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Interpersonal distance preferences: an unexplored consequence of hearing loss

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Abstract

Background Interpersonal distance (IPD), which reflects the physical space between people, ensures the regulation of social behavior in interaction as part of nonverbal communication. Our research aims to reveal whether there is a difference in personal distance preference between individuals with hearing loss and normal hearing (NH).

Methods Thirty-five adults (26.54 ± 7.05 years) were divided into three groups according to hearing status: hearing aid (HA) users, cochlear implant (CI) users, and NH individuals. The preferred interpersonal distance scale (PIPDS) and a stop distance paradigm were employed for measurements in various environments. Personal space violations were monitored using an electrodermal activity (EDA) wristband.

Results Our findings showed a significant relationship between preferred interpersonal distance (PID) and hearing loss duration ($r = 571$; $p < .01$) and a significant difference in PIDs between CI users and NH individuals ($p = .025$). There was a correlation between PIPDS results and interpersonal distance preference in two outdoor conditions where the experimenter was male. However, there was no correlation between interpersonal distance and EDA results.

Conclusions For the CI group, PIPDS results indicated an increased interpersonal distance preference with the severity of hearing loss, possibly to enhance lip-reading cues and conceal visible hearing aids. Understanding these preferences is essential for effective communication and good interpersonal relationships among individuals with hearing loss.

Keywords Interpersonal distance, Personal space, Proxemic, Hearing loss, Cochlear implants, Hearing aids

Background

Proxemic is a general term used to describe the observations and theories of human use of space including interpersonal distance. While individuals interact socially, they adjust their distance from other people where they feel safe. Hall divided the interpersonal distance on the horizontal plane into four main sections: intimate space, personal space, social space, and public space [1]. The safe buffer zone that individuals maintain between themselves and others is called interpersonal distance (IPD) [1]. Senses such as touch, vision, hearing, and smell are of great significance in spatial perception and personal relations, and interpersonal distance is shaped according to these senses. Interpersonal space or interpersonal

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distance creates and determines the dynamics of social interactions [2]. Studies show that IPD is affected by many factors such as culture, gender, age, and direction [1, 3–5].

Personal space is the region that a person psychologically accepts as his/her own. Most people value their personal space and feel discomfort, anger, or anxiety when their personal space is violated [6]. When defining personal space, characteristics such as age, gender, mood, and facial expression of the approaching person may affect the preferred interpersonal distance [7]. For example, it has been found that younger individuals prefer closer interpersonal distances than older individuals [4]. For individuals with typical development, personal space can be instantly organized by the guidance of situational clues, social clues, and cultural norms [8]. However, studies have shown that psychopathic traits [9, 10], social anxiety [11, 12], neurological disorders [13], and neurodevelopmental disorders [14–16] can interfere with the regulation of personal space.

Studies investigating the personal and interpersonal space have examined proxemic behavior through different measuring methods. The most frequently used methods are the stop distance paradigm [16–18], paper-and-pencil validated measurements [19], designing different experimental environments [20], and measurements based on physiological activities such as blood pressure and heart rate [21].

Since proxemic behaviors and preferred distances for communication are dependent on hearing, it may vary in individuals with hearing loss who cannot rely on their hearing when determining proxemic behaviors [22]. Hearing loss is an important problem affecting all developmental areas of individuals. The individual with total hearing loss does not only lose his/her sense of hearing but also confronts secondary problems like speech impairment, voice disorder, social isolation, and psychological, academic, professional, and economic problems. Early diagnosis, treatment, and amplification are essential to minimize such problems. Amplification approaches can be divided into two main categories: hearing aid and implantable hearing aids. Depending on the degree, type, and anatomical integrity of hearing loss, one of these approaches is preferred.

Increasing listening distances may increase listening effort while worsening listeners' speech comprehension performance [23]. When people try to communicate over long distances, they may miss the significant nonverbal components of speech, such as gestures and facial expressions [24, 25]. Furthermore, some physiological deficiencies, such as hearing impairment, can distort the transmitted message or its intention. This can lead to disruption of the communication process or undesirable communicative results [26]. Therefore, verbal communication problems of individuals with hearing loss may affect their personal space preference.

Since individuals with hearing loss are unable to hear environmental sounds adequately, they rely more on visual information in case of any threat and may prefer a wider personal space to expand their field of vision. However, it is also possible that they prefer a narrower interpersonal distance to hear people better and to catch nonverbal cues during communication. Therefore, it can be assumed that hearing loss can regulate the proxemic regions. There are a limited number of studies previously examining the effect of hearing loss on proxemic behavior. Most of these studies have been conducted on individuals with total hearing loss, and to our best knowledge, there is no study examining the effect of hearing restoration on these behaviors. This study aims to investigate whether there is a difference in personal distance preferences between individuals with normal hearing and individuals with hearing loss who use hearing aid (HA) and cochlear implants (CI).

Methods

The sample size of the study was determined using G*Power version 3.1.9.7 (HHU, Düsseldorf, Germany). According to the power analysis, it was determined that at least 10 participants in each group should be included in the study for a reliable statistical evaluation, with a confidence interval of 95% and a power of 0.8.

Participants

The individuals participating in the study were divided into three groups. The study group included 10 individuals with unilateral HA (7 males, mean age: 31.8 ± 9.05) with normal otoscopic and immittancemetric findings and bilateral moderate flat sensorineural hearing loss without additional impairment and 13 adult individuals with unilateral CI (6 males, mean age: 27.07 ± 4.88). The control group consisted of 12 individuals (5 males, mean age: 21.58 ± 2.90) from an audiology undergraduate student with NH. None of the participants knew sign language, and they were all Caucasian. The demographic characteristics of the participants are given in Table 1.

Procedure

The Beck Depression Scale and Beck Anxiety Scale were administered to all individuals by a clinical psychologist and individuals whose depression and anxiety scores within normal limits were included. For comparison with real-time measurements, all participants were asked to complete a simple preferred interpersonal distance scale (PIPDS). The PIPDS includes two human figures labeled as person A on the left and person B on the right, as

Table 1 Demographic characteristics of the participants

Participants	*n*
Age	
26.54 ± 7.05 years	35
Gender	
Male	18
Female	17
Marital status	
Single	22
Married	13
Level of education	
Primary school	3
Secondary school	3
High school	11
University	18
Type of hearing device	
Normal hearing (NH)	12
Hearing aid (HA)	10
Cochlear implant (CI)	13

described in the study of Sorokowska et al. [4] (shown in Fig. 1). The distance between the figures is divided into equal intervals of 20 cm and is 220 cm long in total. Each participant was asked to imagine herself/himself as person A and to determine the comfortable interpersonal distance between herself/himself and person B. The participant marked the point where person B should stand on the scale.

A stop distance paradigm was designed to measure the preferred interpersonal distance (PID). Considering the social space limits (1.2–3.7 m) determined by Hall [1], the experimenter and the participant were positioned face to face at 4 m to each other. Afterward, the participants were asked to perform the stop distance paradigm tasks. Before starting the stop distance paradigm tasks, an Empatica E4 (*Empatica*, *Milan*, *Italy*) wristband (measuring electrodermal activity, EDA) was worn on the participants' wrists to collect objective physiological data.

Two experimenters were selected: a female (163-cm height) and a male (176-cm height). They were Caucasian, brown haired, and 23 years old with normal hearing, and their clothes are simple and neutral colors. During the measurement, the experimenter was requested to make eye contact with the participant without speaking in a vertical body posture and neutral facial expression.

Measurements were made in two different environments: (1) an outdoor environment with a sunny walkway, away from people but not completely silent, with plants and trees on both sides and (2) an indoor environment which is a polyclinic corridor surrounded by rooms on both sides. Three different conditions were created in the study. In Condition 1 (C1), while the participant was standing, experimenter moved toward the participant. In Condition 2 (C2), while the experimenter was standing, participant moved toward the experimenter. In Condition 3 (C3), the participant and the experimenter walked toward each other. Trials were performed in two different environments, and under three different conditions,

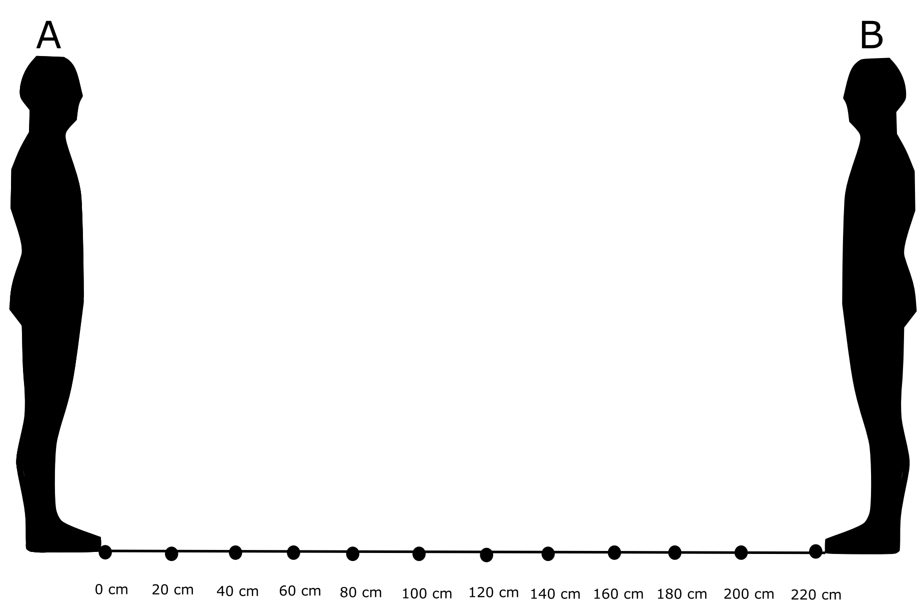

Fig. 1 Preferred interpersonal distance scale (PIPDS). The participant is asked to imagine themself as person A and to mark on the scale how close the other person B can get without disturbing them

with a female and a male experimenter (shown in Fig. 2). All the conditions were met first with a male and then a female experimenter to avoid the complexity. Participants conducted a total of 12 trials in a single session (3 approaching situations × 2 environments × 2 experimenter gender), and the session lasted about 1 h. In Condition 1, the participants were asked to stop the experimenter verbally at a distance they felt comfortable. In Condition 2, the participants were asked to stop at the distance where they felt comfortable. In Condition 3, the participants were asked to stop at the distance where they felt comfortable and verbally stop the experimenter. In all the trials, the interpersonal distance between the participant and the experimenter was measured from hip to hip with a laser meter. During the trials, EDA in the wristband was recorded.

Statistical analysis

Statistical Package for the Social Sciences (SPSS) version 24.0 and MATLAB R2019a were used for statistical analysis. Jarque–Bera test was used for testing the normality of the dataset. Independent samples *t*-test and one-way ANOVA were used to compare parametric numerical measurements according to categorical variables. Mann–Whitney U and Kruskal–Wallis tests were used for the non-parametric data. Paired samples *t*-test and repeated measures ANOVA were used for paired comparisons of parametric repeated numerical measurements. Wilcoxon and Friedman's tests were used for the nonparametric data. For analyzing the relationships between scale results and numerical measurements, Spearman correlation and Spearman's rank-order correlation tests were used for parametric and nonparametric data respectively. The level of significance was taken as $\alpha = 0.05$.

Results

Mann–Whitney *U*-test revealed that there is no significant difference between the PIPDS of the participants and their gender and marital status ($p > 0.05$). Also, the one-way ANOVA and Kruskal–Wallis test showed no significant difference between the PIPDS of the participants and their educational degrees ($p > 0.05$). While there was no significant difference between the PIPDS of NH participants (61.67 ± 20.37 cm) and the PIPDS of HA users (74 ± 18.97 cm) ($p = 0.191$), a significant difference was observed between the PIPDS of NH participants and the PIPDS of CI users (81.54 ± 27.64 cm) ($p = 0.025$). Spearman correlation and Spearman's rank-order correlation analysis were used to compare PIPDS results with variables of the duration of hearing loss, age, height, and weight, and a significant correlation value ($r = 0.571^{**}$; $p < 0.01$) was found only with hearing loss (Fig. 3). Therefore, the results show a positive and significant relationship between PIPDS and the duration of hearing loss.

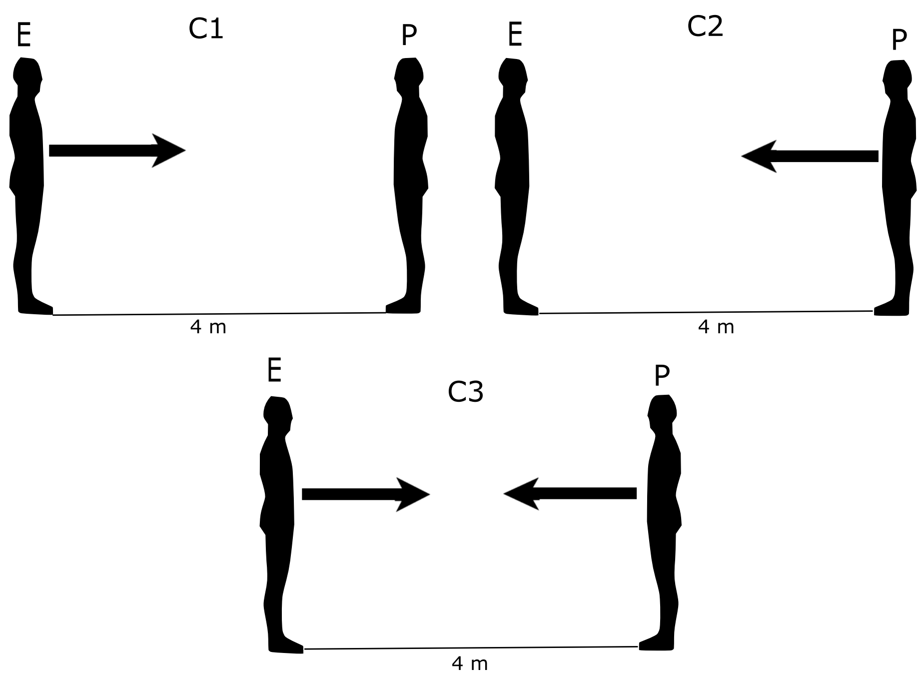

Fig. 2 Study design. In Condition 1 (C1), the experimenter walks toward the participant, and the participant is asked to say "stop" at the distance where he/she feels uncomfortable. In Condition 2 (C2) , the participant walks toward the experimenter and is asked to stand at a distance from which he/she feels uncomfortable. In Condition 3 (C3), the experimenter and the participant approach each other; the participant is asked to stand at a distance where he/she feels uncomfortable and say "stop"

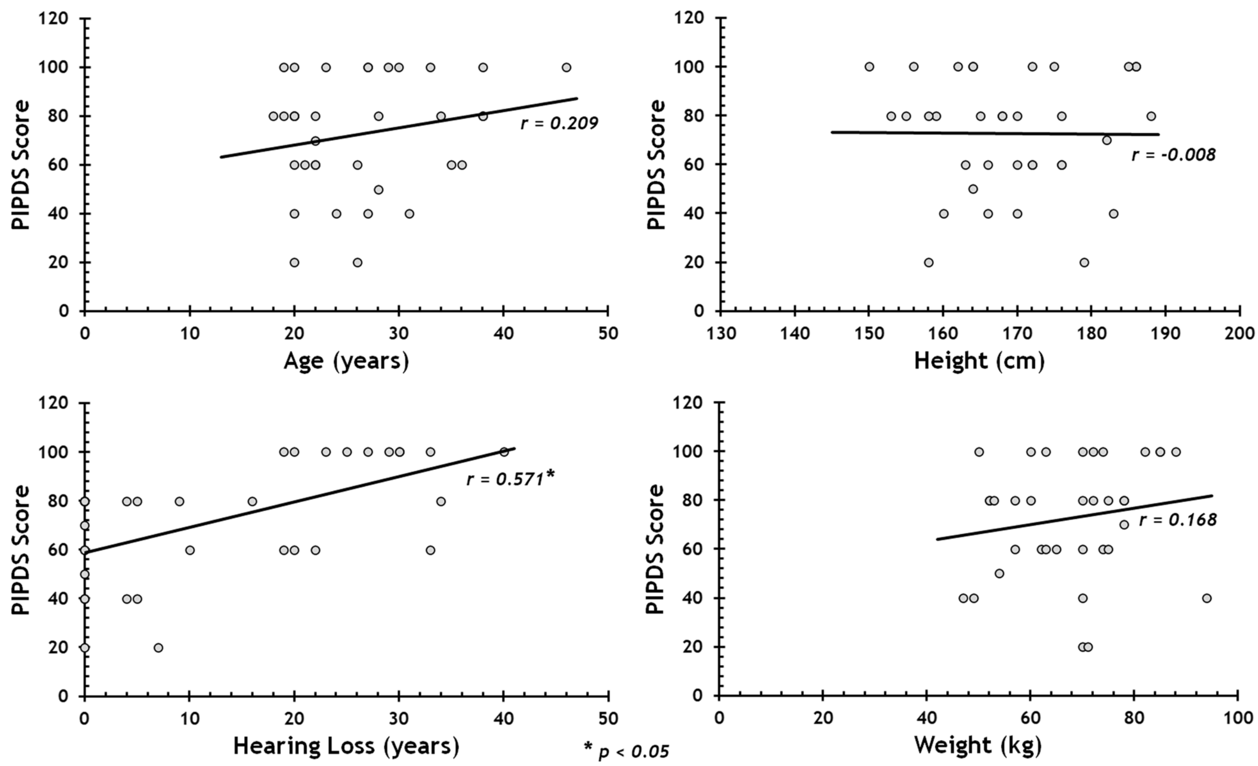

Fig. 3 Correlations between preferred interpersonal distance scale (PIPDS) results and participants' age, height, weight, and duration of hearing loss

To compare the difference between indoor and outdoor conditions for three conditions of the stop distance paradigm, all participants were tested using the paired samples *t*-test and Wilcoxon test. In the experimental conditions with a male experimenter, it was found that the PID was wider in the outdoor (0.84 ± 0.35 m, 0.72 ± 0.33 m) area compared to PID in the indoor area (0.72 ± 0.32 m, 0.67 ± 0.30 m) for both C1 and C2 ($p = 0.009$, $p = 0.042$). However, there was no significant difference in PID between outdoor (0.61 ± 0.24 m) and indoor areas (0.58 ± 0.22 m) of C3 ($p = 0.437$). In addition, in the experimental conditions with the female experimenter, no significant difference was observed between C1, C2, and C3 indoor and outdoor PIDs ($p > 0.05$).

Repeated measures ANOVA and Friedman tests were used to compare the three experimental conditions (C1, C2, and C3) among themselves, both outdoor and indoor, for both male and female experimenters. Regardless of the environmental situations and gender of the experimenter, the mean of interpersonal distance in C1 was higher than the mean of interpersonal distance in C2 and C3, and the mean of interpersonal distance in C2 was higher than the mean of interpersonal distance in C3. The means of interpersonal distances of the study and control groups in three experimental conditions according to the experimenter's gender and experimental environment are shown in Table 2. Paired samples *t*-test and Wilcoxon test revealed that no significant difference was observed between the preferred interpersonal distance according to the gender of the experimenter in three different experimental conditions (for both outdoor and indoor). In addition, the gender of the experimenter did not affect interpersonal distance preferences in any of the NH, HA, and CI groups in all three experimental conditions (both outdoor and indoor) ($p > 0.05$) (Table 3).

The PIPDS was the paper representation of Condition 2 (C2), but the experimenter's gender was not specified in the PIPDS. The Spearman correlation test showed the

Table 2 The results of the stop distance paradigm measurement made in different conditions depending on the environmental situations and the gender of the experimenter

Experimenter	C1	C2	C3
Outdoor			
Male	0.84 ± 0.35 m	0.72 ± 0.33 m	0.61 ± 0.24 m
Female	0.76 ± 0.34 m	0.65 ± 0.26 m	0.60 ± 0.21 m
Indoor			
Male	0.72 ± 0.32 m	067 ± 0.30 m	0.58 ± 0.22 m
Female	0.73 ± 0.27 m	0.66 ± 0.26 m	0.57 ± 0.21 m

C conditon, *m* meter

Table 3 Stop distance paradigm measurement results of the study and control groups according to the experimenter gender and the experimental environment

	Outdoor			Indoor		
Experimenter	**NH**	**HA**	**CI**	**NH**	**HA**	**CI**
Male						
C1	0.84 ± 0.22 m	0.92 ± 0.36 m	0.77 ± 0.44 m	0.68 ± 0.19 m	0.68 ± 0.20 m	0.80 ± 0.47 m
C2	0.70 ± 0.29 m	0.60 ± 0.18 m	0.82 ± 0.43 m	0.68 ± 0.21 m	0.53 ± 0.16 m	0.77 ± 0.41 m
C3	0.58 ± 0.18 m	0.59 ± 0.22 m	0.66 ± 0.31 m	0.63 ± 0.20 m	0.47 ± 0.18 m	0.62 ± 0.25 m
Female						
C1	0.66 ± 0.29 m	0.76 ± 0.31 m	0.86 ± 0.39 m	0.73 ± 0.21 m	0.65 ± 0.24 m	0.79 ± 0.34 m
C2	0.62 ± 0.21 m	0.56 ± 0.19 m	0.75 ± 0.32 m	0.65 ± 0.21 m	0.52 ± 0.20 m	0.77 ± 0.30 m
C3	0.59 ± 0.16 m	0.49 ± 0.19 m	0.69 ± 0.24 m	0.59 ± 0.18 m	0.47 ± 0.15 m	0.63 ± 0.25 m

C condition, *NH* normal hearing, *HA* hearing aids, *CI* cochlear implant

correlation between PIPDS results and interpersonal distance preference at C2 and C3 in the outdoor condition where the experimenter was male ($r = 0.368^*$, $p < 0.05$) (Fig. 4). Finally, the Spearman correlation and Spearman's rank-order correlation tests revealed no significant correlation between interpersonal distance and EDA results in any of the stop distance paradigm tasks (12 tasks) ($p > 0.05$).

Discussion

Since people with hearing loss cannot rely on the auditory system to regulate proxemic behavior, they may have different interpersonal distance preferences than individuals with normal hearing [22]. Studies on interpersonal distance preferences of individuals with hearing loss show inconsistency. A previous study has examined the personal space preferences of children with hearing loss attending regular school and children with hearing loss attending deaf school [27]. The results of the study showed that individuals with hearing loss attending regular school have a similar personal space preference to normal children, but that children with hearing loss attending deaf school prefer wider distances in their interaction with people with normal or hearing loss. Similarly, it has been reported that a greater distance is preferred in sign language users due to eye contact and better visibility of signs [28]. However, there are also findings to the contrary. In a study claiming the opposite, it was stated that the proxemic behaviors of deaf university students were not significantly different from those of normal university students, and it was thought that this was due to deaf individuals wanting to be accepted as normal individuals [22].

An individual with hearing loss can easily maintain communication in a quiet and well-lit environment, thanks to the visual cues and linguistic context received from the speaker, while in a noisy environment, if the lighting is poor and the visual cues are limited, it may be difficult to maintain communication [29]. Although hearing aid and cochlear implants improve the audibility of the speech signal, in some cases, the auditory input provided by the hearing devices may be insufficient. It has been shown that children using CI continue to have communication difficulties, especially in unfavorable listening situations such as background noise or crowds [30].

Individuals with hearing loss can spontaneously improve their lip-reading abilities to compensate for their [31, 32]. Lip reading is known to improve speech intelligibility, especially when the speech signal is reduced [33]. In our study, although all participants were using verbal communication, and none of them knew sign language, the highest PIPDS results were obtained for the cochlear implanted group. The greater personal distance preference of the cochlear implanted group may indicate that as the degree of hearing loss increases, the interpersonal distance is rearranged to better reach lip-reading cues. In addition, as the duration of the hearing loss increases, the increase in interpersonal distance has shown that it is a parameter that should be considered in personal space regulation.

Personal space is part of the existing space, and the shape of the personal space varies depending on the room's shape and size [34]. In our study, it was observed that in the C1 and C2 performed with a male experimenter, a greater distance preference was observed in the outdoor area than in the indoor area. The lack of clear boundaries in the open environment and the higher perception of the threat may have affected the results. However, no difference was observed between the outdoor and indoor areas in C1 and C2 conditions with the female experimenter. In situations where people think that they are more vulnerable (open space), their perceptions of

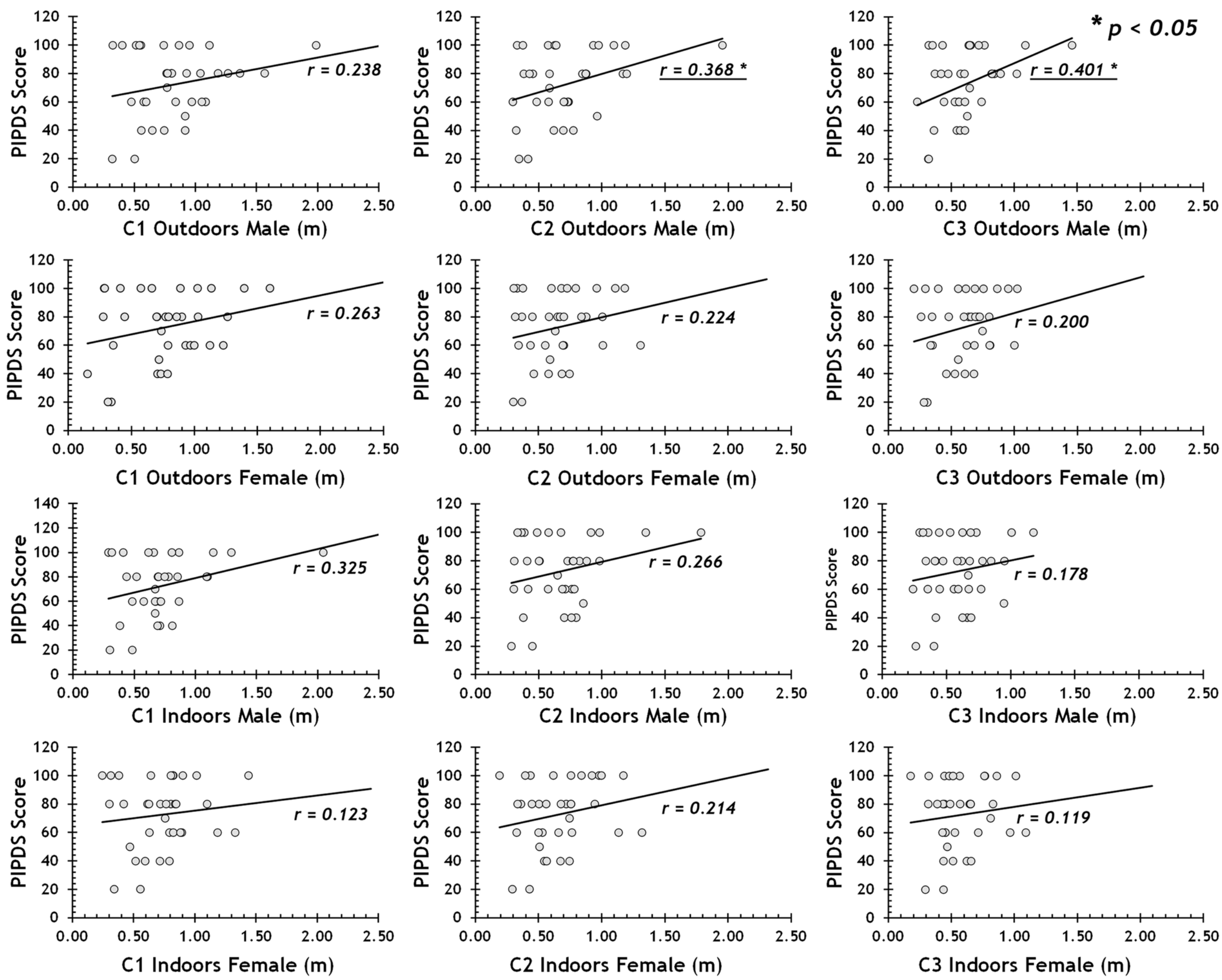

Fig. 4 Correlations of stop distance paradigm results in different conditions (C) with preferred interpersonal distance scale (PIPDS) scores

the approaching person may play a role in adjusting the interpersonal distance. Studies show that characteristics such as gender, age, and height of the approaching person are important in determining interpersonal distance [5, 35–38]. It has been observed that especially women prefer a greater distance between themselves and stranger men [39]. In our study, PIPDS results were only correlated with the recorded results of C2 (r=0.368*) and C3 (r=0.401*) with a male experimenter in an outdoor area. Participants may have determined their interpersonal distances in PIPDS according to the situation in which they imagined they were most vulnerable (the outdoor area where the approaching person is male).

Personal space, an imaginary safety zone, should not be violated by others [36], so perceiving a stimulus closer to the body as a threat may lead to an increase in defense responses. Individuals with hearing loss may be concerned about their safety while interacting with strangers. When this concern is combined with anxiety and fear, the misrepresentation of the spatial location of the threatening element can lead to the illusion that the element is closer than it should be [40]. Also, it was observed that personal space tends to be greater among anxious and introverted individuals [41]. Prejudice or stigma against a person with hearing loss can create an adverse reaction to social contact for that person. For example, the interviews with working women with hearing aids revealed that they needed to hide their hearing aids [42]. In a scoping review by David and Werner [43], it was reported that while hiding hearing difficulties was the most common stigma behavior, the size and the visibility of the hearing aid were the determinants of this behavior [43]. In our study, we did not assess stigmatization due to hearing loss. However, anxiety levels were investigated at the beginning of the study, and those with normal results were included. The need for participants to hide their hearing aid and cochlear implants may have contributed to an increase in interpersonal distance preferences.

There are very few studies on the personal spaces of individuals with hearing loss. The few studies we found are also old-dated studies on deaf individuals. To our best knowledge, our study is the first study on interpersonal distance preferences of individuals with hearing loss using assistive devices. Despite some limitations, this study offers a new perspective on the personal space arrangement of individuals with hearing loss. Since the stop-distance paradigm is performed in an experimental setting, it may not fully reflect real-life interpersonal distance preferences. We assumed that studies supported by objective measurements in natural environments can provide more reliable information about the interpersonal distance preferences of people with hearing loss. In the literature, physiological measurements such as heart rate (HR), blood pressure, electrodermal activity, or neuroimaging techniques such as fMRI have been used to determine the physiological effects of personal space violation [21, 44, 45]. In our study, no relationship was found between interpersonal distance and EDA. This outcome may be due to the stop-distance paradigm we use. In the present study, the participants were asked to determine the comfortable interpersonal distance. Comfortable interpersonal distance is the distance that an individual communicates with the other person without discomfort. Cartaud et al. [44] reported that physiological responses (an increase in EDA) were only observed when interpersonal comfort distance was violated after exposure to an angry facial expression. In our study, the interpersonal comfort space was not violated between the participants and the experimenters. In other words, the comfortable personal space was preserved. The fact that the personal space between the participants and the experimenters was not violated may have caused no significant increase in physiological responses (EDA). In addition, although the stop-distance paradigm was conducted with an unfamiliar experimenter, the environment was familiar to the participants with hearing loss. In this situation, the participant may have perceived the experimenter as a reliable stranger, and this perception may have led to a decrease in his perception of danger, as stated in Lough's study [17]. Since children's perception of adult strangers as more threatening may lead to different results, the results to be collected from children with hearing loss will be valuable [7].

Conclusions

The study found a significant correlation between the degree of hearing loss and interpersonal distance preferences, particularly among cochlear implant users. Also, the results highlight the potential need for an adjustment in interpersonal distance to facilitate more effective lip-reading cues and to accommodate the visibility of hearing aids.

Despite the limitations of our study, it is valuable in that it is the first study to determine the interpersonal distance preferences of individuals with hearing loss who use hearing aids. Future studies with larger sample groups will provide a clearer picture of the personal distance preferences of people with hearing loss. It is another issue that needs to be investigated what physiological and emotional responses will be shown when the interpersonal comfort space of the hearing loss is violated. Finally, there is a need to investigate how many factors such as culture, gender, age, and direction, as well as factors such as the degree and duration of the loss, affect the interpersonal space preference of individuals with hearing loss.

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Authors' contributions
Concepts, SY, BD, IB, TÇ, ED, KA, and HK; literature search, RD, FT, ED, KA, and HK; data acquisition, RD, FT, ED, KA, and HK; statistical analysis, RD, FT, and ME; manuscript preparation, SY, BD, IB, TÇ, RD, and FT; and manuscript review, SY, BD, IB, TÇ, and ME.

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Availability of data and materials
The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request. The data will be available within 6 months to 2 years after the article is published.

Declarations

Ethics approval and consent to participate
This study was approved by the Cerrahpaşa Medical Faculty Local Ethics Committee under protocol (59491012–604.01.02) and has been carried out in accordance with the Declaration of Helsinki. Written informed consent to participate was obtained from all participants.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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