Digital-based audio-visual training program for Arabic-speaking adults with hearing aids

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ABSTRACT

Dana Al Wattar, student of the Master in Clinical Audiology and Hearing Therapy developes in her **thesis** a program that enhances auditory and audio-visual speech perception among older adults in Lebanon and the Arab world. It is a unique program as it is one of the first computer-based auditory program being used in the region. Combining that with clinic-based auditory program results in a homogenous and complete training protocol that aims to improve greatly the auditory skills of older adults. The use of hearing aids is one main factor for the success of the training program.

Several methods were proposed in this thesis to develop the optimal auditory training program. The affectivity of each method was studied in this thesis and considerations were taken to the unique case of the Arab world. The optimal training program consists of a combination of computer-based and clinic-based setting that tackles both synthetic and analytic cues using audio-visual training protocol for a period of 6 weeks. The only computer training program that is converted to Arabic is called **Baldi** which used a three-dimensional head to convey the proper way of speech and assists in hearing. This enables us to device the training program around it and strengthen it using one-to-one encounters with the audiologists for further training and immediate feedback.

1. METHODOLOGY

1.1 Program Development Options

The literature describes several approaches to auditory skills training protocols. They all aim at improving the patient's ability in identifying both synthetic and analytic speech, enhancethe individual's ability to pick up the acoustic cues required for acquisition of auditory skills, and improving their speech recognition and retain plasticity (Rao, 2016;Sweetow & Sabes, 2010). Moreover, all of these programs aim at those who wear hearing aids (HA) and have proven that training in auditory skills resulted in improving and refining a very important component of aural rehabilitation, as well as improving auditory sentence identification in noise ability in elderly hearing aid users (Olson, 2010; Ross, 2011; Moradi et al., 2017). The following section briefly describes prominent approaches to auditory and audio-visual skills training.

a) Auditory Training at Home for Adult Hearing Aid Users

Olson (2010) developed an auditory training program based on LACE protocol. The main goal of this training program is to improve the auditory skills as well as behavioral improvements in ability to understand speech in noise right after the program and after the program.

The LACE™ program by Sweetow & Sabes (2010) is a commercially available training program that adult Hearing Aid users can use at home. The study focused on the computerized training program format since it was the only format available at the time that the research was conducted. The computerized format requires users to download software to a personal laptop. The training is comprised of twenty lessons that take approximately 4-weeks to complete. An additional aspect of this training program is that performance can be monitored remotely by clinicians via a secure internet server

Olson (2010) used another version of the program which is the LACE™ DVD format. The DVD training is comprised of ten sessions which take approximately 30 minutes per day, five days per week to complete. The training program takes 2 weeks to complete which is half of the original program. Therefore, participants in this study were evaluated at both the 2-week and 4-week intervals to determine how performance changed over time. To achieve 4-weeks of training, participants completed ten lessons over the first 2-weeks of training and then repeated the same ten lessons over an additional 2-week training period.

The first benefit of this program is that patients are able to train in their home environment rather than receive training in a clinical setting. It helps significantly improve speech understanding in challenging situations such as noisy environments, rapid talkers and competing voices. It improves listening and communication skills by providing lots of helpful hints and communication strategies and it exercises the brain, improve cognitive skills, and increase the speed of processing and auditory memory to enable them to better follow a conversation. Moreover, it provides sentence-based training that is self-paced and adaptive, so that training is neither too hard nor too difficult.

Results of people with auditory problems were measured through an automated version of RSPAN (Olson, 2010). It lets people who have done the training to recall a

series of letters which appear on a screen one at a time and they enter their responses with a mouse click, then people demonstrated readingcomprehension by reading sentences on the computer screen and judging if they were true or false. The third task combined the first and second tasks, so that participants read a sentence, decided if it was true or false, and then saw individual letters on the screen in between sentences. According to Olson (2010, p.48), "Sentences and letters were presented in varying set sizes which ranged from three to seven. For example, if the set size was five, then the participant had to read a sentence, judge if each was true or false and view a letter. This sequence for a set size of five occurred five times. After all the five sentences and five letters had been presented, participants were asked to recall the five letters that they had seen. Letters were selected from a template of 12, pre-selected letters." The test takes around 20 minutes to complete to cover three sets of each set size of sentences. The total number of target letters recalled measures the working memory and the RSPAN is scored from 0 to 75. The higher the score, the better working memory span.

b) Baldi

Baldi is a general-purpose speech/language tutor embodied in a 3D talking head with synthetic and natural speech that has been used in speech training (Alghamdi, 2017). The program produces accurate auditory and visible speech, as well as realistic facial expressions, emotions, and gestures in several languages (Ouni et al., 2003).

Baldi produces reasonably accurate visible speech, as well as realistic facial expressions, emotions, and gestures and is composed of a 3D wireframe with parametrically controlled movements, controllable texture mapping, and internal structures (hard palate, velum, teeth and tongue). The development of the internal structures is important as it improves the visible speech quality and accuracy, and is of great value for pedagogically illustrating correct articulation(Ouni et al., 2003). The analysis of this program showed that improvements were directly related to the duration of time that a subject worked on it.Baldi relies on audiovisual training, which has been shown to be superior to auditory training alone in enhancing auditory perceptual learning (Rao, 2016).

The Baldi training is recommended for as many sessions as possible. It is up to the user to determine the duration for that session. It is recommended for approximately 30 minutes per day, five days per week in average. This is a digital training program therefore an application on Android or Appleare installed on smartphones making it possible to all users to have it on day to day basis and with minimum cost.

1.2. Program Criteria and Selection

A formal auditory training program must meet certain criteria. First of all, and especially during our current times, it must be cost effective for the audiologist and the patients. It must be sufficiently engaging to sustain participation, not too easy and not too difficult or else they will lose interest and the training program won't be effective. The training program must be practical and easily accessible to the clients as it has been proven in the literature review that there is a need to select programs that are digital/computer based with longer duration in order to retain the new auditory skills acquired from the training program. For a program to be successful, it should provide immediate feedback regarding responses to the user and to the audiologist who will then track their

improvements on a day-to-day basis and at the end of the program. Optimally, it should incorporate elements of both bottoms up and top down processing as well as the including the active collaboration of a knowledgeable professional.

As previously mentioned, there are no literature review and studies regarding computer-based auditory program in Arabic for older adults using Hearing Aids. Therefore, the selected training program must be adapted to the conditions of the users who are non-native English speaker and who only speak Arabic.

1.2.1. Language

The only computer based auditory training program for adults available in the world-wide market that is adapted to the Arabic language is Baldi. The main language for this training program is English but Ouni et al. (2003) added new languages through the introduction of new visual phonemes and thedefinition of their articulation and co-articulation. The Arabic language was the main focus as it was extensively studied and was enhanced by comparing it with native speaking Arabic users so that it can be optimized for usage with those with hearing difficulties. The name of the talking head changed from Baldi to Badr so it can reflect its change to Arabic. In their study, the authors got positive results in their experiment of 19 participants where they had a great improvement for the recognizedwords in bimodal synthetic face (54%), which is close tothe performance of the natural face (69%) compared to only uni-modal auditory condition (30%)(Ouniet al, 2003)

1.2.2 Duration

The duration of the training program is very important because users in the Arab world especially in Lebanon are older adults ranging in the age of 60 to 80 years old. It also depends whether they have hearing aids or notand whether it was installed recently or for quite some time. This paper focuses on those with hearing aids and, according to the literature review, a continuous use of the training program is sufficient enough to improve perceptual auditory skills regardless of nature of the training program. According to Moore (2002), trained adults in the timeand level cues for sound localization has shown that the long-term,intensive training is often considered necessary to obtain robustimprovements in auditory skills among older adults. Therefore, the optimal training program for the Lebanese case is a long-term training protocol.

1.2.3. Nature and content of training program

Auditory skills can be learned by practice, and ease of use. That gives the ability to develop effective training interventions based on scientific evidence (Anderson & Kraus, 2013). According to Alghamdi, (2017); Moradi et al., (2017); Ouni et al. (2003); Taylor et al. (2012),the most common and effective training methods used are a combination of auditory and visualfor the optimal training program as well as the inclusion of analytic and synthetic cues for maximizing auditory perception during noise. Alghamdi (2017), proved through studies that Pre- and post-auditory test results showed a significant improvement in recognition scores (1% to 40%, respectively) when using audio-visual training program. Moreover, research findings recommend that these learning methods should revolve around home-based, daily users' activities

and reflect the demands that are required in their performance improvement.

Therefore, the most well-defined program content that covers all these methods will be similar to the content developed by Ouni et al. (2003)which consists of a phone app/computer-based program for individuals called Baldi. The computer-based program which has been upgraded to a phone application and consists of audio-visual with synthetic and analytic cues.This makes it very convenient for users as most of the population have a smartphone in hand and it is accessible all the time. This application is also meant for those with hearing aids (HA) or those with Cochlear Implants (CI) which means that it is accessible for wide range of users with hearing difficulties.

It is a speechreading training which is provided by means of a talking head (Baldi) that can generate speech from text under noise conditions. Speed of speech production can be controlled and provides revealing views of Baldi, such as making the skin transparent to show movements mainly views of the vocal tract (positions of the tongue relatively to the palate and teeth, and facial views of some phonemes) (Ouni et al., 2003). According to Alghamdi, (2017), higher-level representation in a sensory perception pathway (visual) can be utilized to support the acquisition of a low-level representation in another sensory perception pathway (auditory), and that improves speech recognition and reading (see figure 2)

The introduction to an academic master's thesis serves as the inaugural chapter, setting the intellectual stage for the ensuing exploration. Within this preliminary section, the researcher endeavours to explicate the contextual landscape within which the study unfolds. A delineation of the research problem, replete with its broader significance, establishes the *raison d'être* for the undertaken inquiry. This is underscored by a judicious review of pertinent literature, elucidating existing scholarly conversations and identifying lacunae that precipitate the current investigation.

Moreover, the introduction delves into the formulation of research objectives, delineating the specific aims that guide the research trajectory. The theoretical framework, a conceptual scaffold upon which the study rests, is meticulously articulated to elucidate the intellectual underpinnings shaping the inquiry. Importantly, the methodological approach is expounded upon, providing a transparent exposition of the strategies employed in data collection and analysis.

In maintaining the formality intrinsic to academic discourse, the introduction employs a language that befits the gravity of scholarly inquiry. It serves as a scholarly prologue, inviting readers, including students, into the intricate tapestry of the research landscape. As such, the introduction acts as a critical compass, orienting the audience toward the research's intellectual terrain while furnishing a compelling rationale for the pursuit of knowledge encapsulated within the master's thesis.

Source: Adapted from Alghamdi, N. M. (2017). *Visual Speech Enhancement and its Application in Speech Perception Training.* Sheffield: University of Sheffield.

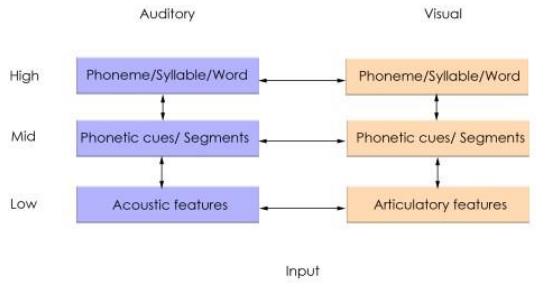

Figure 1. *A higher-level representation in a sensory perception pathway*

1.2.4. Mode of Delivery

Use of computer-based interventions could optimize service provision in the Arab World especially in Lebanon. For instance, computer-assisted aural rehabilitation programs according to the previous literature review in this report save time and improve the organisation of the data on each client (Sweetow & Sabes, 2007). However, there seems to be limited literature regarding use of such technology locally and it also seems that practical training using the programs is limited. On the other hand, older adults in Lebanon still prefer to have someone physically interact with them (audiologist) and get immediate feedback. Therefore, the optimal mode of delivery that would be suitable for the Lebanese case is the combination of both computer/app-based and clinic-based training program. The training program is unified in such a way that is complimentary and covers both top-down and bottom-up cues. The application or the app is available all the time. Hence, it is recommended to have 20 sessions, each session for 30 minutes, for 4 weeks. In addition to that, clinical based meetings with the audiologist shall be done twice weekly for the first 2 weeks then once weekly for the next 2 weeks, totaling 6 sessions of 1 hour each. This allows the user to get feedback of their progress and the audiologist should incorporate stimuli thatvary in difficulty from simple (syllables, words) to more difficult (phrases, sentences and connected discourse).

It will also allow the listener to improve in using knowledge about the location of the target, the voice of the talker, the topic of the discussion, visual information provided by the talker, and by events and objects in the scene, and whatever other sources of supportive context are available to help tune the matching of the speech signal that the listener is trying to understand with stored knowledge about language and the world. (Pichora-Fuller & Levitt, 2012)

Such skills could be trained by audiologists using conversational therapy approaches and involve significant others which in return improves neural plasticity(Anderson & Kraus, 2013).Since it was proven that the long-term learning is necessary for the success of the training program, the audiologist shall meet with the users once per month after the initial 4-week program to check progress. In this way, it would be practical for the audiologist and the user as it will not incur direct costs.

2. PROGRAM SELECTION

From the criteria above, the table below represents the optimal training program for Adults with hearing aids in Lebanon.

Study Characteristic	Modified Badir with Clinic-Based Program
Study Type	Synthetic + Analytic
Training Subjects (age)	Older adults (60-80 years old)
Hearing Loss	Mild-to-severe sloping sensorineural Hearing Loss (SNHL)
Hearing-aid users	Yes
Intervention	Individual computer/app based + Clinical-based training
Training Duration	20 sessions of Badr of 30 minutes each (4 weeks) + 6 sessions of Clinic-based of 1 hour each (2 on first 2 weeks, 1 on the next 2 weeks; and once/month after 1st month)
Listening Condition	Sound field using Hearing aid(s)
Subject Interface	Auditory and Visual display and feedback
Audibility Control	Amplification with own hearing aid
Pre/post-testing	Untrained words and sentences (HINT, CST-A, CST-AV) and Abbreviated Profile of Hearing Aid Benefit (APHAB) self-report scale.
Other measures	Self-assessed task load, hearing-aid satisfaction

Table 1.*Description of the Selected Auditory Training Program*

2.1. Attitudinal and Behavior Outcomes

The main outcome to be achieved from the chosen training auditory program is to induce positive change to the attitudes and behaviors of users. This will reflect positively on patients and on the overall enhancement of the audiologist's training program. The chosen auditory training program will essentially improve the user's ability to hear, listen, comprehend and communicate such improvement back to society. It will also improve quality of life with their family and friends.

Auditory training will provide a systematic framework for users through learning how to recognize speech, how to actively listen and talk to any person they encounter.When this training program is applied, it will improve attentiveness of patient's emotional verbal and non-verbal communications.

2.2. Evaluation

2.2.1. Evaluation of the program

With the effectiveness of audio-visual and auditory only methods to improve and train for better hearing, we need to evaluate the program and the individuals in the program. To evaluate the program, pretest and posttests shall be performed to determine what is suitable and what actually works. Evaluation will take place by using the "HINT" Method. According to Moradi et al., (2017):"Hearing-in-Noise Test was employed to measure participants' auditory sentence identification in noise before the training (pre-test), promptly after training (post-test), and 1 month after training (one-month follow-up).

Multiple factors are taken into consideration when evaluating the program and its individuals. Further tasks regarding auditory and audio-visual training are still performed to determine the efficiency of audiovisual or auditory only methods

The HINT consists of everyday sentences, from minimum three to maximum seven words in length on a background of steady-state speech-shaped noise. The first sentence in each list (in both the practice and experimental lists) was presented at 65 dB SPL and 0 dB SNR. The participants are asked to listen and repeat each sentence correctly. An automatic, adaptive up-down procedure shall be used to determine the SNR of each participant at a correct response rate of 50%. If all words are correctly repeated, the SNR is decreased by 2dB and if one or more words are not correctly repeated, the SNR is raised by 2 dB (Moradi et al, 2017).

When evaluating the program and the individual the CST method is used.It is the connecting speech test that analyses the

benefit of auditory only and audiovisual programs. By definition CST according to Cox, Alexander, Gilrnore, & Pusakulich (1989): "Connected Speech Test (CST) is used to measure the intelligibility of everyday speech; it is intended primarily for quantifying hearing aid benefit. The test consists of 48 passages of conversationally produced connected speech, each passage concerning a familiar topic and comprising 10 sentences. Listeners are apprised of the passage topic in advance and are required to repeat the sentences one at a time."

We perform pre-testing and Post-testing on the individual and we determine what is more beneficial for the person. The clues that audio visuals give with the help of the hearing aid amplification highly assists the person to perceive the subject more and be interacted in the program. We test the efficiency not only before or during the program, we perform post testing after the program has finished to assure continuity and efficiency.

2.2.2 Self-Evaluation

Another type of evaluation is self-evaluation. To self-evaluate we must follow the APHAB (abbreviated profile of hearing aid benefit). It is a self-evaluation system that is based on multiple questions that places the individual in multiple situations. APHAB is a 24-item self-assessment inventory in which patients report the amount of trouble they are having with communication or noises in various everyday situations(Cox & Alexander, 1995). Benefit is calculated by comparing the patient's reported difficulty in the unaided condition with their amount of difficulty when using amplification. The APHAB produces scores for 4 subscales: Ease of Communication (EC), Reverberation (RV), Background Noise (BN), and Aversiveness (AV) (Cox & Alexander, 1995). It helps the person evaluate himself in an aided and unaided situation. Asking whether it was too crowded while a conversation was happening to where the person missed out on a couple of words in a normal family conversation. Questions that help the person determine how the program is helping them. Evaluation through multiple pre and post testing is a necessity to guarantee the efficiency of the program. Tests, questions following up are all part of a cycle that an individual with hearing aid has to go through. As mentioned earlier amplification is a start but it will not help the individual if he is not trained, evaluated and aided to cope with his situation. Leading to a better lifestyle and the general health of the elderly with hearing-impaired patients.

3. CONCLUSION

This thesis has developed a computer/app-based audio-visual training program for older adults with hearing aids in the Arab world, specifically Lebanon. This program is designed to be the gateway for auditory rehabilitation and improvement in Lebanon as it tackles clinical tools and methods that have not been used before. The ease of use of the Badr (computer-based training program) along with the constant follow up by the audiologists during a substantial period of time increases the possibility of the training program to succeed and most importantly be effective in improving auditory skills. Moreover, the introduction of the first Arabic digital training program for older adults is a first in Lebanon and the Arab world. For the training program to stay successful, the clinical tools should be maintained and evaluated on a continuous

basis so it can be relevant linguistically and culturally (Makhoba & Joseph, 2016).

The success of the training program relies on the promotion of doctors and audiologists who install hearing aids on users to this program. Audiologists and medical doctors should advise all with hearing difficulties to immediately initiate the training program so that their auditory skills be improved and effective (Olson, 2010).

The results of this auditory training protocol over the first year will determine if the program developed will have a positive impact on patient audibility and skills so that this program can be part of the audiologist's methods for years to come.

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