Original Article

Artigo Original

Software use in the (re)habilitation of hearing impaired children

O uso de um software na (re)habilitação de crianças com deficiência auditiva

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Keywords

Hearing loss
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ABSTRACT

Purpose: To verify the applicability of a software in the (re)habilitation of hearing impaired children. **Methods:** The sample comprised 17 children with hearing impairment, ten with cochlear implants (CI) and seven with hearing aids (HA). The *Software Auxiliar na Reabilitação de Distúrbios Auditivos – SARDA* (Auxiliary Software for the Rehabilitation of Hearing Disorders) was used. The training protocol was applied for 30 minutes, twice a week, for the necessary time to complete the strategies proposed in the software. To measure the software's applicability for training the speech perception ability in quiet and in noise, subjects were assessed through the Hearing in Noise Test (HINT), before and after the auditory training. Data were statistically analyzed. **Results:** The group of CI users needed, in average, 12.2 days to finish the strategies, and the group of HA users, in average 10.14 days. Both groups presented differences between pre and post assessments, both in quiet and in noise. Younger children showed more difficulty executing the strategies, however, there was no correlation between age and performance. The type of electronic device did not influence the training. Children presented greater difficulty in the strategy involving non-verbal stimuli and in the strategy with verbal stimuli that trains the sustained attention ability. Children's attention and motivation during stimulation were fundamental for a successful auditory training. **Conclusion:** The auditory training using the SARDA was effective, providing improvement of the speech perception ability, both in quiet and in noise, for the hearing impaired children.

Descritores

Perda auditiva
Software
Reabilitação de deficientes auditivos
Aplicação de informática médica
Terapia assistida por computador

RESUMO

Objetivo: Verificar a aplicabilidade de um *software* na (re)habilitação de crianças com deficiência auditiva. **Métodos:** A amostra foi composta por 17 crianças com deficiência auditiva, sendo dez usuárias de Implante Coclear (IC) e sete usuárias de Aparelho de Amplificação Sonora Individual (AASI). Foi utilizado o "Software Auxiliar na Reabilitação de Distúrbios Auditivos (SARDA)". Aplicou-se o protocolo de treinamento durante 30 minutos, duas vezes por semana, pelo tempo necessário para a finalização das estratégias que compõe *software*. Para mensurar a aplicabilidade do *software* no treinamento da habilidade de percepção da fala no silêncio e no ruído, foram realizadas avaliações com o *Hearing in Noise Test* (HINT) pré e pós o treinamento auditivo. Os dados foram analisados estatisticamente. **Resultados:** O grupo de usuários de IC necessitou em média 12,2 dias para finalizar as estratégias e o grupo de usuários de AASI em média 10,14 dias. Os dois grupos apresentaram diferença entre as avaliações pré e pós no silêncio e no ruído. As crianças mais novas apresentaram maior dificuldade durante a execução das estratégias, porém não houve correlação entre a idade e o desempenho. Não houve influência do tipo do dispositivo eletrônico durante o treinamento. As crianças apresentaram maior dificuldade na estratégia que envolvia estímulos não verbais e na estratégia com estímulos verbais que treina a habilidade de atenção sustentada. A atenção e a motivação da criança durante a estimulação foram fundamentais para o bom rendimento do treinamento auditivo. **Conclusão:** O treinamento auditivo com o SARDA foi eficaz, pois propiciou melhora na habilidade de percepção da fala, no silêncio e no ruído, das crianças com deficiência auditiva

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INTRODUCTION

The auditory training is one of the methodologies applied for the auditory (re)habilitation of people that use Cochlear Implant (CI) and/or Hearing Aids (HA). This training contributes to the development of auditory abilities that are the basis for oral language acquisition and development[1].

In the case of the hearing impaired, one of the prerequisites in order to initiate an auditory training program is the adaptation of the HA or the CI, because these devices allow that speech sounds become audible. The auditory training does not improve the auditory sensitivity, but the ability to use the available sound information[2].

Among the models of auditory training, the formal model – that uses electroacoustic equipments and/or computers – has been used in individuals with (central) auditory processing alterations and individuals with hearing aids. The aim of this model is to strengthen synapses and promote the formation of new engrams, improving auditory abilities[3].

Researches[4,5] refer that the auditory training using the computer can improve auditory abilities. Using the functional magnetic resonance, studies[6,7] have shown the increase in the activation of different brain areas after training with the software *Fast ForWord*, proving that the computerized training allows neural plasticity.

Authors[8] affirm that the use of the computer in therapeutic intervention is an innovating practice that brings great contributions, because it offers a more attractive training and with the capacity to adjust the stimuli to the communication needs and the interests of the individual. Consequently, this type of intervention will stimulate the individual to meet the therapy program.

Recent researches[8-10] have demonstrated the efficacy of this kind of proposal, as well as the favorable relationship between cost and benefit of the computerized procedures of auditory training. The relationship between cost and benefit is justified by the fact that CI and/or HA users are able to conduct the training at their own home computers and be monitored by audiologists from a distance. In face of this innovative and interactive possibility of use of the computer for auditory training, it is important for Audiology to develop researches that disclose and assure the effectiveness of this practice.

Within this context, this study had the aim to verify the applicability of the "*Software Auxiliar na Reabilitação de Distúrbios Auditivos – SARDA*" (Auxiliary Software for the Rehabilitation of Hearing Disorders) in the (re)habilitation of children with hearing impairment. For this purpose, subjects' performance in speech perception, both in quiet and in noise, were analyzed, as well as their performance on the software strategies, before and after the auditory training.

METHODS

Casuistry

This research was approved by the Research Ethics Committee of the Bauru School of Dentistry (FOB) from the Universidade de São Paulo (USP), under number 078/2009. Children were considered for inclusion in the research if their parents or legal guardians signed the free and informed consent.

Participants were selected from a population of 64 hearing impaired users of CI and/or HA, who attended the Educational Center for the Hearing Impaired (CEDAU) and the Center of Audiological Research (CPA), both from the Hospital of Rehabilitation of Craniofacial Anomalies (HRAC) and the Clinic of Speech-Language Pathology and Audiology from FOB/USP.

Inclusion criteria were: ages between 6 and 12 years; female or male gender; a student connection with the CEDAU or a patient connection with the Clinic of Speech-Language Pathology and Audiology; use CI and/or HA; auditory category six[11]; language category five[12]; availability to participate in both SARDA stimulation and evaluation with the proposed protocol. Children with previously known neurological, psychiatry and psychological diseases were excluded.

After application of exclusion and inclusion criteria, 17 children were selected, ten CI users and seven AASI users.

Hearing in Noise Test (HINT)

To verify the applicability of the software in speech perception development we used the HINT[13], in quiet and in noise, before and after computerized auditory training.

The HINT is a speech perception test that can be performed in quiet or in the presence of competitive noise. This test aims to evaluate the auditory functional capacity, in order to verify how much a patient is able to hear and understand speech in noisy environments[14]. The test adaptation into Brazilian Portuguese and the first research using this version of the HINT was accomplished and published by Bevilacqua et al.[15].

The following parameters were used when the HINT was used in silence: sentences were spoken at 0° azimuth and initial intensity of 65 dB. In the presence of competitive noise, sentences were presented at 0° azimuth and initial intensity of 70 dB, and the noise at 180° azimuth and the intensity of the fixed noise was 65 dB. The acoustic boxes were place one meter away from where the patient was standing.

The result of the test in the silence corresponds to the Sentence Recognition Thresholds (SRT), in which the patient presented 50% recognition of the sentences[14]. In this case, the decrease of the SRT in a re-assessment is considered positive. On the other hand, the HINT result with competitive noise is equivalent to the signal/noise (S/N) ratio, in which the patient recognized 50% of the presented sentences[14]. It is emphasized that a negative S/N ratio or even the decrease of this value between assessment and re-assessment characterizes a better performance of the subject.

SARDA

The SARDA is based on the American software Fast ForWord Language, and its main purpose is to assist audiologists in the treatment of children with auditory processing disorders and/or hearing impairment. The software has the aim to decrease or eliminate learning and language difficulties, in order to improve the children's quality of life. Moreover, the SARDA can be used by teachers, in the school environment, for stimulation of auditory abilities in students that present normal auditory levels[16].

Five of the six strategies that are part of SARDA were put available for the children in this research.

1) Jumping with Dinho the Dolphin (*Pulando com o Dinho Golfinho*): develops the abilities of auditory discrimination, auditory recognition and memory. Non-verbal stimuli are used, with variations of frequency, duration and interval between stimuli[16,17];
2) Singing with Tuca the Toucan (*Cantando com o Tuca Tucano*): approaches the auditory abilities of discrimination and recognition. Verbal auditory stimuli (vowel-consonant-vowel, consonant-vowel-consonant, consonant-consonant-vowel and consonant-vowel) are used, with variations in the intervals between stimuli, in the acoustic expansion, and in the differences between acoustic and articulatory characteristics of vowels and consonants of the Brazilian Portuguese language[16,17];
3) Playing with Ze the Alligator (*Jogando com o Zé Jacaré*): has the purpose to develop the abilities of auditory discrimination and sustained attention. Verbal auditory stimuli (vowel, vowel-consonant-vowel, consonant-consonant-vowel and consonant-vowel) are used, with variations in the intervals between stimuli, in the acoustic expansion, and in the differences between acoustic and articulatory characteristics of vowels and consonants of the Brazilian Portuguese language[16,17];
4) Running with Leo the Lion (Correndo com o Leão Léo): develops the ability of selective attention. Verbal auditory stimuli (sentences and words) are used, with variations in the acoustic expansion of the stimuli, in the acoustic expansion and in the differences of the acoustic and articulatory characteristics of vowels and consonants of the Brazilian Portuguese language[16,17];
5) Animal Memory (Memória Animal): develops the auditory memory, considering that, in this memory game, children can only count on auditory stimuli. Verbal auditory stimuli (consonant-vowel) are used, with variation in their acoustic expansion, as well as in the acoustic and articulatory characteristics of vowels and consonants of the Brazilian Portuguese language[16,17].

The SARDA's strategies have basically the same structure, with a progressive level of difficulty. The *software* has three stages (initial, intermediary, advanced), each stage has four phases (1, 2, 3 and 4), and each phase has three difficulty levels (1, 2 and 3).

The strategies that are part of the software allow the child to accomplish previous training and understand how the strategy works. Anyhow, the children in this study were supervised by an audiologist researcher that, when necessary, helped them for the best use of the training.

The auditory training with children from CEDAU was performed in the center's computer room, and the intervention accomplished with children from the Speech-Language Pathology and Audiology Clinic took place in one of the clinic's therapy rooms. The researcher's laptop computer was used during training, and broad band internet access was offered where the research took place. The training was played in the notebook's acoustic boxes at a comfortable intensity level for the patient.

The SARDA was performed according to the following protocol: applied twice a week, 30 minutes sessions, for the time necessary to accomplish the software's strategies.

It is pointed out that each strategy is automatically liberated by the software for 10 minutes every day, which allowed the training of three strategies per session.

Statistical analysis

Children were divided into two groups, according to the electronic device that they used: a group of CI users and a group of HA users.

It was used: Student's t test for paired data, in order to analyze the results of the pre- and post-training assessments; Student's t test for independent data, in order to compare the results between groups; and Pearson's Correlation test for correlation analyses between the assessments of the groups, the characteristics of the groups, and the time dispensed by the groups for finalization of the strategy. The significance level adopted was of $p<0,05$.

RESULTS

The results show the clinical history of the children that participated of the auditory training with the SARDA (Table 1). There was a difference between the groups of CI users and HA users, regarding the thresholds in free field, indicating better performance of the CI users.

The total time of stimulation was in average of 12.2 ± 3.82 days for the IC children and 10.14 ± 2.73 days for the HA children. The database of the SARDA provided descriptive data of the time taken by CI and HA users to finalize each strategy (Table 2). The number of subjects is different in each task, considering that some children weren't able to accomplish some of the strategies. No difference was found in the comparison between the performances of the groups. Moreover, there was no correlation between ages and audiometry thresholds in free field with the time taken to finalize the games.

The Animal Memory strategy, which trains auditory memory ability, was available for the first four children that accomplished the training. These four children started the strategy, but weren't able to pass the initial stage/phase three. This phase presents 12 cards that are supposed to be paired in ten minutes. This time was not enough for the auditory discrimination of the cards, because the children needed many repetitions. Hence, the researcher opted to withdraw this strategy from the training protocol as soon as the first children presented difficulties.

There was a difference between the HINT assessments before and after stimulation using the SARDA protocol, in both groups. When the groups were compared, no difference was found in the HINT results (Table 3).

Table 1. Characterization of the groups of cochlear implant and hearing aids users

	Chronological age		Auditory age	Audiometry in free field (dB)	
	CI (n=10)	HA (n=7)	CI (n=10)	CI (n=10)	HA (n=7)
Mean	8y 11m	10y 4m	5y 9m	24.38	42.14
SD	2y 10m	1y 0m	1y 11m	4.72	7.42
Median	8y 6m	10y 4m	5y 5m	23.13	46.25
Minimum	6y 0m	8y 3m	3y 7m	20.00	31.25
Maximum	12y 7m	11y 4m	9y 1m	33.75	48.75
p-value	0.240		---	0.000*	

* Significant values (p<0.05) – Students' t test for independent data
Note: HA = hearing aid; CI = cochlear implant; SD = standard deviation; y = years; m = months

Table 2. Time used for finalization of the strategies by cochlear implant and hearing aids users

	Jumping with Dinho the Dolphin (min)		Singing with Tuca the Toucan (min)		Running with Leo the Lion (min)		Playing with Ze the Alligator (min)	
	CI (n=9)	HA (n=6)	CI (n=10)	HA (n=7)	CI (n=10)	HA (n=7)	CI (n=7)	HA (n=6)
Mean	63.82	52.61	55.11	52.34	53.05	43.28	100.26	91.58
SD	26.13	6.21	11.20	9.47	12.45	8.99	24.41	12.96
Median	55.25	52.55	56.29	51.18	55.28	45.12	92.03	92.32
Minimum	35.15	44.92	37.53	37.88	37.45	32.72	75.52	71.43
Maximum	115.58	61.30	69.50	66.23	79.40	58.62	142.48	105.78
p-value	0.326		0.602		0.097		0.452	

Students' t test for independent data (p<0.05)
Note: HA = hearing aid; CI = cochlear implant; SD = standard deviation

Table 3. Sentence Recognition Thresholds and Sinal/Noise ratio in HINT before and after training with SARDA in cochlear implant and hearing aids users

	SRT (dB)				S/N ratio (dB)			
	CI (n=10)		HA (n=7)		CI (n=10)		HA (n=7)	
	Before	After	Before	After	Before	After	Before	After
Mean	62.50	55.28	61.8	55.27	5.19	1.34	5.89	2.43
SD	8.26	4.55	10.16	8.02	5.34	4.45	5.98	5.89
Median	65.70	54.35	59.8	52.8	5.35	-0.10	3.7	2.5
Minimum	48.00	47.20	49.8	47.2	-2.30	-3.30	0.3	-3.7
Maximum	72.60	62.40	77.9	69.1	14.80	11.20	15.7	12.0
p-value	0.004*		0.004*		0.001*		0.0001*	

* Significant values (p<0.05) – Students' t test for paired data
Note: SRT= Sentence Recognition Thresholds; S/N = sinal/noise; HA = hearing aid; CI = cochlear implant; SD = standard deviation

DISCUSSION

The results showed that the group of implanted children was younger and needed more days of stimulation to finalize the games, when compared to the group of children who used HA. However, these differences were not significant. Yet, data showed there was no correlation between the ages of the groups and the time taken to finish the strategies.

When the CI group was compared to the group of HA users, there was a difference between auditory thresholds. However, we believe that the auditory thresholds did not affect the stimulation, since the training was accomplished at a comfortable sound intensity, adjusted by the children themselves, and, also, because there was no difference between the performances of the groups during the auditory training and in the assessments with the HINT.

Children from both groups used a larger amount of time to finish the strategy that used non-verbal sounds (Jumping with Dinho the Dolphin) and the strategy with verbal sounds that directly involved sustained attention (Playing with Ze the Alligator). Moreover, the strategies Singing with Tuca the Tucan and Running with Leo the Lion, both using verbal auditory stimuli, presented less variability in the time taken for finalization, and were more appreciated by children. This difference may be due to the fact that verbal synthesized sounds are easier to work with than non-verbal synthesized sounds, according to the literature[18].

This explains the fact that the non-verbal strategy (Jumping with Dinho the Dolphin) was one of the strategies that took longer to be accomplished (children weren't able to finish it in the given time), and it was the strategy that the children least liked. However, this is not true for the verbal sound strategy Playing with Ze the Alligator. In this last case, we believe that children's attention affected the performance in this strategy.

In the task Jumping with Dinho the Dolphin, all children needed help from the audiologist to finish the stages. In all cases, help was provided in the third and fourth phase of each stage, constituted by 1536 Hz and 2048 Hz stimuli, respectively. It was decreased half-octave for the descendant stimuli, and, for the ascending stimuli, it was increased half-octave to the same value above.

Phases 3 and 4 of the advanced stage were also the ones that brought more difficulties for the children, in which the duration of the stimulus and the interval between stimuli varied closer to 100 ms and 25 ms, respectively. These findings show that the difficulty of the children in phases 3 and 4 of the initial and intermediary stages were due to the frequency worked in each of these phases. On the other hand, the difficulty presented in phases 3 and 4 of the advanced stage, besides being due to the frequency, also showed correlation with the duration and the interval between stimuli.

It should be noted that in a research[16] with ten students who were users of HA with ages between 8 and 15 years, no difficulties were reported for the fulfillment of the strategy Jumping with Dinho the Dolphin. However, the stimulation of these children was carried out using a headphone that did not produce feedback (open and semi-open headphones shell). The headphone allowed that the children received the stimuli near the microphone, with less interference of the environmental noise. This scenario might have generated a difference in the children's perception of the stimuli in the present research, because stimulation was carried out using stereo boxes.

The strategy Jumping with Dino the Dolphin approaches, more directly, auditory temporal processing abilities. Among them, are abilities of temporal order, temporal sequencing and temporal resolution[19]. A research[20] have described a progression in the performance on the Duration Pattern Test – temporal sequencing and ordering abilities – as the children grow older for verbal and non-verbal responses of CI users and children with normal hearing from 7 to 11 years old. The results of the studies might explain the reasons why all the children presented greater difficulties in phases 3 and 4 of the advanced stage of the strategy Jumping with Dinho the Dolphin. It is believed that the test used in the previous study, as well as the strategy Jumping with Dinho the Dolphin, require the same abilities.

Other authors have also stated that the intensity of the stimulus affects the temporal resolution performance[21,22]. With this, it is important to question whether the comfort intensity determined by the children was enough so they could present a better performance in this activity.

Discussions about the intensity of the stimulus used in the computerized auditory training deserve prudence and attention. It is not possible the standardization of the intensity in the software, because the determinate pattern can be uncomfortable for some children. This variable was not controlled in this study, and we believe that further studies might have the same difficulty when it comes to controlling the variable intensity. Like the present study, other researches have referred that the intensity used during the computerized auditory training was that which was comfortable for the patient[4,5,19,23].

The strategy Playing with Ze the Alligator, in both groups, was one of the strategies that presented the greatest standard deviation in the time of execution, even presenting verbal stimuli. This was also one of the strategies that needed greater therapeutic interference. Such variation might be justified by the fact that this strategy trains sustained auditory attention, an ability that is directly linked to the child's interaction and focus during the training. Based on the observations of the researcher, it was found that children presented greater difficulty in this strategy, since it demands attention maintenance for a longer period of time, as well as difficulty in the perception of the distracter syllable.

The difficulty in the perception of the distracter syllable occurred mainly in the levels 2 and 3, in which, except for phase 1, stimuli are composed of consonant-vowel and are marked by the difference of articulatory point and voicing, respectively. The strategy Playing with Ze the Alligator wasn't performed by the three younger children in the CI group. We believe that the non achievement of this task happened for two reasons: difficulty in the auditory recognition of the shift of the stimulus and, consequently, longer time taken to respond to the stimulus – which was considered error by the software and hindered the promotion to the next phase; and the children's difficulty to keep attention during the execution of the strategy. It is pointed out that, in this strategy, attention is the target of the training.

The time of attention of younger children is restrict[3]. In face of that, it is necessary and important to deepen the discussion regarding the attentional behavior of younger children. The maintenance of attention is fundamental for the children to be able to inhibit irrelevant stimuli, but this function is difficult when the pre-frontal area is immature[24]. Literature also refers that, between 9 and 12 years of age, the mechanisms of selective attention are mature, but the mechanisms of response inhibition are still immature[24]. Hence, it is believed that the younger children were not able to accomplish the Playing with Ze the Alligator strategy due to maturational issues, mainly because they are younger than the sample studied in the mentioned study. Moreover, researches[24,25] have referred that the attention ability becomes more efficient with age.

For some authors[1-3], many times the informal auditory training is the right kind of training for younger children that don't adjust to a directed intervention, due to the attention span or even motivation reasons. It is important to point out that it was unanimous among the children the fact that the strategy Playing with Ze the Alligator was the most challenging and less appreciated, not only because it was difficult to keep paying attention during the training time, but also because of the time taken to execute it. Because it is a sustained attention strategy, the phases took about ten minutes to be completed.

In the group of HA users, one of the children was not able to accomplish the strategies Jumping with Dinho the Dolphin and Playing with Ze the Alligator, even being older than the average. We believe that this result is related to the child's characteristics. Even fitting in the inclusion criteria, she presented worse hearing thresholds and worse oral language performance, when compared with most children in the group. Moreover, she presented the greater difficulty for attention maintenance.

The strategies Singing with Tuca the Toucan and Running with Leo the Lion were the most appreciated by children, and presented less variability in the standard deviation when compared to the other tasks. In the case of these two verbal strategies, the appreciation and the less variability can be explained by the structure of the auditory training, which presents expanded stimuli. The expanded speech is referred as a facilitator for auditory training, since it supplies greater acoustic hints for phoneme discrimination. Moreover, synthesized stimuli are easy to understand, when compared to non-verbal stimuli[18]. Hence, it is believed that these two strategies presented less variability and greater appreciation of the children because they increased the difficulty of the verbal stimuli with training.

In the strategy Running with Leo the Lion, the vocabulary verification of the children facing the figures presented in the strategy was fundamental so there was no loss in the performance during its progress. The figures were presented to the children on the first day of stimulation.

The Animal Memory strategy was available for the first four children that accomplished the training. Those children, however, were not able to pass beyond the initial stage/phase 3. This phase presents verbal auditory stimuli (consonant-vowel) marked by the difference in articulatory mode, articulatory point and voicing, with expansion of 100% and 12 cards to be paired in ten minutes. This time was insufficient for the children to be able to accomplish the auditory discrimination of the cards, because they needed several repetitions to find the right pairs. It is emphasized that, in the initial studies with SARDA (during its development), this strategy was not available. For this reason, researchers hadn't had previous experience with this task.

Hence, it is important to observe and adequate the auditory training to the development of auditory abilities and to the children's age. Authors have referred that it is very important that the auditory training contemplate auditory abilities adequate to the subject's age[1,3,26].

During the stimulation, two aspects left the children unmotivated: tiresome due to the duration of therapy, since the protocol took 30 minutes of training using the SARDA; and despondency towards the negative feedback of the software, such as the number of animations in the elapse of the training, the reference to the mistake when the children answered incorrectly, and the controlled duration of the strategy (in some situations the time of the strategy ran out when the child was about to finish the phase).

To this end, motivation strategies were applied by the researcher: building a scoring table to be filled by the children; distribution of free samples (stickers, armbands and pens) when the children completed a specific number of phases; use of other online games that did not involve auditory abilities in the last few minutes of therapy; drawings and games that dealt with writing and the theme of the strategies; and strategies of the puzzle game created by SARDA.

Specifically in the schedule of the animations and the time, the researcher was not able to interfere, considering that these variables are set by the software itself. However, because the software might be used in research, the authors made a commitment to provide reports regarding software updates or repairs to the administrative team of the SARDA.

Regarding the time of therapy, the use of closed protocols is important to prove the efficacy of computerized auditory training. However, it is important that, in clinical practice, the auditory training is accomplished during the time the child is paying attention and motivated. It is fundamental that the audiologist has a good perception when choosing the protocol and when creating motivation strategies. Authors[27] have commented that the level of attention is directly influenced by the meaning of the information, that, when related with personal interests, they are more prone to receive attentional resources.

Another important consideration is about the layout of the strategies. Authors[26] have referred that the design of the game must be appropriate to the age range, and that in the case of children with hearing impairments, the computerized training must be playful, with an appealing design and proper audio-visual tasks. Thus, we can observe that the drawings and the general context of the SARDA (ecological park) were appealing to children, because they made positive remarks about it.

It is important to point out the fact that the SARDA has an online data base presents many facilities, among them the strategy programming, the possibility to access the game in different computers without the need of installation drives, and the availability of the auditory training at home, monitored by a distance. However, some disadvantages were observed regarding the need for high-speed stable internet connection, and the dependency of the functioning of the software's server and the UNIVALI internet network.

There was a difference between both assessments using the HINT, in quiet and in noise, before and after training. This difference might be due to the fact that the SARDA is composed by strategies that seek the development of auditory abilities based on: non-verbal stimuli manipulated for duration, frequency and interval between stimuli, with progressive increase of difficulty level; and verbal stimuli manipulated based on the acoustic expansion of sentences, words with and without meaning, vocal syllables and phonemes that, along the stages, become closer to the natural speech pattern. These characteristics of the SARDA are referred by some authors as essential for the training of auditory abilities, explaining the improvement of the children's speech perception after training.

Authors have clarified that the use of computer allows control over the presentation and manipulation of the parameters of frequency, duration, interval between stimuli, and intensity of the auditory stimulus, which allows the training of auditory abilities[3,18]. The manipulation of verbal sounds in the auditory training is an important parameter that allows the development of auditory abilities[18]. Yet, the expansion of acoustic hints might facilitate the phonological discrimination and comprehension, because they involve temporal manipulation of the stimulus[28].

The gradual progression of the difficulty of the tasks[3,18] and the training of the same ability in different strategies promote the development of auditory abilities[3]. These statements corroborate the results obtained in the assessments using the HINT. As mentioned before, the structure of the SARDA follows a hierarchy of difficultness and allows that the same auditory ability is worked in different strategies.

The improvement of the speech perception ability in quiet and in noise after stimulation using the software might be justified, because authors[3] have assured that auditory training is a set of conditions and/or acoustic tasks that are determined to activate auditory and correlate systems and to modify the neural basis and auditory behaviors. Moreover, the auditory training promotes neuronal modifications and the reorganization of the central auditory system[29].

It is emphasized that all participants in the present study were enrolled in speech-language therapy twice a week, along with the SARDA intervention. This variable was not controlled because it is believed that the use of computer in therapy is a tool that helps the speech therapist and audiologist in the training of the child's auditory abilities. This equipment allows the manipulation of different parameters that cannot be controlled during traditional therapy, and can be used outside the therapeutic setting.

The studies mentioned and the results presented in this manuscript show the applicability of the auditory training. However, the descriptive data of this research suggests that the use of the software must be auxiliary in the speech-language pathology and audiology intervention, and not a substitute, since the orientation and intervention of the professional speech-language therapist during the application of the SARDA was essential.

CONCLUSION

The *Software Auxiliar na Reabilitação de Distúrbios Auditivos – SARDA* (Auxiliary Software for the Rehabilitation of Hearing Disorders) presented applicability in the training of auditory abilities of hearing impaired children, promoting improvement in the speech perception ability in quiet and in noise after the stimulation. Moreover, it is a tool that awake children's attention, because it uses the computer as means for the auditory training. The SARDA allows the speech-language pathologist and audiologist to set and to monitor each child's auditory training through its database, which is an important and differential point of the software.

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