The Time Course of Emotional Authenticity Detection in Nonverbal Vocalizations

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Abstract

Previous research has documented perceptual and brain differences between spontaneous and volitional emotional vocalizations. However, the time course of emotional authenticity processing remains unclear. We used event-related potentials (ERPs) to address this question, and we focused on the processing of laughter and crying. We additionally tested whether the neural encoding of authenticity is influenced by attention, by manipulating task focus (authenticity *vs*. emotional category) and visual condition (with *vs*. without visual deprivation). ERPs were recorded from 43 participants while they listened to vocalizations and evaluated their authenticity (volitional *vs.* spontaneous) or emotional meaning (sad *vs.* amused). Twenty-two of the participants were blindfolded and tested in a dark room, and 21 were tested in standard visual conditions. As compared to volitional vocalizations, spontaneous ones triggered reduced N1 in the case of laughter and increased P2 in the case of crying. At later cognitive processing stages (1000-1400 ms), more positive amplitudes were observed both for spontaneous laughter and crying. Task focus and visual condition did not influence brain responses to authenticity. Our findings suggest that authenticity information is encoded early and automatically during vocal emotional processing. They also point to a potentially faster encoding of authenticity in laughter compared to crying.

Keywords: Authenticity; Emotion; Voice; Event-related potentials.

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The ability to perceive emotional information from the voice is fundamental for social interactions. Research on vocal emotions is challenged by the fact that our vocal repertoire of emotions is complex and variable. It relies on both automatic and voluntary production mechanisms that might be intentionally and flexibly adjusted according to the social context and the speaker's communicative intentions (Scott et al., 2014; Sidtis, & Kreiman, 2012). Consider the distinct social meanings of a laugh spontaneously produced in response to a funny situation, for instance, compared to a laugh voluntarily produced to communicate polite agreement. From the listener's perspective, differentiating authentic (*spontaneous*) from more deliberate (*volitional*) emotional expressions is an important social skill, with potential implications for cooperation, affiliation, and bonding (Bryant et al., 2018; Gervais & Wilson, 2005; Wood et al., 2017). There has been a growing research interest in this issue in recent years, but the neural mechanisms involved in processing emotional authenticity in nonverbal emotional vocalizations remain poorly understood.

Differentiating Spontaneous from Volitional Vocal Emotional Expressions

Most research on auditory emotion perception relies on acted vocal portrayals (Scherer & Bänzinger, 2010). Such stimuli are typically obtained by inviting professional or nonprofessional actors to pose a given emotional expression, without a corresponding eliciting event. Acted portrayals are considered suitable for research on vocal emotions, allowing for more control over stimulus features (Scherer & Bänziger, 2010). Nonetheless, recent experiments have pointed out that these acted portrayals differ from spontaneous emotional expressions in important ways (e.g., Anikin & Lima, 2017; Bryant & Aktipis, 2014; McGettigan et al., 2015; Neves et al., 2017). For example, differences in the acoustic features of spontaneous and volitional vocalizations may reflect distinct vocal production mechanisms (Anikin & Lima, 2017; Bryant & Aktipis, 2014; Lavan et al., 2016; McKeown et al., 2015). Moreover, spontaneous vocalizations are characterized by higher and more variable fundamental frequency (F0) and lower harmonicity than volitional expressions (Anikin & Lima, 2017). At the perceptual level, although most research has focused on laughter (e.g., Bryant & Aktipis, 2014; Lavan et al., 2016; Neves et al., 2017), there is initial evidence that listeners are able to differentiate spontaneous from volitional vocalizations of amusement, sadness, achievement, anger, disgust, fear, pain, and pleasure (Anikin & Lima, 2017). These studies highlight the relevance of investigating vocal emotional perception using spontaneous expressions, and of further examining the differences between authentic and volitional vocalizations.

At the brain level, the few existing studies on authenticity focused on laughter, and they identified distinct cortical responses to spontaneous and volitional expressions (Lavan et al., 2017; McGettigan et al., 2015). McGettigan et al. (2015) found that passively listening to spontaneous (*vs.* volitional) laughter induced greater activation in the bilateral superior temporal gyrus, whereas volitional laughter elicited enhanced activation in anterior medial prefrontal and anterior cingulate cortices, i.e., brain regions involved in mentalizing processes. Lavan et al. (2017) have further observed that the dissociable brain responses to spontaneous *vs.* volitional laughter related to the perceived authenticity and affective properties (i.e., valence and arousal) of the stimuli. Laughs rated as less authentic were associated with stronger activation in brain regions related to mentalizing (i.e., anterior medial prefrontal cortex), and laughs rated as more authentic and arousing were associated with stronger activation in regions related to voice perceptual processing (Heschl's gyrus and superior temporal gyrus). These findings document cortical differences related to the emotional authenticity of laughter, but it remains unclear whether this is laughter-specific or extends to other emotional vocalizations, such as crying. Crucially, given the poor temporal resolution of fMRI, the time course of authenticity processing in emotional vocalizations remains unknown. Is authenticity processed at early sensory, or at later higher-order stages of voice perception? Event-related potentials (ERPs) are ideal to address these questions. To our knowledge, however, no previous studies have used this technique to examine authenticity processing in vocalizations.

ERP studies with acted vocal expressions have shown a differential processing of emotional and neutral vocalizations at distinct processing stages: emotional *vs.* neutral vocalizations typically trigger reduced N1, a component associated with sensory processing, and enhanced P2, a component associated with salience detection (Jessen & Kotz, 2011; Liu et al., 2012; Sauter & Eimer, 2010). At later processing stages, the Late Positive Potential (LPP) component is thought to reflect sustained attention and cognitive evaluation of emotionally and motivationally significant information (Jessen & Kotz, 2011; Pell et al., 2015; Pinheiro et al., 2016a; Pinheiro et al., 2017). The LPP is more pronounced around 400-600 ms after stimulus onset, yet it may last for up to one second following stimulus offset (Hajcak & Olvet, 2008; Schupp et al., 2006). More positive LPP amplitudes for emotionally salient *vs*. neutral stimuli have been documented for emotional speech prosody (Paulmann et al., 2013), emotional pictures (Cuthbert et al., 2000; Hajcak & Nieuwenhuis, 2006), and faces (Foti et al., 2010). The extent to which the LPP is sensitive to the emotional content of vocalizations is unclear. Pell et al. (2015) found that the LPP amplitude was increased for angry compared to sad and happy vocalizations, whereas Jessen and Kotz (2011) reported non-significant emotional modulations of LPP. Pinheiro et al. (2016b) provided evidence for an enhanced attentional orienting (increased P3a) for emotional (happy and angry) *vs.* neutral vocalizations, suggesting that emotionally salient voice information captures attentional resources more.

Attention Focus and Vocal Emotional Processing

The few existing studies testing the relationship between attention and vocal emotional processing have examined speech prosody and they suggest that attentional focus might affect brain responses (Grandjean et al., 2005; Sander et al., 2005). In a dichotic listening study, Sander et al. (2005) reported enhanced activation in the orbitofrontal cortex and cuneus when listening to angry prosodic stimuli that were presented in the to-be-attended ear *vs.* to-be-ignored channel during a gender evaluation task. This suggests that attention affects cortical responses to emotional prosody, but this study also provided evidence for automaticity: in the right amygdala and bilateral superior temporal sulcus (STS), responses to angry prosody were similar regardless of whether the stimuli were presented in the to-be-attended or to-be-ignored ears. In a different study, Ethofer et al. (2006) found increased activation in the right posterior MTG and STS, and bilateral inferior/middle frontal gyrus, when participants' attention was on the emotional prosodic cues of spoken stimuli *vs.* the content of the words. In the same vein, Frühholz et al. (2012) found distinct responses in the mid-STG, left inferior frontal gyrus, anterior cingulate cortex and amygdala when discriminating emotions (*vs.* gender) in prosodic stimuli, thus further documenting task effects on neural responses to vocal emotions.

Another way of studying the role of attention on voice perception is by manipulating the amount of visual information available in the environment, for instance by blindfolding participants (Landry et al., 2013; Lewald, 2007), or by asking them to close their eyes (Wöstmann et al., 2018). Research on the effects of temporary visual deprivation on the remaining sensory functions has demonstrated improvements on auditory (Fengler et al., 2015; Gibby et al., 1970; Landry et al., 2013; Lewald, 2007; Tabry et al., 2013) and tactile perceptual tasks (Facchini & Aglioti, 2003; Merabet et al., 2008). For instance, short-term visual deprivation improves the perception of harmonicity (Landry et al., 2013), and of loudness and pitch (Gibby et al., 1970), and reduces inaccuracies in auditory spatial localization tasks (Lewald, 2007). The degree to which temporary visual deprivation affect vocal emotional processing remains to be established.

The Current Study

Using ERPs, we examined the time course of brain responses to spontaneous and volitional nonverbal vocalizations. We further asked whether these responses are affected by attention, via two orthogonal manipulations: task focus (authenticity *vs.* emotion detection) and visual condition (standard visual condition *vs.* visual deprivation). Vocalizations included laughter and crying, thereby allowing us to probe the generalizability of authenticity and attention effects across positive and negative expressions. As for the task focus manipulation, in one condition participants were asked to judge the emotional authenticity of vocalizations, whereas in the other they focused on the emotional category of the sounds. Approximately half the participants were assigned to a visual deprivation condition, in which they were blindfolded, whereas the other half were assigned to a standard visual condition.

Based on previous ERP experiments (e.g., Jessen & Kotz, 2011; Liu et al., 2012; Pell et al., 2015), our focus was on the auditory N1, P2, and the LPP components. These components are reliable online measures of the processing stages underlying vocal emotional processing: sensory, salience detection, and cognitive evaluative stages. Since no previous studies examined the ERP correlates of authenticity processing, our hypotheses concerning the magnitude and directionality of the effects were exploratory. Nonetheless, we expected authenticity to modulate early sensory (N1), salience detection (P2), and late cognitive (LPP) stages of vocal emotion perception. Effects of authenticity at early sensory and salience detection processing stages were expected because there is evidence of important acoustic and affective differences between volitional and spontaneous vocalizations (Anikin & Lima, 2017; Bryant & Aktipis, 2014; Lavan et al., 2016), and we know that the N1 and P2 are sensitive to physical acoustic features of sounds (Näätänen & Picton, 1987; Seither-Preisler et al., 2006), and to their affective features (Jessen & Kotz, 2011; Liu et al., 2012; Pell et al., 2015). Authenticity modulations at late decoding stages, reflected in the LPP, would be consistent with evidence that spontaneous vocalizations tend to be perceived as being more arousing than volitional ones (Anikin & Lima, 2017; Bryant & Aktipis, 2014; Lavan et al., 2016), and we know that this component is sensitive to arousal (Cuthbert et al., 2000; de Rover et al., 2012). An effect at later evaluative stages would be also consistent with behavioral evidence that listeners are able to reliably discriminate spontaneous from volitional vocalizations in explicit evaluation tasks (e.g., Anikin & Lima, 2017; Bryant & Aktipis, 2014; Lavan et al., 2016; Neves et al., 2017). As for potential effects of attention, our approach was primarily exploratory. The presence of attention effects, both in terms of focus and in terms of visual conditions, would be suggestive of a role of more deliberate processes in authenticity processing. By contrast, the absence of such effects would highlight the role of automatic processes.

Methods

Participants

Forty-three undergraduate students participated in this study for course credit. They were randomly assigned to one of two conditions: visual deprivation, VD (n = 22; 7 males, M_{age} = 21.14, SD = 4.09); or standard visual condition, SV (n = 21; 6 males, M_{age} = 20.33, SD = 3.65). In the VD condition, participants were blindfolded in a dark and electrically shielded room and performed the auditory tasks with no concurrent visual information. In the SV condition, participants performed the auditory tasks inside an electrically shielded room with typical concurrent visual information signaling the beginning of each trial and the questions. For both experimental conditions, the inclusion criteria were: being right-handed (Oldfield, 1971); normal or corrected-to-normal visual acuity; normal hearing; no history of electroconvulsive treatment, neurological illness, or DSM-IV diagnosis of drug or alcohol abuse; no present medication with potential impact on the electroencephalogram (EEG), or with neurological and/or cognitive functioning consequences. Participants provided their informed consent, previously assessed by the local Institutional Review Board committee from the Faculty of Psychology at the University of Lisbon (Lisbon, Portugal).

Stimuli

The experimental stimuli consisted of 80 nonverbal vocalizations portraying amusement (40 laughs) or sadness (40 cries). Each emotional category comprised 20 volitional and 20 spontaneous stimuli, recorded by six speakers (three women) within an anechoic chamber at the University College London. To record volitional laughter and crying, speakers were asked to voluntarily produce these expressions, without a corresponding emotional eliciting event, and to make them sound as natural as possible. Spontaneous laughter was induced through an amusement induction condition, whereby speakers watched self-selected amusing video clips, which they considered funny and would easily make them laugh aloud (for a similar procedure, see McGettigan et al., 2015). Spontaneous crying was evoked by using an emotion induction procedure: speakers were asked to recall difficult (upsetting) past episodes and/or to initially pose crying to promote a shift into spontaneous crying linked with genuine experienced sadness (see Lavan et al., 2016). Of note, feelings of amusement and sadness throughout and after recording the corresponding genuine vocalizations were reported by the six speakers. These vocalizations have been previously used in behavioral and neuroimaging experiments (Lavan et al., 2015, 2016; Lima et al., 2016; O’Nions et al., 2017; Neves et al., 2017). The acoustic features of the stimuli are summarized in Table 1.

<INSERT TABLE 1 HERE>

Procedure

Participants were tested in individual sessions lasting around 40 minutes (breaks included). They were seated in a comfortable chair at a distance of 100 cm from the computer monitor, in an electrically shielded and sound attenuated room. Voice stimuli were binaurally presented through headphones. Presentation® software (Version 20.1, Neurobehavioral Systems, Inc., Berkeley, CA, www.neurobs.com) was used to control stimulus timing and presentation, as well as to register participants' responses.

Each participant completed two tasks, one involving an authenticity evaluation (volitional *vs.* spontaneous) and the other an emotion evaluation (sadness *vs.* amusement). The order of tasks was counterbalanced across participants. In each of them, the 80 vocalizations were randomly presented twice, originating a total of 160 trials per task. Each trial was presented as follows (see Figure 1 for details): 1) a warning sound (VD condition) or attention mark (SV condition) signaled the beginning of each trial (100 ms); 2) after a varying inter-stimulus interval (ISI; 500 – 1500 ms), a vocalization (< 3000 ms) was presented; 3) after a 1000 ms interval, a question sound (VD condition; 150 ms) or the written question (SV condition; 150 ms) was presented to signal the beginning of the response time (< 3000 ms). The inter-trial interval (ITI) lasted 1000 ms. In the SV condition, a fixation cross (presented centrally on the screen) remained until the end of the trial to minimize eye movements.

<INSERT FIGURE 1 HERE>

EEG Data Acquisition

EEG data were recorded using a 64-channel BioSemi Active Two System (http://www.biosemi.com/products.htm) at a digitization rate of 512 Hz. Electrodes placed at left and right temples (horizontal electrooculogram – EOG) and one below the left eye (vertical EOG) were used to monitor eye movements. Electrodes were also placed at left and right mastoids for offline referencing.

Brain Vision Analyzer 2.0.4 software (www.brainproducts.com) was used for offline analysis of EEG data. A .01 Hz high-pass filter was applied. EEG data were referenced offline to the average of the left and right mastoids. Individual ERP epochs of 1800 ms, time-locked to voice onset, were created and included a -200 ms pre-stimulus baseline. Ocular artifacts were corrected based on Gratton et al. (1983). Individual epochs containing excessive eye blinks or movement artifacts (±100 μV criterion) were excluded from the analyses. After artifact rejection, individual ERP averages were based on a minimum of 75% of segments per condition for each subject (visually deprived condition [authenticity focus condition: volitional crying = 33.45 ± 3.58 ; volitional laughter = 34.68 ± 3.99; spontaneous crying = 34.59 ± 2.81; spontaneous laughter = 34.41 ± 3.28; emotion focus condition: volitional crying = 35.45 ± 3.90; volitional laughter = 34.14 ± 3.98; spontaneous crying = 34.41 ± 3.29; spontaneous laughter = 34.36 ± 3.66]; standard visual condition [volitional crying = 34.10 ± 3.71; volitional laughter = 33.57 ± 3.91; spontaneous crying = 33.86 ± 3.26; spontaneous laughter = 33.81 ± 3.28 ; emotion focus condition: volitional crying = 34.29 ± 3.39 ; volitional laughter = 34.52 ± 3.11; spontaneous crying = 34.10 ± 3.53; spontaneous laughter = 34.71 ± 3.16]).

Based on previous auditory ERP studies and on close visual inspection of grand-averaged waveforms, the following time windows after vocalization onset were selected for computing the mean amplitudes of N1, P2 and LPP measures: 130-170 milliseconds (N1 – Lu et al., 2015; Pinheiro et al., 2014), 220-280 milliseconds (P2 – Lu et al., 2015; Pinheiro et al., 2014), 450-700 milliseconds (early LPP – Jessen & Kotz, 2011; Masuda et al., 2018; Pell et al., 2015; Schindler et al., 2015), 700-1000 milliseconds (middle LPP – Brown & Cavanagh, 2017; Masuda et al., 2018; Schindler et al., 2015), and 1000-1400 milliseconds (late LPP – Brown & Cavanagh, 2017; Brown et al., 2012; Spreckelmeyer et al., 2006). For the N1 and P2 components, the selected regions-of-interest (ROIs) considered the average of fronto-central (FC1, FCz, FC2) and central (C1, Cz, C2) electrodes, consistent with previous studies (e.g., Liu et al., 2012, 2015; Pell et al., 2015; Pinheiro et al., 2017; Rigoulot et al., 2015). For the LPP, the selected ROIs considered the average of parietal (P1, Pz, P2) and parieto-occipital (PO3, POz, PO4) electrodes (e.g., Brown & Cavanagh, 2017; Masuda et al., 2018; Pell et al., 2015; Schirmer & Gunter, 2017; Spreckelmeyer et al., 2006).

Statistical Analyses

The data were analyzed using standard frequentist and Bayesian statistical approaches. A Bayes Factor (BF_{10}) statistic was estimated for each analysis, which compares the likelihood of the data fitting under the alternative and null hypotheses. All analyses were conducted on JASP Version 0.13.1 (JASP Team, 2020), using default priors (Rouder et al., 2012; Wagenmakers et al., 2018a, 2018b). BF_{10} values were interpreted based on Jeffreys' guidelines (Jarosz & Wiley, 2014; Jeffreys, 1961), according to which values above 1 provide evidence in favor of the alternative hypothesis (1–3, weak/anecdotal evidence; 3–10, substantial evidence; 10–30, strong evidence; 30–100, very strong evidence; >100, decisive evidence), and values below 1 correspond to evidence for the null hypothesis (0.33–1, weak/anecdotal evidence; 0.10–0.33, substantial evidence; 0.03–0.10, strong evidence; 0.01–0.03, very strong evidence; <0.01, decisive evidence).

Behavioral Data

The accuracy of judging the authenticity and emotion of vocalizations was analyzed by computing two measures: d-prime, a measure of sensitivity that considers how accurately the participant discriminates signal from noise; and c', a measure of response bias that sheds light into the participant's decision-making process (if they experience uncertainty, they might provide a positive or negative response, corresponding to a liberal or conservative strategy, respectively; Macmillan & Creelman, 2005; Stanislaw & Todorov, 1999).

Regarding authenticity, the proportion of *hits* and *false alarms* was determined separately for laughter and crying: volitional laughs classified as “volitional” were considered *hits*, and spontaneous laughs classified as “volitional” were considered *false alarms* (the same was done for crying). Sensitivity (d’) and response bias (c) were calculated in line with Macmillan and Creelman (2005). The resulting d’ and c’ scores were submitted to separated mixed analyses-of-variance (ANOVAs), with visual deprivation (VD, SV) as between-subjects factor, and emotion (sadness, amusement) as within-subjects’ factors.

Regarding the emotion task, the proportion of *hits* and *false alarms* were determined separately for volitional and spontaneous vocalizations: cries classified as “sadness” were considered *hits*, and laughs classified as “sadness” were considered *false alarms*. The resulting d’ and c’ scores were submitted to separated mixed ANOVAs, with visual deprivation (VD, SV) as between-subjects factor, and authenticity (volitional, spontaneous) as within-subjects’ factors.

Significant interactions were followed up by comparisons between theoretically relevant conditions (using t-tests), with Bonferroni adjustment for multiple comparisons. Analyses were corrected for non-sphericity using the Greenhouse-Geisser correction method. Partial eta squared values (η_p^2) for main effects and interactions are reported.

ERP Data

Mixed ANOVAs were conducted separately for the mean amplitudes of N1, P2, and LPP (early, middle, and late LPP time windows), with visual condition (VP, VD) as between-subjects factor, and task focus (authenticity, emotion), authenticity (volitional, spontaneous), and emotion (sadness, amusement) as within-subjects factors.

Results

Behavioral Data

Authenticity Detection

The accuracy of authenticity detection per emotion type is presented in Table 2.

Sensitivity (d' scores). Participants in the VD condition were less accurate than those in the SV condition at discriminating posed from authentic vocalizations, as indicated by a main effect of visual deprivation, $F(1,41) = 15.755$, $p < .001$, $\eta_p^2 = .278$, $BF_{10} = 53.321$. We also found a main effect of emotion, $F(1,41) = 6.427$, $p = .015$, $\eta_p^2 = .136$, although the Bayesian evidence was weak, $BF_{10} = 2.233$. Additionally, a very strong interaction between emotion and visual deprivation, $F(1,41) = 11.496$, $p = .002$, $\eta_p^2 = .219$, $BF_{10} = 33.652$, indicated differences in the way both groups discriminated authenticity from laughs and crying. Follow-up analyses showed decisive evidence that participants in the SV condition were more accurate than those in the VD condition at detecting crying authenticity [$t(41) = -5.162$, $p <.001$, $BF_{10} >100$], while no condition effects were found for laughter [$t(41) = -1.044$, $p = 1$, $BF_{10} = 0.464$]. Additionally, the emotion effect was significant for the SV condition, with better performance for crying *vs.* laughter [$t(20) = -4.401$, p < .001, $BF_{10} > 100$], but not for the VD condition [$t(21) = 0.581$, $p = 1$, $BF_{10} = 0.260$].

Response bias (c' scores). A main effect of visual deprivation, $F(1,41) = 17.833$, $p < .001$, $\eta_p^2 = .303$, $BF_{10} = 37.739$, indicated group differences regarding their tendency to categorize stimuli as "volitional" or "spontaneous" or: VD participants had a stronger bias for categorizing vocalizations as "spontaneous", whereas participants in the SV condition had a stronger bias for categorizing them as "volitional" (VD c' values = .308; SV c' values = -.292). A main effect of emotion, $F(1,41) = 52.966$, $p < .001$, $\eta_p^2 = .564$, $BF_{10} > 100$, revealed that participants were more likely to categorize crying stimuli as "volitional" when compared to laughter (sadness c' values = -.265; happy c' values = .286). No interaction was found between emotion and visual deprivation ($p = .603$, $BF_{10} = 0.325$).

Emotion Detection

The accuracy of emotion detection per emotion type is presented in Table 3.

Sensitivity (d' scores). A main effect of authenticity, $F(1,41) = 139.310$, $p < .001$, $\eta_p^2 = .773$, $BF_{10} > 100$, revealed decisive evidence for higher accuracy in emotional judgements of volitional compared to spontaneous vocalizations. No main effect of visual deprivation or interaction between the two factors were found (lowest $p = .389$, highest $BF_{10} = 0.384$).

Response bias (c' scores). We found a main effect of authenticity, $F(1,41) = 81.225$, $p < .001$, $\eta_p^2 = .665$, $BF_{10} > 100$. Although the main effect of visual deprivation was not significant ($p = .352$, $BF_{10} = 0.533$), a weak interaction between authenticity and visual deprivation was observed, $F(1,41) = 4.647$, $p = .037$, $\eta_p^2 = .102$, $BF_{10} = 1.714$: participants were generally less biased to discriminate emotion from volitional *vs.* spontaneous vocalizations, but the evidence was stronger for the SV group (VD: $t(21) = -4.301$, $p < .001$, $BF_{10} = 98.586$; SV: $t(20) = -9.438$, $p < .001$, $BF_{10} > 100$).

ERP Data

N1 Component

N1 amplitude was affected by both authenticity, $F(1,41) = 7.751$, $p = .008$, $\eta_p^2 = .159$, $BF_{10} = 13.704$, and emotion , $F(1,41) = 10.855$, $p = .002$, $\eta_p^2 = .209$, $BF_{10} = 6.155$. An interaction between authenticity and emotion was also observed, $F(1,41) = 4.605$, $p = .038$, $\eta_p^2 = .101$, $BF_{10} = 2.449$. Follow-up analyses indicated that, for laughter, the N1 was reduced for spontaneous *vs.* volitional laughs, $t(42) = -3.575$, $p < .001$, $BF_{10} = 32.918$. For crying, on the other hand, there was substantial evidence for the absence of differences between spontaneous and volitional stimuli, $t(42) = -0.466$, $p = 1$, $BF_{10} = 0.183$.

Additionally, effects of emotion depended on authenticity: for volitional vocalizations, the N1 was more negative in response to laughter *vs.* crying, $t(42) = 3.413$, $p = .006$, $BF_{10} = 21.697$; whereas for spontaneous stimuli, we found substantial evidence for the lack of differences between emotions, $t(42) = 0.372$, $p = 1$, $BF_{10} = 0.176$. No other main effects or interactions were found, which suggests that laughter authenticity affected N1 amplitude regardless of task focus and visual condition (lowest p = .211, highest BF_{10} = 0.648).

P2 Component

We found a main effect of authenticity, $F(1,41) = 8.629$, $p = .005$, $\eta_p^2 = .174$, BF_{10} = 7.816, but not of emotion, $F(1,41) = 2.504$, $p = .121$, $\eta_p^2 = .058$, $BF_{10} = 0.29$). Furthermore, we found a very strong interaction between authenticity and emotion, $F(1,41) = 14.780$, $p < .001$, $\eta_p^2 = .265$, $BF_{10} > 100$. For crying, the P2 was more positive in response to spontaneous compared to volitional cries, $t(42) = -4.401$, $p < .001$, $BF_{10} > 100$. For laughter, however, there was substantial evidence for the absence of differences, $t(42) = 0.644$, $p = 1$, BF_{10} = 0.201.

Besides, for volitional vocalizations, the P2 was more positive for laughter than crying, $t(42) = -3.637$, $p < .001$, $BF_{10} = 38.737$; whereas for spontaneous stimuli, no significant differences were observed , $t(42) = 1.999$, $p = .208$, $BF_{10} = 1.005$. No other main effects or interactions were observed, indicating that crying authenticity affected P2 amplitude regardless of task focus and visual condition (lowest p = .146, highest BF_{10} = 0.752).

Early LPP (450-700 ms)

There was substantial evidence for the absence of a main effect of authenticity (p = .469, $BF_{10} = 0.167$) and emotion (p = .925, $BF_{10} = 0.117$). However, a main effect of task focus, $F(1,41) = 5.278$, $p = .027$, $\eta_p^2 = .114$, $BF_{10} = 2.607$, indicated a more positive amplitude when the focus was on authenticity *vs.* emotion. There was also substantial evidence for an effect of visual condition, $F(1,41) = 6.120$, $p = .018$, $\eta_p^2 = .130$, $BF_{10} = 3.221$: the LPP was more positive in the VD relative to the SV group. No significant interactions were identified (lowest p = .063, highest $BF_{10} = 0.838$).

Middle LPP (700-1000 ms)

We found substantial evidence for the absence of a main effect of authenticity (p = .197, BF_{10} = 0.269), indicating that the amplitude of the LPP, within this time range, was similar for spontaneous and volitional stimuli. A main effect of emotion, $F(1,41) = 4.858$, p = .033, η_p^2 = .106, indicated more positive LPP in response to laughter than crying. However, the Bayes factor indicated little evidence for the presence or absence of an effect (BF_{10} = 0.949). A significant main effect of visual condition, $F(1,41) = 6.178$, p = .017, η_p^2 = .131, BF_{10} = 3.194, revealed that the LPP was more positive in the VD group compared to the SV group. We also found decisive evidence for a main effect of task focus, $F(1,41) = 8.957$, p = .005, η_p^2 = .179, $BF_{10} > 100$, as well as a significant interaction between task focus and authenticity, $F(1,41) = 5.261$, p = .027, η_p^2 = .114, BF_{10} = 2.343. When the task was focused on emotion, the LPP was increased for spontaneous *vs.* volitional vocalizations, $t(42) = -2.445$, p = .038, BF_{10} = 2.328. However, when the focus was on authenticity, there was substantial evidence for the absence of differences between spontaneous and volitional stimuli, $t(42) = 0.822$, p = .832, BF_{10} = 0.227. No other interactions were observed (lowest p = .059, highest BF_{10} = 1.565).

Late LPP (1000-1400 ms)

We observed a significant main effect of authenticity, $F(1,41) = 10.951$, p = .002, η_p^2 = .211, BF_{10} = 44.193, indicating more positive amplitude for spontaneous *vs.* volitional vocalizations. Nonetheless, no interaction between authenticity and other factors were found (lowest p = .054, highest BF_{10} = 1.086), demonstrating that the impact of authenticity at this stage of processing was independent of emotion, task focus, or visual condition.

Additionally, we found a weak interaction between emotion and visual condition, $F(1,41) = 5.362$, p = .026, η_p^2 = .116, BF_{10} = 1.194: amplitude was more positive for laughter *vs.* crying in the SV condition, $t(20) = -2.813$, p = .022, BF_{10} = 4.751; whereas there was substantial evidence for the lack of differences between emotions in the VD group, $t(21)$ =

0.164, $p = 1$, $BF_{10} = 0.226$. Moreover, emotion also interacted with task focus, $F(1,41) = 4.233$, $p = .046$, $\eta_p^2 = .094$, although Bayesian statistics did not support the presence of an effect ($BF_{10} = 0.857$). Based on follow-up analyses, when the task focus was directed to authenticity, $t(42) = -2.732$, $p = .018$, $BF_{10} = 4.283$, there was substantial evidence for an increased amplitude in response to laughter *vs.* crying. On the other hand, when the focus was on emotion, there was substantial evidence for the absence of differences between emotions, $t(42) = 0.037$, $p = 1$, $BF_{10} = 0.165$.

Discussion

The current study examined whether and how the authenticity of emotional vocalizations impacts ERP responses at distinct vocal processing stages. It also probed the extent to which these effects are affected by attention (i.e., task focus and visual condition).

Early Processing Stages

The auditory N1 component indexes early sensory acoustic processing (Näätänen & Picton, 1987), and is modulated by attention (Woldorff et al., 1993). At this processing stage, we found a strong authenticity effect for laughter, while for crying we found evidence for no authenticity effects. Considering the existing evidence on the functional significance of the N1 (Liu et al., 2012; Meyer et al., 2007; Pell et al., 2015), this finding suggests an early preferential sensory analysis of spontaneous (*vs.* volitional) laughter, but not crying. Crucially, the authenticity effects for laughter were observed regardless of task focus and of visual condition. This suggests that they are automatic to an important extent. These findings confirm our hypothesis of authenticity effects on early sensory processing stages.

Since the N1 is sensitive to the physical acoustic features of the stimulus (Näätänen & Picton, 1987; Seither-Preisler et al., 2006), the observed N1 modulation by laughter authenticity is likely to reflect differences in the physical acoustic temporal and spectral profiles of spontaneous *vs*. volitional laughter. Volitional laughs are characterized by lower fundamental frequency, shorter length, longer bursts with smaller unvoiced breaks, and they tend to be more nasal and more affected by supralaryngeal control mechanisms (Anikin & Lima, 2017; Bryant & Aktipis, 2014; Lavan et al., 2016; Vettin & Todt, 2005). (Anikin & Lima, 2017). Spontaneous laughs, on the other hand, tend to display a more heterogeneous acoustic profile that is difficult to mimic and is less subject to supralaryngeal mechanisms, being characterized by higher and more variable fundamental frequency, and by smaller bursts and longer (and more variable) inter-bursts intervals (Anikin & Lima, 2017; Bryant & Aktipis, 2014; Lavan et al., 2016). The N1 component is thought to be originated from neural sources placed in the STG and supratemporal plane (Näätänen & Picton, 1987). Hence, the increased N1 for volitional *vs*. spontaneous laughter is consistent with previous literature showing distinct responses for volitional and spontaneous laughter in the bilateral STG (Lavan et al., 2017; McGettigan et al., 2015), and extend these studies by showing that this dissociation initiates early in voice processing. On the other hand, this initial sensory processing stage was unaffected by the authenticity of crying. This suggests that, at 130-170 ms post-stimulus onset, the acoustic differences between spontaneous and volitional crying might not be sufficiently prominent to modulate processing mechanisms, and that more time (and hence, a greater amount of acoustic information) is needed for authenticity discrimination. Differences in the N1 authenticity effects for laughter *vs.* crying might also result from distinct degrees of exposure and familiarization to these vocalizations. Crying is often expressed in individual (solitary) settings and relatively less frequent in adults (Vingerhoets & Bylsma, 2016; Zeifman, 2001), whereas laughter is typically expressed (and more often to occur) in the presence of others (Provine, 2001). The facilitated sensory processing of authenticity from laughter could, therefore, be a consequence of the enhanced exposure to laughter in daily social interactions.

Furthermore, our findings also showed that sensory processing stages are sensitive to the emotional quality of the voice in the case of volitional stimuli: volitional laughter elicited more negative N1 when compared to crying. This selective effect suggests heightened sensitivity of sensory processing mechanisms to the emotional quality of vocal expressions when they are less spontaneous and arguably more prototypical. Volitional vocalizations comprise less acoustic variability than spontaneous expressions (Anikin & Lima, 2017; Lavan et al., 2015), and hence, they might exhibit a more homogeneous acoustic profile that exaggerates the acoustic distinctions between emotions, facilitating initial stages of acoustic sensory processing. The absence of emotion-specific effects for spontaneous vocalizations might reflect a more demanding sensory analysis of spontaneous expressions of sadness and amusement, which are associated with greater acoustic variability (Anikin & Lima, 2017; Lavan et al., 2015) and, potentially, perceptual ambiguity.

Since the N1 is modulated by the physical properties of sound (Näätänen & Picton, 1987; Seither-Preisler et al., 2006), the emotion-specific effects for volitional vocalizations might reflect differences in the acoustic parameters of volitional laughter *vs.* crying. Originating from mammalian social play, acoustically, laughter exhibits a unique rhythm of nearly five syllables per second uttered on a single exhalation (Anikin et al., 2018; Bryant & Aktipis 2014; Provine, 2001). Distinct from laughter, human crying displays lengthier voiced syllables that are modulated by the respiratory cycles, and is characterized by a more tonal sound (Anikin et al., 2018; Provine, 2012). Our findings of increased N1 for volitional laughter *vs.* crying are consistent with earlier experiments providing evidence for specific emotion effects on this component (Jessen & Kotz, 2011; Pell et al., 2015).

While for the N1 the authenticity effects were limited to laughter, the authenticity effect was limited to crying in the case of the P2. In the context of vocal emotion processing, the P2 component reflects the detection and integration of emotionally salient acoustic cues from the auditory signal (Liu et al., 2012; Paulmann & Kotz, 2008; Pell et al., 2015; Schirmer & Kotz, 2006). Our findings of enhanced P2 for spontaneous compared to volitional crying suggested facilitated detection of emotional salience from spontaneous crying. These modulations were independent of task focus (authenticity *vs.* emotion) and visual condition (visual deprivation, standard visual), indicating that authenticity of crying is detected in a relatively automatic manner, at salience detection stages. Evidence for the automatic processing of emotionally salient information from nonverbal vocalizations was previously reported (Lima et al., 2019; Pinheiro et al., 2015). Also, our findings suggest that the time course of authenticity processing depends on emotion, with authenticity properties being processed earlier for laughter (at N1 range) than for crying (P2). Considering earlier evidence showing emotion effects on the P2, arguably due to arousal effects of emotionally salient voices (Liu et al., 2012; Paulmann & Kotz, 2008; Sauter & Eimer, 2010; Schirmer et al., 2013), our observation of increased P2 for spontaneous crying might reflect differences in the arousal properties of spontaneous and volitional crying. This interpretation is consistent with previous suggestions that the perception of emotional authenticity relies on arousal properties (Anikin & Lima, 2017), and with earlier studies demonstrating that spontaneously produced vocalizations (i.e., laughter) tend to be perceived as being more arousing and extremely valenced than volitional expressions (Lavan et al., 2016; McGettigan et al., 2015).

Of note, the interactive effects between authenticity and emotion also revealed enhanced P2 for laughter compared with crying, but limited to volitional vocalizations. These findings replicate previous work with posed vocalizations (Pell et al., 2015) and might reflect increased arousal of volitional laughter. They demonstrate that the sensitivity of the early salience detection stages to distinct emotions depends on the authenticity of vocalizations, being enhanced for volitional expressions. They suggest easier decoding of emotionally salient information from posed prototypical expressions of emotion than from spontaneous sounds. This advantage seems to initiate at early sensory processing stages (indexed by the N1) and is subsequently reflected in the following processing stage of salience detection (P2 range). Together, our findings on the N1 and P2 measures demonstrate a dynamic interplay between authenticity and emotion salient information during the early stages of vocal emotion processing.

Late Processing Stages

The LPP is believed to index sustained attentional mechanisms at later high-order processing stages, as well as the cognitive evaluation of the emotional meaning of a stimulus (Paulmann et al., 2013; Pell et al., 2015; Pinheiro et al., 2017; Schirmer et al., 2013). Our results yield strong evidence for authenticity effects, yet limited to late LPP time window (i.e., 1000-1400 ms): spontaneous vocalizations elicited more positive amplitude than volitional expressions. More positive LPP amplitudes for emotional (*vs.* neutral) stimuli have been documented (emotional prosody – Paulmann et al., 2013; emotional pictures – Cuthbert et al., 2000; Hajcak & Nieuwenhuis, 2006; faces – Foti et al., 2010). The amplitude enhancement is thought to reflect greater sustained attention and facilitated processing of emotionally salient information. The LPP is also modulated by arousal (Cuthbert et al., 2000; de Rover et al., 2012). Our findings suggest enhanced sustained attention for emotionally relevant spontaneous (*vs.* volitional) vocalizations. They might reflect the heightened salience of spontaneous vocalizations in signaling a high arousing state of the vocalizer (as shown by previous studies – Anikin & Lima, 2017; Bryant & Aktipis, 2014; Lavan et al., 2016), as well as in influencing the behavior of the listener. The fact that authenticity effects at late LPP were observed irrespective of emotion, task focus, and visual condition reveals that the later cognitive stages of authenticity processing are automatic to an important extent.

Nonetheless, we found little evidence for effects of authenticity being modulated by task focus (between 700 and 1000 ms post-stimulus onset), which could suggest enhanced cognitive processing of spontaneous expressions when judging emotion. However, one should consider that the evidence for these interactive effects is weak, which underscores the need for additional studies. Furthermore, we found no substantial evidence for specific effects or interactions involving emotion at late decoding stages. Even though emotion effects on the LPP have been reported for different stimulus modalities (Foti et al., 2010; Hajcak & Nieuwenhuis, 2006; Paulmann et al., 2013; Pinheiro et al., 2017), the available studies with vocalizations have produced less consistent findings (Jessen & Kotz, 2011; Pell et al., 2015). Our findings keep with Jessen and Kotz (2011) who reported non-significant valence effects on the LPP, as well as with Pell et al. (2015) showing non-significant differences between laughter and crying.

Regarding our attentional manipulations, we found some evidence in favor of the modulatory role of task focus and visual deprivation in the ERP responses to vocalizations. Our observation of enhanced positivities (at early, middle, and late LPP), when participants focused on the authenticity *vs.* emotion of vocalizations, might be linked to differences in the complexity and difficulty between the two tasks (e.g., discriminating authenticity from vocalizations might be a more sophisticated task, implicating more subtle acoustic distinctions). Our findings are consistent with earlier studies showing that the focus of attention shapes the magnitude of brain responses to emotionally salient events (e.g., Bach et al., 2008; Sander et al., 2005).

Suggesting that visual deprivation impacted the later neural processing stages of vocal emotion, we found evidence for enhanced high-order attention in the visually deprived (*vs.* SV) group at all time ranges of the LPP. Performing the auditory task with no concurrent visual input may have enhanced the attentional and perceptual resources available (that would be otherwise directed to visual information) to process task-relevant nonvisual input, in line with previous studies (Vredeveldt et al., 2011; Wöstmann et al., 2018). Empirical support for enhanced attention through visual deprivation comes from research demonstrating that an eyes closed (*vs.* open) condition enhanced alpha power, a neural oscillatory measure of auditory attention, yet it did not improve the perceptual sensitivity to detect tones during an auditory attention task at the behavioral level (Wöstmann et al., 2018). Similarly, in our study enhanced attention in the visually deprived group did not translate behaviorally into improved discrimination of emotion or authenticity. Although the capacity to differentiate emotion remained unaffected by visual condition, the detrimental effect of visual deprivation on authenticity discrimination of crying stimuli (as demonstrated by our d' scores) might be linked to enhanced attention in processing stages reflecting the cognitive evaluation of the significance of the voice. Aberrant attentional resources towards vocalizations might have made specific sound features (otherwise neutral) abnormally salient, biasing the explicit judgement of authenticity. Indeed, participants in the visually deprived condition were more likely to perceive vocalizations as "authentic" than in the SV group.

Our behavioral data shed light on the later stages of vocal emotion processing reflecting the evaluation and integration of stimulus emotional meaning (Schirmer & Kotz, 2006). They indicated that the authenticity of vocalizations modulated emotion recognition: emotion was better discriminated (and with a lower bias) from posed (*vs.* authentic) expressions, consistent with previous studies (vocalizations – Sauter & Fisher, 2017; facial expressions – Russell, 1994; Motley & Camden, 1988). Emotion is more easily differentiated from these voluntary expressions, since as produced on demand, posed vocalizations are likely to be more representative exemplars of a given emotion (Sauter & Fisher, 2017; Scherer & Bänziger, 2010). These observations might be linked to the facilitated processing, at early sensory and salience detection stages, of emotional salient information from volitional expressions. Furthermore, we found that participants were more likely to categorize crying as "volitional" ('conservative' response) when compared to laughter. These results are in good agreement with earlier evidence of and of a general bias to judge crying as less spontaneous and laughter as more 'spontaneous' (Anikin & Lima, 2017). The observed differences in authenticity perception as a function of emotion might be linked to highly distinct communicational functions of these vocalizations in daily social settings, which might request very distinct behaviors from the listener (e.g., a more cooperative response in the case of crying *vs.* rewarding experience associated with laughter). Laughter is typically expressed in positive social contexts, promoting and reinforcing social bonds (Provine, 2001). Laughter might express a variety of meanings and intentional states, such as joy, amusement, cheerfulness, affiliation, triumph, nervousness, dominance, taunt or schadenfreude (i.e., laughing about other's misfortune) (Szameitat et al., 2009a, 2009b; Wood et al., 2017). Crying, however, is a salient expression for signaling sadness and vulnerability from the sender, as well as for requesting empathy and prosocial behavior from the listener (Hendriks et al., 2008; Provine et al., 2009; Vingerhoets & Bylsma, 2016). Therefore, the more variable and complex social meanings of laughter might have turned the process of authenticity discrimination more complex and ambiguous as compared to crying.

It is worth noting that our manipulation of authenticity was categorical (i.e., vocalizations were assessed as either spontaneous or volitional). However, some authors have suggested that authenticity properties are better represented as dimensional, since all expressions of emotion within a given social context are restricted by cultural and social norms, and hence, they represent to a greater or lesser extent 'posed' expressions (Sauter & Fischer, 2017; Scherer et al., 2011). Future studies addressing these issues are warranted. In addition, future research should investigate authenticity processing in the context of distinct laughter types representing both positive (e.g., joyful laughter, tickling laughter) and negative emotions (e.g., 'schadenfreude' laughter, taunting laughter). Also, future investigations should examine authenticity effects in the context of other vocalizations (e.g., fear, anger, disgust, pleasure achievement), as well as different stimulus sets, as this will contribute to expand our claims.

Conclusion

Together, our findings provide support for the influential role of authenticity in modulating the various stages of vocal emotion processing – early sensory (N1), salience detection (P2), and late cognitive evaluative stages (LPP), even when task-irrelevant. They provide evidence for an early and automatic processing of the authenticity of vocal emotions. These findings add to current models of vocal emotional perception (Schirmer & Kotz, 2006) by demonstrating that authenticity and emotion are simultaneously and interactively processed from the earliest stages of voice processing.

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Table 1

Acoustic characteristics of the stimuli

Authenticity	Emotion	*f*0 (Hz)	*f*0 min (Hz)	*f*0 max (Hz)	Duration(ms)	Intensity (dB)
Authentic	Amusement	270.78	171.96	370.69	2402	66.09
	Sadness	287.53	180.51	385.06	2689	65.86
Posed	Amusement	228.78	115.15	319.48	2270	66.03
	Sadness	260.90	125.23	392.65	2520	66.09

Table 2

Average accuracy scores for the authenticity detection task, considering emotion type and visual condition.

Authenticity	**Emotion**	**Condition**			
		Visual Deprivation - VD		**Standard Visual - SV**	
		Hits	***False alarms***	***Hits***	***False alarms***
Spontaneous	Amusement	.83 *(.19)*	.47 *(.18)*	.75 *(.12)*	.32 *(.2)*
	Sadness	.66 *(.14)*	.32 *(.20)*	.64 *(.15)*	.11 *(.09)*
Volitional	Amusement	.53 *(.15)*	.17 *(.08)*	.68 *(.20)*	.25 *(.12)*
	Sadness	.68 *(.20)*	.34 *(.14)*	.89 *(.09)*	.36 *(.15)*

Note. SDs are given in italic.

Table 3

Average accuracy scores for the emotion detection task, considering authenticity and visual condition.

Emotion	**Authenticity**	**Condition**			
		Visual Deprivation - VD		**Standard Visual - SV**	
		Hits	***False alarms***	***Hits***	***False alarms***
Amusement	Spontaneous	.94 *(.06)*	.17 *(.17)*	.95 *(.05)*	.20 *(.11)*
	Volitional	.95 *(.05)*	.07 *(.12)*	.95 *(.05)*	.05 *(.04)*
Sadness	Spontaneous	.83 *(.17)*	.06 *(.06)*	.78 *(.09)*	.05 *(.05)*
	Voltional	.93 *(.12)*	.05 *(.05)*	.95 *(.04)*	.05 *(.05)*

Note. SDs are given in italic.

Table 4

Mean amplitude of N1, P2, and LPPs in each visual condition, for the authenticity and emotion detection tasks

	Authenticity	Emotion	N100	P200	LPPs		
					450-700	700-1000	1000-1400
Authenticity detection task							
VD	Spontaneous	Amusement	-0.46 *(2.96)*	4.12 *(2.46)*	0.71 *(2.59)*	2.68 *(2.84)*	2.77 *(3.17)*
		Sadness	0.10 *(3.05)*	5.15 *(2.90)*	1.27 *(2.49)*	1.84 *(2.80)*	2.03 *(2.83)*
	Volitional	Amusement	-1.37 *(2.77)*	4.48 *(3.73)*	1.66 *(3.21)*	2.66 *(3.02)*	2.01 *(2.69)*
		Sadness	-0.80 *(3.54)*	3.37 *(3.12)*	1.42 *(2.48)*	2.30 *(3.02)*	1.74 *(3.34)*
SV	Spontaneous	Amusement	-1.53 *(3.23)*	5.47 *(2.78)*	-0.57 *(3.00)*	0.80 *(3.17)*	1.16 *(3.19)*
		Sadness	-1.71 *(3.53)*	5.46 *(3.03)*	-0.85 *(2.53)*	-0.72 *(3.52)*	-0.67 *(3.87)*
	Volitional	Amusement	-2.59 *(3.67)*	5.79 *(2.93)*	-0.05 *(3.19)*	0.41 *(3.87)*	0.52 *(3.91)*
		Sadness	-1.14 *(2.95)*	4.82 *(2.42)*	-0.14 *(2.94)*	0.31 *(3.21)*	-0.56 *(3.82)*
Emotion detection task							
VD	Spontaneous	Amusement	-0.72 *(3.14)*	4.07 *(3.20)*	0.49 *(2.42)*	1.46 *(1.67)*	1.11 *(2.19)*
		Sadness	-0.40 *(2.88)*	5.27 *(3.08)*	0.89 *(2.44)*	1.66 *(2.60)*	1.81 *(2.41)*
	Volitional	Amusement	-2.14 *(3.18)*	4.12 *(3.63)*	-0.07 *(2.09)*	-0.22 *(1.99)*	-0.71 *(2.30)*
		Sadness	-0.66 *(2.93)*	2.56 *(2.73)*	0.75 *(2.18)*	0.55 *(2.69)*	-0.21 *(2.64)*
SV	Spontaneous	Amusement	-1.34 *(2.34)*	5.12 *(1.93)*	-0.15 *(2.88)*	0.86 *(3.55)*	0.02 *(3.11)*
		Sadness	-1.65 *(3.12)*	5.16 *(2.55)*	-1.23 *(2.19)*	-0.88 *(2.70)*	-0.50 *(2.76)*
	Volitional	Amusement	-2.72 *(4.10)*	5.17 *(2.89)*	-0.65 *(3.11)*	-0.08 *(3.48)*	-0.80 *(3.99)*
		Sadness	-1.69 *(2.79)*	3.94 *(3.18)*	-0.89 *(2.77)*	-0.75 *(3.59)*	-1.48 *(2.98)*

Note. Mean scores represent the average amplitude of the ROI electrodes for each component (N1 and P2: FC1, FCz, FC2, C1, Cz, C2; LPPs: P1, Pz, P2, PO3, POz, PO4). SDs are given in italic. LPP, late positive potential; SV, standard visual condition; VD, visual deprivation condition.

Figure 1

Illustration of an experimental trial

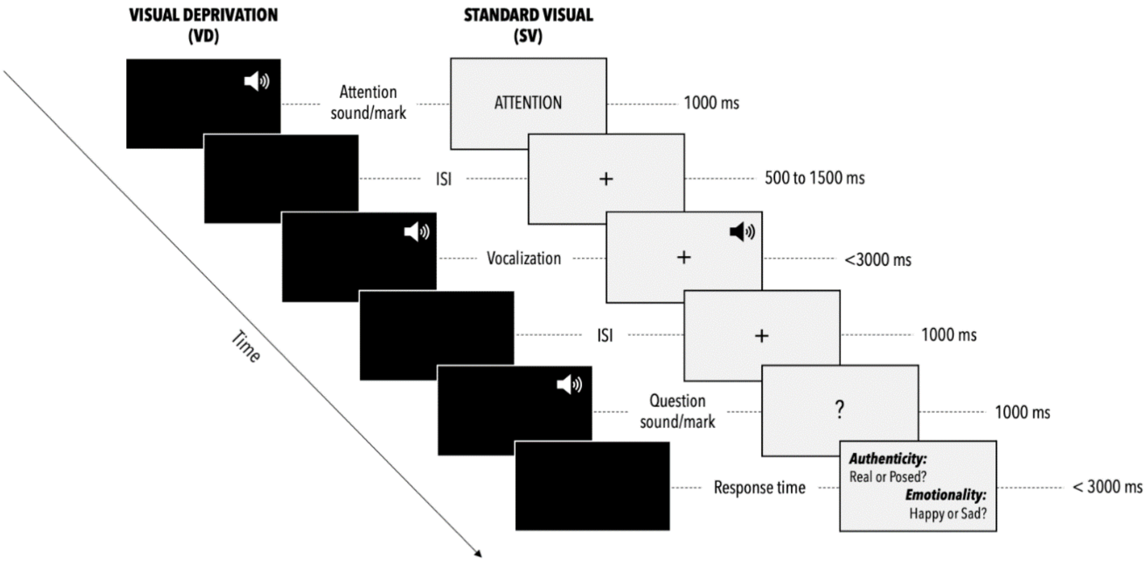

Figure 2

Grand average ERP waveforms for spontaneous and volitional vocalizations, in the authenticity detection task, at Cz and Pz electrodes.

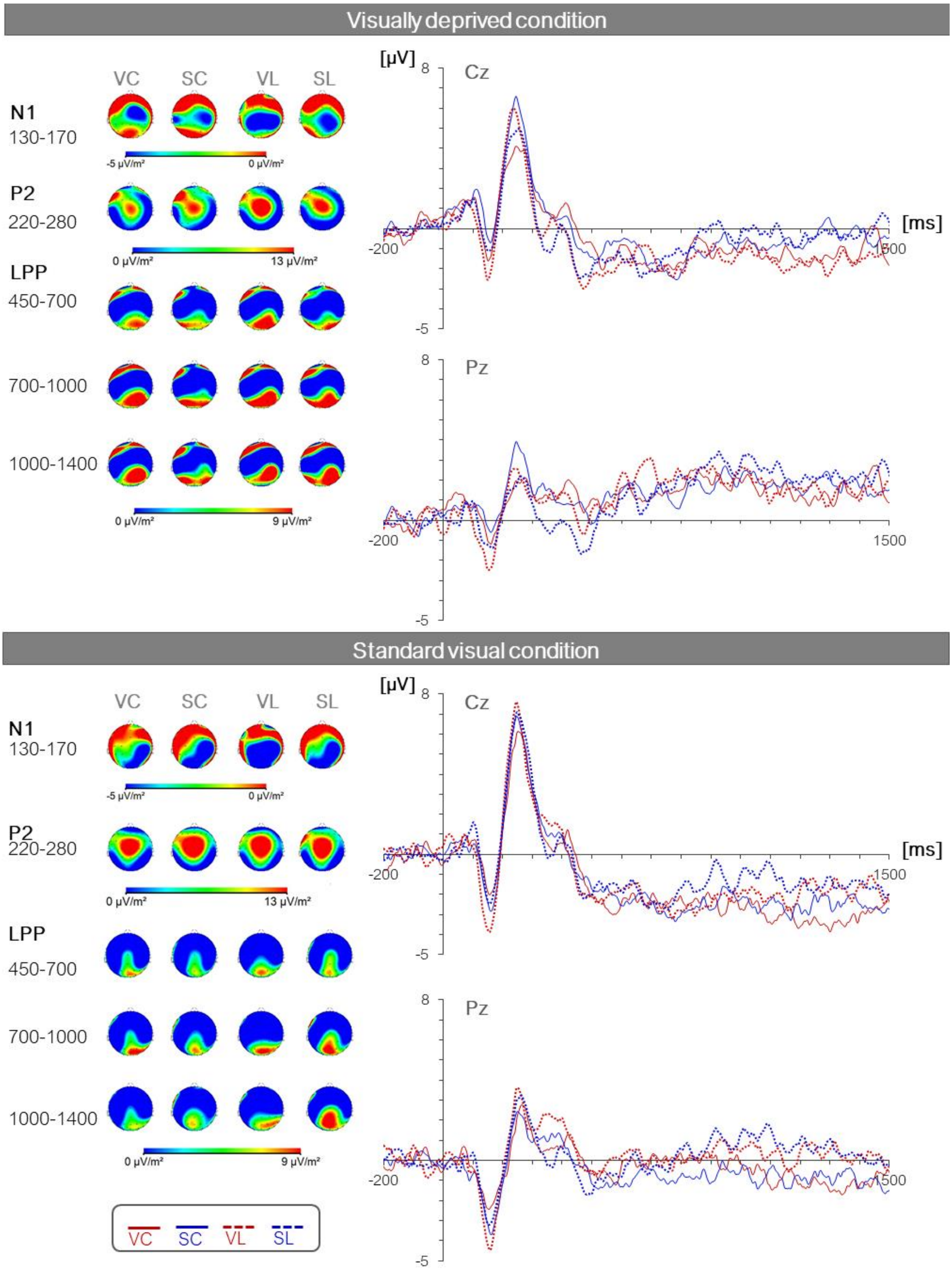

Figure 3

Grand average ERP waveforms for spontaneous and volitional vocalizations, in the emotion detection task, at Cz and Pz electrodes.