The 14th International Conference on Auditory-Visual Speech Processing
25-26 August 2017, Stockholm, Sweden

The effect of age and hearing loss on partner-directed gaze in a communicative task

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Abstract

The study examined the partner-directed gaze patterns of old and young talkers in a task (DiapixUK) that involved two people (a lead talker and a follower) engaging in a spontaneous dialogue. The aim was (1) to determine whether older adults engage less in partner-directed gaze than younger adults by measuring mean gaze frequency and mean total gaze duration; and (2) examine the effect that mild hearing loss may have on older adult's partner-directed gaze. These were tested in various communication conditions: a no barrier condition; BAB2 condition in which the lead talker and the follower spoke and heard each other in multitalker babble noise; and two barrier conditions in which the lead talker could hear clearly their follower but the follower could not hear the lead talker very clearly (i.e., the lead talker's voice was degraded by babble (BAB1) or by a Hearing Loss simulation (HLS). 57 single-sex pairs (19 older adults with mild Hearing Loss, 17 older adults with Normal Hearing and 21 younger adults) participated in the study. We found that older adults with normal hearing produced fewer partner-directed gazes (and gazed less overall) than either the older adults with hearing loss or younger adults for the BAB1 and HLS conditions. We propose that this may be due to a decline in older adult's attention to cues signaling how well a conversation is progressing. Older adults with hearing loss, however, may attend more to visual cues because they give greater weighting to these for understanding speech.

Index Terms: speech communication, partner-directed gaze, hearing loss, Diapix

1. Introduction

People will occasionally look at each other (partner-directed gaze) even when engaged in a communicative task that involves looking away from their partner. Lindblom [1] suggests that partner-directed gaze occurs to maintain 'communicative empathy'. That is, periodically maintaining visual contact with a conversational partner can be an important part of feeling that one is ***in*** a conversation with that person. Indeed, it has been suggested that face-to-face conversation promotes expressiveness, social orientation and provides an attentional focus [2].

More concretely, according to [1] the patterns of eye contact in a conversation help interlocutors establish communicative goals and helps each person to take into account the other's point of view. Furthermore, eye contact is important for scheduling turn-taking and pausing, as well as for understanding the attentional disposition of the interlocutor [3]. In short, nonverbal/paralinguistic cues gained through monitoring a conversational partner provide a scaffold for engaging communication.

Looking at the talker becomes even more important when there is a barrier to spoken communication, e.g., when speech occurs with background noise or when the listener has hearing difficulties. This is because, under such conditions, seeing the talker (auditory-visual, AV speech) provides a considerable boost to speech intelligibility that can help off-set speech masking [4]. Consistent with this observation, we observed that the frequency of mutual gaze in a map task was more than double in babble noise than in silence [5].

In the current study we take the first step in characterizing the use of partner-directed gaze in communication involving older talkers. Given the multifaceted use of gaze in dialogues, e.g., extending from linguistic to social functions [6], it is difficult for a single study to evaluate all functional attributes. Here we simply aim to determine whether older adults exhibit different degrees of partner-directed gaze by determining mean gaze frequency and the mean of total gaze duration.

Before describing the details of the study, it is useful to consider why older adult's partner-directed gaze behaviour might be different from that of younger adults. At a broad level, it has been suggested that older adults might suffer declines in basic social perception [7] and in joint attention [8]. These changes are consistent with findings that older talkers do not engage as much as younger adults in 'audience design' [9]. For instance, older talkers tend not to adjust their narration (words and gestures) on the basis of whether the content is old or new [10]. Also, age-related declines in the ability to understand and engage in joint attention fit with a similar decline in the use of eye gaze and other social cues [11].

To our knowledge, only one previous study has compared partner directed gaze in young and older adults when engaged in a spontaneous dialogue task [12]. In this study, the dialogue task involved a 'director' and a 'matcher' who each had a card showing six line-drawn faces positioned in a grid pattern (participants could not see each other's cards). The director's task was to verbally guide the matcher to achieve the same order of faces as on their card. It was found that during the task, younger adults gazed at their partners more than older adults did. Interestingly, this difference only occurred for the director's role and it was suggested that the use of gaze was greatly constrained by task-related demands [12].

In the current study, we used the DiapixUK, [13], a more flexible spontaneous dialogue task than the one used by Lysander and Horton [12]. In the DiapixUK, each member of a participant pair is given a cartoon-style picture and engages in a 'spot the difference' task. We also examined the effects of mild hearing loss and how different types of barrier to communication may influence partner directed gazing. Importantly, two of the communication barrier conditions that were used involved the talker having to put themselves in the hearer's position. That is, in these conditions, the talker could

10.21437/AVSP.2017-3

clearly hear their partner, but the partner heard a degraded version of the talker's voice (see Method for details).

2. Method

2.1. Participants

For the experiment, which was conducted at the Speech Hearing and Phonetic Sciences laboratory, UCL, UK, fifty-seven single-sex pairs of native Southern English adult talkers between the ages of 19 and 84 years were recruited.

Participants were selected to form three groups; two older adult groups and one younger adult one. These groups consisted of:

1) An Older adults with mild Hearing Loss group (OA_HL), N = 19 (11 female; Female Mean age = 72.4 years, Male Mean age 75.8 years); for which mild hearing loss was defined in terms of participants having a hearing threshold of < 45 dB between octave frequencies 250-4000 Hz, with a symmetrical downward slope of pure tone threshold in the high frequency range typical for an age-related hearing loss profile.

2) An older adult normal hearing group (OA_NH), N = 17 (12 female; Female Mean age = 70.1 years, Male Mean age 73.6 years); where normal hearing was defined as a hearing threshold of < 25 dB between octave frequencies 250-4000 Hz.

3) A young adult normal hearing group (YA_NH), N = 21 (13 female; Female Mean age =21.5 years, Male Mean age = 20.5 years). Normal hearing for the YA participants was defined as having a hearing level of 25 dB or better at octave frequencies between 250-8000 Hz in both ears.

Participants reported no history of speech or language impairments.

2.2. Procedure

In the Diapix task, a participant was assigned the role of a primary talker ('Talker A') or a secondary talker ('Talker B'). The primary talker was instructed to take the lead and do most of the talking.

Secondary talkers were always younger adults, and older adults (who were always "primary talkers", Talker A) were paired with younger adults in sex-matched pairs. We used only young participants as Talker B based on findings that both young and older participants exhibit a higher level of social skill, as measured by the composite partner attention score, when paired with young adults than when paired with older adults [14]. Likewise, studies have found that participants who are familiar with each other gaze at each other more than unfamiliar subjects [15]. Given that it would be difficult to equate familiarity, it was decided to use people who did not know each other.

The task was conducted under four presentation conditions: A 'No Barrier' (NB) and three barrier conditions. In the NB condition, both talkers heard normally. In the BAB1 condition, Talker B heard Talker A in 8 talker babble noise (the SNR for the BAB1 condition was individually set using an adaptive procedure to equate performance for the HLS condition (below) on the Modified Rhyme Test (MRT). In the BAB2 condition, both talkers heard each other in 8 talker babble noise (at 0 dB SNR). In the 'Hearing Loss Simulation' (HLS) condition, speech to Talker B was delivered in a manner that simulated severe-to-profound hearing loss. That is, Talker B heard Talker A via a real-time hearing loss simulator modelling a profound sensorineural loss at levels 40-50-60-90 dB at frequencies 250-500-1000-4000-8000 Hz (HeLPS, the Hearing Loss and Prosthesis Simulator, [16]).

Participants were always given the No Barrier condition first and the order of the three adverse listening conditions was randomized. Participants were given a different picture from the DiapixUK set (see Figure 1) for each presentation condition. They were instructed that the pictures contained 12 differences and that they had a time-limit of 10 minutes to find these differences.

Figure 1: *A pair of pictures from the DiapixUK set.*

Auditory and video recording were made of Talker A (the auditory recording with an Eagle G157b lapel microphones and the video with a 640 x 480 (VGA) camera at 30 fps). The data were transferred to ANVIL AV annotation software [17].

2.3. Data processing

The video recording (of Talker A) from each task was annotated using the ANVIL annotation editor. In ANVIL, the user marks events that occur in the video by using tracks that run along the time axis. In the current study, an annotator marked when the talker raised their head to look at their conversational partner. The onset and offset times of the marked event and its duration are recorded and the annotation comment appears overlayed on the video stream to enable a quick review of marker placement. The data from ANVIL can be used to compile an event map for a particular behaviour (see Figure 2). Event data can be used to calculate the mean number of events (in this case, number of times Talker A looked at their partner) and the mean of the sum duration of events (i.e., the mean total partner-directed gaze time).

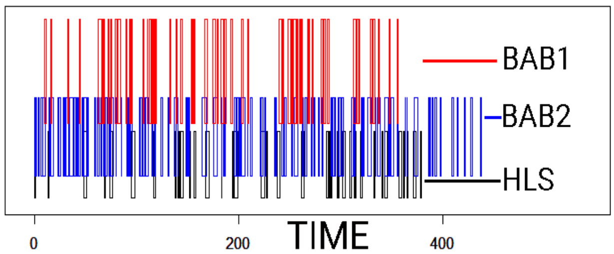

Figure 2: *A map of partner-directed events for an older adult participant for the three barrier conditions. Each vertical rectangle represents the onset/offset of an event*

3. Results

An important aspect of partner-directed gaze concerns the number of times during a dialogue that gazing occurred (this gives an idea of the degree to which Talker A was visually monitoring Talker B).

Figure 3 shows the average number of partner-directed gazes for the three participant groups as a function of presentation condition.

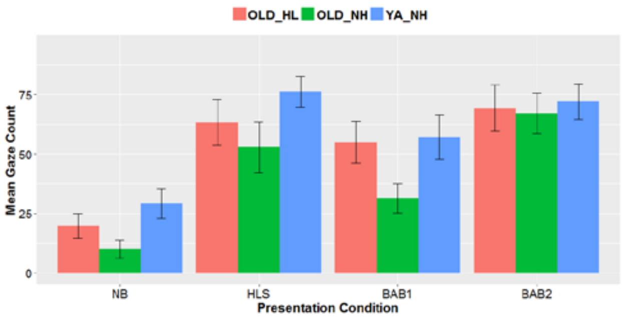

Figure 3: *Mean number of partner-directed gazes as a function of Presentation Condition and Participant Group.*

As can be seen, there was a greater number of partner-directed gazes in the barrier conditions (BAB1, Mean = 47.8; BAB2, Mean = 69.4 and HLS, Mean = 64.0) than in the no barrier (NB) condition, Mean = 19.7.

The number of partner-directed gazes for each participant and condition were analysed using linear mixed-effects regression, LMER, with the lme4 package in R [18]. Effects were taken as random at the participant level and p values were calculated using the lmerTest package [19].

There was a main effect of presentation condition, $F(3,171) = 51.65$, $p < 0001$. This difference was largely driven by the NB condition; however, when data from this condition were removed from the analysis, the difference between conditions was still significant, $F(2,114) = 12.59$, $p < 001$.

Figure 3 also shows that there was a numerical difference in the number of partner-directed gazes across the participant groups (OA_HL, Mean = 51.7; OA_NH, Mean = 29.3 and YA_NH, Mean = 58.5). Once again the data were analysed using a LMER model. There was no overall effect of participant group, $F(2,57) = 2.00$, $p = 1.14$; however it is clear from the figure that the pattern for the OA_NH group was different from the other two conditions. Indeed, a planned contrast between the OA_NH and the YA_NH group indicated that there was a significant difference, $F(1,37) = 4.37$, $p < 0.05$.

In addition to the number of times that Talker A gazed at Talker B, it is important to determine the mean total looking time involved. That is, a person could gaze less often at their conversational partner but each gaze could be of a longer duration. To examine this, the total looking time for each participant in each presentation condition was determined; these data are summarized in Figure 4.

As can be seen in the figure, there was a difference in the duration of gazing across the presentation conditions (BAB1, Mean = 81.4 sec; BAB2, Mean = 109.7 sec; HLS, Mean = 115.9 sec and NB, Mean = 27.4 sec). As with the gaze event count data, the mean gaze duration data was analysed using LMER with participants as a random effect.

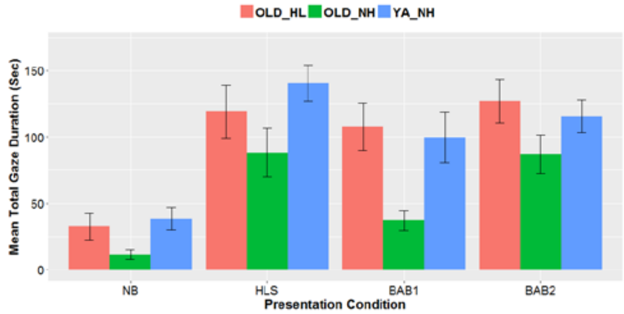

Figure 4: *Mean total partner-directed gaze time as a function of Presentation Condition and Participant Group.*

There was an overall effect of presentation condition, $F(3,170.22) = 50.07$, $p < 0.0001$. As with the gaze event count data, this difference appears to be largely driven by the NB condition; however, when data from this condition were removed from the analysis, the difference between conditions was still significant, $F(2,113.3) = 12.02$, $p < 0001$.

Figure 4 also shows that there was a difference in the number of partner-directed gazes across the participant groups (OA_HL, Mean = 96.5 sec; OA_NH, Mean = 47.7 sec and YA_NH, Mean = 98.4 sec). These data were analysed as above. There was an overall effect of participant group, $F(2,64) = 5.03$, $p < 0.01$. A planned comparison between the OA_NH and the YA_NH group indicated that there was a significant difference, $F(1,41) = 9.47$ $p < 0.005$.

4. Discussion

The current study examined the partner-directed gaze patterns of old and young talkers (in the role of Talker A) when engaged in a spontaneous dialogue task with Talker B under different communication conditions. For two of these conditions (BAB1 and HLS), a one-way transmission barrier was setup such that Talker A's voice was disrupted for Talker B but Talker B's voice was left intact. This meant that if Talker A was to alter their communication to Talker B, she/he would have had to infer any difficulty that Talker B was having from their vocal and/or visually assessable behaviour (and it is this type of mentalizing skill that may be compromised in old age).

The count data of gaze events (Figure 3) showed that older adults with normal hearing (OA_NH) produced fewer partner-directed gazes than either the older adults with hearing loss (OA_HL) or the younger adults with normal hearing (YA_NH) for the BAB1 and HLS conditions, but had a similar frequency of gazes in the BAB2 condition (where the speech from both interlocutors was disrupted). As mentioned above, the BAB1 and HLS conditions were the ones in which the talker does not experience a communication barrier themselves. The observed partner-directed gaze patterns for these condition fits with the idea that older adults (at least those without hearing loss) may be less sensitive to cues emitted by their interlocutor. It is noteworthy that when measured by total gaze duration, the older adults with normal hearing spent less overall time looking at their conversational partner even in the BAB2 condition where both talkers were heard in noise. That is, even though older adults with normal hearing looked a similar number of times as younger adults did under noisy conditions; they spent less time per glimpse.

The number of partner-directed gazes for the older adults who had mild hearing loss did not change as a function of the type barrier condition (BAB1; BAB2 or HLS) and was similar that produced by younger adults. It seems that older adults with hearing loss may be used to looking at their communication partners; that is, they likely give greater weighting to visual cues for understanding speech and so generally look more at their conversational partners.

It should be noted that, at this stage, we have not examined the relationship between patterns of partner-directed gaze and performance on the diapixUK task. This is of course an important piece of evidence in terms of understanding how gaze affects interaction in a communicative task and we are currently in the process or examining this.

At this stage, we also do not know what factors condition partner-directed gaze. Past studies that have used communicative dialogue tasks (e.g., the map task) have shown that instruction followers looked at their partners significantly more often when discussing features that differed between maps compared with features which did not differ [20] and we suspect that the same may be the case for the diapixUK task.

There are of course many possible reasons for why the older adults did not look at their conversational partners as often or as long as younger adults did. We have suggested that the cause may be based in a decline in older adult's ability to be responsive to the cues from others that signal whether communication is running smoothly or not. However, in interpreting a similar finding, Lysander and Horton [12] suggested that the characteristics of older adult's partner-directed gaze pattern may be shaped by a relative decline in short-term memory playing out in terms of task demands, i.e., because older adults have to pay more attention to the visual aspect of the matching component of the task they have less time to look at their partners. While this may have been the case in their particular task, several reasons suggest that it is an unlikely explanation for the current task. First, a decline in short-term memory does not explain why older gaze patterns were affected by hearing status. Second, there was no difference in forward or backward digit span scores between the older adult groups or between the older and younger adults.

5. Conclusions

We found that older adults without hearing loss looked less frequently and for less time at their conversational partners in a spontaneous dialogue task compared to younger adults. We propose that this result may be due to a decline in older adult's attention to cues signaling how well a conversation is progressing. Interestingly, older adults with mild hearing loss looked as frequently and as long at their partners as did younger ones. This suggests that having experience in communication difficulties may motivate talker/hearers to pay more attention to cues concerning how well a conversation is understood.

6. Acknowledgements

The authors wish to acknowledge support of an ESRC project grant ES/L007002/1. And thank Leo Chong for his assistance in data processing.

7. References

[1] Lindblom, B. (1990). On the communication process: Speaker-listener interaction and the development of speech, Augmentative and Alternative Communication, 6, 220-230.

[2] Fish, R., Kraut, R., Root, R., & Rice, R. (1993). Evaluating Video as a Technology for Informal Communication", Bly S., Harrison S. and Irwin S. Media Spaces: Bringing People Together in a Video, Audio and Computing Environment", Communications of the ACM, 36(1).

[3] Rossano, F. (2013). "Gaze in conversation," in Handbook of Conversation Analysis, Eds T. Stivers and J. Sidnell (Chichester: Wiley-Blackwell), 308–329.

[4] Sumby, W. H., & Pollack, I. (1954). Visual contribution to speech intelligibility in noise. The journal of the Acoustical Society of America, 26, 212-215.

[5] Mixdorff, H., Pech, U., Davis, C., & Kim, J. (2007). Map Task dialogs in noise–a paradigm for examining Lombard speech. In Proc. 16th International Congress of Phonetic Science (pp. 1329-1332).

[6] Kleinke, C. L. (1986). Gaze and eye contact: a research review. Psychological bulletin, 100(1), 78.

[7] Slessor, G., Phillips, L. H., & Bull, R. (2008). Age-related declines in basic social perception: evidence from tasks assessing eye-gaze processing. Psychology and aging, 23(4), 812.

[8] Erel, H., & Levy, D. A. (2016). Orienting of visual attention in aging. Neuroscience & Biobehavioral Reviews, 69, 357-380.

[9] Horton, W. S., & Spieler, D. H. (2007). Age-related differences in communication and audience design. Psychology and Aging, 22(2), 281.

[10] Schubotz, L., Holler, J., & Ozyurek, A. (2015). Age-related differences in multi-modal audience design: Young, but not old speakers, adapt speech and gestures to their addressee's knowledge. In 4th GESPIN-Gesture & Speech in Interaction Conference (pp. 211-216). Université of Nantes.

[11] Deroche, T., Castanier, C., Perrot, A., & Hartley, A. (2016). Joint Attention is Slowed in Older Adults. Experimental aging research, 42(2), 144-150.

[12] Lysander, K., & Horton, W. S. (2012). Conversational grounding in younger and older adults: The effect of partner visibility and referent abstractness in task-oriented dialogue. Discourse Processes, 49, 29-60.

[13] Baker, R., & Hazan, V. (2011). DiapixUK: task materials for the elicitation of multiple spontaneous speech dialogs. Behavior Research Methods, 43, 761-770.Vandeputte et al (1999).

[14] Vandeputte, D. D., Kemper, S., Hummert, M. L., Kemtes, K. A., Shaner, J., & Segrin, C. (1999). Social skills of older people: Conversations in same-and mixed-age dyads. Discourse Processes, 27(1), 55-76.

[15] Beattie, G. W. (1980). The role of language production processes in the organization of behavior in face-to-face interaction. Language production, 1, 69-107.

[16] Zurek, P. M., & Desloge, J. G. (2007). Hearing loss and prosthesis simulation in audiology. The Hearing Journal, 60, 32-33.

[17] Kipp, M. (2014) ANVIL: A Universal Video Research Tool. In: J. Durand, U. Gut, G. Kristofferson (Eds.) Handbook of Corpus Phonology, Oxford University Press, Chapter 21, pp. 420-436.

[18] Bates, D., Maechler, M., Bolker, B., & Walker, S. (2014). lme4: Linear mixed-effects models using Eigen and S4. R package version, 1(7).

[19] Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2015). Package 'lmerTest'. R package version, 2.

[20] Boyle, E. A., Anderson, A. H., & Newlands, A. (1994). The effects of visibility on dialogue and performance in a cooperative problem solving task. Language and speech, 37(1), 1-20.