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Emotional Recognition and Empathy in both Deaf and Blind Adults

Ana Teresa Martins*, Luís Faísca, Helena Vieira, and Gabriela Gonçalves

University of Algarve, Centre for Biomedical Research (CBMR) and Centre for Spatial and Organizational Dynamics (CIEO)

*Correspondence should be sent to Ana Teresa Martins, Department of Psychology, University of Algarve, Campus de Gambelas, 8005-139 Faro, Portugal (e-mail: atmartins@ualg.pt)

Abstract

Studies addressing the recognition of emotions in blind or deaf participants have been carried out only with children and adolescents. Due to these age limits, such studies do not clarify the long-term effects of vision and hearing disabilities on emotion recognition in adults. We assessed the ability to recognize basic emotions in 15 deaf adults (aged 32.4 ± 8.1 yrs) and in 15 blind adults (48.3 ± 10.5 yrs). Auditory and visual stimuli expressing six basic emotional states were presented to participants *(Florida Affect Battery)*. Participants also performed an empathy test. Deaf participants showed difficulties in emotion recognition tasks compared to the typical hearing participants; however, differences were only statistically reliable for Facial Emotion Discrimination and Naming tasks (specifically, naming expressions of fear). Deaf participants also revealed inferior levels of cognitive empathy. Concerning blind participants, their performance was lower than the controls' only when the task required the evaluation of emotional prosody while ignoring the semantic content of the sentence. Overall, although deaf and blind participants performed reasonably well on tasks requiring recognition of basic emotions, sensory loss may hinder their social perception skills when processing subtle emotions or when the extraction of simultaneous prosodic and semantic information is required.

Facial expressions and voice tone, together with gestures and body positions, are the main sources of nonverbal information during social interactions (Ekman et al., 1987; Leinonen, Hiltunen, Linnankoski, & Laakso, 1997). The use of the information conveyed simultaneously by those sources – *multimodal information* (Mehu & van der Maaten, 2014) – is the most effective way to recognize emotions, infer the mental states of others and predict their actions.

Indeed, the emotional signals present in social environments are cross-modal: facial expressions are rarely seen in isolation, and most of the time are accompanied by speech prosody or body postures. Klasen, Kreifelts, Chen, Seubert, and Mathiak (2014) showed that multimodal stimulation (simultaneous face and voice) yielded faster and more accurate judgments of emotion compared to unimodal presentation (face or voice only). It is also known that individuals rely more on speech prosody when facial expressions are ambiguous, and the same happens in the opposite direction (de Gelder & Vroomen, 2000). The integration of visual and auditory information about emotions seems to be a mandatory process, unconstrained by attentional resources (Takagi, Hiramatsu, Tabei, & Tanaka, 2015; Vroomen, Driver, & de Gelder, 2001).

Since emotional processing is so dependent on concurrent visual and auditory cues, sensory difficulties may interfere in the process of integrating this information, hindering emotional evaluation accuracy during social interaction (Takagi et al., 2015). Being deaf or blind reduces access to relevant sources of social information, since the individual cannot simultaneously access facial expressions, body positions and nonverbal vocal cues such as tone of voice or prosody.

The pertinence of auditory information in emotion processing motivated some researchers to evaluate emotion recognition in deaf participants. According to the study by Wiefferink, Rieffe, Ketelaar, De Raeve, and Frijns (2013) with children who

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are deaf, such children seem to make more errors in recognizing facial emotion compared to participants from a matched control group (Cohen's $d = 0.38$, favouring controls).

Similar results were obtained by Ludlow Heaton, Rosset, Hills, and Deruelle (2010), who tested the ability of deaf children to recognize perceptual aspects of emotions depicted in upright or inverted human and cartoon faces. Their data showed that, in comparison with both chronological- and mental-age-matched controls, deaf children were significantly worse at identifying emotions (Cohen's $d = 1.64$), especially in sad, happy and angry faces. Similarly, Most and Michaelis (2012) found that young deaf children performed less well than children with typical hearing in an emotion recognition task (Cohen's $d = 0.53$, favouring controls). As infants, children learn nonverbal communication in social–emotional interactions, making the face rather than speech the dominant communication channel; however, during their development, children become verbal agents and facial expressions and other nonverbal communication elements begin to be processed more implicitly. Without the access to early verbal communication, deaf children lose these multiple subconscious elements, crucial to efficient emotion recognition. Another explanation for such difficulties may be a split-attention effect due to the need for deaf individuals who communicate in spoken language to focus on the mouth to lip-read, thus possibly missing emotional relevant information expressed in the eyes zone (Rigo & Liberman, 1989).

However, different results were obtained by Hosie, Gray, Russell, Scott, and Hunter (1998), who did not find systematic differences between deaf and typical hearing children on tasks requiring the ability to match, identify and label emotional expressions (happiness, sadness, anger, fear, disgust and surprise faces; Cohen's d values ranged from – 0.39 favouring controls in anger recognition to 0.74, favouring deaf children in disgust recognition). Jones, Gutierrez, and Ludlow (2018) found moderate differences between deaf children and their matched typical hearing children (Cohen's $d = 0.65$, favouring controls) but only with static emotional faces; when dynamic stimuli were used (videos with an actor portraying basic emotions), the control advantage decreased significantly (Cohen's $d = 0.16$).

The inconsistencies across studies with deaf participants may result, in part, from methodological differences, particularly the heterogeneity of the samples (age range; comparison between adolescent and child performances), the level of participant's hearing loss and the cognitive demands of the tasks proposed (some studies used discrimination, others matching or naming tasks and differences in performance are evident when comparing tasks).

The effects of hearing impairment on emotion recognition during the development of deaf subjects until adulthood are also an unsolved question. In fact, Dyck, Farrugia, Shochet, and Holmes-Brown (2004), using a battery for emotion recognition and emotion-understanding abilities, found that the deficit in emotion recognition observed in the deaf group decreased with age. Deaf adolescents demonstrated significantly better performance than deaf children (Cohen's $d = 0.66$), although they still performed at a lower level than their age-matched typical hearing controls (Cohen's $d = 0.69$, favouring controls). In a recent study, however, Memisevic, Mujkanovic, and Ibralic-Biscevic (2016) showed that deaf adolescents (mean age: 16.2 years) did not perform worse than matched typical hearing adolescents in an emotion identification task (Cohen's $d = 0.03$, favouring controls). According to Sprung Münch, Harris, Ebesutani, and Hofmann (2015), emotion comprehension is likely to advance rapidly along with development via rich parental or social conversational input about real-life feelings. We can speculate that, just as a typical hearing child improves his emotion recognition abilities across the years, deaf children, through their experience with sign explicit language or with compensatory formal education, were given more opportunities to converse with others, increasing their capacity to recognize and process emotions, albeit later than their peers.

Auditory information seems to be primary in social interactions (Rezlescu et al., 2015). Listeners associate the speaker's speech characteristics to physical, biographical and personality attributes, including trustworthiness, attractiveness, dominance and emotional states (Rezlescu et al., 2015; Zuckerman & Driver, 1989). For blind subjects, speech prosody is the primary source for decoding the emotional states of others. Although language and testimony are particularly powerful tools for explicit learning about the invisible contents of other minds, namely emotional states (e.g., Bedny & Saxe, 2012), lack of access to the visual channel, which allows the processing of facial expressions, may bring specific difficulties in emotional recognition for blind individuals.

A review study conducted by Valente, Theurel, and Gentaz (2018), that examined the production of facial emotions in blind subjects (particularly the impact of visual experience from infancy to adulthood), obtained mixed results. Most of the studies reviewed by the authors pointed out that lacking visual experience during development seems to not have a major impact on the emotional expression production generated spontaneously in real contexts.

While these studies assessed the production of emotional states, to our knowledge, there are few studies exploring the auditory emotional prosody recognition in blind participants. Minter, Hobson, and Pring (1991), using a sample composed of eight congenitally blind children, found that blind participants revealed more difficulties in emotional prosody recognition than their controls, a deficit that was specific to emotion sounds (rather than non-emotional sounds). Similar results were obtained by Dyck and colleagues (2004), showing that blind participants had more difficulty than controls in emotional recognition based on vocal cues (Cohen's $d = 0.88$).

In sum, children are perhaps less able to deal with multimodal emotional cues, making emotion recognition and expression more difficult, particularly for subtler or ambiguous emotions (i.e., sadness and anger). Given that emotion recognition is a central prerequisite for the successful empathic maturation (Netten et al., 2015), the study of empathic skills in deaf or blind individuals is particularly relevant.

According to Netten and colleagues (2015), empathy, from a development perspective, can be divided into different dimensions: emotional empathy, cognitive empathy and prosocial motivation. Emotional empathy (also considered emotional contagion) is a process in which the emotional states of others produce a level of arousal in the observer. This is an unconscious behavioral mimicry of the other's facial expressions, vocal and positions signs. On the other hand, cognitive empathy implies a more sophisticate understanding of the emotional state of the other person. This comprehension of others implies that the observer can distinguish between one's own emotions and the other's emotions; understanding the other leads to support and care for the other person. In sum, the joint effect of cognitive empathy and prosocial motivation can promote healthy relationships.

Empathy requires the ability to monitor external cues of emotion to accurately discern the emotional states of others and respond appropriately (Balconi & Bortolotti, 2013). A recent study has demonstrated that the ability to integrate multimodal social cues correlates positively with measures of empathy and emotional reactivity (Regenbogen et al., 2012). Considering this evidence, sensory losses are expected to hinder the empathic skills of deaf or blind children.

Studies on the development of empathy in deaf are scarce and have yielded mixed results (Bachara, Raphael, & Phelan, 1980; Ketelaar, Rieffe, Wiefferink, & Frijns, 2013; Valente et al., 2018). Recent studies (Netten et al., 2015; Peterson, 2016) seem to confirm that young deaf children scored lower than their matched-controls in cognitive and behavioral measures of empathy. However, no differences were found in emotional empathy; this result is not surprising since emotional empathy is considered a behavioral mimicry that is not conscious of the facial, vocal and corporeal expressions of others and is present in children despite their social learning experiences (Netten et al., 2015; Peterson, 2016). Cognitive empathy develops as children grow up, however, and involves a more elaborate understanding of the emotional state of others. According to some authors, subjects with deafness exhibit lower cognitive empathy because they are less responsive to subtle stimuli from others, which seem to depend primarily on social learning rather than mimicry, this last underlying affective empathy (e.g., Netten et al., 2015). This conclusion was made based on the results of a study on deaf and hard of hearing older children and adolescents (age 9–16), that reported only lower levels of cognitive empathy and prosocial motivation than their typical hearing controls. During the observations, deaf and hard of hearing participants showed more attention to the emotion-evoking events but less supportive behavior than their typical hearing peers.

Peterson (2016) refers that empathy and theory of mind (*ToM*: the understanding that behavior is guided by true and false beliefs) are foundations of social life and human relationships. In contrast to *ToM*, there has been little study of empathy's development in deafness. Concerning *ToM*, the restricted early access to family conversation about thoughts and feelings when parents are not fluent signers seems to contribute to a delay of ToM (e.g., Peterson & Siegal, 1999). A review conducted by Glenn (2007), revealed findings consistent with Peterson and Siegal's (1999), and suggested that deaf children appear to have difficulties in perspective-taking and emotional reactions, but these skills may develop later. The authors stated there is limited evidence as to whether the deficits continue through adolescence and adulthood.

Several authors pointed out that lack of vision interferes in empathy development and *Theory-of Mind* acquisition during childhood (both essential in social cognition). These studies yielded findings that children and adolescents with visual impairment struggle with social or friendship related problems, consequence of a ToM delay (e.g., Gold, Shaw, & Wolffe, 2010).

In a study conducted by Raghibdoust, Sobati, and Shaghaghi (2018) it was suggested that, among the three false belief tasks, congenitally blind children had only poor performance in the story narration task, because this task was more dependent on the visual sense. Although the authors recommended that congenitally blind children must be exposed to further tactile and olfactory inputs during early infancy to mitigate this delay, the authors obtained similar performances between blind and sighted children in the majority of mental inference tasks.

Overall, the studies that address emotion recognition in deaf individuals or recognition/expression in blind individuals have been performed with children or adolescents. This restriction in the studied age groups does not clarify the question related to the lack of visual and hearing experience on emotional recognition and empathy in adults. With this background, our main objective was to evaluate both deaf adults and blind adults to assess their emotional recognition and empathic abilities. For that purpose, we selected the *Florida Affect Battery*, which captures different basic emotions through tasks recruiting different cognitive abilities (naming, discrimination, matching and identification) and using visual and auditory emotional stimuli (facial expressions and prosody). We expected that both groups (deaf and blind) would have more difficulties in emotional recognition than their matched control groups, particularly for subtler emotions. Relative to the tasks proposed, we expected a worse performance in the *naming* and *conflictual* recognition tasks, because stimuli from these tasks present fewer or conflicting cues. Concerning empathy, we expected deaf and blind participants to be at a disadvantage, particularly in cognitive empathy measures.

Method

Participants

Our study included a group of 15 congenitally deaf participants (seven males and eight females) with a mean age of 32.4 years (SD = 8.14) and a mean of educational level of 12.4 years (SD = 3.07), and a matched control group (A) (15 participants; seven males and eight females), with a mean age of 31.2 years (SD = 7.66) and a mean of educational level of 11.1 years (SD = 2.48). The gender distribution (Chi-square = 0.0, p = 1.000), age (U = 100.0, p = .624) and educational level (U = 73.0, p = .106) did not differ significantly between groups. Participants in the deaf group used sign language as their primary form of communication.

A group of 15 congenitally blind participants (11 males and four females) and a control group B (15 participants; nine males and six females) were also recruited for this study. While gender distribution (Chi-square = 0.6, p = .439) and educational level (10.3 ± 3.77 for blind and 12.0 ± 3.84 for controls, U = 82.5, p = .217) did not differ between groups, the mean age of the blind group (48.3 years ± 10.52) was higher than the control group (38.1 years ± 13.94; U = 64.5, p = .045).

The selection criterion for congenitally deaf participants was the presence of profound hearing loss (hearing loss above 90 dB, in the best ear). Only congenitally blind participants (visual acuity of 3/60 and less) were included. Control participants had typical hearing or vision. Exclusion criteria for all participants were learning disabilities or concomitant disorders such as attention deficit, autism or severe neurological and psychiatric illness.

Instruments

Florida Affect Battery [FAB]

The Florida Affect Battery (FAB; Bowers, Blonder, & Heilman, 1999) has been used to assess social-perceptual skills through different sensory modalities (visual and auditory). For the present study, the visual subtests were administered only to the deaf participants, while the auditory subtests were administered to the blind participants.

According to authors, the FAB battery was designed to assess the perception and understanding of nonverbal communicative signals (facial expressions and tones of voice) under a variety of task demands. The FAB includes eleven different subtests (five using pictures of faces as stimuli, four using speech stimuli and two using cross-modal stimuli); the visual and auditory stimuli used in these subtests expressed five different emotional states: happiness, sadness, anger, fear and neutral. In this way, the FAB is particularly suited to evaluate emotion recognition skills both in visually impaired populations (since it assesses these skills through emotional auditory cues related to speech prosody) and in deaf populations (since it uses facial affect expressions).

In the first subtest ("Facial Identity Discrimination"), pairs of unknown faces are shown, and the participant is asked to identify whether the faces are the same or different. The stimuli are photographs of women with neutral facial expressions and a surgical cap covering their hair, to reduce the influence of other visual clues besides facial features. This subtest does not involve emotion processing and serves as perceptual "control" for the subsequent tasks involving facial affect. In the second subtest ("Facial Emotion Discrimination"), the participant is asked to identify whether the two presented faces portray the same or different emotions; this subtest simply assesses the ability to discriminate facial affect and does not require identifying the emotions expressed. On the contrary, in the third subtest ("Facial Emotion Naming"), the participant is asked to label the emotion expressed in the presented faces (i.e., happy, sad, angry, fear, neutral). The fourth subtest ("Facial Emotion Selection") evaluates the ability to select which face (among five) expresses the emotion named by the examiner (who asks, i.e., "please, point to the happy face"). Finally, in the fifth subtest ("Facial Emotion Matching"), the participant must match the picture of an emotional face with another face expressing the same emotion, chosen from among five faces showing different emotional expressions.

Prosody subtests are composed of sentences recorded by the same speaker in different expressive tones. The first prosody subtest ("Non-emotional Prosody Discrimination") includes a set of pairs of semantically neutral simple sentences (for example, "Shoes are in the closet") spoken in either an interrogative or declarative tone of voice. The participant has to decide whether the intonation of the sentences is the same or different. This subtest does not involve the recognition of emotional prosody and serves as control for the subsequent tasks involving emotional auditory cues. The second prosody subtest ("Emotional Prosody Discrimination") presents pairs of semantically neutral sentences uttered in the same or in a different emotional tone of voice. The participant must decide whether the affective prosody is the same or whether it is different in both sentences; here, the participant only has to discriminate the affect prosody and is not required to identify the emotions expressed. The third prosody subtest ("Emotional Prosody Naming") evaluates the ability to recognize and name the emotion expressed by prosody. Semantically neutral sentences are presented to participants in one of five affective tones of voice (happy, sad, angry, fear, and neutral) and the participant must label the emotional prosody of each sentence. The fourth prosody subtest ("Conflicting Emotional Prosody") is again an emotion-naming task; however, sentences are not semantically neutral: affectively intoned sentences have a semantic content that may conflict with (incongruent items: "all dogs are dead," said in a happy tone of voice) or parallel the message (congruent items: "all dogs are dead," said in a sad tone of voice). In this subtest, the participant has to identify the tone of the emotion expressed in the speaker's voice (disregarding the semantic content of the sentence).

The last two FAB subtests require the participants to match the affect conveyed by the facial expression with a corresponding prosodic stimulus or vice versa and were not used in this study since they are unsuitable for groups with visual or hearing difficulties.

The FAB has good psychometric proprieties and has been validated as a measure of emotion perception deficits in a variety of brain-disordered patients, including patients with unilateral stroke and Parkinson disease (Bowers et al., 1999; Bowers, Bauer, & Heilman, 1993; Bowers, Blonder, Feinberg, & Heilman, 1991). Its test–retest reliability ranges from .89 to .97 (Bowers et al., 1999). In this study, we used the Portuguese version of the battery (Nascimento, 2016).

Empathy Quotient [EQ]

Empathy was evaluated through the short form of the Empathy Quotient scale (Portuguese version: Rodrigues et al., 2011; Original form: Wakabayashi et al., 2006). This self-report measure consists of 22 items and responses are given in a four-point rating scale, ranging from "strongly agree" to "strongly disagree." In the Portuguese version, EQ presents four dimensions (Rodrigues et al., 2011): (1) Cognitive empathy (five items, $\alpha = .80$), which represents the ability to accurately infer the feelings and thoughts of the other person without experiencing them (Falcone et al., 2008); (2) Emotional reactivity (five items, $\alpha = .71$), which reflects the tendency to respond appropriately to the mental states of others; (3) Social skills (five items, $\alpha = .70$), which represents the ability to judge social situations intuitively and spontaneously; and (4) Empathic difficulties (six items, $\alpha = .66$), which assesses the participants' limitations to respond appropriately to other people's mental states and to spontaneously assess social situations. The EQ original scores were reversed in order that high scores correspond to high levels of empathy.

Procedures

Informed consent was first obtained from participants, after clarifying the goal of the study and the voluntary and confidential nature of their participation. Deaf participants were instructed using written and sign language, and blind participants using oral communication. Second, participants answered a sociodemographic questionnaire. Subsequently, the FAB was administered to all participants. Only the first five tasks were administered to the deaf participants (task 1: Facial Identity Discrimination; task 2: Facial Emotion Discrimination; task 3: Facial Emotion Naming; task 4: Facial Emotion Selection; task 5: Facial Emotion Matching). The blind participants were given the tasks related to prosody (task 6: Non-emotional Prosody Discrimination; task 7: Emotional Prosody Discrimination; task 8: Emotional Prosody Naming; task 8b: Conflicting Emotional Prosody). After administering the tasks from the FAB, some participants were given the short version of the EQ (Wakabayashi et al., 2006). The EQ is a self-administered measure, so controls and deaf participants answered directly on the questionnaire sheet form; for the blind participants, the EQ was administered during an oral interview.

Analysis

Accuracy differences between the groups (deaf vs. typical hearing; blind vs. typical vision) were evaluated through nonparametric procedures, considering the small sample sizes ($n = 15$ per group): the *Mann–Whitney U test* was used to statistically evaluate those differences and Vargha and Delaney's A[12] (2000) was computed as an effect size indicator. This measure is a nonparametric estimate of the probability that a randomly chosen member from group 1 scores higher than a randomly chosen member from group 2. Thus, $A_{12} = .5$ indicates that both groups are equivalent. Following Vargha and Delaney's suggestions (2000), a small effect size is expressed by $A_{12} = .56$; medium effect sizes occur when $A_{12} = .64$ and large effects sizes when the A_{12} probability is higher than .70. Considering the inflated risk of Type I error due to multiple testing on the same group, the Benjamini–Hochberg procedure was used to hold the false discovery rate constant at 5% (Benjamini & Hochberg, 1995; Yekutieli & Benjamini, 1999). Statistical analysis was carried out using the SPSS software, version 21.0 (IBM Corporation, Armonk, NY).

Results

Performance in FAB Tasks

Typical hearing participants outperformed deaf participants for all FAB visual tasks (Table 1), but differences were almost non-significant. We observed large effect sizes for the Facial Emotion Discrimination and Naming tasks and moderate effect sizes in the Facial Emotion Selection task, although the advantage of typical hearing participants was significant only for the Discrimination task (Mann–Whitney, $p < .05$, corresponding to $p\text{-}c = .060$ after correcting for the inflated risk of false-positives; $A_{12} = .76$). In the Facial Emotion Naming task, typical hearing participants obtained a higher result, probably due to their superior accuracy in naming expressions of fear. Deaf participants showed a higher performance than typical hearing group in some types of emotions, but these differences never reached significance.

Table 2 presents the performance of the blind participants on the auditory tasks. The typical vision group performed better than the blind participants in all tasks. However, this advantage approaches statistical significance only in the Conflicting Emotional Prosody task (Mann–Whitney, $p = .068$, corresponding to $p\text{-}c = .272$ after correcting for the inflated risk of false-positives; $A_{12} = .68$). A more detailed analysis of the performance on this task reveals that participants with typical vision clearly benefit more than blind participants when the semantic content of the sentence was congruent with the emotional prosody used (Mann–Whitney, $p = .035$, corresponding to $p\text{-}c = .070$ after correcting for the false-positive rate; $A_{12} = .72$).

Empathy Quotient

Table 3 presents the scores obtained in the abbreviated version of EQ by some of the participants from each group. Deaf and blind participants always scored lower than their controls; however, only one of these differences reached statistical significance: the deaf participants scored clearly lower in Cognitive empathy (Mann–Whitney, $p = .021$, corresponding to $p\text{-}c = .105$ after correcting for the false-positive rate; $A_{12} = .80$). There were no other significant differences between groups for any of the empathy subscales.

Discussion

Our main objective was to explore basic emotion recognition and empathy in deaf adults and blind adults. The literature has shown that facial and vocal emotional expressions interact in emotion perception (de Gelder & Vroomen, 2000; Massaro & Egan, 1996), so we expected that the specific sensory loss characterizing each group would bring some degree of difficulty in emotion recognition.

According to our expectations, deaf participants showed greater difficulty in subtle emotion recognition tasks compared to participants with typical hearing; differences were detected only for Emotion Discrimination (in general) and in the Naming task (only for fear emotion). Wells, Gillespie, and Rotshtein

Table 1 Accuracy while performing FAB visual tasks by deaf and typical hearing participants (%)

	Deaf (n = 15) *M ± SD*	*Typical Hearing A (n = 15)* *M ± SD*	A_{12}	*U*	*p*	*p-c*
Facial Identity Discrimination	98.0 ± 5.61	99.0 ± 2.07	.52	108.0	.774	.966
Facial Emotion Discrimination	88.7 ± 6.94	95.0 ± 3.78	.76	54.5	**.012**	.060
Facial Emotion Naming	84.7 ± 10.93	91.0 ± 9.49	.69	70.0	.073	.182
Happiness	91.7 ± 12.20	90.0 ± 15.81	.51	110.0	.900	.900
Sadness	73.3 ± 29.07	81.7 ± 24.03	.58	94.5	.423	.900
Fear	75.0 ± 21.13	96.7 ± 8.80	.81	42.0	**.001**	**.005**
Anger	88.3 ± 16.00	90.0 ± 15.81	.53	105.5	.732	.900
Neutral	95.0 ± 10.35	96.7 ± 8.90	.53	105.0	.630	.900
Facial Emotion Selection	87.0 ± 11.62	92.7 ± 7.29	.63	83.0	.212	.353
Happiness	98.3 ± 6.45	98.3 ± 6.45	.50	112.5	.999	.999
Sadness	93.3 ± 14.84	86.7 ± 12.91	.65	79.0	.099	.283
Fear	80.0 ± 23.53	90.0 ± 18.42	.63	83.5	.170	.283
Anger	88.3 ± 20.85	90.0 ± 15.81	.51	110.5	.918	.999
Neutral	85.0 ± 31.05	98.3 ± 6.46	.60	89.0	.133	.283
Facial Emotion Matching	88.7 ± 9.90	90.0 ± 5.35	.49	115.5	.966	.966
Happiness	96.7 ± 8.80	98.3 ± 6.46	.53	105.0	.550	.550
Sadness	86.7 ± 24.76	86.7 ± 16.00	.56	99.0	.513	.550
Fear	93.3 ± 14.84	91.7 ± 12.20	.56	100.0	.501	.550
Anger	76.7 ± 14.84	85.0 ± 15.81	.64	80.5	.133	.332
Neutral	90.0 ± 15.81	80.0 ± 16.90	.67	75.0	.084	.332

M ± SD – mean ± standard deviation; A_{12} – Vargha and Delaney's nonparametric effect-size measure ($A_{12.} \approx .56$ corresponds to small effect size; $A_{12} \approx .64$ to medium effect size; $A_{12} \approx .70$ to large effect size); *U* – Mann–Whitney *U* test statistic; *p* – *p*-value; *p-c* – *p*-value corrected by the Benjamini–Hochberg procedure.

Table 2 Accuracy while performing FAB auditory tasks by blind and typical vision participants (%)

	Blind (*n* = 15) *M* ± *SD*	*Typical Vision B* (*n* = 15) *M* ± *SD*	A_{12}	*U*	*p*	*p-c*
Non-Emotional Prosody Discr.	94.2 ± 12.82	97.5 ± 7.01	.62	86.0	.774	.801
Emotional Prosody Discrim.	96.7 ± 12.90	99.3 ± 1.76	.53	106.0	.605	.801
Emotional Prosody Naming	75.7 ± 23.21	81.3 ± 8.55	.53	106.5	.801	.801
Happiness	76.7 ± 32.00	90.0 ± 20.70	.62	86.0	.201	.999
Sadness	70.0 ± 30.18	75.0 ± 25.00	.54	104.5	.728	.999
Fear	53.3 ± 37.64	56.7 ± 29.07	.50	111.5	.966	.999
Anger	91.7 ± 26.16	96.7 ± 8.80	.50	111.5	.944	.999
Neutral	86.7 ± 28.14	85.0 ± 20.70	.56	99.0	.503	.999
Conflicting Emotional Prosody	81.9 ± 15.99	90.4 ± 8.26	.69	69.0	.068	.272
Happiness	84.0 ± 17.65	92.0 ± 18.21	.66	77.0	.108	.216
Sadness	83.7 ± 21.36	96.3 ± 5.42	.66	77.5	.104	.216
Anger	79.2 ± 21.48	84.2 ± 14.54	.55	101.5	.637	.637
Neutral	77.6 ± 20.59	85.9 ± 12.22	.62	85.0	.238	.317
Congruent	83.1 ± 15.54	93.9 ± 8.18	.72	63.0	**.035**	.070
Incongruent	79.0 ± 17.57	87.3 ± 9.93	.62	85.0	.249	.249

M ± *SD* – mean ± standard deviation; A_{12} – Vargha and Delaney's nonparametric size measure (A_{12}. ≈ .56 corresponds to small effect size; A_{12} ≈ .64 to medium effect size; A_{12} ≈ .70 to large effect size); *U* – Mann–Whitney *U* test statistic; *p* – *p*-value; *p-c* – *p*-value corrected by the Benjamini–Hochberg procedure.

Table 3 Empathy Quotient (EQ) scores for deaf and blind groups and their controls

	Deaf (*n* = 10) *M* ± *SD*	*Typical Hearing A* (*n* = 10) *M* ± *SD*	A_{12}	*U*	*p*	*p-c*
Cognitive empathy (max. 20)	9.5 ± 2.12	12.1 ± 2.60	.80	20.0	**.021**	.105
Emotional reactivity (max. 20)	9.2 ± 1.93	10.3 ± 2.87	.61	39.5	.421	.702
Social skills (max. 20)	8.0 ± 2.26	8.4 ± 2.91	.54	46.0	.760	.790
Empathic difficulties (max. 24)	15.6 ± 3.37	16.1 ± 4.36	.54	46.5	.790	.790
	Blind (*n* = 10) *M* ± *SD*	*Typical Vision B* (*n* = 10) *M* ± *SD*	A_{12}	*U*	*p*	*p-c*
Cognitive empathy (max. 20)	11.0 ± 2.05	12.4 ± 2.63	.66	34.5	.237	.542
Emotional reactivity (max. 20)	8.8 ± 2.30	10.2 ± 1.69	.69	31.0	.146	.542
Social skills (max. 20)	8.9 ± 2.28	9.9 ± 2.92	.58	41.5	.510	.638
Empathic difficulties (max. 24)	14.9 ± 3.21	15.5 ± 3.84	.55	45.0	.704	.704

M ± *SD* – mean ± standard deviation; A_{12} – Vargha and Delaney's nonparametric size measure (A_{12}. ≈ .56 corresponds to small effect size; A_{12} ≈ .64 to medium effect size; A_{12} ≈ .70 to large effect size); *U* – Mann–Whitney *U* test statistic; *p* – *p*-value; *p-c* – *p*-value corrected by the Benjamini–Hochberg procedure.

(2016) observe that fear is the basic emotion most difficult to recognize for the general population. Fear is a negative and subtle emotion, usually socially concealed, and often lacks a social context for interpretation. It is simpler to express and recognize this emotion when a stimulus triggers an automatic response (e.g., showing a snake and observing what happens). According to the *affect circumplex model* (Posner, Russell, & Peterson, 2005) negative emotions are the most difficult emotions to classify because, from the social point of view, they are more ambiguous. It is not surprising that deaf individuals, not being able to rely on prosody for extra help in identifying ambiguous emotions, face more difficulty in their interpretation (Merabet & Pascual-Leone, 2010). Compared to previous studies with children and adolescents (Most & Michaelis, 2012), our deaf group obtained better results in emotion recognition. We had good reason to suppose that emotional impairments in adults with deafness were not so salient as observed in most of the studies that focus on emotional recognition in children and adolescents. Sign language acquisition and testimony are particularly powerful tools for learning about the invisible contents of other minds along development (e.g., Bedny & Saxe, 2012). This knowledge about others' minds includes causal relations among abstract concepts (such as emotions, beliefs and desires), and can be learned from many sources of evidence, not limited to first-person experiences.

For the blind participants, their performance was lower than the controls' only when the task required the evaluation of emotional prosody while ignoring the semantic content of the sentence. We speculate that blind subjects were engaged with the semantic content of the sentence, disrupting the recognition of its intonation. These results suggest that blind individuals, in the absence of visual cues, tend to rely more on discourse semantic content to evaluate emotions in social situations than non-blind individuals.

To our knowledge there are no studies focused on conflicting emotional prosody performance and blindness. Several authors have noted that visual experience is extremely important for social, cognitive and complex pragmatic skill acquisition (McConachie & Moore, 1994). The complex skills required to complete conflictual prosody tasks seem reduced in adults with congenital vision loss.

Overall, although individuals with sensory impairment performed reasonably well on tasks requiring basic emotion recognition, their sensory limitations may hinder their social-perception skills when processing subtle emotions (in the case of deaf participants) or when the simultaneous extraction of prosodic and semantic information is required (in the case of blind participants). This fact can probably explain the lower levels of cognitive empathy observed in deaf participants.

According to some authors, individuals less responsive to subtle social stimuli may exhibit lower levels of cognitive empathy because responsiveness to social stimuli seems to depend more on social learning than on mimicry, which in turn seems to underlie affective empathy (Netten et al., 2015). It has been argued that affective empathy (i.e., feeling what the other person feels) is neurologically hard-wired and is, for example, present in children despite their social learning experiences. On the other hand, the level of cognitive empathy (i.e., understanding another's emotions) depends on the extent to which children can participate in a social environment. Netten and colleagues (2015) also observed lower levels of cognitive empathy in deaf preadolescents compared with their typical hearing controls. The groups did not differ in their ability to recognize emotions, but the deaf subjects seemed more attached to emotion-evoking events and presented less supportive behavior compared to their typical hearing controls. Because of the continuous development of cognitive empathy in childhood and preadolescence, the authors mentioned above expected an increase of cognitive empathy in their deaf adolescents but observed the maintenance of this delay. Unfortunately, our deaf adults also revealed deficits in cognitive empathy. Some authors have observed that a cognitive empathy delay appears when an appropriate intervention program did not exist during childhood (Netten et al., 2015).

In sum, with this study we hope to have created awareness not only of emotion recognition but also of the reduced cognitive empathic skills observed in deaf persons. This lack of skills severely interferes in their social life, given the association between empathy and the quality of personal relationships (Chow, Ruhl, & Buhrmester, 2013). Not being able to empathize with others may result in less participation and cooperation, causing isolation and psychological problems (Netten et al., 2015; Wauters & Knoors, 2008). According to Netten and colleagues (2015) and Bedny and Saxe (2012), the socio-emotional development of deaf or blind children could benefit from their language and communication skills. Thus, professionals and parents should actively involve deaf or blind children in emotion-evoking situations, particularly by talking about emotions and their contexts more often and deeply. Future research should focus on the development of rehabilitation programs for blind or deaf participants (not only for children but also for adolescents and adults) that actively support the development of empathic abilities.

Limitations and Future Work

While our results seem to be pertinent to the on-going discussion about the development of emotion recognition and empathy skills in both deaf and blind adults, the present study has some limitations that hamper more direct conclusions. First, the small number of participants forces us to look at the results with caution, due to the lack of statistical power to detect even moderate size effects. Second, we must point out that our cross-sectional design prevents us from drawing conclusions about the time-course of the emotional recognition processes. Longitudinal data collection is necessary to confirm the development assumptions made in our discussion.

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Conflicts of Interest

No conflicts of interest were reported.

References

Bachara, G. H., Raphael, J., & Phelan, W. J. (1980). Empathy development in deaf pre-adolescents. *American Annals of the Deaf*, *125*, 38–41. doi:10.1353/aad.2012.1175.

Balconi, M., & Bortolotti, A. (2013). Emotional face recognition, empathic trait (BEES), and cortical contribution in response to positive and negative cues. The effect of rTMS on dorsal medial prefrontal cortex. *Cognitive Neurodynamics*, *7*, 13–21. doi:10.1007/s11571-012-9210-4.

Bedny, M., & Saxe, R. (2012). Insights into the origins of knowledge from the cognitive neuroscience of blindness. *Cognitive Neuropsychology*, *29*, 56–84. doi:10.1080/02643294.2012.713342.

Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: A practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society - Series B*, *57*, 289–300. doi:10.2307/2346101.

Bowers, D., Bauer, R., & Heilman, K. M. (1993). The nonverbal affect lexicon: Theoretical perspectives from neuropsychological studies of affect perception. *Neuropsychology*, *7*, 433–444. doi:10.1037/0894-4105.7.4.433.

Bowers, D., Blonder, L. X., Feinberg, T., & Heilman, K. M. (1991). Differential impact of right and left hemisphere lesions on facial emotion and object imagery. *Brain*, *114*, 2593–2609. doi:10.1093/brain/114.6.2593.

Bowers, D., Blonder, L. X., & Heilman, K. M. (1999). *The Florida Affect Battery*. University of Florida, Center for Neuropsychological Studies, Cognitive Neuroscience Laboratory. Retrieved from: http://neurology.sites.medinfo.ufl.edu/files/2011/12/Florida-Affect-Battery-Manual.pdf.

Chow, C. M., Ruhl, H., & Buhrmester, D. (2013). The mediating role of interpersonal competence between adolescents' empathy and friendship quality: A dyadic approach. *Journal of Adolescence*, *36*, 191–200. doi:10.1016/j.adolescence.2012.10.004.

de Gelder, B., & Vroomen, J. (2000). The perception of emotions by ear and by eye. *Cognition & Emotion*, *14*, 289–311. doi:10.1080/026999300378824.

Dyck, M. J., Farrugia, C., Shochet, I. M., & Holmes-Brown, M. (2004). Emotion recognition/understanding ability in hearing or vision-impaired children: Do sounds sights, or words make the difference? *Journal of Child Psychology and Psychiatry*, *45*, 789–800. doi:10.1111/j.1469-7610.2004.00272.x.

Ekman, P., Friesen, W. V., O'Sullivan, M., Chan, A., Diacoyanni-Tarlatzis, I., Heider, K., … Scherer, K. (1987). Universals and cultural differences in the judgments of facial expressions of emotion. *Journal of Personality and Social Psychology*, *53*, 712–717. doi:10.1037/0022-3514.53.4.712.

Falcone, E. M., Ferreira, M., Luz, R., Fernandes, C. S., Faria, C., D'Augustin, J., … Pinho, V. (2008). Empathy Inventory (EI): Development and validation of a Brazilian measure. *Avaliação Psicológica*, *7*, 321–334. doi:10.1590/S1413-82712013000200004.

Gold, D., Shaw, A., & Wolffe, K. (2010). The social lives of Canadian youths with visual impairments. *Journal of Visual Impairment & Blindness*, *104*, 431–443. doi:10.1177/0264619691009002l8.

Glenn, S. (2007). *The Development of Theory of Mind in Deaf People* (doctoral dissertation). Retrieved from: http://etheses.whiterose.ac.uk/3085/1/485121.pdf.

Hosie, J. A., Gray, C. D., Russell, P. A., Scott, C., & Hunter, N. (1998). The matching of facial expressions by deaf and hearing children and their production and comprehension of emotion labels. *Motivation and Emotion*, *22*, 293–313. doi:10.1023/A:1021352323157.

Jones, A. C., Gutierrez, R., & Ludlow, A. K. (2018). The role of motion and intensity in deaf children's recognition of real human facial expressions of emotion. *Cognition and Emotion*, *32*, 102–115. doi:10.1080/02699931.2017.1289894.

Ketelaar, L., Rieffe, C., Wiefferink, C. H., & Frijns, J. H. (2013). Social competence and empathy in young children with cochlear implants and with normal hearing. *The Laryngoscope*, *123*, 518–523. doi:10.1002/lary.23544.

Klasen, M., Kreifelts, B., Chen, Y. H., Seubert, J., & Mathiak, K. (2014). Neural processing of emotion in multimodal settings. *Frontiers in Human Neuroscience*, *8*, 822. doi:10.3389/fnhum.2014.00822.

Leinonen, L., Hiltunen, T., Linnankoski, I., & Laakso, M. L. (1997). Expression of emotional–motivational connotations with a one-word utterance. *The Journal of the Acoustical Society of America*, *102*, 1853–1863. doi:10.1121/1.420109.

Ludlow, A., Heaton, P., Rosset, D., Hills, P., & Deruelle, C. (2010). Emotion recognition in children with profound and severe deafness: Do they have a deficit in perceptual processing? *Journal of Clinical and Experimental Neuropsychology*, *32*, 923–928. doi:10.1080/13803391003596447.

Massaro, D. W., & Egan, P. B. (1996). Perceiving affect from the voice and the face. *Psychonomic Bulletin & Review*, *3*, 215–221. doi:10.3758/BF03212421.

McConachie, H. R., & Moore, V. (1994). Early expressive language of severely visually impaired children. *Developmental Medicine & Child Neurology*, *36*, 230–240. doi:10.1111/j.1469-8749.1994.tb11836.x.

Mehu, M., & van der Maaten, L. (2014). Multimodal integration of dynamic audio-visual cues in the communication of agreement and disagreement. *Journal of Nonverbal Behavior*, *38*, 569–597. doi:10.1007/s10919-014-0192-2.

Memisevic, H., Mujkanovic, E., & Ibralic-Biscevic, I. (2016). Facial emotion recognition in adolescents with disabilities: The effects of type of disability and gender. *Perceptual and Motor Skills*, *123*, 127–137. doi:10.1177/0031512516660781.

Merabet, L. B., & Pascual-Leone, A. (2010). Neural reorganization following sensory loss: The opportunity of change. *Nature Reviews. Neuroscience*, *11*, 44–52. doi:10.1038/nrn2758.

Minter, M. E., Hobson, R. P., & Pring, L. (1991). Recognition of vocally expressed emotion by congenitally blind children. *Journal of Visual Impairment & Blindness*, *85*, 411–415. doi:10.1177/0264619601019003O6.

Most, T., & Michaelis, H. (2012). Auditory, visual, and auditory: Visual perceptions of emotions by young children with hearing loss versus children with normal hearing. *Journal of speech, Language, and Hearing research*, *55*, 1148–1162. doi:10.1044/1092-4388.

Nascimento, V. V. (2016). *Adaptação da Florida Affect Battery à população Portuguesa*. (Unpublished master's dissertation). University of Algarve, Faro, Portugal.

Netten, A. P., Rieffe, C., Theunissen, S. C., Soede, W., Dirks, E., Briaire, J. J., & Frijns, J. (2015). Low empathy in deaf and hard of hearing (pre) adolescents compared to normal hearing controls. *PLoS One*, *10*, e0124102. doi:10.1371/journal.pone.0124102.

Peterson, C. C. (2016). Empathy and theory of mind in deaf and hearing children. *The Journal of Deaf Studies and Deaf Education*, *21*, 141–147. doi:10.1093/deafed/env058.

Peterson, C. C., & Siegal, M. (1999). Representing inner worlds: Theory of mind in autistic, deaf, and normal hearing children. *Psychological Science*, *10*, 126–129. doi:10.1111/1467–9280.00119.

Posner, J., Russell, J. A., & Peterson, B. S. (2005). The circumplex model of affect: An integrative approach to affective neuroscience, cognitive development, and psychopathology. *Development and Psychopathology*, *17*, 715–734. doi:10.1017/S0954579405050340.

Raghibdoust, S., Sobati, E., & Shaghaghi, V. (2018). Theory of mind and its neural mechanisms: A case study of Kurdish-Persian congenitally blind children in Ilam city. *Journal of Basic Research in Medical Science*, 5, 39–47. doi:10.29252/jbrms.5.2.39.

Regenbogen, C., Schneider, D. A., Finkelmeyer, A., Kohn, N., Derntl, B., Kellermann, T., … Habel, U. (2012). The differential contribution of facial expressions, prosody, and speech content to empathy. *Cognition and Emotion*, *26*, 995–1014. doi:10.1080/02699931.2011.631296.

Rezlescu, C., Penton, T., Walsh, V., Tsujimura, H., Scott, S., & Banissy, M. (2015). Dominant voices and attractive faces: The contribution of visual and auditory information to integrated person impressions. *Journal of Nonverbal Behavior*, *39*, 355–370. doi:10.1007/s10919-015-0214-8.

Rigo, T. G., & Liberman, D. A. (1989). Nonverbal sensitivity of normal hearing and hearing-impaired older adults. *Ear and Hearing*, *10*, 184–189.

Rodrigues, J., Lopes, A., Giger, J. C., Gomes, A., Santos, J., & Gonçalves, G. (2011). Measurement Scales of the Empathy/Systematization Quotient: A validation test for the Portuguese population. *Psicologia*, *25*, 73–89. doi:10.17575/rpsicol.v25i1.280.

Sprung, M., Münch, H. M., Harris, P. L., Ebesutani, C., & Hofmann, S. G. (2015). Children's emotion understanding: A meta-analysis of training studies. *Developmental Review*, *37*, 41–65. doi:10.1016/j.dr.2015.05.001.

Takagi, S., Hiramatsu, S., Tabei, K., & Tanaka, A. (2015). Multisensory perception of the six basic emotions is modulated by attentional instruction and unattended modality. *Frontiers in Integrative Neuroscience*, *9*, 1. doi:10.3389/fnint.2015.00001.

Valente, D., Theurel, A., & Gentaz, E. (2018). The role of visual experience in the production of emotional facial expressions by blind people: A review. *Psychonomic Bulletin & Review*, *25*, 483–497. doi:10.3758/s13423-017-1338-0.

Vargha, A., & Delaney, H. D. (2000). A critique and improvement of the CL common language effect size statistic of McGraw and Wong. *Journal of Educational and Behavioral Statistics*, *25*, 101–132. doi:10.3102/1076998602500210.

Vroomen, J., Driver, J., & de Gelder, B. (2001). Is crossmodal integration of emotional expressions independent of attentional resources? *Cognitive, Affective & Behavioral Neuroscience*, *1*, 382–387. doi:10.3758/CABN.1.4.382.

Wakabayashi, A., Baron-Cohen, S., Wheelwright, S., Goldenfeld, N., Delaney, J., Fine, D., & Weil, L. (2006). Development of short forms of the Empathy Quotient (EQ-Short) and the Systemizing Quotient (SQ-Short). *Personality and Individual Differences*, *41*, 929–940. doi:10.1016/j.paid.2006.03.017.

Wauters, L. N., & Knoors, H. (2008). Social integration of deaf children in inclusive settings. *Journal of Deaf Studies and Deaf Education*, *13*, 21–36. doi:10.1093/deafed/enm028.

Wells, L. J., Gillespie, S. M., & Rotshtein, P. (2016). Identification of emotional facial expressions: Effects of expression, intensity, and sex on eye gaze. *PLoS One*, *11*, e0168307. doi:10.1371/journal.pone.0168307.

Wiefferink, C., Rieffe, C., Ketelaar, L., De Raeve, L., & Frijns, J. (2013). Emotion understanding in deaf children with a cochlear implant. *The Journal of Deaf Studies and Deaf Education*, *18*, 175–186. doi:10.1093/deafed/ens042.

Yekutieli, D., & Benjamini, Y. (1999). Resampling-based false discovery rate controlling multiple test procedures for correlated test statistics. *Journal of Statistical Planning and Inference*, *82*, 171–196. doi:10.1016/S0378-3758(99)00041-5.

Zuckerman, M., & Driver, R. E. (1989). What sounds beautiful is good: The vocal attractiveness stereotype. *Journal of Nonverbal Behavior*, *13*, 67–82. doi:10.1007/BF00990791.