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Emotional valence and arousal induced by auditory stimuli among individuals with visual impairment

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Abstract

Despite significant vision loss, humans can still recognize various emotional stimuli via a sense of hearing and express diverse emotional responses, which can be sorted into two dimensions, arousal and valence. Yet, many research studies have been focusing on sighted people, leading to lack of knowledge about emotion perception mechanisms of people with visual impairment. This study aims at advancing knowledge of the degree to which people with visual impairment perceive various emotions – high/low arousal and positive/negative emotions. A total of 30 individuals with visual impairment participated in interviews where they listened to stories of people who became visually impaired, encountered and overcame various challenges, and they were instructed to share their emotions. Participants perceived different kinds and intensities of emotions, depending on their demographic variables such as living alone, loneliness, onset of visual impairment, visual acuity, race/ethnicity, and employment status. The advanced knowledge of emotion perceptions in people with visual impairment is anticipated to contribute toward better designing social supports that can adequately accommodate those with visual impairment.

Keywords

Arousal, blindness, emotion, perception, valence, visual impairment

Introduction

Humans react to stimuli by making emotional responses; for example, an individual identifies the emotional significance of a stimulus, produces, and regulates an emotional state (Phillips, Drevets, Rauch, & Lane, 2003). Emotions can be sorted into two dimensions, arousal and valence that are typically represented geometrically as orthogonal dimensions (Russell, 2003; Russell & Barrett, 1999). Arousal is defined as the degree to which an individual is excited (e.g., high and low) while

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valence is defined as the polarity of emotion (e.g., positive and negative; Bradley, Codispoti, Cuthbert, & Lang, 2001). For example, perceived emotions are categorized as high-arousal positive emotions (e.g., excited and active), low-arousal positive emotions (e.g., calm and placid), high-arousal negative emotions (e.g., fearful and hostile), and low-arousal negative emotions (e.g., drowsy and dull; Hoyt, Craske, Mineka, & Adam, 2015; Kuperman, Estes, Brysbaert, & Warriner, 2014).

Human emotion perception is likely to be influenced by various factors such as age, gender, and loneliness. For example, older adults are more likely to show a decreased negative arousal and an increased positive low arousal as compared to their younger peers (Kessler & Staudinger, 2009). Older adults tend to consider negative pictures as more arousing but positive pictures as less arousing (Grühn & Scheibe, 2008). According to a national survey ($n = 340{,}847$) in the United States (Stone, Schwartz, Broderick, & Deaton, 2010), people tend to report that they have an increased psychological well-being after the age of 50 years; have affective states *Stress* and *Anger* declined from the early 20s; have another affective state *Worry* elevated through middle age and then declined; but the degree to which they feel *Sadness* tends to be constant over the lifespan. With regard to gender, it is argued that females are more likely to be sensitive to subtle differences in arousal emotions expressed by others (e.g., facial expressions) compared to male counterparts (Thayer & Johnsen, 2000). Deng, Chang, Yang, Huo, & Zhou (2016) found that female participants perceived higher levels of arousal while watching videos that induced anger, amusement, and pleasure. Loneliness is also known as one of the factors influencing emotion perception. People who feel lonelier tended to rate bonding pictures (e.g., a parent interacting with a baby/child via eye contact and hug) as less pleasant and less arousing as compared to their peers who feel less lonely (Silva et al., 2017). It is also documented that more lonely people are less likely to identify visual social cues (Kanai et al., 2012). People with loneliness are less likely to anticipate good social interactions and more likely to avoid social stimuli (Gable, 2006).

Although people are visually impaired (including blind), they could still rely on the remaining vision (or the remaining sensory modalities such as hearing) in perceiving emotions in other people. Theory of mind (Premack & Woodruff, 1978) refers to the ability to attribute mental states (e.g., true and false beliefs) to self and others, which is one of the critical elements for social interaction in that an individual would infer states (that are not directly observable) to predict the behavior of others and/or our own. It is reported that children with visual impairment can still develop the theory of mind although they are delayed in acquiring the theory of mind (McAlpine & Moore, 1995; Minter, Hobson, & Pring, 1991; Peterson C, Peterson J, & Webb, 2000). Peterson et al. (2000) claimed that the theory of mind deficits in people with visual impairment are likely induced by the limited access to social and conversational experiences in early life.

Yet, the vast majority of research on emotion recognition abilities have been centered around sighted people over people with visual impairment, leading to lack of knowledge about emotion perception mechanisms among people with visual impairment. We have found a few published reports that discuss the emotion perception in people with visual impairment. For example, people with visual impairment were less likely to understand emotion sounds as compared to their peers without visual impairment (Minter et al., 1991). Dyck, Farrugia, Shochet, & Holmes-Brown (2004) uncovered that people with visual impairment were delayed on emotion recognition tasks compared to their peers without visual impairment. There is also evidence showing a close relationship between visual impairment and emotional challenges, leading to perceiving negative emotions such as distress, depression, and loneliness (Choi, Lee M, & Lee S, 2018; Nyman, Dibb, Victor, & Gosney, 2012). Gleeson, Sherrington, Lo, Auld, & Keay (2017) observed a high level of self-reported depressive symptoms in participants with visual impairment (approximately one-third of 120 participants aged 50 to 90 years). After participants with visual impairment were exposed to a

Table 1. Descriptions of the participants.

Participants	$n = 30$
Visual acuity	
Between 20/200 and 20/400	9
Between 20/400 and 20/1200	4
Less than 20/1200, but has light perception	15
No light perception at all	2
Duration of visual impairment (years)	17.63 ± 23.11
Onset of visual impairment (years)[a]	
Early onset ($n = 10$)	0.4 ± 1.26
Late onset ($n = 20$)	45.81 ± 17.13
Age (years)	59.7 ± 17.84
Gender	
Male	11
Female	19
Race/ethnicity	
African American	11
European American	17
Hispanic American	1
Others	1
Occupation	
Employed	9
Unemployed	21
Head of household	
Living alone	9
With family, relatives, friends, or combination of them	21
Loneliness (UCLA loneliness scale)	
High ($n = 5$)	56.20 ± 6.46
Moderate ($n = 10$)	39.20 ± 3.88
Low ($n = 15$)	27.07 ± 4.56

UCLA: University of California Los Angeles.
[a]Participants with early onset of vision loss had lost their sight before 11 years of age (Voss, Gougoux, & Guillemot, 2004).

set of musical stimuli (Park & Chong, 2019), they showed a significantly higher arousal and stronger intensity for the emotion of sadness as compared to their peers without visual impairment. Donoyama & Takeda (2007) reported that massage therapists with visual impairment tended to perceive a higher level of anxiety than did their peers without visual impairment.

We noticed that there is lack of understanding about how people with visual impairment perceive a combination of high- or low-arousal emotions and positive or negative emotions. Thus, this study focuses on exploring the degree to which people with visual impairment perceive various emotions when given a set of emotional stimuli.

Methods

Participants

As shown in Table 1, a total of 30 research participants were invited to this research. Inclusion criteria were English speaking, 18 years old or older, and visual impairment. Visual impairment

were categorized into two groups, that is, the visual acuity between 20/200 and 20/400 is considered severe visual impairment and the visual acuity less than 20/400 is considered blindness (World Health Organization, 2008). Participants who had difficulty in hearing and communicating (e.g., hearing loss) were not invited for this study. Participants' perceived loneliness was measured using the University of California Los Angeles (UCLA) loneliness scale (version 3; Russell, Peplau, & Ferguson, 1978). The UCLA scale consists of 20 items, which should be completed using a 4-point Likert-type type scale (1 = *Never* to 4 = *Often)*. In this study, we considered a score < 35 as a low degree of loneliness, a score $\geqslant 35$ as a moderate degree, and a score $\geqslant 50$ as a high degree (Kusaslan Avci, 2018; Perry, 1990). Participants' responses to the UCLA scale showed adequate internal consistency (Cronbach's $\alpha = .92$).

Materials

A demographic survey form (including the UCLA loneliness scale) was used to obtain a deep understanding of participants' characteristics such as visual acuity, age, gender, loneliness, and so on. Stimuli of emotional speech were voice-recorded (approximately 10 min in total) using the stories of people with visual impairment (e.g., how they lost their vision, what challenges they encountered, and how they overcome the challenges), publicly available from the homepage of the Minnesota State Services for the Blind.

Procedures

Participants with visual impairment were individually invited to an interview by phone ($n = 3$) and Zoom ($n = 27$) as three participants did not have access to Zoom. It lasted no longer than 60 min for each participant. For example, the interviewer played the pre-recorded audios using an audio player. After participants listened to the recordings all at once, they were instructed to discuss which emotion they perceived. They also used a rating scale from 0 (*Not at all*) to 8 (*Strongly*) to report the degree to which they perceived high-arousal positive, low-arousal positive, high-arousal negative, and low-arousal negative emotions. This study was approved by the Institutional Review Board.

Data analysis

The data were analyzed using the descriptive statistics, the Cronbach's α for internal consistency, and the Kruskal–Wallis test with the post hoc Mann–Whitney test. Statistical analyses were performed using the IBM SPSS Statistics for Macintosh, version 24 (IBM Corp., 2016).

Results

Positive emotion

Although participants were equally exposed to the same emotional stimuli, they perceived emotions differently. For example, this research found individual differences in positive emotion perception (e.g., amusements, happy, interest, joy, love, and pride) among participants who had different living conditions (living with oneself or others) and different levels of perceived loneliness. The number of positive emotions perceived by participants was significantly different between participants living alone and with others, $U = 52.50$, $z = -1.99$, $p = .047$, $r = -.36$. Participants living alone perceived more various positive emotions ($5.33 \pm .87$) than did their peers living with others (4.33 ± 1.49). The intensity of positive emotions perceived by participants living

alone (5.80 ± 1.41) was greater than that (4.44 ± 1.95) by those living with others, $U = 51.50$, $z = -1.95$, $p = .05$, $r = -.36$. The number of positive emotions (4.40 ± 1.34) perceived by participants with a high level of loneliness was significantly fewer than that ($5.60 \pm .63$) by those with a low level of loneliness, $U = 12.00$, $z = -2.47$, $p = .01$, $r = -.45$. The intensity of positive emotions (4.57 ± 2.20) perceived by participants with a moderate level of loneliness was significantly weaker than that (6.32 ± 1.44) by those with a low level of loneliness, $U = 35.00$, $z = -2.22$, $p = .03$, $r = -.41$.

High- and low-arousal positive emotion

We conducted a more in-depth analysis by breaking the data of positive emotion perception into "high-arousal" positive emotion (e.g., happy and love) and "low-arousal" positive emotion (e.g., amusement, interest, joy, and pride).

High-arousal positive emotion. This study found significance in high-arousal positive emotion perception between participants who had different levels of perceived loneliness and who had different onset times of vision loss. For example, a significant difference was found in emotion intensity among participants who had different levels of perceived loneliness, $H(2) = 5.79$, $p = .05$. A post hoc analysis found a significant difference between participants with a low level of loneliness and their peers with a moderate level of loneliness, $U = 33$, $z = -2.34$, $p = .02$, $r = -.43$. The emotion intensity of those with a low level of loneliness (5.77 ± 2.15) was higher than that (3.65 ± 2.43) of those with a moderate level of loneliness. A significant difference in emotion intensity was also found between participants with early onset and late onset of vision loss, $p = .05$, $z = -1.92$, $u = 56.50$, $r = -.35$. The perceived intensity was stronger in those with late onset of vision loss (5.30 ± 2.32) than their peers with early onset (4.75 ± 2.82).

Low-arousal positive emotion. A significant difference was found in low-arousal positive emotion between participants who had different living conditions (i.e., living alone and living with others), different race/ethnic backgrounds, and different employment status. For example, there was a significant difference in emotion intensity between participants living alone (4.17 ± 1.74) and living with others (4.95 ± 1.86), $U = 51.50$, $z = -1.95$, $p = .05$, $r = -.36$, as well as between African American participants (4.95 ± 1.85) and European American participants (4.62 ± 1.84), $U = 52.50$, $z = -1.97$, $p = .05$, $r = -.36$. The number of emotions perceived by participants who were employed and unemployed was significantly different, $U = 52.50$, $z = -2.05$, $p = .04$, $r = -.37$ in that employed participants perceived more various low-arousal positive emotions ($3.56 \pm .53$) than did unemployed participants (2.81 ± 1.03).

Low-arousal negative emotion

The number of emotions perceived by participants was significantly different depending on the degree to which their vision was impaired, $U = 47.00$, $z = -2.28$, $p = .02$, $r = -.42$. Participants with severe visual impairment perceived more various low-arousal negative emotions (1.33 ± 1.22) than did their peers with blindness ($.76 \pm .89$). No significance was found for high-arousal negative emotions.

Discussion

Participants living with others tended to perceive less frequently and less intensively positive emotions as compared to their peers living alone. Fingerman et al. (2021) also reported a similar result

that older adults living alone were found to be more related with perceiving positive emotions while interacting with people. Living with someone in the house would not necessarily mean that they are not lonely (Perissinotto, Stijacic Cenzer, & Covinsky, 2012). As the demographic survey in this study did not include questions about their social contact frequency and network size, it may be hypothetically argued that the participants with severe visual impairment and blindness who lived alone might have been more active in social life (e.g., making more effort to interact with a variety of people more often), leading to perceiving more frequently and more intensively positive emotions as compared to their peer participants who lived with others. Thus, social activities should be investigated in the future research to examine the relationships between social activities, vision loss, and positive/negative emotion perception.

Positive emotions play an important role in quality of life as there are many potential health benefits of living with positive emotions. A study by Newall, Chipperfield, Bailis, & Stewart (2013) argued that positive emotions would contribute to attenuating the negative effects of perceived loneliness, leading to enhancing physical activity and reducing mortality. Queen, Stawski, Ryan, & Smith (2014) also empirically observed that less lonely participants perceived more positive emotions while performing activities of daily living such as watching television, doing household chores, and using the computer. A combination of living with vision loss and living alone could be a significant challenge in daily life, probably leading to fewer opportunities to go outside and socially interact with people. Yet, people with vision loss may consider using a workaround method, for example, participating in online support groups by phone or Zoom as there is evidence that virtual interactions help to reduce loneliness (Hu, 2009).

When positive emotions were broken down into high- and low-arousal positive emotions, lonelier participants tended to perceive less intensively high-arousal positive emotions (e.g., happy and love), and participants with earlier onset of vision loss also tended to do so. The findings are consistent with literature; for example, Pels & Kleinert (2016) found that loneliness was likely to be closely related with being less active, leading to the lower arousal state. It is also documented that emotions with different arousal levels contribute differently to human behavior and activities (Clark, Milberg, & Ross, 1983). For example, high-arousal emotions are considered as energized states contributing to preparing actions, but low-arousal emotions are states of being inactive associated with rest and satiety (Russell, 2003). Russell (2003) claimed that low-arousal states could be considered as times of inaction, likely caused by abandonment of goals. Given the logic, participants with early onset of vision loss who showed "less intensively" high-arousal emotions would theoretically be anticipated to show, for example, "lower rates" of employment. Yet, there is evidence that earlier onset of vision loss is positively associated with higher employment rates. For example, higher employment rates were observed in people who lost their vision earlier (e.g., those who lost it before 16 years of age; Clements, Douglas, & Pavey, 2011); those who lost it before 5 years of age (La Grow, 2004), and those who were congenitally blind compared to their peers who became blind later in life (Bell & Silverman, 2018). Wahl (2013) asserted that people with later onset of vision loss are more likely to suffer from a variety of psychological challenges. It could hypothetically be argued that the experience with earlier onset of vision loss would somehow contribute to elevating the level of arousal states of individuals with vision loss, leading to being well-adjusted for the life with vision challenges and well-prepared for their career in the future. As many emotion studies tended to focus on sighted people, our future research will examine in more detail how onset of vision loss is related with high/low-arousal emotions and how the relationship would affect their emotional intelligence – that is, a determinant contributing to successful life adjustment (Sjöberg, 2008).

Less-intensive low-arousal positive emotions were perceived by participants who lived alone than those who lived with others as well as by European American participants than African

American participants. Pauly, Lay, Nater, Scott, & Hoppmann (2017) also examined the relationship between the experience of spending time alone and the low-arousal positive emotions. Both the study by Pauly et al. and this study included participants who reported that they spent time alone and felt low-arousal positive emotion, but the study by Pauly et al. observed that participants who spent time alone reported a higher intensity of low-arousal positive emotions as compared to participants who spent time with others, which is contradictory to the results of this study. Yet, it should be noted that the two studies were conducted under slightly different experimental conditions; that is, the study by Pauly et al. included sighted participants, while this study included participants with severe visual impairment and blindness. It may hypothetically be argued that the status of vision loss would somehow contribute to reducing the perceived intensity of low-arousal positive emotions among those who lived alone.

Deer, Shields, Ivory, Hostinar, & Telzer (2018) also investigated the individual differences in low-arousal positive emotion perception among people with different racial/ethnic backgrounds. They found that African American participants showed a lower intensity of low-arousal positive emotions compared to European American participants, which is contradictory to the results of this study. As participants in the study by Deer et al. were sighted, while participants in this study were all visually impaired, it may hypothetically be argued that the status of vision loss may somehow contribute to feeling the low-arousal positive emotions more intensively in African American participants than European American participants. However, it should be noted that the data collection method was not identical between the two studies as Deer et al. asked participants to keep a daily mood diary for 14 days to report the degree to which they perceived different emotions: high/low-arousal positive/negative emotions on a daily basis; on the contrary, this study asked participants to listen to stories about other people who lost their vision, encountered various challenges, and overcame them, and then report how they felt. Thus, participants in the study by Deer et al. responded to their own life stories, while participants in this study responded to other people's life stories. Our future research will, thus, incorporate the daily mood diary approach for several days to observe the degree to which people with vision loss respond emotionally to their daily challenges associated with vision loss.

In addition to intensity, frequency was also influenced differently in perceiving low-arousal positive emotions among participants with different demographic variables. For example, participants who were unemployed (compared to those who were employed) tended to perceive less frequently low-arousal positive emotions. It is well-documented that unemployment is a stressful event, leading to perceiving negative emotions such as depression (Egan, Daly, & Delaney, 2016) and a low level of self-esteem (Bell & Blanchflower, 2011). Unemployment problems in people with vision loss have been considered as a serious issue. Many studies addressed the lower employment rates of people with vision loss as compared to their sighted peers (Cimarolli & Wang, 2006; McDonnall, 2011; Wolffe & Spungin, 2002). There are many factors leading to such lower employment rates including personal, physical, institutional, social, and psychological factors (Aroonsrimorakot, Laiphrakpam, Paisantanakij, & Nilthongkum, 2020). By considering those various factors, adequate interventions should be designed to address properly the lower employment rates and relevant poor emotional well-being in those with vision loss.

We also found individual differences among participants with different levels of vision loss. Participants who were blind tended to perceive less frequently low-arousal negative emotions compared to their peers who were severely visually impaired. The research team by Rai, Rohatgi, & Dhaliwal (2019) compared the coping strategies to address negative emotions between people with blindness and severe visual impairment. People with severe visual impairment tended to rely more on proactive coping strategies compared to their peers with blindness. Individuals using proactive coping strategies (Greenglass, Schwarzer, Jakubiec, Fiksenbaum, & Taubert, 1999) make effort to

anticipate or detect potential stressors associated with, for example, his or her disability so that they proactively seek resources to overcome any challenges they would encounter in the near future and/or act in advance to prevent them. Rai et al. claimed that as compared to people with blindness, people with severe visual impairment can still rely on residual vision such that they are more likely to visually detect potential stressors, which is contributing to their proactive coping strategies. Given the logic of Rai et al., people with severe visual impairment would feel less negative emotion because they are more likely to take advantage of proactive coping strategies compared to their peers with blindness. However, the logic is not applicable to this study as its result showed the opposite outcome, that is, participants with blindness felt less frequently low-arousal negative emotions compared to their peers with severe visual impairment. It should be noted that this study used auditory emotional stimuli while the study by Rai et al. used visual emotional stimuli. Thus, it can hypothetically be argued that people with severe visual impairment and blindness might use coping strategies differently for visual stimuli and auditory stimuli. Future research will examine the relationships between a "type of emotional stimuli and a 'degree" of vision loss with regard to coping strategies and positive/negative emotion perceptions.

This study may have been affected by a few limitations. The emotion perception data were collected virtually by using phone calls or Zoom meetings. Participants' perception might have been different if they interacted with the stimuli of emotional speech in person and/or on a daily basis. The recorded emotional speech samples were prepared with adult female voice such that participants' perception might have been different if voice was recorded with different characteristics in terms of gender, age, and accent. Participants listened to the emotional speech samples all at once, which might have affected their memory, leading to difficulty in recalling their emotions although the samples were relatively short, lasting ~10 min in total. As this study was not aimed to make participants perceive a particular emotion, the speech stimuli samples were prepared using the true stories (non-fiction). On the contrary, the samples were not scientifically validated; thus, samples with different stories might have induced different emotions. Our future research will be conducted by addressing those limitations.

Conclusion

Although vision is impaired, people can still rely on their remaining sensory modalities (e.g., hearing) to perceive a range of emotions. As there is lack of understanding of emotion perception mechanisms of people with visual impairment, this study contributed to advancing knowledge of how they perceive various emotions in terms of high/low arousal and positive/negative emotions. The advanced knowledge is anticipated to play a critical role in designing social supports that accommodate adequately the needs and concerns in people with visual impairment who are at risk of experiencing emotional distress associated with work, family, aging, and health problems.

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