p], however, in the moments of production of [b], there was a variation of values between -40 ms and -70 ms; in the post-test, values of [b] ranged from -47 ms to -125 ms.

For comparisons of the values of formants F1 and F2 of vowels, normalized theoretical frameworks were used, presented in a study on comparative analysis of oral vowels in Brazilian Portuguese – here focused on infant speech – in which physiological differences were restricted and were only the linguistic differences between the production of children and adults are considered [13]. According to such values analyzed in the literature, the appropriate comparisons are as follows:

Regarding the sustained emission of the vowel [a], all children showed improvements in the values of F1 and F2 in the post-test, since we observed changes in the amplitude of the vowel triangle due to changes in [a]. For the sustained emission of the vowel [i], the children in the pre-test had F1 values, despite the normal values. However, the post-test showed values closer to those proposed by the study aforementioned[13]. Regarding F2 values, all participants showed progress, despite the young age, including Marta. Regarding the sustained emission of the vowel [u], Renata and Cláudio had F1 values close to normal values in their post-tests. Regarding the F2 values, the children showed improvements in their post-test, especially participant Cláudio, who normalized the F2 values.

As far as the games home screen is concerned, calibration information and minimum and maximum settings are required in order for them to be customized. According to a study[14], if the maximum frequency of the child is different from that considered the average standard of the listener of the same gender and age, it will be necessary to configure minimum and maximum frequency values, which will allow the child to control the object. This should also apply to phases that require intensity adjustments. Therefore, frequency adjustments are essential to bring the voice of the deaf closer to the standard values of the listeners, because *"[...] we will have sufficient spectral content to produce all the sounds of the language, and a voice with greater spectral richness which facilitates intelligibility and consequently oral communication"*[14].

Considering the settings for the intensity training phases, all the children demonstrated difficulties for the frequency of 50 dB to 75 dB in the balloon stage, a range that represents values closer to those of normal speech intensity. Therefore, when considering the altered control over the level of speech intensity of the deaf individual, such values linked to the background noise level will allow configuring a phase more appropriately.

A study that sought to develop a software for speech therapy for deaf children established initial settings similar to those analyzed in the VoxTraining software, including the parameter "grava_ruído", which characterizes the environment's background noise. After this procedure, the software will generate a value in decibel (dB) and the background noise level will be updated and should be used to set the lower intensity (minimum value) of the phase; such value should be set from 5 to 10 dB above the noise level in phases that work intensity; for those that work with the frequency parameter, the lower and upper Fo values should also be fixed after such measurement[14]. Since no type of configuration manual is provided when purchasing VoxTraining, it is not known for sure what the procedure should be performed after measuring the external noise: considering the aforementioned theoretical framework, the silence criterion should be at least 5 decibels. The shooter phase, for example, showed greater sensitivity of the microphone to capture sounds, since, at times, the shot was fired without emission of phoneme/sound, a factor that may be linked to an inadequate configuration.

In short, therapy should begin with broader values of lower and higher F0 (e.g. 100 Hz and 700 Hz) and, during the sessions, the values should range from 5 to 20 Hz. That is, if the individual has F0 values above the target, it should be reduced from 5 to 20 Hz at each session; if the values are below, they must be increased within this range[14].

FINAL COMMENTS

In this study, all children had a late diagnosis of deafness, which, consequently, delayed the subsequent processes of care for the individual, such as delay in cochlear implant placement and insertion in Libras after the critical age of language acquisition. Therefore, the children in this study are in the process of simultaneously acquiring Libras as their mother tongue and oral Portuguese as a second language, as well as have vocal and articulatory alterations consistent with their hearing loss and sensory deprivation time.

The results suggest that the participants are interested in the software, due to the request to repeat the games, and these contribute to a better understanding of the vocal and articulatory exercise to be performed, due to the stimulus of visual feedback.

Despite the limited number of sessions and therapy time, the findings show that working with deaf children using digital games facilitates therapy and improves voice and speech. They also show that technology is only a mediation resource between the therapists, their goals and the individual undergoing therapy. Therefore, no matter how scientifically based the technological resource, it does not exclude the primary role of the speech therapist.

ACKNOWLEDGEMENTS

To the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for its support to carry out this research through the scholarship grante.

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