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The Effect of Captioning in Understanding Televised Speech in Geriatric Hearing Aid Users

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Abstract

The present study aims to evaluate combined use of captioning and hearing aids and captions in hearing aid users. 60 subjects participated in the study. They were divided into two groups of Group A (Young adults) of 20-45 y and Group-B (Older adults) of 50-85 years. Two types of stimuli were created. Sentence stimuli (S1) and Context Stimulus (S2). S1 consisted of sentences with and without captions each with two score able words. S2 consisted of four video-clips for two minutes duration each, with and without captions. The participants were shown the stimulus in four viewing conditions 1) Baseline 2) With hearing aids 3) With captions and no hearing aids 4) with captions and hearing aids. They were required to answer 10 comprehension questions after each presentation. The results showed significant improvement in scores during combined use of captioning and hearing aids with scores of 75% and 92% in S1 and S2 in adults Group A and scores of 73% and 91% in group B IN s1 and S2 respectively. No significant difference was found between the scores in condition with hearing aid vs. without hearing aid and young adult vs. Older adults. additionally, it was found that the frequency distribution of participants on results of questionnaires was different across the two groups indicating that the young adults and older adults differ in their television viewing habits' and also that the subjective perception the hearing aid benefit is different in two populations. Thus, concluding that captioning helps in improving the understanding of televised content in Hearing aid users.

Keywords: Captioning; Television; Hearing aid users; Speech perception; Closed captioning; Hearing impaired

Introduction

Television (TV) is most efficient mode of information, awareness, cultural integrity and entertainment and plays an important role in the social construction of reality [1]. In recent years television viewing is not only restricted to the home or theaters. It has become more personalized. Now people watch television content on multiple platforms of computer, mobile phone, laptop etc. This has further increased viewership of television content. Watching television is reported to be the most popular leisure activity in elderly [2]. It is the activity that increases the most after retirement; in fact, over half of the increased leisure time people have after retirement is spent watching television [3]. According to a recent Nielsen television ratings report, USA adults over 65 watch more television than any other segment of the population. But unfortunately, it is seen that most of elderlies have hearing loss and thus difficulty understanding the televised speech. According to World Health organization (WHO) 30% to 35% patients above 60 years and 40% to 45% patients above 70 years of age, are hard of hearing and have presbycusis i.e. hearing impairment associated with aging. If a person is unable to detect sounds quieter than 90 dB HL considered deaf while a person having a range of hearing loss from mild to severe is hard of hearing. It is seen that 360 million people in the world suffer from disabling hearing loss. This constitutes 5.3% of the world's population. In India, 63 million people (6.3%) suffer from significant hearing loss [4]. There are estimated to be around 10 million people who are deaf or hard of hearing in the United Kingdoms. Of these around 8.3 million suffer from mild to moderate deafness [5]. This perceptual impairment, permanently limits their access to the audio component of the televised speech, thus depriving this population of information, education, entertainment and pleasure of watching television affecting their quality of life. A survey carried out by the BBC in 2010 indicates that 60% of viewers had difficulty in understanding speech on Television [6].

Several measures have been used to increase the accessibility of television by increasing audibility and improving signal to noise ratio. These include use of conventional hearing aids and assistive listening devices (ALD) e.g. hardwires options, Frequency Modulation transmission, induction loops, television band radios, infrared etc. As televised signal, already consists of speech and competition noise, conventional hearing aids are unable to improve the signal to noise ratio [3]. In certain situations, even these ALDs don't show any benefit. These include situations when there is significant background competition in the original broadcasted signal, as in televised signal and, when the patient has severe to profound hearing loss. There are many factors that make the speech on television difficult to understand. These factors include the wide variety of speakers, rapid change of topics and rate of speech, background noise, and factors intrinsic to the listener. Televised speech is often presented at twice the rate as conversational speech; this contributes to making TV difficult to understand [7]. In these cases, accessibility of the visual component of the television has immerged out to be valuable tool which provides an alternative mode of information input. The substituted visual signal i.e. the text captioning, offers the accessibility for television content.

Closed Captioning (CC) is a process of converting the audio content of a television broadcast, webcast, film, video, CD-ROM, DVD, live event, and other productions into text which is displayed on a screen monitor. Studies have shown that use of hearing aids alone do not significantly improve recognition of televised speech [8]. Gordon-Salant evaluated 15 adult participants (ages 59 to 82 years) with

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bilateral sensor neural hearing loss (SNHL) with hearing aids across three types of television programs (news, dramas, and game shows). They compared scores of speeches perception with no hearing aids and no closed caption to scores with hearing aids only, closed caption only, and combined hearing aids with closed captions. Their results indicated use of personal hearing aids did not significantly improve recognition of televised speech compared to the unaided condition. Across all measures, participants demonstrated significantly improved speech recognition scores using CC as compared to conditions without benefit CC [9]. Several other studies demonstrate the same effect, video with audio and with captions have shown to yield highest levels of comprehension, both for deaf children and for hearing children [10-12]. Studies have also evaluated different parameters of captioning for example, rate of caption delivery [6] edited vs. live captioning [13] effect of caption rate and text reduction [14] but very few studies have investigated the benefits of closed captioning among hearing aid users especially in Indian Population.

Gernsbacher MA, reviewed the articles which indicated the benefits of captioning [15]. It is seen Captioning not only benefit hearing aid users but are known to benefit children and adults with normal hearing. It is known to improve children's reading skills [16], boost adolescents' written and spoken vocabulary [17], increase college students' attention to lectures [18] enhance second-language learners' pronunciation [1], and raise literacy rates in developing countries [19].

Uses of Captioning have the potential to give persons with disabilities the means to live on a more equitable basis within the global community in a manner that previously was not possible. In India there is confluence of barriers to accessibility with inaccessibility and unaffordable technologies. Providing captions of the televised content for people with hearing loss supports the cause of persons with disability (PWD) act. PWD act was in acted in India in 1995. This act recognized the right to full participation and equality for disabled in society by 1) providing equal opportunities through accessibility of information regarding education, employment, and development, 2) protecting their right by fair, equal and non-discriminatory access and 3) providing opportunities for full participation in society. This is provided in UN convention (2006) under Article 9 (Accessibility to information, communication, and other services, including electronic services and emergency services) and Article 21 (Access to Information encouraging the mass media, including providers of information through the Internet, to make their services accessible to persons with disabilities). India, it is also signatory to both United Nations Committee on rights of persons with Disabilities (UNCRDP) towards an inclusive barrier free and right based society for persons with disability in Asia and pacific. The National Telecom Policy 2011 strategizes the need to recognize telecom and broad band connectivity as a basic necessity like education and health and work towards right to brad band act. Yet no Indian study or survey was found on demography or status of captioning in India. Despite tremendous benefits of captions, in India many video audiences and video creators are naïve about the importance and implementation of captions. To our knowledge, in India none of the studies have evaluated the effect of captioning in hearing aid users. Thus, in this research we aim to study the effect of combined use of captioning and Hearing aids in order to determine whether the combination of these two assistive devices provide greater comprehension of televised speech than either of these devices alone. Secondly we aim to evaluate the benefit of hearing aids in understanding televised speech in Hearing aid users. Thirdly to compare the difference of the effects of captions in understanding televised speech across different age groups younger adult's vs. Older adults. Additionally, distribution percentage of hearing aid users on TV viewing and captioning habits is analyzed with the help of a questionnaire.

Material and Methods

Total 60 subjects (34 males and 26 females) in the age range of 20-85 years participated in the study. Participants were included in the study only if they had their vision corrected to near normal by contact lenses or glasses, were fluent in written and spoken Hindi language and did not have any history of associated medical illness. Participants were selected from the patients reporting to the Audiology dept. of AYJNIHH. Inclusion criteria: Age 20-85 years, Hearing loss ranging from mild to severe, subjects using hearing aids for more than 2 months (increase the likelihood that hearing aid benefit and acclimatization had occurred), Normal vision or vision corrected to normal by glasses of contact lenses. Exclusion criteria: Subjects with associated medical mental health conditions. 30 young adults who were selected in the age range of 20-45 years (38.5 y). this is designated as Group A in the article. Among these 15 were using bilateral hearing aids and 20 had digital hearing aids. The other 30 older adults were selected in the age range of 45-85 years (mean 60.75 y). This is designated as Group A among these 19 had bilateral hearing aids and only 10 used digital hearing aids. Table 1 shows the number, gender, mean age of the participants. To ensure the adequacy of vision, memory, reading skills and basic conceptual knowledge required for the task, the participants were required to do visual acuity test where they were required to view and read four practice sentences on screen and also had to write down or say aloud the content of the sentences with 80% accuracy as recommended by Kothari et al. [20]. The selection criteria were not specific regarding degree of hearing loss, type of loss, word recognition score, use of unilateral or bilateral hearing aids and digital or analogue hearing loss because the hearing aid users in itself present a heterogeneous groups.

Stimulus and scoring

Two types of stimuli were created. The sentence stimulus (S1) was prepared, to target the word recognition. These were intended to determine the perception of exact word presented on screen. Context stimulus (S2) targeted comprehension and inferential ability which required the participants to understand the content and extract information out of it with available contextual cues. Sentence stimulus (S1) included sentences or parts of sentences from different television programs of Hindi language. Clips of 80 sentences or parts of sentences were obtained from different shows. Four lists of 20 sentences each were prepared. Four additional practice sentences were extracted for visual acuity test. Sentences were considered for inclusion only if they contained at least four score able Hindi content words and no more than 6 non-score able words. Content words included nouns, verbs, adjectives, adverbs, and prepositions, while articles, pronouns, and conjunctions were considered non-content words. The sentences were edited from original video using Studio (version 9) video editing software. Editing was done by starting and stopping each sentence at an appropriate location. Twenty-five seconds of silence and blank (black screen) were inserted between each sentence to provide time for listeners to record their response on a record sheet or say it aloud to be recorded by the examiner. 80 sentences were evaluated for the possible

Groups	Gender	No.	Mean Age (Years)
GROUP-A	Male	16	41. 5
	Female	14	35. 1
GROUP-B	Male	20	64. 2
	Female	10	57. 3

Table 1: Number, gender and mean age, of the participants.

inclusion in experiment. Out of total 80 sentences (4 lists) 40 were selected for the final testing. Selection of sentences was based on their equivalency in terms of 1) number of the content words, 2) clarity of the audio signal; 3) type of scene, 4) difficulty level of the content words 5) number of words in the sentence. This equivalency in complexity and reading level was obtained by following two main steps.

Rating of the content

Ten normal hearing educated subjects were made to rate each stimulus sentence. Three-point scales was used for rating the sentences on difficulty level, where 0 denoted very easy, 1 denoted average and 2 denoted very difficult. Sentences with the rating 0 and 2 were discarded.

Scene by scene comparison: Scene by scene comparison was done to ensure that four lists included clips equivalent in type of scene, i.e. All four lists included equal number of clips with three television viewing conditions 1) clear head shots with audio and lip-reading cues, 2) with audio and visual cues and 3) only audio without any other cue. Based on the criteria of selection 40 sentences (10 from each list) were selected for the inclusion from 80 (20 in each list). Captions were incorporating in 2 lists (in 20 sentences) out of the four (40 sentences).

Captions were added with Studio (version 9) software. The captions were added 1 sec prior and lasted 1 sec after the verbal sentences. The onscreen times of captions were minimum of 3 sec. Captions were incorporated at the bottom center of the screen which was highlighted on the black background. Edited captioning was used rather than near verbatim captioning as it is proved to be better than verbatim captioning. This is because edited captions give greater flexibility in terms of manipulations of rate and complexity of the captions which is necessary to be able to adjust these parameters to appropriate levels for deaf viewers.

Scoring

From each sentence, two content words were selected for scoring. Each content word was allotted score 1. Therefore, each list had 20 score able words with 2 words in each sentence. In total there were 80 score able words from 4 lists. Context stimulus consisted of short Hindi Video clips on the topic of e-governance. This was chosen from the three short television series. The criteria for choosing the video-clips were 1) No offensive or controversial content 2) Video and audio clarity 3) Shorter than 10 min in duration 4) Adequate vocabulary and 5) Hindi language. The whole video was downloaded from YouTube and was clipped into 5 parts of approximately equal duration (1.55-2.05 min). First part was the introduction of the topic. The other four parts had small drama enacted on benefit of e-governance. In each of the four video clips, one complete aspect of e-governance was emphasized. This was necessary to maintain the equivalency of the four video clips on the difficulty level, focus of the topic, amount of information provided, and scoring criteria. Three questions were formulated for each of the four video-clips. Only inferential questions were formed, which targeted the subjects' ability to assimilate information from the immediate and general contextual cues. The questions were created to target similar type of response in each video clip and were designed to be approximately similar in both complexity and difficulty. The questions were related to the theme of the drama, events and interpretation of the meaning which required subjects to make use of linguistic, social and physical context. Each video was rated on 5-point scale of difficulty level by 10 normal hearing, Hindi speaking subjects, with high grade qualification. In this 5-point scale "0" indicated very easy, "1" indicated easy, "2" indicated medium difficulty, "3" indicated difficult and 4 indicated very difficult. Out of 10 subjects, all the four video clips were rated as 2 (indicating medium difficulty) by 8 subjects. To ensure that questions were equivalent, these were also rated similarly by 10 subjects on 5-point scale. Subsequent modifications were made in the questions to equalize the difficulty of the questions. No questions were formed on the first part of the video. Out of the 4 video clips, captioning was incorporated in the two of them. The caption speed was approximately 100 wpm. Captioning was added with Studio (version 9) video editing software. The captions were added 1 sec prior and lasted 1 sec after the verbal sentences. The onscreen time of the captions was never less than 4-5 sec. and also depended on the length of the sentence. The number of lines on screen did not exceed 2. The equivalency in complexity was further ensured by two similar steps as applied to sentence stimulus. Rating of the content of the captions was done by 5 subjects. Scoring of the S2 was based on the answers of open ended comprehension question. Each question carried two scores. Maximum score for each video clip was 6 (two from each question). The scoring was based on the extent of understanding of the event, interpretation of the meaning and inferences drawn. Incomplete but correct answer was scored as 1. Correct and complete answer was scored 2. Small questionnaire was formulated to acquire information regarding the television habits, caption use and hearing aid use. It included questions on television viewing in Quite or Noisy Environment, time spent in watching television, use of Captions, duration of hearing aid use in a day, subjective benefit of hearing aid for television viewing.

Procedure

Whole testing procedure was divided into three phases' viz, Pre-experimental, experimental and post experimental phase. Pre-experimental phase: From all subjects an informed consent was taken to participate in the study. Brief case history was taken and prior audio logical reports were retrieved from the subject. In case the audio logical testing was done before 6 months, the testing was repeated. The tests included pure-tone testing (250-8000 Hz) for each ear, immittance measurements (tympanometry and ipsilateral acoustic reflex testing at 500, 1000, and 2000 Hz), speech recognition threshold or speech detection threshold (SRT or SDT). Listening check of hearing aid was performed prior to the experimental testing. Each participant was presented with a 5-monosyllabic word recognition list in quiet at 3 ft and 5 ft while wearing their hearing aids set. This was done to observe the level of the participant's speech recognition performance while using their hearing aids set to normal usage settings. For all hearing instruments, a listening check was performed to test for audibility of Ling sounds.

Experimental phase: Participants were seated in a comfortable chair in front of 22 inch, flat-screen with adequate level of lightening, 32" off the ground. Testing was performed in a quiet room. Testing conditions were kept constant. Testing was done in a group of 3 or 5 subjects. Participants were allowed to adjust the location of sitting to obtain the most comfortable viewing distance. Participants were also allowed to adjust the volume as per their comfort. This was followed by visual acuity test. The stimulus was presented with Laptop "Aspire Model No. 4720Z" on DVD player with external speakers. For Group A and B Stimulus was presented in 4 conditions 1) Baseline (BSNL), 2) Aided with hearing aids (HA), 3) Unaided with captions (CC), 4) Aided with captions (HA+CC). 40 sentences (10 sentences of one list × 4 conditions were presented. Following each sentence presentation, participants were asked to write down the sentence on a record sheet. Participants were given 25 seconds of blank screen during which answers were written on record sheets. Forty sentences (10 sentences × 4 conditions) yielding a total of 80 score able words (20 per condition

× 4) were presented. For Contextual stimulus (S2), five video-clips were shown. The first video clip was the introduction. This was shown in an attempt to familiarize the subject to the topic, to rule out the effect of familiarity on the responses and to make the other four videos equally familiar to the subject. Questions were not formed on this part of the video. Among rest of the 4 videos, each video was shown in one condition. After each video, participants were required to answer 3 comprehension questions based on the presented video clip; there was no time limit for completion. Post experimental phase: In this, the participants were given open ended feedback questions regarding their perception of benefit from the captioning and any difficulty faced by them. The answers were either rated on 4-point scale. Written or said orally which were recorded by the investigator. The whole procedure was completed in 1-1/2 hours and it was 1-1 1/2 hour. Participants were given breaks as needed or requested.

Results

It was hypothesized that the combined use of two assistive devices (Hearing aids and caption) in young and older adult hearing aid users would result in better comprehension of televised speech than either of it alone. To determine this comprehension scores obtained in four viewing conditions were analyzed. The scores were first converted in percentage. In Group A the scores obtained were high for CC condition as compared to BL or HA. The scores were 73% and 80% for S1 and S2 respectively. The scores were highest for the CC+HA condition which were 75% and 92% for S1 and S2 respectively. In group B the scores obtained were high for CC condition as compared to BL or HA. The scores were 71% and 86% for S1 and S2 respectively. The scores were highest for the CC+HA condition which were 73% and 91% for S1 and

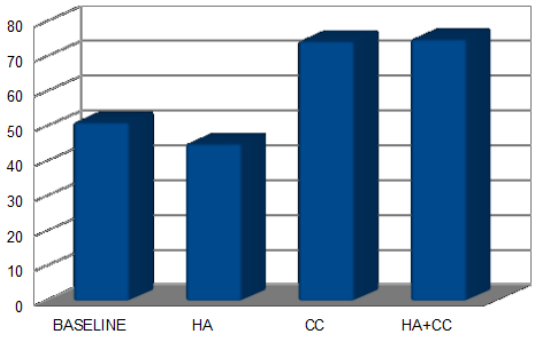

Figure 1: % scores of young adults (group a) for stimulus-1 (s1) in four viewing conditions i.e base line, aided (ha); with captions (cc); and with captions with hearing aid (HA:CC).

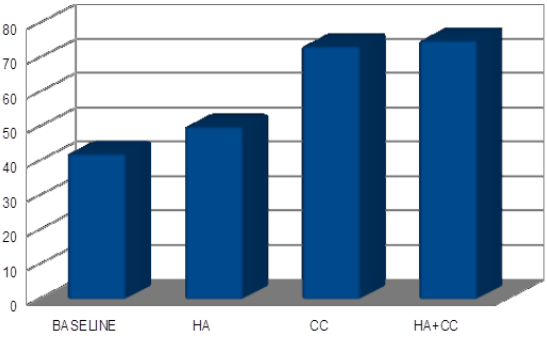

Figure 2: % Scores of older adults (Group B) for Stimulus-1 (S1) in four viewing conditions i.e. base line, aided (HA); with captions (CC); and with captions with hearing aid (HA:CC).

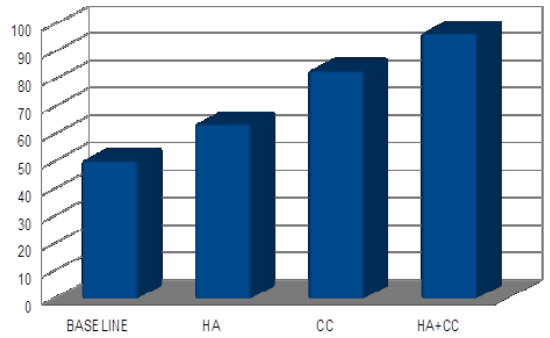

Figure 3: % scores of younger adults (Group A) for stimulus-2 (S2) in four viewing conditions i.e. Base line, Aided (HA); with captions (CC); and with captions with hearing aid (HA:CC).

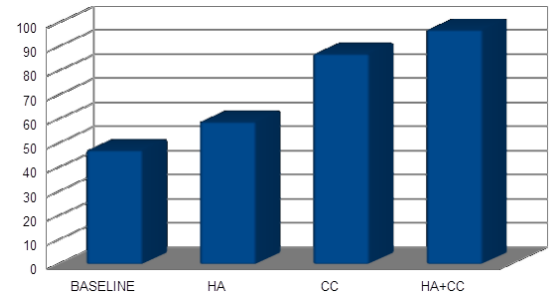

Figure 4: % scores of older adults (Group B) for stimulus-2 (S2) in four viewing conditions i.e. base line, aided (HA); with captions (CC); and with captions with hearing aid (HA:CC)

S2 respectively. Figures 1-4 shows the % scores for young and older adults HA users for stimulus 1 and 2 respectively. Mixed analysis of variance (ANOVA) with repeated measures was applied to evaluate the difference between four viewing conditions. 4 × 2 × 2 Design ANOVE with four viewing conditions (BSNL, HA, CC, HA + CC) and stimulus type S1 and S2 (sentence and context) as a within subject factor and Group A and B (Young Adults and Older Adults) as the between subject factor was used. The dependent variable for this analysis was the scores obtained, and the independent variables were four viewing conditions, age groups and stimulus type. S1 and S2 were taken separately for the analysis because in S1 was based on word recognition were sentences were presented in isolation and required listening exact words as there was no contextual information available, in contrast, S2 was based on comprehension where the video clip presented had sentences which had continuity, making the contextual cues available. Thus, S2 simulated televised speech more appropriately. Results revealed significant effect of conditions $F(2, 28)=11$, $p<0.01$ and significant effect between stimulus type and conditions $F(1.51, 21.13, p<0.01)$ But no significant effect between Hearing aid group and conditions. Post hoc comparison indicated that the scores obtained in CC and CC+HA was significantly higher than the other two conditions in for both the stimulus type. Thus, proving the hypothesis that there is a significant improvement in the understanding televised speech in presence of combined use of the captioning and HAs in young as well as older adults. Additionally, there was no statistically difference between BSNL and HA condition showing that Hearing aids do not benefit significantly in televised speech. Though, the second assumption, that a significant difference would be seen between the scores with and without HA was not proved to be true scores. The results also revealed that there was no effect of age on the benefits of Captions or hearing aids use on the comprehension scores.

The results of the questionnaire revealed that 53.3% of older adults viewed television frequently but only 20.1% younger adults reported watching television frequently. 50% of the younger adults reported good subjective benefit from hearing aids while watching television but only 15% young adults reported the same. 60% young adults reported that they would prefer using captions while only 40% older adults reported the same.

Discussion

The results concluded that there was a significant improvement in understanding televised speech with combined use of HA and captions in Young as well as older adults. The results also showed that, this improvement was similar to CC condition, concluding that no significant integration of the auditory and the text input had taken place, rather participants were exclusively using captions for understanding the content for S1 where word recognition was the main task. While for S2 where the stimulus was longer with contextual cues, the improvement was seen to be more in presence of HA and CC as compared to CC showing that integration of the auditory and the text input had taken place. This is supported by the findings of Gordon-Salant et al. which also showed that, use of CC (Closed captioning) while watching television dramatically improves in speech understanding by older hearing-impaired adults [15]. This was expected, as captioning provides an alternative mode of information input and conveys unambiguous information about the spoken messages that is not affected by the audibility of the speech signal or the availability of the speech reading cues. Improvement OF scores in HA+CC Over CC condition could be attributed to integration of bimodal sensory (auditory and the text) input. Several researchers have shown that bimodal sensory input enhances participants' ability to perceive and derive information from speech signals [15,21,22]. The basis of this perceptual advantage with bimodal input has been studied and is known to result, either, due to "selective attention" towards two sources of information, or from the "special information" available in combination, which is not available when there is no combination of two inputs. This special information is the result integration of two sources of information. The integration takes place at different levels i.e. at feature level; phoneme level or cognitive level depending on the type of inputs to be combined. The extent of advantage would depend on the efficiency of the integration between two inputs, which, in turns depends on the compatibility of the two inputs. In the current study, two inputs are captions and speech. Though written text is not derived from articulation, but it encodes phonemes of spoken language and has same structural levels as spoken language, as words sentences etc.

Recent neurophysiologic evidences have also demonstrated a significant interaction between orthographic and phonological system in visual lexical decision tasks and semantic classification tasks [23]. Many recent psycholinguistic models show that orthographic and phonological systems are interconnected by sets of bidirectional links. Thus, they assume that orthographic, phonological and semantic representations are heavily interconnected by direct automatic connections as in interactive interaction model, MROM-P model of Jacobs [12]. The evidence for orthographic influences on speech perception comes from three sources 1) the reciprocal relationship between phonological awareness and reading ability in children [24]. 2) Comparisons of literate and non-literate adults. Morais and colleagues found that Portuguese illiterates performed much more poorly than literates on a series of PA tests [16]. These studies demonstrated that illiterate adults had extreme difficulty in identifying onsets, unlike the literate subjects and 3) comparisons of speakers having different orthographic traditions. Non-alphabetic systems have not been shown to help with PA. Morais et al. compared the phoneme awareness of Chinese readers who had been taught in the alphabetic reading system 'Pinyin' to those who had been taught only the traditional reading system [25]. Only the alphabetized readers scored similar to literates in phonological awareness. Chereau C, examined the involvement of orthography in spoken word processing and showed surprising level of orthographic involvement in speech perception, providing clear evidence for automatic orthographic activation during spoken word recognition [26]. Thus, the higher scores in combined use of caption and HA are supported by the recent studies of higher cognitive integration of multiple senses and integration of orthography and auditory modes. Thus, orthographic input helps directing attention to the phonemic cues in speech perception. For stimulus 1, this integration did not take place effectively to have a significant impact on the understanding. It is assumed that the lack of integration could be due to degraded auditory signal. Though hearing aids compensates for the loudness and loudness perception, the temporal aspect and frequency resolution may be still distorted. In addition, televised speech place greater demands on temporal aspects, that are not managed well, even by the advanced hearing aids.

The other possible factor, which could have resulted in this finding, is the fact that, sample used in the study was a heterogeneous group of subjects ranging from mild to severe hearing loss with varying configurations and may have differences in speech perception with hearing aids. Owing to this discrepancy, some might have exhibited appropriate access to the spoken input while the others may have had minimal HA benefit. This might have resulted in the random sampling error of mean scores.

The second finding showed that there was no improvement in understanding televised content with hearing aids; despite the availability of audible speech information. The availability of audible speech information was ensured by performing a listening check prior to the testing. Significant improvement was found in adults when contextual cues were present in stimulus -2. In addition to speech information, participants also had either speech reading cues or visual cues present in the extracted video clips. Based on to the availability of such additional cues, improvement was expected from the hearing aids. Studies of listener's performance with hearing aids have always reported that they derive a significant benefit with amplification for understanding speech and even greater benefit when amplification is combined with visual speech reading cues [22]. The lack of congruence between current findings and those reported earlier is likely due to the difference in the stimulus type. Most of these studies have used either the natural speech or the single talker facing camera who pronounced words in clear and deliberate style, which provided consistent speech reading cues. In contrast the material used here, were video clips of televised speech made up of combination of sentences. The sentences used, simulated television viewing by combination of different types of sentences e.g. Sentences with speech reading cues only, visual cues only and with only audio. This combination of sentences did not provide consistent speech reading cues, as the talker did not always face the camera. In addition, televised speech is difficult to understand than the natural speech with the overall rate almost twice as the conversational speech rate. Other factors also complicate televised signal e. g. signal to noise ratio in the broadcasted signal, varied speakers etc. The increased rate of speech results in production of time compressed acoustic signal. In hearing impaired individual, the mechanism underlying difficulty in speech perception is not only the loss of audibility but also deteriorated supra-threshold processing of auditory system in terms of lack of non-

linearity, decreased frequency and temporal resolution. Studies have been done on the effect of deteriorated temporal resolution on speech perception. Gordon-Salant and Fitzgibbons [15] presented speech modified in time domain to the subjects and observed reduced speech perception with HF SNHL even though the frequency range of the loss was beyond the speech frequency range. The properly fit amplification can often solve the problem of reduced audibility and impaired loudness perception, but it does not yet address the impaired frequency resolution or losses of temporal processing exhibited by many people with sensor neural hearing loss. Additionally, increased speech rate, results in rapid articulatory and lip movements which would have further restricted the possibility to speech read effectively. These findings are supported by the study of Gordon-Salant and Callahan, Gordon-Salant concluded that use of hearing aids did not significantly improve recognition of televised speech compared to unaided condition. This study was conducted on older adults (59-82 y) and lack of aided benefit was attributed to complexity of the televised signal and age-related changes in auditory system [27]. This age-related change could be cognitive decline in speed of information processing, difficulty in perceptual normalization i.e. adapting to changes in the talkers from one stimulus to next and inability to inhibit irrelevant signals [28]. In addition, the present study also shows that even in adult listeners' hearing aid does not contribute to the significant improvement in speech perception indicating that it is not only the age-related deterioration in the auditory system but also deterioration in frequency and temporal processing related to damaged hearing mechanism which results in inability to use televised signal with hearing aid. Therefore, hearing aids alone cannot compensate for the deficit.

Salthouse proposed a processing speed theory of adult age differences in cognition, the theory states that increased age is associated with a decrease in speed of execution of many processing operations. The third finding of the study showed that there is no significant difference in the benefit accrued from captions and hearing aids between adult and elderly group with hearing impairment [28]. In contrast, Gordom-Salant, had found suboptimal scores of older listeners with captioning as compared to normal adults and associated it with cognitive changes in aging. They proposed that in older individuals' reduced ability to inhibit irrelevant information might have resulted in excessive difficulty in focusing on relevant information. Additionally, presence of three inputs i.e. auditory, visual–captioning and visual-speech reading might have led to increased cognitive load on older adults. The contrast finding in the present study is assumed to be the result of difference in the stimulus material. The captioning speed in the present study was less than 100 wpm and special care was taken that the duration of captions on screen was never less than 3 sec. No such consideration was taken in the above-mentioned study of Gordom-Salant, where some of the sentences would have been too fast for older adults to process the information. Studies have shown that older readers' process text at slower rate than adults. The slow captioning speed would have therefore resulted in less temporal demands in processing text. The reduced speed of processing is because of limited time mechanism and simultaneity i.e. in older adults processing is slow when operations cannot be successfully executed due to limited time for task completion and, when two tasks are to be done simultaneously. In the present study, presentation of reduced caption speed would have resulted in less temporal demands on elderly group, and utilization of only captions indicates that no two tasks were done simultaneously. This might have resulted in similar findings in adult and elderly group.

The time spent in television viewing was different in both the groups which could be due to different pattern TV viewing habits. It has been reported that elderly enjoy watching TV more than adults. Fewer % of older adults reported subjective benefit of HA in televised speech. This could be due to decline in auditory processing skills of the elderly's e.g decline to process signal presented at rapid speech rate, inability to inhibit irrelevant information, and decline in speed of signal processing. However, despite this improvement studies have also reported that most adults preferred to watch television with captioning as compared to elderlies. Elderly people, it is difficult to keep up with reading captioned text. Others simply do not enjoy watching TV as much when they have to read, though the study is conducted with best possible care There are certain lacunas in the current study as the participants were quite heterogeneous in terms of auditory characteristics like degree of hearing loss, configuration of the hearing loss type of hearing aids, HA fitting as the hearing aid may not be the ideal fit for the subject and sign language use. The sample size per group was not very large. Though stimulus was created to simulate the actual television viewing programs the captioning speed was quite slow. Typical captioning speed is 141 words per minute which is known to be comfortable captioning speed for young adults [19]. Though good care was taken while administering the questionnaire used in the study it covered only limited aspects i.e. may have been influenced by changes of emotions, behavior, feelings etc.

Conclusion

Effectively utilizing the technology of captioning can drastically improve the understanding of television content in hearing impaired population. Though findings do not provide indications of efficacy of combined use of Hearing aids and captioning, they do indicate that, there is possibility of integration of these two sources at some level which should be investigated further. It is also concluded that adults as well as elderly can derive equal benefit from captioning, if the programs are captioned taking into account the ability of the viewers in terms of vocabulary and speeder for television and other mass media both the options could be made available to make it more accessible to persons with hearing impairment or those with difficulty in hearing. Captions are not only for television but are now been used to make all public media, emergency information accessible to hard of hearing population (as theater, public announcements, bus services, railway services) in developed countries. It is also used in public environments where people may not be able to hear over the background noise. With the advent of the captioning, television has become the most effective educational medium captioning is known to be beneficial for not only for hard of hearing but also for children with a wide variety of difficulties. Research has shown that watching video appears to have a positive impact on comprehension skills, and combining viewing with text or captions appears to boost vocabulary acquisition, addressing skill deficits of struggling readers. Specially in country like India, where there is limited awareness of assistive listening devices for television viewing and most people cannot afford high technology hearing aids, Captioning can prove to be the most beneficial and cost effective assistive devise for hearing impaired population in providing satisfaction in their daily lives and vital communicational needs and interests. In most countries Federal laws have provided the framework to make video content more uniformly accessible to all population through closed captioning. The Americans with Disabilities Act (ADA) 1990 mandates all government/government funded and public service programming especially emergency information to be closed captioned before transmission for the benefit of the hearing-impaired population. In India Persons with Disabilities Act, 1995 is the fundamental act in protecting the rights of people with disabilities. It works to ensure Equal Opportunities, Protection of Rights and Full Participation for persons with disability. In India, the draft Communications Convergence Bill

2000 allows for "fair, equitable, non- discriminatory access to network infrastructure or service" but no specific law has been framed to caption the television programs as the awareness is increasing in India, efforts are being taken to make the public media more accessible. Our results shown drastic benefits from captioning and considering the ease and cost-effectiveness of captioning it is recommended that all programs should be captioned to make them accessible to hearing impaired population. Indian laws should mandate captioning all television programs similar to the other countries. New Criteria for captioning parameters should be made taking into account reading skills and processing speed of the viewer Criteria of captioning should also take into account the characteristics of the Program being captioned. As a more effective assistive tool. Formal standards of captioning should be formulated so that all programs are captioned adequately and effectively throughout the country.

In compliance with chronic care model developed by Wagner et al, patient and care givers, health professionals may be informed regarding the availability of CC as an assistive device in hearing aid users. When patients are informed regarding the same they may become involved and strive to take make CC available to promote better outcomes for hearing impaired.

There is a dearth of research addressing the effect of captioning in understanding televised speech. Therefore, further studies are required to investigate the same so that captioning could be made more effective as an assistive tool. In particular, research need to focus on how the parameter of captions and characteristics of the television programs can be merged more effectively. Future investigations should be carried out to assess the effects of captions and hearing aids with different degree of loss, configuration and type of hearing loss. Researchers should investigate what factors affecting the orthographic and speech integration and what modifications can be made to enhance orthography and speech integration.

Declaration of Interest

The authors report no conflicts of interest.

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