The effect of bottom-up and top-down auditory program training on the development of children's auditory processing skills

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Abstract
Although there have been several previous investigations on the role of auditory training for the development of auditory processing skills, it still remains unknown whether children with auditory processing difficulties can get improved auditory skills after exposure to a multi-modal training experience comprising both visual and tactile stimuli. The present study, therefore, attempted to use electronic game applications to foster the auditory processing skills of children who suffer from deficits in their listening abilities. For this purpose, the Listening Inventory for Education (LIFE) questionnaire was administered to the potential number of learners and those learners scoring below the mean were selected as the participants. Children were then assigned to one of two experimental groups: bottom-up (n = 15) and top-down (n = 15). Each group was required to complete a training program on an iPad, using the Auditory Workout app for top-down training and Auditory Processing Studio app for bottom-up auditory training. Their progress was recorded through their responses to the LIFE questionnaire. Results were then analyzed quantitatively through the use of an independent samples t test. Findings revealed the significant effectiveness of both bottom-up and top-down approaches in bring about enhanced auditory skills; results are further discussed with respect to the existing literature.

Keywords: auditory processing difficulty, bottom-up, top-down, electronic game applications

Introduction

Auditory processing difficulties (APD) can potentially influence the way that individuals are able to understand the sound, listen to signals, or listen to language production in background noise (Jerger & Musiek, 2000). These challenges can significantly have an influence upon a child's skills to learn, particularly in the classroom context where a one-on-one teacher help is restricted. The group of children who go through auditory processing difficulties is distinct in nature with respect to the differences in observed listening and learning concerns in each child and the likely changes in physiological factors.

Auditory training has been proposed as a method to fill this gap, and has brought about effective outcomes in previous controlled experiments (Bellis & Anzalone, 2008; Moore, Rosenberg, & Coleman, 2005; Moore, Halliday, & Amitay, 2009). However, there is restricted evidence for direct remediation of auditory skills transmitting to advantages in daily listening and communication contexts (Moore et al., 2009). Furthermore, it is unknown whether children with auditory processing difficulties can take advantage of a multi-modal training approach that consists of both imagery and tactile stimuli (Moore et al., 2005; Moore et al., 2009).

In recent years, with the surge of technological developments, there has been a rise in the appearance of several applications, or app, games produced that are aimed at specifically rehabilitating auditory processing difficulties and being research-oriented (Virtual Speech Center, 2013). These games are accessible on hand-held iPad tablet computers by any consumer with no need for consultation being required from an expert, speech-language therapist, or other expert in the field. While these app games might be useful for children with APD, they have not been systematically subjected to measurement for efficacy. The format of an app game on a tablet computer contributes appropriately to the multi-modal training approach by including both visual and tactile stimulus modes together with auditory. As a result, the purpose of this study was to assess whether children with auditory processing challenges could take advantage of the interactive, multi-modal training approach making use of both the bottom-up and top-down approaches.

Review of the Literature

Auditory Processing

The name auditory processing is related to the processes the central auditory system employs to analyze and interpret an auditory signal (Bellis, Chermak, Weihing, & Musiek, 2012). Traditionally, there were discrepancies with respect to the definitions of auditory processing abilities and auditory processing deficits. Four points were underscored to not have concordance within the APD field – basic science, assessment, communication issues, and clinical factor (ASHA Task Force on Central Auditory Processing Consensus Development, 1996). In 1993, ASHA attempted to provide a discussion and resolve these issues.

The ASHA (ASHA Task Force on Central Auditory Processing Consensus Development, 1996) definition of auditory processing skills included:

●sound localization
●auditory discrimination
●auditory pattern recognition
●temporal aspects of audition (resolution, masking, integration, and ordering)
●and reduction of speech perception with competing or degraded acoustic signals as central auditory processes

ASHA's 1996 outline has been utilized in a report published in 2005, making an outline of new findings (ASHA, 2005). The ASHA description has become mostly applied, but the disagreement still continues with regard to the determination and management of individuals with deficits in the auditory processing skills.

In the past, empirical research concerning the auditory processing problems mostly involved adults with acquired neural injuries, such as tumors in the auditory nervous system and traumatic brain injury, and tests of auditory processing were designed in order to evaluate the functional auditory processing skills of these individuals and to specify the injury and its location (Musiek, Pinheiro, & Wilson, 1980; Musiek & Pinheiro, 1987; Noback, 1985). It was quickly demonstrated that children with interaction problems that showed identical symptoms should also be evaluated for central auditory dysfunction (Griffiths, Bamiou, & Warren, 2010; Jerger & Musiek, 2000; Pinheiro, 1977; Willeford, 1985). As a result, the field has moved from a view of disorders in auditory processing only with respect to neural damage, and now appreciates that brain injuries might have various processes in different people. There appears to be three main groups in which APD takes place – individuals with acquired brain injuries, older adults with auditory processing decrease due to aggravating aging in the auditory system and small hearing loss, and children with developmental disorders (Bellis, 2003; Kraus & Anderson, 2013). Children with developmental APD are especially important since this can exert negative impacts on learning and communication capabilities (Cacace & McFarland, 2009; Sharma et al., 2006; Sharma, Purdy, & Kelly, 2009).

Cognitive Training

The study by Schochat et al. (2010) indicated that the children's performance in behavioral tests of auditory processing was improved after training. Overall, the current literature on auditory training in children with APD or learning disorders is limited and unclear (Wilson et al., 2013). Fey et al. (2011) critically examined the literature to address this void of information regarding auditory training effectiveness. They found that the results lacked quality, particularly with respect to a lack of blinding of testers, an absence of random sampling, few evaluations of statistical significance or precision, and limited patient monitoring during training (Fey et al., 2011).

Another significant issue is the rise of cognitive training programs especially electronic ones. Cognitive training programs, such as those developed for working memory, have led to a large number of media coverage attempts with respect to their applicability for a wide range of individuals and availability in new technology formats, such as apps. While there is still debate around their efficacy (Melby-Lervag & Hulme, 2013), these programs have been showing some promise for improving academic achievement for learners (Alloway, Bibile, & Lau, 2013; Khezrlou, 2018; Khezrlou, Ellis & Sadeghi, 2017). There have been recent studies that explored the educational results for 10-11-year-old children after in-classroom training for 10 weeks through Dr. Kawashima's Brain Training game (Miller & Robertson, 2010; Miller & Robertson, 2011). Two groups were compared in this study – one group that was exposed to the rain Training game and a control group – for measures of mental computation skills and self-perception. Results indicated that although both the Brain Training and no-treatment groups could enhance their speed and accuracy in the Number Challenge test throughout the testing period; the gains were significantly higher in the Brain Training group (Miller & Robertson, 2011). The Brain Training group also represented a small but significant development in their overall attitude towards school as measured by means of the Marsh's Self-Description Questionnaire (Miller & Robertson, 2011).

At the moment, the specification of auditory processing skills is crucial to foster children's auditory skills specially through advanced tools and training programs. One way is to use bottom-up and top-down training.

Bottom-up versus Top-down Training

There are different perspectives with regard to the best and most effective approach to auditory training that can lead to the most positive change. There are two training modes that are discussed in the literature: bottom-up and top-down. Top-down and bottom-up approaches to auditory training have been overviewed in several studies and books (e.g., Bellis, 2002; Chermak, 2007; Musiek et al., 2007), and each we discuss here.

Bottom-up training is concerned with the use of particular auditory skills for development by enhancing neuroplasticity (Bellis, 2003; Bellis & Anzalone, 2008). Primarily, auditory skills that an individual is weak in need to be particularly identified by the employment of a battery of tests that address the different skills (Musiek et al., 2007). After the identification of the weaknesses, specific auditory training activities can be utilized in order to enhance these skills. There are many different training activities that can be used for any single auditory processing deficit, and Bellis and Anzalone (2008) present a great list of several formal and informal activities for many different deficits. Occasionally, an integration of formal and informal approaches is most welcomed to prevent boredom and expand skill generalization (Musiek et al., 2007). Bellis and Anzalone (2008) present an instance of an eight-year old boy with APD who demonstrated deficits in processing of low-pass filtered speech test, competing sentences, and dichotic listening. Specific auditory training for this child consisted of speech-sound discrimination, phonological awareness, and speech-in-noise activities together with computer-based Earobics training. The results revealed significant progress in all of the impaired auditory processing skills notified after 12 weeks of training (Bellis & Anzalone, 2008). Bellis and Anzalone (2008a) report another example of a 14-year old girl who was exposed to auditory processing deficits and competing sentences test after a traumatic brain injury (Bellis & Anzalone, 2008). In addition to the environmental enrichment and compensatory strategies training, particular auditory training encompassed discrimination training for progressively difficult tone sequences varying in frequency and duration, as well as prosody and speech pattern training (Bellis & Anzalone, 2008). The results were also positive for this instance.

As opposed to the bottom-up training, the top-down strategies try to create active listening skills and augment cognitive processes. Top-down activities address three areas – cognitive skills (auditory attention and memory), metacognitive skills (problem solving, reasoning, persistence, and motivation), and metalinguistic (vocabulary, phonological awareness, prosody, and auditory closure) (Bellis & Anzalone, 2008; Chermak, 2007). The tasks that can be carried out to foster these skills might entail training for effective use of memory and attention, efficient use of metalinguistic information, speech-reading, listening and learning strategies, information chunking, and problem-solving skills (Bellis & Anzalone, 2008; Medwetsky, Riddle, & Katz, 2009). An outstanding technique and a starting point for compensatory strategy training is active listening techniques, which make the child sit up straight, have no movement, and watch the speaker (Bellis & Anzalone, 2008; Bellis, 2002). This strategy is effective for the listening skills of all children, and so is consistently instructed at school from an early age. Many of these strategies are often utilized by hearing impaired individuals to compensate for their hearing loss, and they are simple and inexpensive to teach (Medwetsky et al., 2009).

Several scholars suggest the use of both top-down and bottom-up approaches for maximal assistance through development of complementary skills (Bellis, 2003). Sharma et al. (2012) concluded that bottom-up and top-down training approaches were both accompanied with improving FPT performance.

In order to test these assumptions, the present study examined Iranian EFL learners' auditory processing improvement after the exposure to bottom-up and top-down training. The following research question was addressed:

RQ: Is there any statistically significant difference between top-down and bottom-up training regarding Iranian EFL learners' auditory processing deficit improvement?

Method

Participants

A total number of 30 children from two English language institutes in Boukan were selected for this study. The children were asked to fill out the Listening Inventory for Education (LIFE) Questionnaire. Those students that got a score below the mean score were considered to be in need to auditory training. The selected children's age varied from 10 years to 12 years. They were both male (n = 12) and female (n = 18) and they had an English learning experience from the age of 4 to 12. Selected participants were assigned into two experimental groups of bottom-up (n = 15) and top-down (n = 15). All of the written parental consent was obtained before the study and starting the auditory training (Appendix A). Each child was required to fill out a pre-training questionnaire and one after the training. Because not all of the children's parents had ipads, the researcher provided additional iphones or ipads with the installed app to practice the training with children.

Instrument

Listening Inventory for Education (LIFE)

The pre- and post-training changes were recorded through asking the children to complete the Listening Inventory for Education (LIFE) questionnaire (Anderson & Smaldino, 1999). The LIFE questionnaire is a 13-question pictorial questionnaire which requires children to answer questions about their listening abilities in the classroom and school environments (Appendix B). It was developed to be used with children aged 6 years and older (Anderson & Smaldino, 1999). The questionnaire was translated in this study to be useable with children all of whom did not know English. It uses a five-point Likert rating scale with 'smiley face' pictorial correlates as shown in Figure 1.

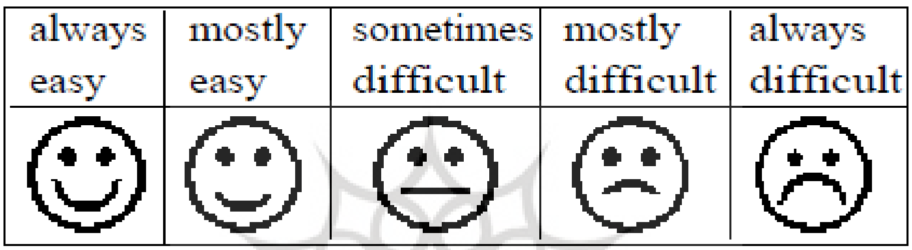

Figure 1. *Five-point visual Likert scale used in the children's Listening Inventory for Education (LIFE) questionnaire*

Children were required to think about their classroom, school, and home experiences when they were filling out the LIFE questionnaire. Average question scores are indicated for the LIFE questionnaire instead of exact total scores due to the fact that a few questions were not applicable to the educational context of some children and were as a result not responded. An average question score was measured by calculating the scores for all answered questions and dividing this number by the total number of questionnaires answered. So, the average question score is between one ('always easy') and five ('always difficult').

Auditory Training

Children were assigned to one of two groups, with each group asked to carry out a training program on an iPad, by means of the Auditory Workout app for top-down training and Auditory Processing Studio app for bottom-up auditory training. Children's parents used the internet in the language institute to download this app to their iPad or iphone. The children were instructed to play the training games on the app they were provided with for 20 minutes each day, 4 days per week, for 2 weeks following the beginning of the training. The length of the training program was decided according to the previous studies and reviews of training methods (Fey et al., 2011; Miller & Robertson, 2011; Musiek et al., 2007; Tallal et al., 1996). Familiarization with the apps was carried out at the pre-training session with all children and their teacher.

Training tasks in the Auditory Processing Studio app asked children to select a picture from two options that showed what was talked (Figure 2), specifying if two spoken words were equal or different (Figure 3), and verbally filling in the gaps in a statement.

Figure 2. *picture selection*

Figure 3. *Same or different words*

For the Auditory Workout app, after the game was played, a basketball coach (see Figure 4) intended to define the general structure of the task and reward system and asked the participants to try their best. The training task then started. In all of the training activities, the children were asked to listen to the set of particular commands and recognize the cue image given, then select the most proper picture from the available five options (Figure 5). An accurate response could assist the participant gain a basketball. The children were asked to repeat a task if an incorrect answer was provided by them.

Figure 4. *Structure of task explanation*

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Figure 5. *Choosing the best picture*

Results

The performance on the bottom-up and top-down training as reflected in the answered questionnaires were analyzed quantitatively through the use of statistical package for social sciences (SPSS) software. Independent samples *t* test was performed to provide an answer to the research question.

First, the scores were analyzed to ensure the assumptions of normality. The results of Kolmogorov-Smirnov tests are presented in Table 1.

Table 1. *Results of K-S Test*

		posttest	pretest
N		30	30
Normal Parameters[a]	Mean	47.3000	21.2333
	Std. Deviation	1.029951	6.40949
Most Extreme Differences	Absolute	.083	.160
	Positive	.066	.160
	Negative	-.083	-.085
Kolmogorov-Smirnov Z		.454	.874
Asymp. Sig. (2-tailed)		.986	.430

a. Test distribution is Normal.

The results of Kolmogorov-Smirnov tests show that the scores are normally distributed ($p > 0.05$). Having ascertained the assumptions of independent samples *t* test as a parametric test (i.e., the normality of data), the next step was to conduct the *t* tests. First, the results of independent samples *t* test for the pretest scores of both experimental groups are presented in Tables 2 and 3.

Table 2. *Descriptive Statistics of Pretest Scores*

	training	N	Mean	Std. Deviation	Std. Error Mean
Pretest	bottom-up	15	20.06	7.55	1.95
	top-down	15	22.40	5.01	1.29

As the mean and standard deviation scores in Table 2 show, there are very nuance differences between the bottom-up (*M* = 20.06, *SD* = 7.55) and top-down (M = 22.40, SD = 5.01) group learners' performance in the pretest. However, in order to get more accurate and reliable results, an independent samples *t* test was run, the results of which are displayed in Table 3.

Table 3. *T test Results of Group Differences in Pre-test*

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
pretest	Equal variances	4.15	.05	-.99	28	.32	-2.33	2.34	-7.12	2.46

	assumed									
	Equal variances not assumed			-.99	24.32	.32	-2.33	2.34	-7.16	2.49

The results of independent samples *t* test show statistically insignificant difference (*t* (28) = -0.99, *p* = 0.32) between the bottom-up and top-down experimental groups in their auditory processing skills.

In order to examine whether there was any significant difference between the bottom-up and top-down experimental groups after the relevant trainings, an independent samples t-test was run. First, the results of descriptive statistics are shown in Table 4.

Table 4. *Descriptive Statistics of Post-test Scores*

	training	N	Mean	Std. Deviation	Std. Error Mean
Posttest	bottom-up	15	45.8667	11.13467	2.87496
	top-down	15	48.7333	9.55784	2.46782

As Table 4 shows, there are not mean differences between the bottom-up (M = 45.86, SD = 11.13) and top-down (M = 45.73, SD = 9.55) group participants' performance in the post-test, both of which equally improved from their pre-test performance. The results of *t* test are indicated in Table 5.

Table 5. *T test Results of Group Differences in Post-test*

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Posttest	Equal variances assumed	.006	.93	-.75	28	.45	-2.86	3.78	-10.62	4.89
	Equal variances not assumed			-.75	27.37	.45	-2.86	3.78	-10.63	4.90

The results of independent samples *t* test show statistically insignificant differences (t (28) = -.75, *p*= .45) between the experimental participants in the posttest scores. Therefore, the findings confirm the equal effectiveness of both the bottom-up and top-down practices in bringing about enhanced auditory processing skills by learners with processing difficulties.

Discussion

The present study was carried out with the purpose of investigating the effectiveness of a bottom-up and a top-down game application on children's development of their auditory processing skills who had low levels of auditory processing capacities. The results of analysis indicated the effectiveness of both approaches in bringing about enhanced posttest scores. On the whole, the use of top-down and bottom-up approaches in separation is suggested for the elimination of auditory processing deficits and an improvement in the listening skills. This finding gets support from the existent studies (Chermak, 1998; Malmierca, & Hackett, 2010; Miller & Robertson, 2011; Nittrouer, Caldwell-Tarr, & Lowenstein, 2013).

It is presumed that the processing of auditory signals asks for the integration of information from both bottom-up and top-down processing (Moore, 2012). In a similar way, auditory training can address either bottom-up or top-down systems.

The two games used in this study are supported as targeting each of these processes in isolation. The Auditory Workout game is defined as taking a 'top-down' approach, where training of general skills such as auditory attention and memory pursues the purpose of generalizing to more specific auditory processing skills and language capacities. The Auditory Processing studio game takes a 'bottom-up' approach, where there is particular training for auditory processing skills, such as auditory discrimination, auditory closure, and phonological awareness.

While these games are defined in this way by the manufacturer, it is still unclear to what extent these games genuinely are either 'top-down' or 'bottom-up' separately. Attention could be instructed with either game, simply by means of the requirement for consistent training and the focus needed to achieve the training for the majority of children (Mukari, Umat, & Othman, 2010; Murphy & Schochat, 2013). Both games have a great amount of linguistic content and could be perceived to be training higher-order language skills. It could be that very small distinctions were observed between the two groups due to the fact that the games they played were more similar than expected.

The Auditory Workout game does seem to address memory and sequencing with its tasks. Most of the tasks ask the listener to listen to and concisely hold in memory a sequence of instructions in order to be able to spot the accurate images or sequence of pictures. An alternative to the Auditory Processing Studio game for training of bottom-up skills could be to have a game with non-verbal rather than verbal stimuli, which would increase verbal language skills after instruction (Murphy & Schochat, 2011). This disregards the loading on higher-order language skills and principally addresses the bottom-up auditory discrimination skills. However, it is still not clear whether this would address the main concerns of parents of children with auditory processing difficulties, which are frequently learning issues.

Conclusion

The results of this study illuminated the potential of both bottom-up and top-down training on children's auditory skills. There were however a number of limitations in this study that need to be considered in the interpretation of the results. The scope of this study was limited by time restrictions and the small group of children from which to select potential participants. Further studies are encouraged to be re-designed and replicated with several modifications to more adequately evaluate whether these games can be functionally advantages for children's auditory processing difficulties. The future investigations are thus encouraged to test all these ambiguities in the field and also to provide better insight on the long-term elimination auditory processing difficulties by adopting a longitudinal and qualitative design. As a second limitation, no control group was used in this study which can be compensated in future research attempts. A control group that takes part in a training program with a non-auditory app needs to be included. Furthermore, more studies are needed to evaluate the subject with other children in different contexts who have different characteristics, first languages, socioeconomic background and learning styles.

References

Alloway, T. P., Bibile, V., & Lau, G. (2013). Computerized working memory training: Can it lead to gains in cognitive skills in students? *Computers in Human Behavior, 29*(3), 632-638.

Anderson, K., & Smaldino, J. (1999). Listening Inventories for Education: A classroom measurement tool. *The Hearing Journal, 52*(10), 74-76.

ASHA. (2005). *(Central) Auditory Processing Disorders—The role of the audiologist*. Rockville, MD, U.S.A.: American Speech-Language-Hearing Association.

ASHA task force on central auditory processing consensus development. (1996). Central Auditory Processing: Current status of research and implications for clinical practice. *American Journal of Audiology, 5*(2), 41-54.

Bellis, T. J. (2002). Developing deficit-specific intervention plans for individuals with auditory processing disorders. *Seminars in Hearing, 23*(4), 287-296.

Bellis, T. J. (2003). Auditory processing disorders: It's not just kids who have them. *The Hearing Journal, 56*(5), 10-19.

Bellis, T. J., &Anzalone, A. M. (2008). Intervention approaches for individuals with (central) auditory processing disorder. *Contemporary Issues in Communication Science and Disorders, 35*, 143-153.

Bellis, T. J., Chermak, G. D., Weihing, J., &Musiek, F. E. (2012). Efficacy of auditory interventions for central auditory processing disorder: A response to Fey et al. (2011). *Language, Speech & Hearing Services in the Schools, 43*, 381-386.

Cacace, A. T., & McFarland, D. J. (2009). Middle latency auditory evoked potentials: Update. In J. Katz, L. Medwetsky, R. Burkard & L. Hood (Eds.), *Handbook of clinical audiology* (6th ed., pp. 373-394). Baltimore, MD, U.S.A.: Lippincott Williams & Wilkins.

Chermak, G. D. (1998). Managing central auditory processing disorders: Metalinguistic and metacognitive approaches. *Seminars in Hearing, 19*(4), 379-392.

Chermak, G. D. (2007). Central resources training: Cognitive, metacognitive, and metalinguistic skills and strategies. In G. D. Chermak, & F. E. Musiek (Eds.), *Handbook of (central) auditory processing disorder: Comprehensive intervention* (pp. 107-166). San Diego, CA, U.S.A.: Plural Publishing.

Fey, M. E., Richard, G. J., Geffner, D., Kamhi, A. G., Medwetsky, L., Paul, D., & Schooling, T. (2011). Auditory processing disorder and auditory/language interventions: An evidence-based systematic review. *Language, Speech & Hearing Services in the Schools, 42*(3), 246-264.

Griffiths, T. D., Bamiou, D., & Warren, J. D. (2010). Disorders of the auditory brain. In A. Rees, & A. R. Palmer (Eds.), *The Oxford handbook of auditory science: The auditory brain* (pp. 509-542). New York, NY, U.S.A.: Oxford University Press.

Jerger, J., & Musiek, F. E. (2000). Report of the consensus conference on the diagnosis of auditory processing disorders in school-aged children. *Journal of the American Academy of Audiology, 11*, 467-474.

Khezrlou, S. (2018). Form-focused instruction in CALL: What do learners think? *RELC*, 1-17. DOI: 10.1177/0033688217738820

Khezrlou, S., Ellis, R., & Sadeghi, K. (2017). Effects of computer-assisted glosses on EFL learners' vocabulary acquisition and reading comprehension in three learning conditions. *System, 65*, 104-116. http://dx.doi.org/10.1016/j.system.2017.01.009

Kraus, N., & Anderson, S. (2013). The effects of aging on auditory processing. *The Hearing Journal, 66*(1), 36.

Malmierca, M. S., & Hackett, T. A. (2010). Structural organization of the ascending auditory pathway. In A. Rees, & A. R. Palmer (Eds.), *The Oxford handbook of auditory science: The auditory brain* (pp. 9-41). New York, U.S.A.: Oxford University Press.

Medwetsky, L., Riddle, L., & Katz, J. (2009). Management of central auditory processing disorders. In J. Katz, L. Medwetsky, R. Burkard & L. Hood (Eds.), *Handbook of clinical audiology* (pp. 642-665). Baltimore, ML, U.S.A.: Lippincott Williams & Wilkins.

Melby-Lervag, M., & Hulme, C. (2013). Is working memory training effective? A meta-analytic review. *Developmental Psychology, 49*(2), 270-291.

Miller, D. J., & Robertson, D. P. (2010). Using a games console in the primary classroom: Effects of 'Brain Training' program on computation and self-esteem. *British Journal of Educational Technology, 41*(2), 242-255.

Miller, D. J., & Robertson, D. P. (2011). Educational benefits of using game consoles in a primary classroom: A randomized controlled trial. *British Journal of Educational Technology, 42*(5), 850-864.

Moore, D. R. (2012). Listening difficulties in children: Bottom-up and top-down contributions. *Journal of Communication Disorders, 45*, 411-418.

Moore, D. R., Halliday, L. F., & Amitay, S. (2009). Use of auditory learning to manage listening problems in children. *Philosophical Transactions of the Royal Society B, 364*, 409-420.

Moore, D. R., Rosenberg, J. F., & Coleman, J. S. (2005). Discrimination training of phonemic contrasts enhances phonological processing in mainstream school children. *Brain and Language, 94*(1), 72-85.

Mukari, S. Z., Umat, C., & Othman, N. I. (2010). Effects of age and working memory capacity on pitch pattern sequence test and dichotic listening. *Audiology and Neurotology, 15*, 303-310.

Musiek, F. E., Chermak, G. D., & Weihing, J. (2007). Auditory Training. In G. D. Chermak, & F. E. Musiek (Eds.), *Handbook of (central) auditory processing disorder: comprehensive intervention* (pp. 77-106). San Diego, C.A., U.S.A.: Plural Publishing Inc.

Musiek, F. E., & Pinheiro, M. L. (1987). Frequency patterns in cochlear, brainstem, and cerebral lesions. *Audiology, 26*(2), 79-88.

Musiek, F. E., Pinheiro, M. L., & Wilson, D. H. (1980). Auditory pattern perception in 'split brain' patients. *Archives of Otolaryngology, 106*(10), 610-612.

Murphy, C. F., & Schochat, E. (2011). Effect of nonlinguistic auditory training on phonological and reading skills. *Folia Phoniatrica Et Logopedica, 63*(3), 147-153.

Murphy, C. F., & Schochat, E. (2013). Effects of different types of auditory temporal training on language skills: A systematic review. *Clinics, 68*(10), 1364-1370.

Nittrouer, S., Caldwell-Tarr, A., & Lowenstein, J. H. (2013). Working memory in children with cochlear implants: Problems are in storage, not processing. *International Journal of Pediatric Otorhinolaryngology, 77*(11), 1886-1898.

Noback, C. R. (1985). Neuroanatomical correlates of central auditory function. In M. L. Pinheiro, & F. E. Musiek (Eds.), *Assessment of central auditory dysfunction: foundations and clinical correlates* (pp. 7-21). Baltimore, U.S.A.: Williams & Wilkins.

Pinheiro, M. L. (1977). Tests of central auditory function in children with learning disabilities. In R. W. Keith (Ed.), *Central auditory dysfunction* (pp. 223-256). New York, U.S.A.: Grune & Stratton.

Sharma, M., Purdy, S. C., & Kelly, A. S. (2009). Comorbidity of auditory processing, language, and reading disorders. *Journal of Speech, Language, and Hearing Research, 52*(3), 706-722.

Sharma, M., Purdy, S. C., Newall, P., Wheldall, K., Beaman, R., & Dillon, H. (2006). Electrophysiological and behavioral evidence of auditory processing deficits in children with reading disorder. *Clinical Neurophysiology, 117*(5), 1130-1144.

Schochat, E., Musiek, F. E., Alonso, R., & Ogata, J. (2010). Effect of auditory training on the middle latency response in children with (central) auditory processing disorder. *Brazilian Journal of Medical and Biological Research, 43*(8), 777-785.

Tallal, P., Miller, S. L., Bedi, G., Byma, G., Wang, X., Nagarajan, S. S., & Merzenich, M. M. (1996). Language comprehension in language-learning impaired children improved with acoustically modified speech. *Science, 271*(5245), 81-84.

Virtual Speech Center. (2013). Auditory Processing Studio. Retrieved December, 2017, from http://www.virtualspeechcenter.com/Resources/auditory_processing_studio_app.aspx

Willeford, J. A. (1985). Assessment of central auditory disorders in children. In M. L. Pinheiro, & F. E. Musiek (Eds.), *Assessment of Central Auditory Dysfunction* (pp. 239-255) Williams & Wilkins.

Wilson, W. J., & Arnott, W. (2013). Using different criteria to diagnose (C)APD: How big a difference does it make? *Journal of Speech, Language, and Hearing Research, 56*, 63-70.

Appendix A
Consent form

Project title: The effect of bottom-up and top-down auditory program training on the development of children's auditory processing skills

1.The study has been explained to me and my questions answered.
2.I agree to take part in this study.
3.I know I am going to play a listening game on an ipad.
4.No one else apart from my parents will know how I do.
5.I understand that I can stop being part of this study if I choose to.

Name:
Signature:
Date:

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Appendix B
Listening Inventory for Education (LIFE) Questionnaire

1	2	3	4	5	6	7	8	9	10	11	12	13

For Office use only Version A:

Student L.I.F.E[1] UK. Listening Inventories for Education UK

Your name............................... **Your class.............................**

Today's date............................... **Date of birth.............................**

Version A

Instructions:

What do you think it is like to be in the picture below? You have to look at the picture carefully and decide how easy it is to hear the teacher. Draw a cross through the box to show your answer.

For example: If you think it is <u>mostly easy</u> to hear the words the teacher is saying mark the box like this:

always easy	mostly easy	sometimes difficult	mostly difficult	always difficult
☺	☺ (X)	😐	☹	☹

When you have finished the first one turn over the page and complete the rest of the questions. You should try and answer all the questions.

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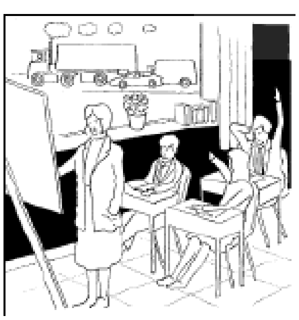
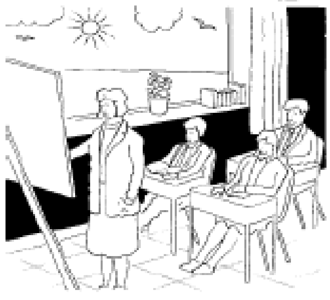


1a. There is traffic outside the classroom.

How well can you hear the teacher's words?

always easy	mostly easy	sometimes difficult	mostly difficult	always difficult
☺	☺	😐	☹	☹

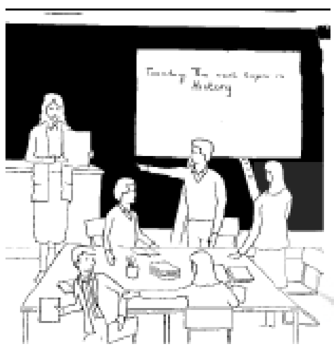
Now turn the page and complete the rest of the questions.



2a. It is a quiet day and there is no noise from outside the classroom.

How well can you hear the teacher's words?

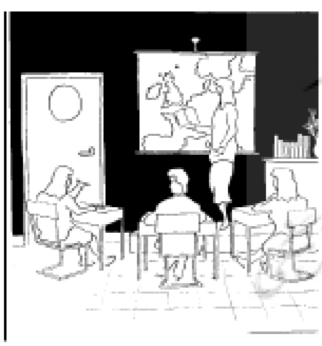
always easy	mostly easy	sometimes difficult	mostly difficult	always difficult



3a. The class have just finished an activity and are tidying up. The teacher says something to the class.

How well can you hear the teacher's words?

always easy	mostly easy	sometimes difficult	mostly difficult	always difficult



4a. The teacher is talking but you cannot see her face.

How well can you hear the teacher's words?

always easy	mostly easy	sometimes difficult	mostly difficult	always difficult

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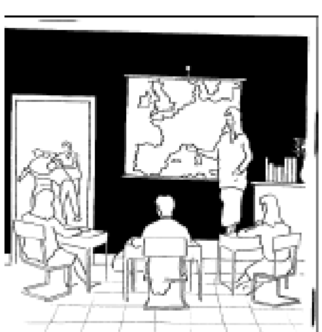

5a. The teacher is talking but there are children making a noise outside your classroom.

How well can you hear the teacher's words?

always easy	mostly easy	sometimes difficult	mostly difficult	always difficult

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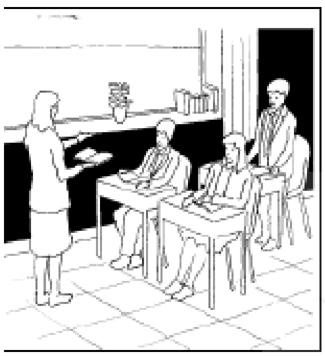
6a. The teacher is talking. Some other children in the class are tidying up their things, moving pencils, paper, chairs, walking around and whispering.

How well can you hear the teacher's words?

always easy	mostly easy	sometimes difficult	mostly difficult	always difficult



7a. The teacher has asked a question to the whole class. Someone is giving an answer.

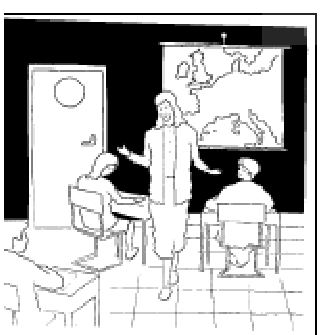
How well can you hear the answer?

always easy	mostly easy	sometimes difficult	mostly difficult	always difficult

8a. The teacher is talking to the class and the overhead projector is on.

How well can you hear the teacher's words?

always easy	mostly easy	sometimes difficult	mostly difficult	always difficult



9a. The teacher is talking and moving around the room.

How well can you hear the teacher's words?

always easy	mostly easy	sometimes difficult	mostly difficult	always difficult

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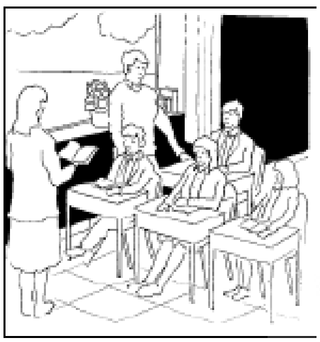
10a. The teacher is giving a test to the class.

How well can you hear the teacher's words?

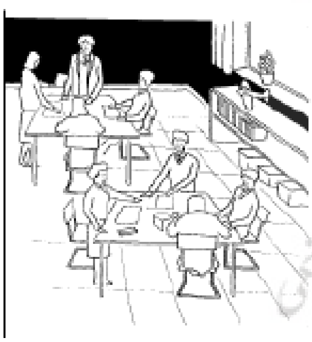
always easy	mostly easy	sometimes difficult	mostly difficult	always difficult



11a. There are two teachers in the class. They are both talking. One of the teachers is talking to you from the front of the class. You need to listen to this teacher.

How well can you hear the teacher's words?

always easy	mostly easy	sometimes difficult	mostly difficult	always difficult



12a. You are all working in groups.

Tell me how well can you hear the words of other children in your group?

always easy	mostly easy	sometimes difficult	mostly difficult	always difficult

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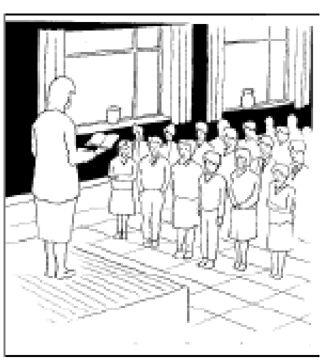

13a. You are in assembly.

How well can you hear the teacher's words?

always easy	mostly easy	sometimes difficult	mostly difficult	always difficult

[1] Based on LIFE by Anderson & Smaldino 1997

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.4a. Have you noticed anything else?

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