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Research Report

Blindness influences emotional authenticity perception in voices: Behavioral and ERP evidence

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ABSTRACT

The ability to distinguish spontaneous from volitional emotional expressions is an important social skill. How do blind individuals perceive emotional authenticity? Unlike sighted individuals, they cannot rely on facial and body language cues, relying instead on vocal cues alone. Here, we combined behavioral and ERP measures to investigate authenticity perception in laughter and crying in individuals with early- or late-blindness onset. Early-blind, late-blind, and sighted control participants ($n = 17$ per group, $N = 51$) completed authenticity and emotion discrimination tasks while EEG data were recorded. The stimuli consisted of laughs and cries that were either spontaneous or volitional. The ERP analysis focused on the N1, P2, and late positive potential (LPP). Behaviorally, early-blind participants showed intact authenticity perception, but late-blind participants performed worse than controls. There were no group differences in the emotion discrimination task. In brain responses, all groups were sensitive to laughter authenticity at the P2 stage, and to crying authenticity at the early LPP stage. Nevertheless, only early-blind participants were sensitive to crying authenticity at the N1 and middle LPP stages, and to laughter authenticity at the early LPP stage. Furthermore, early-blind and sighted participants were more sensitive than late-blind ones to crying authenticity at the P2 and late LPP stages.

Altogether, these findings suggest that early blindness relates to facilitated brain processing of authenticity in voices, both at early sensory and late cognitive-evaluative stages. Late-onset blindness, in contrast, relates to decreased sensitivity to authenticity at behavioral and brain levels.

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1. Introduction

Differentiating spontaneous (authentic) from volitional (posed) emotional expressions is an important social skill (Anikin & Lima, 2018; Gervais & Wilson, 2005). We can spontaneously express our emotions (e.g., crying when a relative dies) but we can also regulate and voluntarily control them (e.g., laughing at a friend's joke to make them happy). A sighted individual learns to decode the emotional states of others based on multisensory cues, such as facial, body, and vocal expressions combined. By contrast, blind individuals rely on vocal cues alone. Understanding whether the loss of sight affects the ability to interpret others' emotions and intentions is of the utmost importance considering that blind individuals often need to trust others in daily life (e.g., when asking for guidance in an unknown street).

1.1. *Vocal emotional perception in blind individuals*

The few existing studies on emotion processing in blind individuals produced mixed findings (Chen et al., 2022; Gamond et al., 2017; Klinge et al., 2010; Martins et al., 2019). A functional magnetic resonance imaging (fMRI) study found that, compared with sighted controls, blind individuals show increased amygdala responses for fearful and angry prosody compared to neutral prosody, along with faster and more accurate emotion discrimination (Klinge et al., 2010). Other studies reported a different pattern of results, though (Chen et al., 2022; Gamond et al., 2017; Martins et al., 2019). For example, Gamond et al. (2017) found that early-blind individuals are as accurate as sighted controls at detecting happiness and sadness in nonverbal vocalizations, a null finding that Chen et al. (2022) also observed for emotional prosody recognition. Nevertheless, Martins et al. (2019) found that early-blind adults perform worse than sighted controls when evaluating sentences in which prosody and semantics are emotionally congruent or incongruent. These inconsistencies might reflect sample specificities (e.g., age of onset of the visual loss or the duration of the visual impairment), task differences (e.g., implicit *vs* explicit processing), or stimulus differences (e.g., prosody *vs* nonverbal vocalizations). It remains therefore unclear whether blind individuals develop compensatory mechanisms for vocal emotional processing (resulting in processing advantages), or whether vision is rather necessary for the typical development of emotion decoding (resulting in processing deficits). Furthermore, except for Chen et al. (2022), the available studies only included early-blind participants (Gamond et al., 2017; Klinge et al., 2010; Martins et al., 2019). Studying late-onset blindness is important, especially if we consider the increasing aging population in developed countries and the association between blindness and aging (Flaxman et al., 2017). Late blindness also provides a model to examine how the brain changes plastically because of a sensory loss after years of normal visual experience.

Crucially, studies of emotion processing in blind individuals rely entirely on volitional expressions. However, there are acoustic differences between volitional and spontaneous emotional expressions (e.g., Anikin & Lima, 2018; Lavan et al., 2016; Pinheiro et al., 2021), and studies of sighted individuals provide evidence that volitional and spontaneous expressions are differentiated at perceptual (e.g., Anikin & Lima, 2018), peripheral physiological (Lima et al., 2021), and cortical levels (Lavan et al., 2017; McGettigan et al., 2015).

1.2. *Perception of emotional authenticity in sighted listeners*

The study of emotional authenticity perception in sighted individuals has attracted increasing interest in recent years (e.g., Anikin & Lima, 2018; Bryant & Aktipis, 2014; Namba et al., 2017; Pinheiro et al., 2021; Zloteanu et al., 2018; Zloteanu & Krumhuber, 2021). In the auditory modality, inferring whether a vocalization is spontaneous or volitional requires a judgment of intentionality based on subtle acoustic cues (Lima et al., 2021). Spontaneous emotional expressions are usually reactive to outside events, while volitional ones reflect more intentional and controlled forms of communication (Bryant & Aktipis, 2014; Cosme et al., 2021; Scott et al., 2014). Whereas spontaneous laughter is often a reaction to positive or surprising events, for example, volitional laughter is a more deliberate communicative expression, often used to convey appreciation, agreement, or to deceive others (Cosme et al., 2021; Scott et al., 2014). Spontaneous crying is usually an authentic reaction to negative or overwhelming positive events, while volitional crying is often associated with manipulation and social deception (ten Brinke and Porter, 2012; Cosme et al., 2021).

Sighted individuals can discriminate spontaneous from volitional vocal expressions with above-chance accuracy across several emotions (Anikin & Lima, 2018; Sauter & Fischer, 2018), including amusement (Bryant & Aktipis, 2014; Cosme et al., 2021; Lavan et al., 2016; Lima et al., 2021; Pinheiro et al., 2021) and sadness (Cosme et al., 2021; Lima et al., 2021; Pinheiro et al., 2021). Compared to volitional laughs and cries, their spontaneous counterparts are perceived as more authentic (Billing et al., 2021; Cosme et al., 2021; Lavan et al., 2016; Lavan & McGettigan, 2017; Lima et al., 2021; Neves et al., 2018; Pinheiro et al., 2021), contagious (Billing et al., 2021; Cosme et al., 2021; Neves et al., 2018), trustworthy (Pinheiro et al., 2021), and arousing (Cosme et al., 2021; Lavan et al., 2016; Lavan & McGettigan, 2017; Pinheiro et al., 2021). Spontaneous laughs are also perceived as more positive than volitional ones (Lavan et al., 2016; Lavan & McGettigan, 2017; Pinheiro et al., 2021). Acoustically, spontaneous laughs tend to have longer total duration than volitional laughs, shorter burst duration, higher and more variable fundamental frequency, brighter timbre, higher percentage of unvoiced segments, higher and more variable harmonics-to-noise-ratio, greater general variability, and lower mean intensity (Anikin & Lima, 2018; Lavan et al., 2016; Pinheiro et al., 2021).

Differences between spontaneous and volitional laughs are also observed in brain activity (Lavan et al., 2017; McGettigan et al., 2015). In a study by McGettigan et al. (2015), passively listening to spontaneous laughter elicited greater activity in bilateral superior temporal gyri, whereas listening to volitional laughter elicited greater activity in the anterior medial prefrontal cortex. These findings suggest a stronger engagement of mentalizing processes in response to nonauthentic vocalizations. Based on the same dataset, Lavan et al. (2017) found an association between brain responses to spontaneous versus volitional laughter and perceived stimulus valence, arousal, and authenticity. Although fewer studies have examined cortical responses to crying authenticity, two recent electroencephalographic (EEG) studies probed authenticity perception in both laughter and crying (Conde et al., 2022; Kosilo et al., 2021). They found effects of authenticity on distinct neural processing stages of vocal emotion (Conde et al., 2022; Kosilo et al., 2021) reflected in modulations of specific event-related potentials (ERP). Specifically, authenticity effects for laughter and crying were observed at early sensory (N1) and salience detection processing stages (P2): volitional (*vs* spontaneous) laughs elicited more negative N1 and more positive P2 amplitudes (Conde et al., 2022), whereas spontaneous cries evoked increased N1 (Kosilo et al., 2021) and P2 amplitudes (Conde et al., 2022). At later stages, associated with sustained attention and cognitive evaluation, authenticity effects were found for laughter and crying, and were reflected in modulations of the Late Positive Potential (LPP; Conde et al., 2022). The LPP is a long-lasting positive deflection that typically emerges 400 msec post-stimulus onset (Hajcak & Foti, 2020; Moran et al., 2013), and is sensitive to the emotional quality of vocalizations (Martins et al., 2022; Pell et al., 2015; Proverbio et al., 2020; but see Jessen & Kotz, 2011).

A different pattern of results across ERP studies could reflect differences in the experimental approach (Conde et al., 2022; Kosilo et al., 2021). Although both studies included spontaneous and volitional laughs and cries, Kosilo et al. (2021) also included neutral vocalizations. Additionally, in the study by Kosilo et al. (2021), participants rated the authenticity of vocalizations using a 7-point Likert scale, whereas in Conde et al. (2022) effects of task instructions were also tested (i.e., participants completed two tasks, focusing on either authenticity or emotion categorization).

Because research on blindness and vocal emotional processing is entirely based on volitional expressions, whether and how blind listeners perceive emotional authenticity differently from sighted listeners remains unknown. One possibility is that they show less efficient authenticity perception abilities, because during development they cannot additionally learn from visual cues that help differentiate spontaneous from volitional expressions, such as the presence of tears or the activity of the orbicularis oculi, the muscle that produces wrinkles around the eye socket (Lima et al., 2021; Grainger et al., 2019). Alternatively, they may develop compensatory mechanisms for voice perception and become more tuned to the acoustic cues that signal authenticity in vocalizations.

1.3. *The current study*

The current study combined behavioral and ERP measures to examine whether and how blindness influences emotional authenticity processing in laughs and cries. We considered early- and late-onset blindness, and we also manipulated task instructions, i.e., explicit focus on authenticity versus focus on the expressed emotion. Because previous evidence is scarce, the study is exploratory to a significant extent. We did anticipate distinct patterns of results depending on the acting mechanism, though. If cortical reorganization is compensatory (Kupers & Ptito, 2014; Singh et al., 2018), such that vocal emotional processing improves to compensate for the lack of vision, we can expect more accurate emotional authenticity perception in early-blind individuals compared with late-blind and sighted ones, along with more prominent differences in neural responses to spontaneous compared to volitional vocalizations. By contrast, if visual input is required for the typical development of vocal emotional processing abilities, we can expect impaired emotional authenticity perception in early-blind compared with late-blind and sighted individuals, along with blunted differences in neural responses to spontaneous compared to volitional vocalizations. A less likely possibility is that visual and vocal emotional processing develop independently from one another, such that no group differences would be observed. Regarding the age of blindness onset, it is plausible that early cortical reorganization could trigger compensatory mechanisms in early-blind individuals, resulting in improved vocal authenticity processing, whereas sensory loss later in life could have the opposite effect. The multisensory experience acquired previously would no longer serve late-blind individuals, and new skills would need to be developed later in life, when plasticity is arguably smaller (Kupers & Ptito, 2014; Sabourin et al., 2022; Singh et al., 2018). If this possibility is true, late-blind individuals could show decreased sensitivity to authenticity compared to early-blind and sighted individuals.

Furthermore, if putative group differences reflect early sensory processing of emotional authenticity or emotional salience detection, they should be observed in the N1 and P2 time windows, respectively. If group differences reflect the cognitive evaluation of emotional authenticity, they should be observed in later processing stages, as reflected in the LPP component or in behavioral measures.

2. Method

2.1. *Participants*

We report how we determined our sample size, all data exclusions, all inclusion/exclusion criteria, whether inclusion/exclusion criteria were established prior to data analysis, all manipulations, and all measures in the study.

Fifty-one individuals participated in the study, including 17 early-blind individuals (14 male; age range: 19–65 years of age; M_{age} = 42.94, SD = 13.98 years; 3 left-handed), 17 late-blind individuals (10 male; age range: 26–62 years of age; M_{age} = 47.06, SD = 9.00 years; 2 left-handed) and 17 sighted controls (9 male; age range: 24–65 years of age; M_{age} = 44.24, SD = 12.94 years; 2 left-handed). The three groups did not differ in age (p = .604), distribution of male and female participants (X^2 (2, N = 51) = 3.61, p = .165), or education (p = .328; the average number of completed years of education was 12.35 for the early-blind group, 11.71 for late-blind group, and 13.00 for the sighted group). In line with previous studies (Scheller et al., 2021), individuals who were blind before the age of eight were considered early-blind, and those who became blind later in life were considered late-blind. This choice is aligned with evidence that the first eight years of life are critical for cross-modal calibration (Cappagli et al., 2017; Scheller et al., 2021). The clinical and demographic characteristics of the early- and late-blind groups are depicted in Table 1.

Participants were recruited from Portuguese associations for the blind (ACAPO, APEDV, and ANDEVIS) and by word of mouth. The size of our sample was determined based on convenience/opportunity. Inclusion criteria were normal hearing, no history of electroconvulsive treatment, neurological illness, drug or alcohol abuse, and no current medication with potential impact on the electroencephalogram (EEG). For the sighed control group, normal or corrected-to-normal vision was additionally required. For the blind groups, the inclusion criteria also included total blindness or no more than rudimentary sensitivity for brightness without pattern recognition. The inclusion/exclusion criteria were established prior to data analyses.

All participants provided written informed consent. This study was approved by the ethics committee of the Faculty of Psychology of the University of Lisbon. The conditions of our ethics approval do not permit sharing of the data supporting the conclusions in this study with any individual outside the author team under any circumstances. However, the study materials, the script of the experimental task, and the code used in data analysis are available at http://osf.io/bhqpv/

2.2. *Stimuli*

The stimuli were 80 nonverbal vocalizations: 20 spontaneous laughs, 20 volitional laughs, 20 spontaneous cries, and 20 volitional cries. They were recorded by six speakers (aged between 24–48 years; three female) within a sound-proof anechoic chamber at University College London (see Lavan et al., 2015; McGettigan et al., 2015). In each condition, half of the stimuli were produced by female speakers.

To elicit spontaneous laughter, the experimenters used an amusement induction procedure in a social interactive setting: the speakers were instructed to watch video clips that they had identified earlier as amusing and that would make them laugh easily (see McGettigan et al., 2015). The experimenters were well acquainted with the speakers and interacted with them during the recording session to promote the social nature and spontaneity of the laughs. Spontaneous crying was elicited with an emotional induction procedure

Table 1 – Clinical and demographic characteristics of the early and late-blind groups.

ID	Age	Gender	Handedness	Years of education	Age of blindness onset	Cause of blindness	Vision Group
EB01	34	M	Left	15	Birth	Congenital Glaucoma	EB
EB02	43	M	Right	12	Birth	Unknown	EB
EB03	65	M	Right	9	Birth	Rubella	EB
EB04	35	M	Right	15	Birth	Childbirth complications	EB
EB05	53	M	Right	12	Birth	Coloboma	EB
EB06	33	M	Right	12	1 year	Cancer	EB
EB07	36	F	Right	12	First months	Impact injury	EB
EB08	38	M	Right	9	Birth	Retrolental fibroplasia	EB
EB09	39	M	Right	12	Birth	Retrolental fibroplasia	EB
EB10	33	M	Right	12	Birth	Congenital Glaucoma	EB
EB11	62	M	Right	15	3	Glaucoma	EB
EB12	65	M	Right	15	Birth	Retrolental fibroplasia	EB
EB13	43	F	Right	12	Birth	Rubella	EB
EB14	51	M	Right	15	Birth	Rubella	EB
EB15	23	M	Left	12	Birth	Retrolental fibroplasia	EB
EB16	58	F	Right	9	5	Measles	EB
EB17	19	M	Left	12	Birth	Congenital Glaucoma	EB
LB01	26	M	Right	12	10	Glaucoma	LB
LB02	46	M	Right	11	25	Glaucoma	LB
LB03	52	F	Right	12	19	Glaucoma	LB
LB04	34	F	Right	12	18	Retinitis pigmentosa	LB
LB05	62	M	Right	12	36	Retinitis pigmentosa	LB
LB06	45	F	Right	12	39	Glaucoma	LB
LB07	46	M	Right	6	30	Impact injury	LB
LB08	55	M	Right	12	30	Unknown	LB
LB09	51	M	Right	9	43	Retinal Atrophy	LB
LB10	51	F	Right	12	20	Retinopathy	LB
LB11	40	F	Right	17	38	Retinopathy	LB
LB12	50	M	Right	15	24	Retinitis pigmentosa	LB
LB13	37	F	Left	17	14	Retinal detachment	LB
LB14	48	F	Right	10	18	Retinal detachment	LB
LB15	58	M	Right	9	26	Glaucoma	LB
LB16	45	M	Left	12	35	Postoperative complications	LB
LB17	54	M	Right	9	19	Impact injury	LB

Note. EB = Early Blind; LB = Late Blind.

(see Lavan et al., 2016): speakers were asked to recall upsetting events from their past and/or to first produce a volitional crying to prompt a transition into spontaneous crying reflecting a genuine experience of sadness. Importantly, the six speakers reported feelings of amusement and sadness throughout and after the recording of the corresponding spontaneous vocalizations. For volitional laughter and crying, the same speakers were instructed to simulate these expressions in the absence of a corresponding emotional eliciting event and to make them sound as credible and natural as possible (Lavan et al., 2015; McGettigan et al., 2015). These stimuli have been used in previous behavioral and neuroimaging studies (e.g., Conde et al., 2022; Lavan et al., 2015, 2016; Lima et al., 2021; Neves et al., 2018; Pinheiro et al., 2021). The acoustic features and the affective ratings of the stimuli (taken from Pinheiro et al., 2021) are summarized in Table 2.

2.3. Procedure

Participants were tested individually, in a single experimental session lasting approximately 2 h (breaks included). They completed two tasks, while electrophysiological data were recorded. In one task, participants were instructed to focus on the authenticity of vocalizations (spontaneous *vs* volitional), and in the other, on their emotional quality (sadness *vs* amusement). The exact task instructions are provided in supplementary materials.

Participants were seated in a comfortable chair inside an electrically shielded and sound attenuated room (http://www.demvox.com/). The vocal stimuli were presented through headphones and at a sound level comfortable for each participant. The experiment was developed and presented using Presentation® software (Version 20.1, Neurobehavioral Systems, Inc., Berkeley, CA, www.neurobs.com). Responses were given through button presses. The order of the buttons and task display was counterbalanced across participants. During the experiment, all participants were asked to keep their eyes closed and all lights were turned off.

In each task, the 80 vocalizations were presented twice in random order (total of 160 trials per task). Each trial included: 1) a 1000 msec warning sound signaling the beginning of the trial; 2) a period of silence of varying duration (inter-stimulus interval, ISI, 500–1500 msec); 3) a vocalization for up to 3000 msec; 4) a 1000 msec period of silence; 5) and a 1000 msec warning sound signaling the beginning of the response time. Participants had up to 3000 msec to answer (see Fig. 1).

After completing the EEG tasks, the same participants performed a behavioral task in *Qualtrics* (https://www.qualtrics.com). They were instructed to rate the perceived arousal of the 80 vocalizations on a 9-point Likert scale ranging from 1 (not arousing at all) to 9 (extremely arousing).

No part of the study procedures or analysis plans was preregistered prior to the research being conducted.

Table 2 – Acoustic and affective properties of the vocalizations.

Acoustic properties	Authenticity			
	Spontaneous		Volitional	
	Laughter	Crying	Laughter	Crying
f0 (Hz)	270.78	287.53	228.78	260.9
f0 min (Hz)	171.96	180.51	115.15	125.23
f0 max (Hz)	370.69	385.06	319.48	392.65
Duration (ms)	2402	2689	2270	2520
Intensity (dB)	66.09	65.86	66.03	66.09
Affective properties				
Valence	6.48 *(1.18)*	3.37 *(.67)*	5.63 *(.98)*	3.29 *(.67)*
Arousal	6.52 *(1.18)*	5.74 *(1.08)*	5.04 *(1.02)*	5.18 *(1.09)*
Authenticity	5.90 *(1.12)*	5.15 *(1.05)*	4.12 *(.98)*	3.90 *(.98)*

Note. SDs are given in italic.

2.4. EEG data acquisition

The EEG was recorded with 64 pin-type active-electrodes (Biosemi B.V, Amsterdam, Netherlands) set on a head cap and following the expanded 10–20 system (American Electroencephalographic Society, 1991). Five flat-type active-electrodes were attached to the participant's face. Two were placed on the external canthus of both eyes and one below the left eye to record horizontal and vertical ocular movements, respectively. The other two were placed in the left and right mastoids to serve as offline reference. A conductive gel was used to lower the electrical impedance, which was kept below 30 μV. The EEG was acquired in a continuous mode at a digitization rate of 512 Hz.

The Letswave 7 software (https://www.letswave.org/) was used for offline analyses of EEG data. A band-pass filter with .1 Hz and 30 Hz (zero phase shift Butterworth, order 4), low and high cutoff frequency, was applied and EEG channels were referenced offline to the average of the left and right mastoids. Individual ERP epochs were created for each stimulus category (spontaneous laughter, spontaneous crying, volitional laughter, volitional crying), with −200 to 1500 msec, pre- and post-stimulus epoch. A baseline correction was performed in the −200 to 0 msec pre-stimulus interval. Ocular artifacts were corrected based on the method of Gratton et al. (1983), and individual epochs containing excessive ocular artifacts (±100 mV) were excluded from the analysis. After artifact rejection, for each condition and participant, a minimum of 70 % of the trials entered the individual ERP averages (early-blind [authenticity detection condition: volitional crying – 39.29 ± 1.10; volitional laughter – 39.35 ± .93; spontaneous crying – 39.53 ± .80; spontaneous laughter–39.18 ± 1.24; emotion detection condition: volitional crying – 39.35 ± 1.00; volitional laughter – 39.06 ± 1.14; spontaneous crying – 39.29 ± 1.45; spontaneous laughter–39.00 ± 1.17]; late-blind [authenticity detection condition: volitional crying – 38.47 ± 3.12; volitional laughter – 38.76 ± 2.02; spontaneous crying – 39.24 ± 1.56; spontaneous laughter–38.76 ± 1.79; emotion detection condition: volitional crying – 38.24 ± 3.19; volitional laughter – 37.88 ± 3.20; spontaneous crying – 38.53 ± 2.92; spontaneous laughter–38.06 ± 2.84]; sighted control [authenticity detection condition: volitional crying – 39.82 ± .73; volitional laughter – 39.76 ± .44; spontaneous crying – 39.76 ± .44; spontaneous laughter–39.71 ± .85; emotion detection condition: volitional crying – 39.65 ± .61; volitional laughter – 39.82 ± .39; spontaneous crying – 39.76 ± .44; spontaneous laughter–39.76 ± .49]. The number of epochs included in the averages did not differ per group and

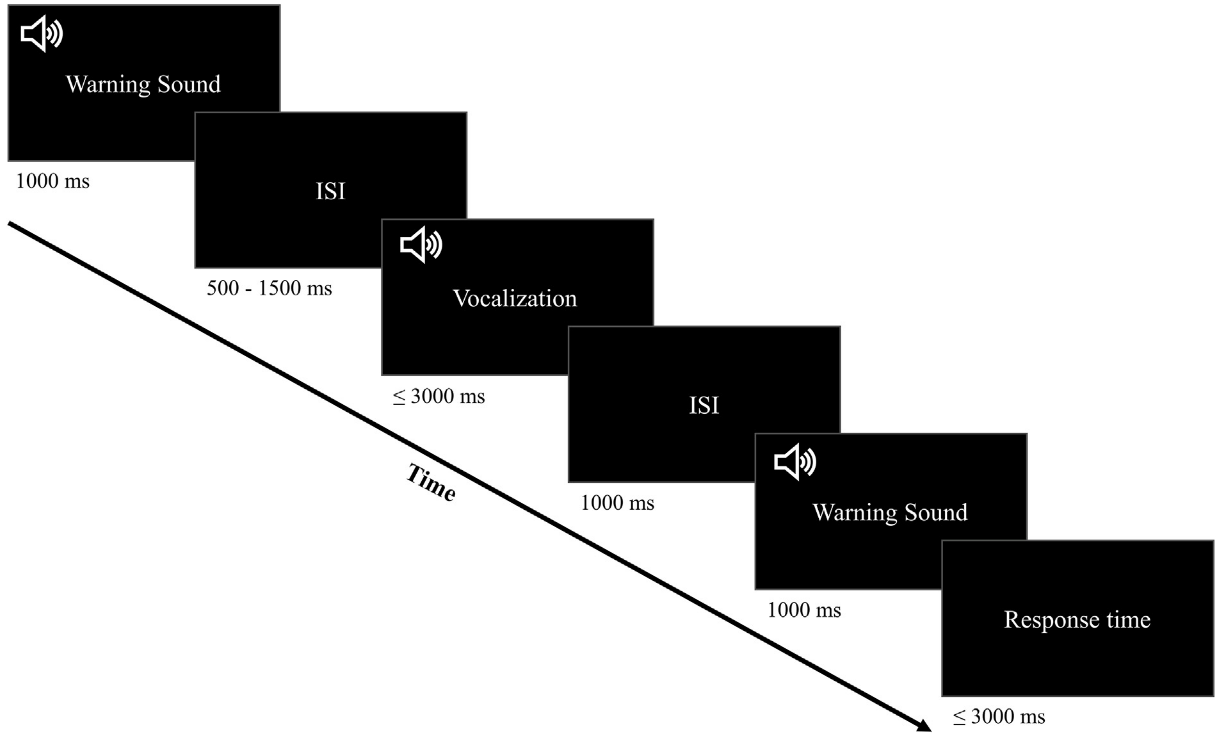

Fig. 1 – Illustration of an experimental trial.

per condition (lowest $p = .168$). Finally, grand average ERP waveforms were created for each of the four stimulus categories in each group.

Based on visual inspection of grand-averaged waveforms and following previous studies (Conde et al., 2022; Pinheiro et al., 2016, 2017), the mean amplitude for each component was measured in a specific time window: 130–210 msec (N1), 215–320 msec (P2), 450–700 msec (early LPP), 700–1000 msec (middle LPP), 1000–1400 (late LPP). Consistent with previous studies (Conde et al., 2022; Pinheiro et al., 2017), both fronto-central (FC1, FCz, FC2) and central (C1, Cz, C2) electrodes were included in the analysis of the N1 and P2 components. For the LPP, the analysis included centro-parietal (CP1, CPz, CP2), parietal (P1, Pz, P2) and parieto-occipital (PO3, POz, PO4) channels (Conde et al., 2022; Pinheiro et al., 2017). Fig. 2 illustrates the scalp distribution of the ERP components.

2.5. *Statistical analyses*

Behavioral and ERP data analyses were conducted using linear mixed-effects models, with lme4 (Bates et al., 2014) and lmerTest (Kuznetsova et al., 2016) packages in R-Studio (Version 1.4.1717; R Core T eam, 2021). Main effects and interactions were followed up with Bonferroni-corrected pairwise comparisons using the "emmeans" package (Lenth et al., 2023).

2.5.1. *ERP data*

We probed group differences (early-blind, late-blind, sighted controls) for each processing stage of emotional authenticity perception, across distinct task instructions (authenticity, emotion). To that end, we tested the main and interactive effects of group, authenticity, emotion, and task focus on the mean amplitudes of N1, P2, and LPPs (early, middle, and late LPP time windows). Distinct linear mixed-effects models were computed for the mean amplitude of each component (N1, P2, early, middle, and late LPP). The mean amplitude of each component was included as outcome, participants were included as random effects, whereas group (early-blind, late-blind, sighted controls), authenticity (spontaneous, volitional), emotion (sadness, amusement), and task focus (authenticity, emotion) were included as fixed effects. Participants' sex and age of blindness onset were not included because they did not improve model fit (see supplementary materials).

2.5.2. *Behavioral data*

We tested whether blindness impacts the accuracy of authenticity and emotion evaluations, by testing the main and interactive effects of group, authenticity, emotion, and task focus, using two distinct linear mixed-effects models. Trial-by-trial accuracy was included as outcome, participants were included as random effects, whereas group (early-blind, late-blind, control), authenticity (volitional, spontaneous), emotion (sadness, amusement), and task focus (authenticity, emotion) were included as fixed effects. Participants' sex and age of blindness onset were not included because they failed to improve model fit (see supplementary materials). To test whether blindness impacts the perception of arousal we used a linear mixed-effects model with arousal ratings included as

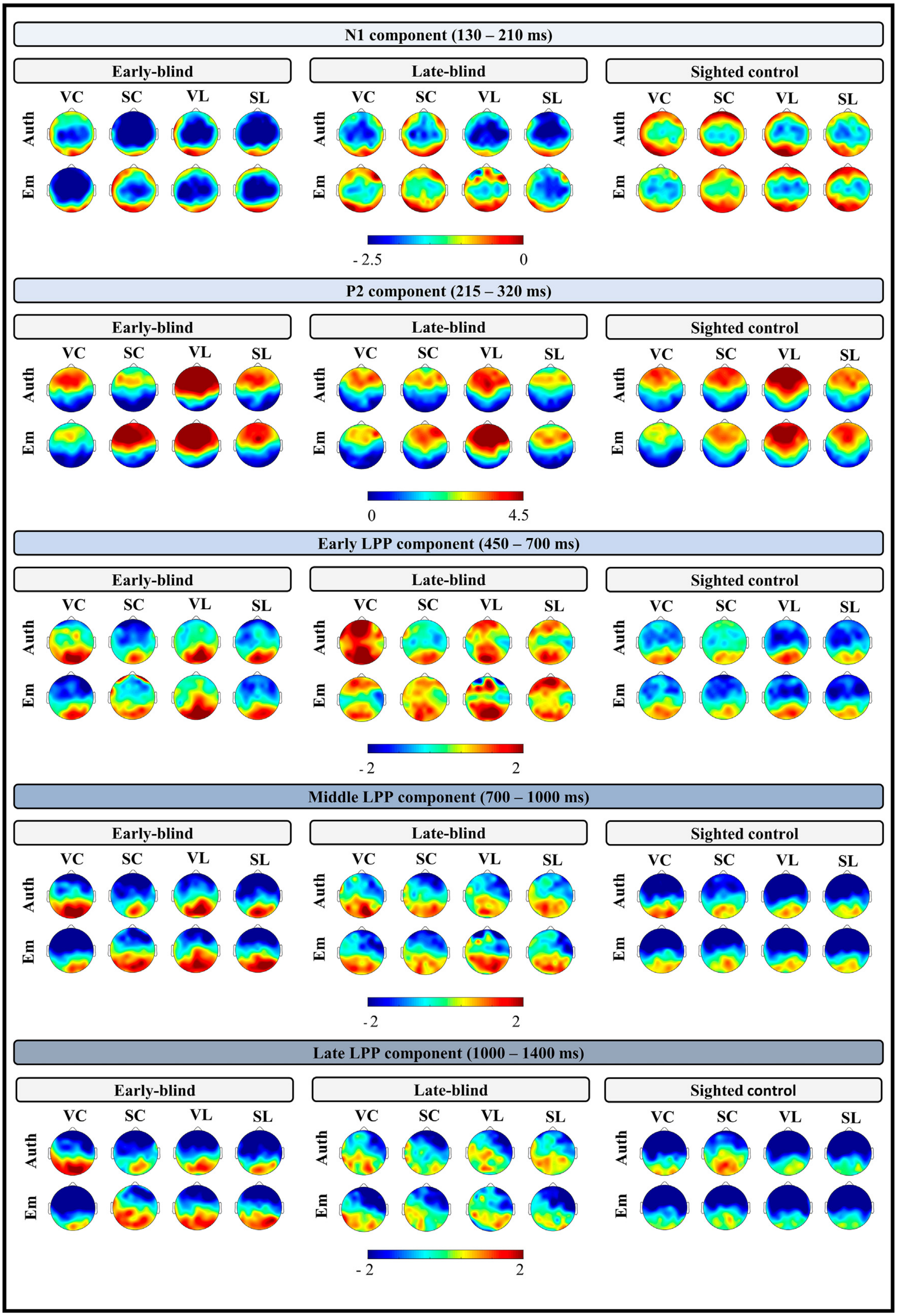

Fig. 2 – Topographic maps showing the scalp distribution of N1, P2, and LPP voltage for spontaneous and volitional vocalizations in the authenticity and emotion detection tasks.

Note. **Auth – Authenticity detection task; Em = Emotion detection task; VC = Volitional crying; SC = Spontaneous crying; VL = Volitional laughter; SL = Spontaneous laughter.**

outcome and the same variables, except for task focus, included as fixed and random effects.

3. Results

3.1. *ERP data*

3.1.1. *N1*

There was a significant interaction between group, authenticity, emotion, and task ($F(2,12189) = 9.94$, $p < .001$), indicating that the N1 was increased (more negative) for spontaneous (*vs* volitional) crying in early-blind compared to late-blind ($B = 1.55$, $SE = .40$, $\beta = .53$, $t(12189) = 3.87$, $p < .001$, 95 % CI: [2.28, .66]) and sighted listeners ($B = 1.54$, $SE = .40$, $\beta = .53$, $t(12189) = 3.85$, $p < .001$, 95 % CI: [2.33, .77]), when the task focused on stimulus authenticity (see Figs. 2–4), i.e., when participants had to decide whether the vocalization was spontaneous or volitional. Post-hoc pairwise comparisons revealed that, in early-blind listeners, the N1 was increased in response to spontaneous versus volitional cries when the task was focused on authenticity ($p < .001$), but the reverse (i.e., increased N1 for volitional cries) was found when the task was focused on stimulus emotion ($p = .006$), i.e., when the participants had to decide whether the vocalization expressed amusement or sadness. Nevertheless, no authenticity effects were observed in the case of late-blind ($p > .999$) and sighted control groups ($p > .999$) or for laughter (lowest $p = .198$). That is, effects of crying authenticity at this early sensory stage of neural processing were limited to early-blind listeners.

3.1.2. *P2*

Group interacted with authenticity, emotion, and task ($F(2,12189) = 4.52$, $p = .011$): the P2 was increased for volitional (*vs* spontaneous) laughs in early-blind compared to sighted listeners when the task was focused on stimulus emotion ($B = 1.43$, $SE = .49$, $\beta = .39$, $t(12189) = 2.92$, $p = .003$, 95 % CI: [.40, 2.35]). Nonetheless, post-hoc pairwise comparisons revealed similar effects of laughter authenticity (i.e., increased P2 to volitional *vs* spontaneous laughs) in all groups, in both authenticity and emotion detection tasks (lowest $p = .016$); however, for crying, the P2 was increased in response to spontaneous vocalizations in early-blind ($p < .001$) and sighted listeners ($p < .001$), when the task focused on emotion discrimination (see Figs. 2–4). In the late-blind group, no significant authenticity effects were found for crying ($p > .999$).

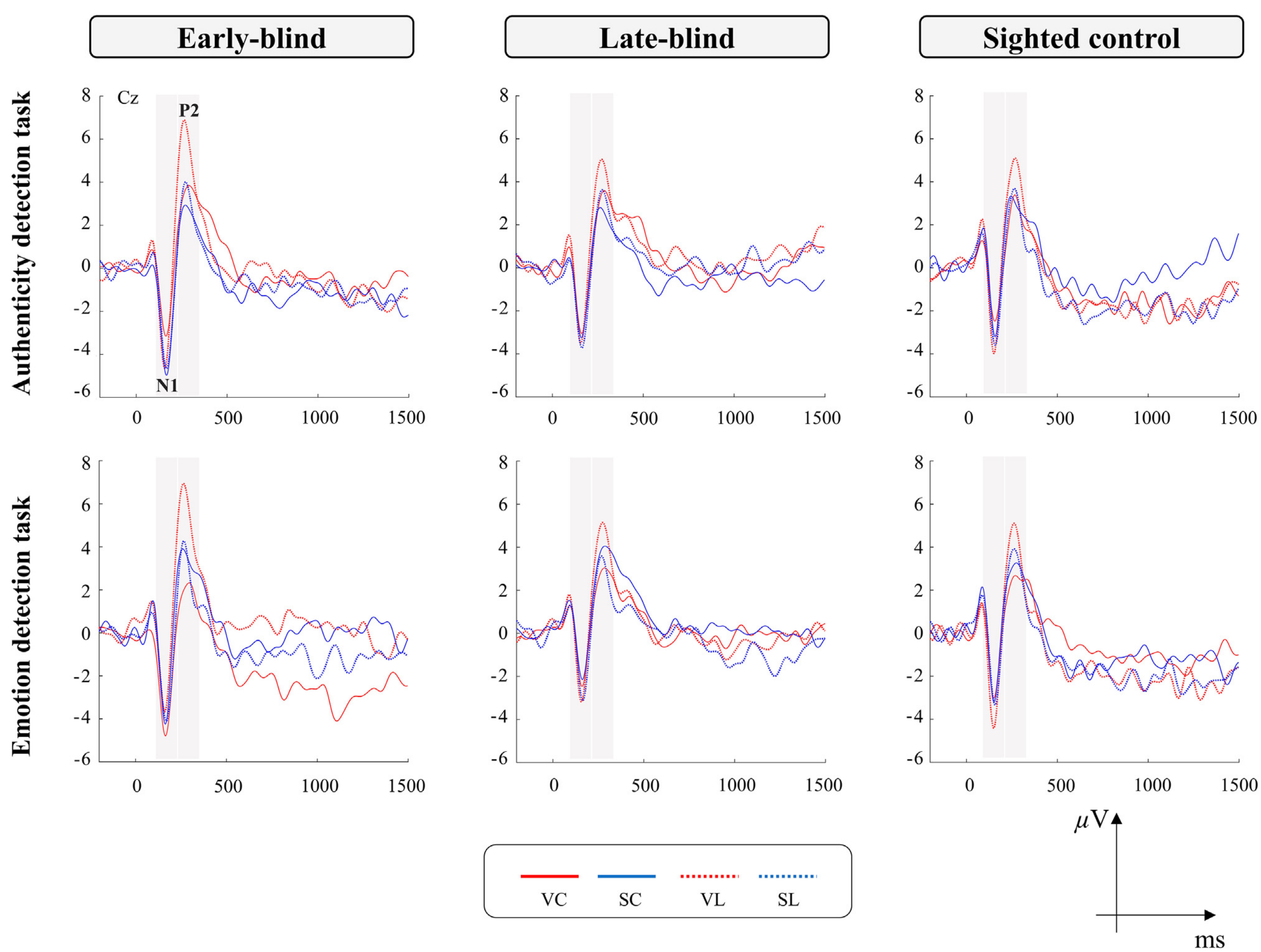

Fig. 3 – Grand average ERP waveforms for spontaneous and volitional vocalizations in the authenticity and emotion detection tasks, at electrode Cz.
***Note.* VC = Volitional cries; SC = Spontaneous cries; VL = Volitional laughs; SL = Spontaneous laughs.**

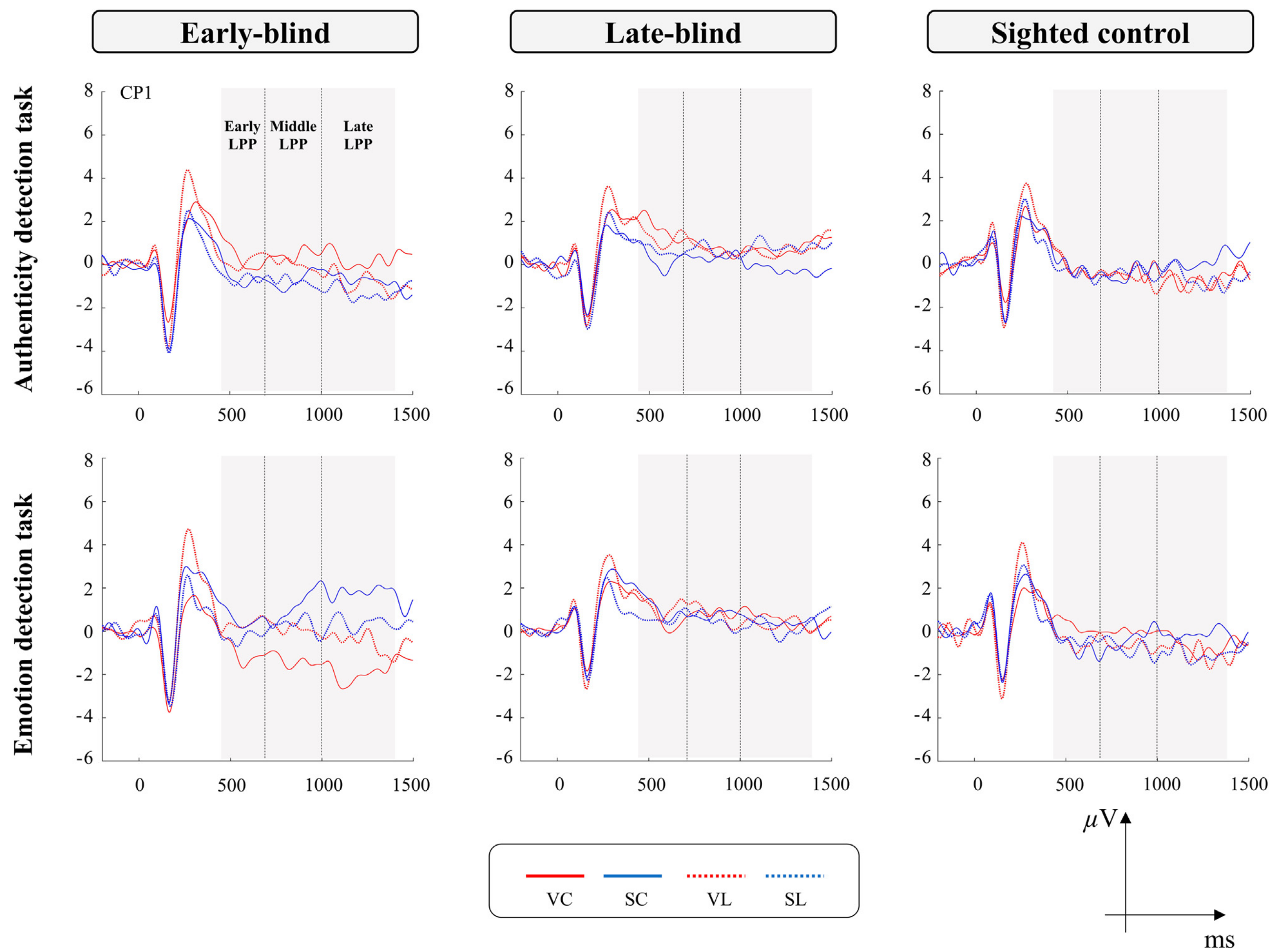

Fig. 4 – Grand average ERP waveforms for spontaneous and volitional vocalizations in the authenticity and emotion detection tasks, over electrode CP1.
***Note.* VC = Volitional cries; SC = Spontaneous cries; VL = Volitional laughs; SL = Spontaneous laughs.**

3.1.3. *Early LPP (450–700 msec)*

The interaction between group, authenticity, emotion, and task focus was significant ($F(2,12189) = 27.66$, $p < .001$): the LPP was more positive for volitional (*vs* spontaneous) cries in early-blind compared to sighted listeners, when the focus was on stimulus authenticity ($B = 3.70$, $SE = .52$, $\beta = 1.02$, $t(12189) = 7.10$, $p < .001$, 95 % CI: [2.59, 4.62] (see Figs. 2–4). Post-hoc pairwise comparisons indicated similar authenticity effects for crying in both early- ($p < .001$) and late-blind listeners ($p < .001$) when the task was focused on stimulus authenticity; however, in the emotion categorization task, enhanced amplitudes were found for volitional (*vs* spontaneous) laughter

Table 3 – Average accuracy scores in the authenticity and emotion detection tasks.

Task	Authenticity	Emotion	Group		
			Early-blind	Late-blind	Sighted
			Hits	Hits	Hits
Authenticity detection task	Spontaneous	Laughter	.81 *(.18)*	.71 *(.20)*	.82 *(.11)*
		Crying	.61 *(.23)*	.55 *(.19)*	.68 *(.17)*
	Volitional	Laughter	.60 *(.28)*	.59 *(.26)*	.69 *(.13)*
		Crying	.66 *(.24)*	.72 *(.21)*	.75 *(.19)*
Emotion detection task	Spontaneous	Laughter	.95 *(.07)*	.94 *(.05)*	.96 *(.06)*
		Crying	.70 *(.13)*	.76 *(.13)*	.77 *(.11)*
	Volitional	Laughter	.93 *(.05)*	.92 *(.07)*	.97 *(.04)*
		Crying	.92 *(.09)*	.92 *(.09)*	.95 *(.07)*

Note. SDs are given in italic.

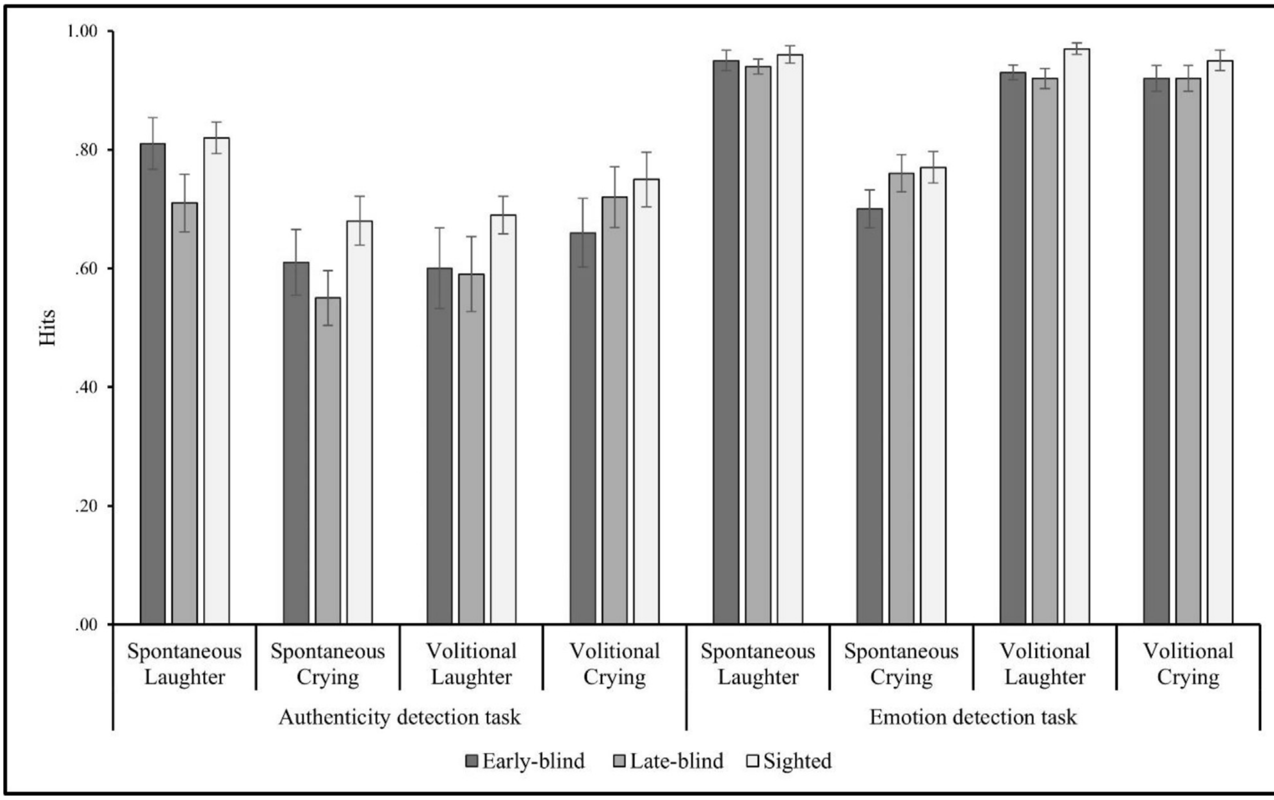

Fig. 5 – Mean accuracy and standard error scores in the authenticity and emotion detection tasks.

($p < .001$) and for spontaneous (*vs* volitional) crying ($p = .011$) in the case of early-blind listeners, but in sighted listeners enhanced amplitudes were found for volitional crying ($p = .015$).

3.1.4. *Middle LPP (700–1000 msec)*

Group interacted with authenticity, emotion, and task focus ($F(2,12189) = 12.29$, $p < .001$): the LPP was increased in response to volitional (*vs* spontaneous) crying in early-blind listeners compared to late-blind ($B = 2.13$, $SE = .58$, $\beta = .53$, $t(12189) = 3.66$, $p < .001$, 95 % CI: [.95, 3.34]) and sighted groups ($B = 2.76$, $SE = .58$, $\beta = .68$, $t(12189) = 4.73$, $p < .001$, 95 % CI: [1.72, 3.95]), when the task was focused on stimulus authenticity (see Figs. 2–4). Follow-up analyses showed that, in early-blind listeners, LPP amplitude was more positive in response to volitional (*vs* spontaneous) cries ($p < .001$) when the task was focused on stimulus authenticity, but in the emotion categorization task the effect was reversed (i.e., amplitude was increased for spontaneous cries) ($p = .004$). However, in late-blind and sighted listeners, no significant authenticity effects were found (all p's $> .999$).

3.1.5. *Late LPP (1000–1400 msec)*

The interaction between group, authenticity, emotion, and task focus was again significant ($F(2,12189) = 21.72$, $p < .001$): the LPP was increased in response to spontaneous (*vs* volitional) cries in early-blind listeners compared to late-blind ($B = 2.03$, $SE = .61$, $\beta = .48$, $t(12189) = 3.33$, $p = .001$, 95 % CI: [.82, 3.27]) and sighted groups ($B = 4.02$, SE, $= .61$, $\beta = .96$, $t(12189) = 6.59$, $p < .001$, 95 % CI: [2.80, 5.25]), when the focus was on emotion categorization (see Figs. 2–4). Post-hoc pairwise comparisons demonstrated that, in early-blind listeners, the amplitude was more positive for spontaneous versus volitional cries ($p < .001$) when attention was focused on stimulus emotion; however, in sighted listeners spontaneous (*vs* volitional) cries elicited more positive amplitude when the task was focused on stimulus authenticity ($p < .001$). That is, in early-blind and sighted listeners, authenticity effects differed across distinct task instructions.

3.2. *Behavioral data*

Table 3 presents the mean accuracy of authenticity and emotion detection tasks (see Fig. 5).

Accuracy: The interaction between group and task was significant ($F(2,16269) = 10.72$, $p < .001$), indicating that sighted listeners were more accurate at detecting authenticity than late-blind listeners ($B = .06$, $SE = .03$, $\beta = .14$, $t(160) = 1.96$, $p = .050$, 95 % CI: [−.00, .12]). Follow-up analyses showed that sighted listeners were more accurate at detecting the authenticity of vocalizations than the late-blind group ($p < .001$), whereas the early-blind group did not differ from the late-blind ($p > .999$) and sighted groups ($p = .053$). In the emotion categorization task, no significant differences between groups were found ($p > .999$). Furthermore, accuracy was also modulated by an interaction between group and emotion ($F(2,16269) = 5.13$, $p = .006$), indicating that accuracy was increased in sighted compared to late-blind listeners in the case of laughter ($B = .06$, $SE = .03$, $\beta = .16$, 95 % CI: [.04, .15], $t(16270) = 2.21$, $p = .027$). Nevertheless, follow-up analyses showed that the between-group effects did not reach statistical significance (lowest $p = .062$).

On the other hand, accuracy was modulated by an interaction between authenticity and emotion ($F(2,16269) = 355.22$, $p < .001$): accuracy was increased for volitional compared to spontaneous cries ($B = .20$, $SE = .03$, $\beta = .48$, 95 % *CI*: [.15, .26], $t(16270) = 6.78$, $p < .001$). Follow-up analyses showed that participants were more accurate at judging volitional (*vs* spontaneous) cries ($p < .001$) and spontaneous (*vs* volitional) laughs ($p < .001$). Furthermore, the interaction between task and emotion ($F(1,16269) = 28.21$, $p < .001$) was significant, revealing that for laughter, accuracy was higher in the emotion compared to the authenticity task ($B = .08$, $SE = .03$, $\beta = .19$, 95 % CI: [.02, .13], $t(16270) = 2.66$, $p = .008$). Follow-up analyses showed that participants were more accurate at discriminating emotion (amusement *vs* sadness) than at discriminating authenticity (spontaneous *vs* volitional) in the case of both laughter and crying (all p's < .001). Additionally, task also interacted with authenticity ($F(1,16269) = 88.61$, $p < .001$): accuracy was increased to volitional (*vs* spontaneous) sounds in the emotion categorization task ($B = .13$, $SE = .03$, $\beta = .32$, 95 % CI: [.07, .19], $t(16270) = 4.52$, $p < .001$). Follow-up analyses indicated that participants were more accurate at decoding the emotion of volitional sounds ($p < .001$), but in the authenticity task they were more accurate when judging spontaneous (*vs* volitional) vocalizations ($p = .027$).

Arousal ratings: Due to scheduling constraints, four late blind individuals and two sighted controls were not able to evaluate the perceived arousal of the vocalizations. Hence, only forty-five participants completed this task (17 early blind, 13 late blind, and 15 sighted controls). The interaction between group and authenticity was significant ($F(2,3546) = 6.60$, $p = .001$). Nonetheless, post-hoc pairwise comparisons indicated no significant differences in the arousal ratings as a function of authenticity in both groups (lowest $p = .868$). No between-group effects or other interactions with this factor were found in the ratings of arousal (all p's > .109) thus indicating that the three groups rated this affective property in a similar way. Furthermore, the main effects of emotion ($F(1,3546) = 413.34$, $p < .001$) and authenticity ($F(1,3546) = 369.13$, $p < .001$) revealed that, overall, participants rated laughs as more arousing than cries ($B = 1.16$, $SE = .06$, $\beta = .67$, 95 % CI: [1.04, 1.27], $t(3555) = 20.31$, $p < .001$) and spontaneous stimuli as more arousing than volitional ones ($B = 1.09$, $SE = .06$, $\beta = .78$, 95 % CI: [.98, 1.20], $t(3555) = 19.19$, $p < .001$).

4. Discussion

In this study we probed whether and how blindness affects emotional authenticity perception in laughter and crying. The main findings are discussed in the following sections.

4.1. *Early processing stages*

The auditory N1 indexes early sensory processing (Näätänen & Picton, 1987) and is sensitive to the emotional quality of vocalizations (e.g., Castiajo & Pinheiro, 2021; Jessen & Kotz, 2011; Liu et al., 2012; Martins et al., 2022). Early-blind listeners responded differently to authentic versus volitional crying at this stage, specifically when the task focused on authenticity. The N1 is modulated by the acoustic properties of the stimulus (Näätänen & Picton, 1987; Seither-Preisler et al., 2006) and spontaneous and volitional cries differ acoustically (e.g., in pitch, timbral brightness, and voicing—Pinheiro et al., 2021). The specificity of crying authenticity effects in early-blind listeners, compared to late-blind and sighted participants, suggests a facilitated processing of the acoustic differences in cries. These findings are consistent with previous ERP evidence that early-blind listeners have facilitated sensory processing of vocal emotions (Topalidis et al., 2020) and speaker identity (Föcker et al., 2012). Early-blindness can lead to cortical reorganization of auditory processing (Collignon et al., 2013; Kupers & Ptito, 2014; Sabourin et al., 2022), resulting in facilitated emotional authenticity perception. Early cortical specialization for vocal emotion processing (Blasi et al., 2011) could also become stronger in early-blind individuals, as a compensation for the absence of visual information. The expansion of the tonotopic representation in the auditory cortex of early-blind individuals (Elbert et al., 2002) could support sensory processes relevant to the acoustic processing of authenticity cues.

That authenticity effects for crying varied across task instructions indicates that, in early-blind listeners, attention focus modulates the weight ascribed to distinct acoustic features of spontaneous versus volitional crying. To date, this is the first study probing task effects on vocal emotion processing in the blind. In sighted individuals, ERP studies on visual (Chen et al., 2018; Ferrari et al., 2008; Schindler & Kissler, 2016) and auditory emotion processing (Conde et al., 2022; Garrido-Vásquez et al., 2013; Paulmann et al., 2013) indicate that task focus does not influence early emotion processing, consistent with our observations in sighted and late-blind listeners (but see Pinheiro et al., 2023). In early-blind listeners, prolonged and consistent visual deprivation may lead to enhanced top-down attentional amplification resulting from task focus manipulation (Hillyard et al., 1998; Pinheiro et al., 2023).

Regarding the P2, which has been linked to emotional salience detection (Jessen & Kotz, 2011; Schirmer & Kotz, 2006), laughter authenticity modulated responses similarly across groups and task focus. The P2 can be affected by stimulus arousal (Han et al., 2013; Olofsson & Polich, 2007; Paulmann et al., 2013) and spontaneous laughs are more arousing than volitional ones (Pinheiro et al., 2021). The P2 enhancement for volitional laughs may therefore reflect sensitivity to arousal differences between volitional and spontaneous laughs. Furthermore, the P2 response is affected by other stimulus properties, such as pitch (Antinoro et al., 1969; Crowley & Colrain, 2004; Wunderlich & Cone-Wesson, 2001). Volitional laughs have lower pitch than their spontaneous counterparts, and spontaneous and volitional laughs are acoustically more distinct than spontaneous and volitional cries (Pinheiro et al., 2021). These differences might have facilitated the detection of emotional salience from volitional and spontaneous laughs, consistent with previous ERP findings (Conde et al., 2022; Kosilo et al., 2021). Our observations support the automatic processing of emotionally salient information from laughter (e.g., Lima et al., 2019; Pinheiro et al., 2016). The presence of authenticity effects at this stage for laughter, but not for crying, might be linked to the greater familiarity with distinct types of laughter in everyday interactions. Laughter is a pervasive expression, typically associated with positive social interactions (Provine, 2001). It can express a variety of meanings, such as joy, amusement, cheerfulness, affiliation, nervousness, triumph, schadenfreude (i.e., laughing about other's misfortune), or taunt (Szameitat et al., 2009a; Szameitat, Alter, Szameitat, Wildgruber, et al., 2009; Wood et al., 2017). Although cries can also express a variety of meanings such as sadness, anger, fear, disappointment, joy, or gratitude (Vingerhoets & Bylsma, 2016), they are less contagious than laughs (Cosme et al., 2021) and tend to be expressed in more private settings (Conde et al., 2022; Vingerhoets & Bylsma, 2016). Therefore, listeners might be more exposed to different types of laughter compared to crying in social interactions.

Authenticity effects for crying (i.e., enhanced P2 for spontaneous cries) were found only in early-blind and sighted listeners, when the task was focused on emotion discrimination. Thus, salience detection mechanisms seem to operate similarly in individuals with early-blindness and normal vision. Changes in the neural processing of vocal information indexed by modulations in this time window were previously found for congenital blind (Topalidis et al., 2020) and late-blind listeners (Föcker et al., 2015). Nevertheless, in the late-blind group, we found that the P2 was unaffected by crying authenticity, indicating that late-blind listeners might not differentiate spontaneous from volitional crying at this processing stage. Such pattern of findings underlines the important role of vision, as well as of the age of blindness onset, in salience detection mechanisms underlying authenticity perception in crying.

4.2. *Late processing stages*

At processing stages associated with sustained attention and cognitive evaluation (Hajcak & Nieuwenhuis, 2006; Paulmann et al., 2013; Pell et al., 2015; Pinheiro et al., 2017), authenticity effects varied across groups, emotion, and task instructions. In the 450–700 msec time window, only early-blind individuals were sensitive to laughter authenticity. In the case of crying, however, authenticity modulated the early LPP similarly across groups. Specifically, volitional (*vs* spontaneous) cries elicited increased amplitude in both early- and late-blind groups (when the task was focused on authenticity), and in sighted listeners (when discriminating emotion). Studies with sighted individuals indicate that the LPP is increased in response to emotional compared to neutral stimuli (Herbert et al., 2008; Schindler & Kissler, 2016), including vocalizations (Martins et al., 2022). Since the LPP is modulated by stimulus arousal (e.g., Cuthbert et al., 2000; de Rover et al., 2012), these effects could reflect sensitivity of cognitive evaluative stages to differences in the arousal properties of volitional versus spontaneous cries. The subjective ratings of the vocalizations used in our study confirmed that spontaneous cries were rated as more arousing than volitional cries (Pinheiro et al., 2021).

The sensitivity of the later processing stages to crying authenticity in all groups may be related to the importance of detecting crying authenticity in everyday interactions. Studies with sighted individuals have reported an enhancement of the LPP component in response to threatening stimuli (Bublatzky & Schupp, 2012; MacNamara & Hajcak, 2010; Schindler & Bublatzky, 2020; Schupp & Kirmse, 2021; Stolz et al., 2019; Wheaton et al., 2013). Thus, one may speculate that, when judging the authenticity of cries and laughs, volitional cries represent the most socially 'threatening' stimuli. While volitional laughs might often represent a prosocial signal (e.g., politeness; Bryant & Aktipis, 2014; Kamiloğ;lu et al., 2022), the communicative intentions of volitional crying are more often associated with manipulation and with obtaining privileges from others (Dawel et al., 2019; Nakayama, 2010; van Roeyen et al., 2020; Vingerhoets & Bylsma, 2016). Volitional cries are frequently used by sociopaths and narcissists as a manipulation tactic (van Roeyen et al., 2020; Vingerhoets & Bylsma, 2016). Therefore, it is possible that the observed LPP enhancement to volitional cries reflects the cognitive evaluation of a more socially 'threatening' stimulus.

Nevertheless, effects of crying authenticity persisted during the 700–1000 msec time window only in early-blind listeners. Such a selective effect of authenticity for crying (700–1000 msec time window) in this group as well as for laughter (450–700 msec) suggests that early-blindness facilitates the cognitive processing of emotional authenticity. These effects might reflect cortical reorganization processes that enabled early-blind individuals to compensate for the lack of vision by enhancing voice processing. The development of vocal (Amorim et al., 2021; Blasi et al., 2011; Chronaki et al., 2018; Shultz et al., 2014) and visual (Chronaki et al., 2015; Young et al., 2020) emotional processing starts at relatively early stages of development. Accordingly, early-blind listeners could develop more robust brain compensatory mechanisms to process emotional authenticity from the voice than individuals who became blind later in life, after several years of normal visual experience. This idea is supported by evidence of larger compensatory plasticity in auditory perception in early-onset compared to late-onset blindness (Kupers & Ptito, 2014; Sabourin et al., 2022; Singh et al., 2018). That is, the developmental period of visual deprivation critically determines how the functional architecture and connectivity of the occipital cortex is reshaped (Collignon et al., 2013), and arguably how its functional specialization for processes relevant to emotion processing is transferred toward other communication channels (e.g., the voice). However, the loss of visual input after childhood (late-blindness) may have compromised the integration of perceptual representations emerging from modality-specific sensory systems (e.g., Schirmer & Adolphs, 2017) or, alternatively, could disrupt cross-modal prediction due to the affected visual modality. In social interactions, facial information precedes vocal information and can, therefore, facilitate subsequent auditory processing, particularly when stimuli have emotional content (Jessen & Kotz, 2013). The facilitation of voice decoding by visual information ceases in late-blind listeners, which could specifically hamper the processing of more subtle vocal information, such as its perceived authenticity. During a time of reduced opportunities for compensatory experiencedependent plasticity, functional or structural reorganization in response to visual deprivation is limited. This could explain the observed reduced ERP modulations. This interpretation is consistent with previous evidence of differences in brain functional reorganization between congenitally and late-blind listeners (Collignon et al., 2013).

In early-blind individuals, the direction of authenticity effects for crying depended on task instructions, at 450–700 msec and 700–1000 msec time windows: spontaneous (*vs* volitional) cries elicited increased amplitude in the emotion categorization task and decreased amplitude in the authenticity task. These findings show that task focus influences the salience of spontaneous versus volitional cries more strongly in early-blind than in the other two groups, which is in good agreement with previous evidence documenting enhanced attentional sensitivity to vocal sounds in early-blind compared with sighted individuals (Collignon et al., 2006; Hugdahl et al., 2004).

At a later time window (1000–1400 msec), both early-blind and sighted listeners were sensitive to authenticity distinctions of crying, but under distinct task instructions: spontaneous cries elicited enhanced amplitudes in early-blind listeners when categorizing emotion, and in sighted listeners when judging authenticity. This could indicate stronger sensitivity to crying authenticity in both early-blind and sighted groups, compared to late-blind listeners. Because the LPP is modulated by stimulus arousal (Leite et al., 2012; Schupp et al., 2000; Schupp & Kirmse, 2021), the amplitude enhancement to spontaneous cries observed in the early-blind and sighted groups might reflect the heightened salience of spontaneous vocalizations in signaling a high arousing state of the vocalizer, as shown by previous studies (Anikin & Lima, 2018; Bryant & Aktipis, 2014; Lavan et al., 2016; Pinheiro et al., 2021). Together, the LPP findings indicate that, at later cognitive processing stages, all groups were sensitive to authenticity information of crying sounds, although to a different extent throughout the various phases of the LPP (i.e., effects were stronger in sighted and especially in early-blind listeners). They also demonstrate sensitivity to laughter authenticity, at the 450–700 msec time window, only in early-blind listeners. Our findings suggest that early blindness leads to cortical reorganization in late processing stages of emotional authenticity perception.

The behavioral findings of the present study shed light on later evaluative stages of vocal emotion perception, when an explicit response is required. They revealed differences in how the groups evaluated the emotional authenticity of laughs and cries, but not their emotional meaning: the sighted group was more accurate than the late-blind group when discriminating emotional authenticity. Because emotion recognition is an early developing mechanism (e.g., Amorim et al., 2021; Chronaki et al., 2018), the loss of vision in late-blind individuals after a critical sensitive period for the development of vocal emotion processing abilities may have accounted for the observed findings. The difficulties in emotional authenticity detection found in late-blind individuals highlight the relevance of developing auditory-based rehabilitative tools to improve vocal emotion perception abilities in this population. The impact of compensatory plasticity on some auditory processing abilities of early-blind individuals is well documented (Fairhall et al., 2017; Fine & Park, 2018), but this is not the case for late-blind individuals to whom the evidence for compensatory plasticity is not so robust (Kupers & Ptito, 2014; Sabourin et al., 2022). The current findings are consistent with the notion that, in early-blind individuals, the loss of visual input before a critical period of development leads to changes in both early and late stages of vocal emotion processing, indexed by stronger modulations of the N1, P2, and LPPs components. These modulations might reflect mechanisms that enabled early-blind individuals to compensate for the lack of vision and to perform at the same level as sighted participants in tasks requiring the detection of authenticity and emotion of vocalizations. Regarding emotion categorization, the lack of differences between groups is consistent with previous findings (Gamond et al., 2017), and suggests that prolonged visual deprivation does not influence the emotional categorization of laughs and cries. The high performance in this task may represent a ceiling effect in emotion discrimination due to low task difficulty.

It is also worth noting that the ERP analyses of the current study considered objective authenticity effects and not the subjective authenticity perceived by the participants. Furthermore, our sample is heterogeneous in age (i.e., from 19 to 65 years) and includes individuals who lost their sight at different stages of development (e.g., the age of blindness onset in the late-blind group ranges from 10 to 43 years). Considering that vocal emotion recognition is known to improve from childhood to early adulthood and to decline in older adulthood (Amorim et al., 2021), it is critical to account for age-related differences in the perception of emotional authenticity in the blind. In the current study, we did not include a neutral condition (e.g., vowel produced with a neutral prosody – Kosilo et al., 2021) due to time constraints. Thus, we cannot be sure that the observed effects are specific to emotional information. Future studies can extend the current findings by including a neutral condition, as well as other positive (e.g., pleasure and achievement) and negative (e.g., anger and fear) emotional expressions.

5. Conclusion

The current findings indicate that visual experience (or lack thereof) shapes behavioral and neural responses to spontaneous and volitional laughs and cries. Irrespective of visual experience, listeners were sensitive to authenticity in laughter (P2 range) and crying (early LPP phase). Crucially, however, early-blindness facilitated the neural processing of emotional authenticity at early sensory (N1) and late cognitive evaluative stages (early and middle LPP phases). By contrast, the behavioral and ERP results suggest that prolonged visual deprivation with late-onset impairs the processing of emotional authenticity. We conclude that: the processing of emotional authenticity in voices is modulated by visual experience, a finding that provides evidence for tight cross–modal interactions in emotional communication; and in blind individuals, plasticity trajectories and effects depend on the age of blindness onset, with early onset potentially leading to benefits in complex auditory abilities, and late onset potentially leading to impairments.

Author contribution

JS: Conceptualization; Methodology; Software; Formal analysis; Investigation; Writing – original draft.

CFL: Conceptualization; Methodology; Funding acquisition; Writing–Review & Editing.

MSR: Formal analysis; Writing–Review & Editing.

SKS: Conceptualization; Resources; Writing–Review & Editing.

APP: Conceptualization; Methodology; Project administration; Funding acquisition; Writing–Review & Editing.

TC: Conceptualization; Methodology; Software; Formal analysis; Investigation; Project administration; Funding acquisition; Writing – original draft.

Conflict of interest

We have no known conflict of interest to disclose.

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Open practices section

The study in this article earned Open Material badge for transparent practices. The materials used in this study are available for access at http://osf.io/bhqpv.

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