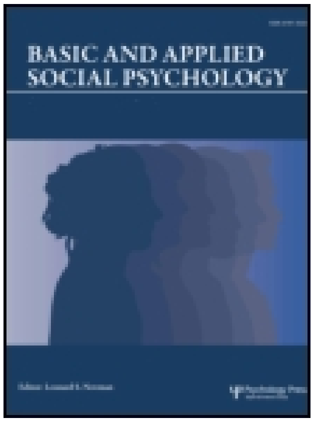

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Pacifiers Disrupt Adults' Responses to Infants' Emotions

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Research shows that pacifiers disrupt infants' mimicry of facial expressions. This experiment examines whether pacifiers interfere with caretakers' ability to mimic infants' emotions. Adults saw photographs of infants with or without a pacifier. When infants had pacifiers, perceivers showed reduced EMG activity to infants' smiles. Smiles of infants using a pacifier were also rated as less happy than smiles depicted without a pacifier. The same pattern was observed for expressions of distress: adults rated infants presented with pacifiers as less sad than infants without pacifiers. We discuss deleterious effects of pacifier use for the perceiver's resonance with a child's emotions.

Emotional competence involves not only the ability to correctly produce facial expressions of emotions but also the ability to accurately decode and respond to such expressions displayed by others. Successful social interactions are based on dialogues of expressions and resonance (Chartrand & Bargh, 1999; Dimberg & Thunberg, 1998). Extant research shows that emotional resonance as well as the recognition and interpretation of other people's expressions are promoted by facial and gestural mimicry (see Niedenthal, 2007, for a review). Simple laboratory manipulations, such as holding a pen between the lips without touching it with the teeth (Strack, Martin, & Stepper, 1988) and having golf tees attached to the eyebrow region and keeping them separate (Larsen, Kasimatis, & Frey, 1992) can reduce not only smiling and frowning, respectively, but also the corresponding subjective experiences of amusement and sadness.

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Facial mimicry can be also inhibited by more invasive methods, such as injections of BOTOX. This neurotoxin, which is being used for cosmetic purposes, erases forehead and frown lines by limiting the contractions of underlying muscles, such that frowning is diminished. The effects of BOTOX injections are not merely cosmetic; such interventions may also restrain facial movements, thereby reducing a person's ability to accurately simulate the perceived emotion in the self, interpret others' emotional facial expressions (e.g., Hennenlotter et al., 2009; Neal & Chartrand, 2011), and process emotional language (Havas, Glenberg, Gutowski, Lucarelli, & Davidson, 2010). On the other hand, BOTOX injections in the glabellar region can also improve mood (Lewis & Bowler, 2009) and even reduce the symptoms of major depression (Wollmer et al., 2012), confirming the key role played by facial expressions in emotional experience.

The relationship between facial activity and the corresponding experience of emotion is particularly important for preverbal infants, because they rely on facial expressions of caretakers for behavioral regulation and learning (Campos, Thein, & Owen, 2003). Therefore, inhibiting infants' facial activity is likely to be detrimental for their development. Recently, Niedenthal and colleagues (2012) proposed that pacifiers interfere with facial responding in a manner similar to that exerted by the methods just reviewed. These researchers predicted that the prolonged use of pacifiers by infants and children would result in impaired facial mimicry and, subsequently, in reduced emotional competences that depend upon the processing of facial expression of emotion. These hypotheses were tested in three studies. In the first, Niedenthal and colleagues (2012) found that the duration of pacifier use as an infant and toddler was associated with less automatic facial mimicry in 6- and 7-year-old boys while observing dynamic facial expressions. Two questionnaire studies further showed that duration of pacifier use predicted less perspective taking and lower emotional intelligence in young adult males. Duration of pacifier use was not, however, found to be associated with negative outcomes for girls.

Moderation of the pacifier–emotion processing relationship by sex of the pacifier user was explained post hoc in terms of boys' greater vulnerability to the inhibition of the mimicry channel for processing emotional information, such as facial expressions (Mumme, Fernald, & Herrera, 1996; Rosen, Adamson, & Bakeman, 1992). Sex differences in the emotional socialization of boys and girls could also explain the moderation. Indeed, parents tend to talk about emotional ideas and events more to girls than to boys (Adams, Kuebli, Boyle, & Fivush, 1995; Fivush, Brotman, Buckner, & Goodman, 2000). Such input for girls might compensate for disruptions of emotional information processing caused by pacifier use.

In the present article we describe an experiment that further explores the effects of pacifiers on emotional expressions. We investigated whether pacifiers negatively affect the infant–caretaker relationship by partially distorting the infant's mouth or hiding it from the view of an adult, in addition to the previously shown effect of reduced facial mimicry in pacifier users (Niedenthal et al., 2012). Such altered perceptions would translate into disrupted processing of infants' facial expressions, reduced facial mimicry, and diminished emotional resonance with the pacifier user.

Beginning with Piaget (1951), researchers have acknowledged the importance of the perceiver—especially caretaker-perceivers—in implicitly teaching an infant what to imitate and when to imitate. Caretakers' "affect mirroring" has since been proposed to play sensitizing and representation-building functions in the infant's emotional development (e.g., Fonagy, Gergely, Jurist, & Target, 2002). More recently, Jones (2006) argued for the notion that being imitated by adults is crucial for developing mirroring abilities in children. Put differently, caretakers play an active role in soliciting the attention and resonance behavior of infants, thereby shaping their emotional responding. Being imitated by others not only helps infants to understand and regulate their affective experiences but also is crucial in their learning of how to imitate others and share their emotions. Under this *embodied emotion* view, when infants use a pacifier, perceivers might not receive the input necessary to engage and resonate with the emotions of the child (Niedenthal, 2007).

Some adults also hold negative beliefs about pacifiers and believe them to be used especially for infants with emotional problems. Non-nutritive sucking on a pacifier has powerful soothing effects (Dipietro, Cusson, O'Brien Caughy, & Fox, 1994; Pinelli & Symington, 2000) and long-term pacifier use is associated with infants' fussiness (Brauch Lehman, Addy Holtz, & Aikey, 1995; Tomerak, 2010). Adults may thus view infants who use pacifiers as especially whiny and difficult and use these beliefs to guide their judgments of infants' facial expressions. Indeed, previous research shows that top-down processes such as attitudes and stereotypes may guide perception and mimicry of facial expressions (Bijlstra, Holland, & Wigboldus, 2010; Hess, Adams, Grammer, & Kleck, 2009; Likowski, Mühlberger, Seibt, Pauli, & Weyers, 2005, Maringer, Krumhuber, Fischer, & Niedenthal, 2011; Niedenthal, Mermillod, Maringer, & Hess, 2010).

Two possible effects of pacifiers on adults' perception of infants' emotions are thus considered in this research. First, pacifiers may cause disruption of facial mimicry in the perceiver. That is, while holding a pacifier in the mouth, an infant may nevertheless express some emotion "behind" the pacifier. Can or will the perceiver of this expression mimic it? Or does the presence of a pacifier affect the perceiver's decoding of the expression and/or motivation to mimic it? Second, perceivers may believe that infants are given pacifiers because they have problems with their experiences of and regulation of emotion. We tested these questions by showing photographs of infant faces displaying neutral, happy, sad, or angry expressions to adult female participants. At the same time participants' electromyographic (EMG) activity was recorded over three relevant facial muscles, that is, the Zygomaticus major, Depressor labii inferioris, and Corrugator supercilii. The infants' facial expressions were completely visible, with the mouth area partly covered by a pacifier, or with the mouth area partly covered by a white square (of similar size as the pacifier). The inclusion of the white square condition allowed us to test the potential impact of negative beliefs about pacifiers and to examine whether the effects of a pacifier are more detrimental than simply hiding perceptual information from the mouth area.

Specifically, an embodiment emotion view will be supported if covering the mouth area with a pacifier or a square is associated with similar reductions mimicry in the perceiver. In contrast, greater mimicry reduction in response to faces with a pacifier than to faces obscured by a white square would suggest that any pacifier effect is at least in part due to adults' negative beliefs about pacifiers rather than to the disruption of embodied processes. Furthermore, if decreases in mimicry are observed when an emotional expression is obscured by a pacifier, then another effect might be expected. Specifically, perceivers receive less feedback from their faces if they do not mimic the facial expressions of infants. This loss of proprioceptive information may distort judgments about the perceived facial expressions and lead to underestimations of affect compared to the situation in which the full stimulus face is visible and mimicry occurs.

To test this specific hypothesis, we collected participants' ratings of the intensity of infants' facial expressions. As for facial mimicry, we tested two alternative predictions. If the presence of the pacifier and the covering of the mouth with a square alter judgments of facial expressions to the same extent, we can assume that the distortions are due to the hiding of perceptual information from the mouth area. Alternatively, if participants hold negative beliefs about pacifiers, and if such beliefs guide judgments of infants' facial expressions, then lower ratings should be found in responses to trials with pacifiers rather than to trials with a white square or with the entire face visible.

METHOD

Participants

Thirty-two French women (age $M = 21.90$, $SD = 3.21$) took part in the study. They were recruited via an Internet posting and paid 10 €/hour for their participation. Only women were tested, because previous findings (Dimberg & Lundquist, 1990) suggest that facial mimicry is stronger in females than males, without being qualitatively different. Out of 32 initial participants, data from one were excluded because the triggers identifying the experimental stimuli had not been recorded. Two others were excluded due to a large number of artifacts caused by excessive movement and resulting in low EMG data quality. Thus, we analyzed EMG data from 29 participants. Of these, one was pregnant and two others had children.[1]

Materials and Procedure

Stimuli were color photographs of two infants created and validated by Gil, Teissèdre, Chambres, and Droit-Volet (2011). The photographs displayed spontaneous expressions of happiness, sadness, and anger and a neutral emotion. The facial expressions were intense and clearly different in terms of perceptual features of the face. Three photographs of each infant expression were prepared, including one with the full face visible, one with the addition of a pacifier covering the mouth, and one in which the mouth area was covered by a white square. This resulted in a total of 24 separate stimuli (see Figure 1 for examples).

FIGURE 1 Photographs of a baby, from left to right: full face, mouth obscured, and with pacifier. Emotional expressions are, from top to bottom row: happy, sad, angry, and neutral.

Participants were sitting in front of a 14-in. screen connected to a PC. On each trial a fixation cross appeared on a white screen for 2 s, followed by a blank screen for 250 ms, and then by the face of an infant (image size of 874×595 pixels) presented for 3 s. After the face disappeared, and following a 500-ms interval, participants rated on scales ranging from 0 (*not at all*) to 8 (*very much*) the extent to which the infant expressed each one of four feelings: happiness, sadness, anger, and neutrality. In addition to assessing the effects of the presence of a pacifier or a white square, these ratings allowed an additional validation of the stimulus set. We expected high ratings of happiness in reaction to photographs of happy facial expressions, high ratings of sadness and anger to photographs of sadness and anger (as these two expressions are similar in infants), and high ratings of neutrality to neutral faces.

To describe typical muscle contractions with EMG and to increase the signal-to-noise ratio, it is necessary to average multiple repetitions of the same response (Kamen & Gabriel, 2009; Konrad, 2005). Therefore, each of the 24 stimuli was seen eight times for a total

[1]Data were analyzed separately with and without the data from participants who were mothers. As the patterns of results were identical in both cases, data from all participants were included in the analyses described next.

of 192 trials, presented in two randomized blocks. The blocks were separated by a self-paced pause.

To assess facial mimicry, we recorded the EMG activity of three muscles: Zygomaticus major, the main muscle involved in smiling; Depressor labii inferioris, the muscle that helps to lower the bottom lip in the facial expression of sadness; and Corrugator supercilii, involved in furrowing the brow, active in expressions of anger and sadness. We expected infants' happy faces to elicit increased activation of participants' Zygomaticus muscle, sad faces to trigger corresponding activations of the Depressor and Corrugator muscles, and angry faces to lead to greater Corrugator contractions. EMG activity of these three muscles was recorded on the left side of the face, according to the established guidelines (Fridlund & Cacioppo, 1986) and using bipolar 10 mm Ag/AgCL surface electrodes. The raw EMG signal was measured with a 16 Channel Bio Amp amplifier (ADInstruments, Inc.), digitized by a 16 bit analogue-to-digital converter (PowerLab 16/30, ADInstruments, Inc.), and stored with a sampling rate of 1000 Hz.

Statistical analyses were performed using PASW Statistics 18 (SPSS, Inc., Chicago, IL) and RStudio (version 0.96.331, RStudio, Inc.). EMG recordings were preprocessed in Matlab (The Mathworks, Inc., Natick, MA) using the EEGLAB toolbox (Delorme & Makeig, 2004). The signal was bandpass filtered (20–400 Hz) and segmented from 1 s before to 3 s after the stimulus onset. Trials were excluded from analyses (on average 13.63 trials out of 192 per participant) if the mean amplitude of their baseline (−1 s before the stimulus onset) exceeded the mean of the baselines of all trials by more than 3 standard deviations. This procedure ensured the exclusion of trials in which participants moved their face prior to the stimulus onset. The remaining data were rectified, smoothed with a 40 Hz low-pass filter, expressed as percentage of the baseline, averaged per condition (mean number of trials per participant: $M = 6.05$, $SD = 1.45$) and averaged over three time windows of one second each.

RESULTS

Facial Mimicry of Full Faces

To confirm that facial expressions were mimicked by participants, we first submitted EMG responses to the photos showing the full faces of the infants (without obstruction by pacifier or white square) to a 3 (Muscle: Depressor, Zygomaticus, Corrugator) × 4 (Expression: Happy, Sad, Angry, Neutral) × 3 (Time: 1st, 2nd, and 3rd second after stimulus onset) repeated measures analysis of variance (ANOVA). This omnibus ANOVA revealed a significant effect of Expression, $F(3, 84) = 2.65$, $p = .05$, $\eta_p^2 = .09$, such that the EMG signal in all three muscles was significantly greater ($t = 2.57$, $p = .02$, Bonferroni corrected) in response to happy ($M = 136.46\,\mu V$, $SE = 7.68$) than to neutral faces ($M = 113.34\,\mu V$, $SE = 4.82$). A significant effect of time was also observed, $F(2, 56) = 10.85$, $p < .001$, $\eta_p^2 = .28$, due to greater EMG amplitudes in the 2nd ($M = 133.84\,\mu V$, $SE = 7.86$) and 3rd seconds ($M = 132.04\,\mu V$, $SE = 5.90$) after the stimulus onset, compared to the 1st second ($M = 109.33\,\mu V$, $SE = 2.03$; both $t\text{s} > 2.0$, $p\text{s} < .006$, Bonferroni corrected).

More important, a significant Muscle × Expression interaction was observed, $F(6, 168) = 4.18$, $p = .008$, $\eta_p^2 = .13$, such that the Zygomaticus muscle was more activated in response to happy faces ($M = 173.73\,\mu V$, $SE = 17.09$) than to neutral ($M = 125.69\,\mu V$, $SE = 9.91$; $t(28) = 3.76$, $p = .001$; sad ($M = 119.01\,\mu V$, $SE = 4.94$), $t(28) = 3.31$, $p = .003$; or angry faces ($M = 115.56\,\mu V$, $SE = 7.54$), $t(28) = 3.06$, $p = .005$; and the Corrugator muscle was more activated when participants viewed sad faces ($M = 154.09\,\mu V$, $SE = 25.59$) compared to neutral faces ($M = 102.83\,\mu V$, $SE = 3.32$), $t(28) = 2.07$, $p = .05$. The Corrugator was also more activate in response to angry faces ($M = 134.23\,\mu V$, $SE = 10.22$) compared to neutral faces, $t(28) = 2.70$, $p = .01$.

Activations of the Corrugator were higher for sad, angry, and neutral faces than for happy faces ($M = 118.15\,\mu V$, $SE = 14.11$). These differences, however, did not reach statistical significance (both $t\text{s} < 1.5$, $p\text{s} > .15$).

The Depressor muscle, involved in facial displays of sadness, showed almost identical activations in response to all four expressions, $F(3, 84) = .26$, $p = .85$.

These results, illustrated in Figure 2, reveal that perceivers' Zygomaticus muscle was the most active in response to happy faces and their Corrugator most active to sad and angry faces. This pattern of findings suggests that happy, sad, and angry faces presented in their entirety elicited responses of the corresponding facial muscles and thus were mimicked by the participants. All other effects were not significant (all $F\text{s} < 2.3$, all $p\text{s} > .096$).

Facial Mimicry as a Function of Photograph Condition

After establishing that participants mimicked the fully visible facial expressions, we examined their facial mimicry across the three photograph conditions. Specifically, we examined the Zygomaticus activity in response to happy faces and Corrugator activity in response to sad and angry faces, averaged over the 3 s of stimulus presentation. The EMG activity of the Depressor was not included in the analyses, given the lack of evidence for facial mimicry in this muscle.

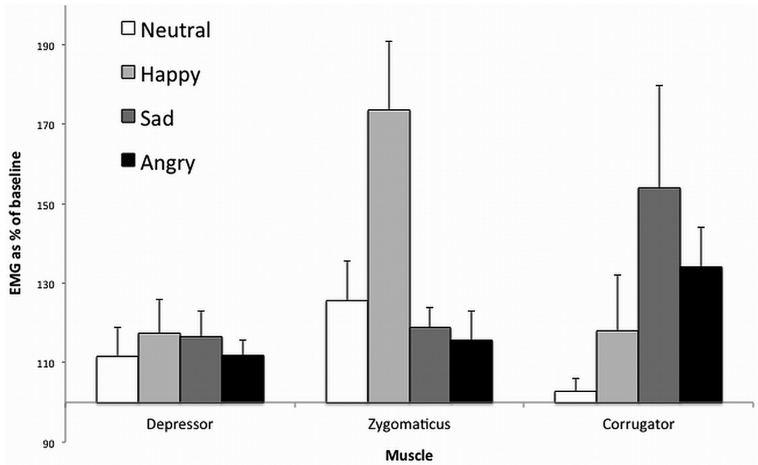

FIGURE 2 Means and standard errors for the EMG activity of each muscle in response to the full (non-obscured) facial expressions. Data averaged over 3 seconds after stimulus onset. This reflects the Muscle by Emotion interaction found in the omnibus ANOVA. *Note.* EMG = electromyographic.

We tested two hypotheses. One possibility was that facial mimicry is reduced equally by both the pacifier and by the obscuring of the mouth with a white square (Contrast 1, full face = 2, square = −1, pacifier = −1), resulting in a disruption in the embodied processing of the infant's face. A second option is that the pacifier and the white square differ in their effects such that the pacifier induces greater reduction in observers' mimicry. Such an effect would be consistent with the idea that perceivers hold negative beliefs about pacifier use. This second prediction was expressed with Contrast 2, testing the difference between the two "covered" conditions (full face: 0, square: 1, pacifier: −1).

Mimicry of smiles. We first explored Zygomaticus activity in response to expressions of happiness. We created two planned orthogonal contrasts to test the two possibilities detailed above. Contrast 1 (full face = 2, square = −1, pacifier = −1) was statistically significant, $F(1, 28) = 6.09$, $p = .02$, $\eta_p^2 = .18$, such that the Zygomaticus major activity was higher in reaction to full faces ($M = 173.73$ μV, $SD = 92.02$) than to faces with the mouth area obscured by a white square ($M = 151.11$ μV, $SD = 65.63$) or by a pacifier ($M = 160.81$ μV, $SD = 92.33$; see Figure 3). The difference between Zygomaticus activity in reaction to faces with pacifier and faces with white square, expressed with contrast 2 (full face = 0, square = 1, pacifier = −1), was not significant, $F(1, 28) = 0.86$, $p = .36$, $\eta_p^2 = .03$.

Mimicry of sadness. A similar analysis was conducted to explore mimicry of infants' expressions of sadness, as indexed by the EMG activity of the Corrugator muscle. Although activations were higher

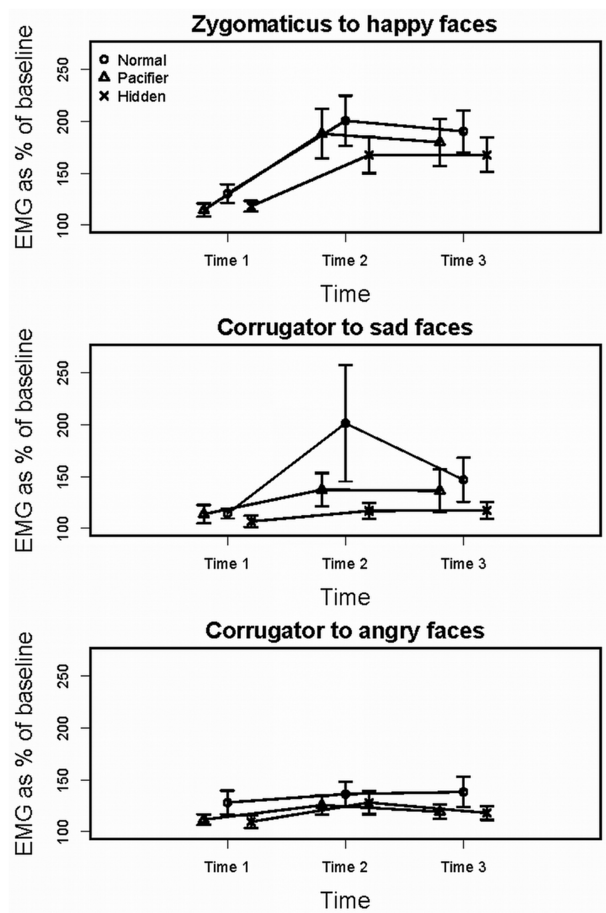

FIGURE 3 EMG activity of the Zygomaticus major (smiles) and Corrugator supercilii muscles (brow furrows) in response to facial expressions presented entirely, with a pacifier or with the mouth area obscured. *Note.* EMG = electromyographic.

when participants viewed full faces ($M = 154.09\,\mu V$, $SD = 137.79$) than when they viewed faces with the mouth covered by a white square ($M = 113.72\,\mu V$, $SD = 34.29$) and faces with pacifiers ($M = 129.13\,\mu V$, $SD = 67.37$; see Figure 3), neither of the two contrasts of interest were significant, $F(1,\ 28) = 1.51$, $p = .23$, $\eta_p^2 = .05$ for Contrast 1; $F(1,\ 28) = 1.21$, $p = .28$, $\eta_p^2 = .04$ for Contrast 2.

Mimicry of anger. EMG responses of the Corrugator supercilii were higher when the participants viewed full anger faces ($M = 134.23\,\mu V$, $SD = 55.04$) than when they viewed anger faces with the white square ($M = 118.89\,\mu V$, $SD = 33.67$; see Figure 3) or with the pacifier ($M = 118.61\,\mu V$, $SD = 40.49$; see Figure 3). Contrast 1 (full face = 2, square = −1, pacifier = −1) was marginally significant, $F(1,\ 28) = 3.58$, $p = .07$, $\eta_p^2 = .11$, whereas Contrast 2 (full face = 0, square = 1, pacifier = −1) was not, $F(1, 28) = 0.004$, $p = .95$, $\eta_p^2 < .001$.

Ratings of Emotions

Participants rated each stimulus twice according to the extent to which the face expressed happiness, sadness, anger, and neutrality. Unfortunately, the data from 15 participants were lost due to an administrative error. Available data from the remaining 17 participants were screened for outliers and averaged over repeated ratings of the same emotion.[2]

To validate the stimuli for our sample, we first examined the ratings of the full-face photos. Results showed that participants correctly associated facial expressions with the corresponding emotions. Namely, happy faces received ratings of happiness significantly higher than 4.0 on the 9-point scale, $M_{diff} = 3.60$, $t(16) = 22.06$, $p < .001$, $d = 5.37$. Mean ratings of other expressions did not exceed 1.0. Similarly, photos of sad and angry infants were rated as more sad than the scale midpoint, $M_{diff} = 3.75$, $t(16) = 46.75$, $p < .001$, $d = 11.36$ for the sadness photos; $M_{diff} = 2.10$, $t(16) = 5.85$, $p < .001$, $d = 1.42$, for the anger photos. The perception of angry infant faces as both angry and sad was consistent with previous research (Gil et al., 2011; Matias & Cohen, 1993; Sullivan & Lewis, 2003). Mean ratings of sadness for neutral and happy facial expressions did not exceed 2.0. Photographs of angry infants were rated as significantly more angry than the scale midpoint, $M_{diff} = 2.72$, $t(16) = 9.68$, $p < .001$, $d = 2.34$. Ratings of other facial expressions were lower than 3.0. Finally, neutral faces received high ratings of neutrality, $M_{diff} = 2.30$, $t(16) = 5.93$, $p < .001$, $d = 1.44$, compared to the midpoint of the scale, and ratings of other facial expressions never exceeded 1.0.

We hypothesized that the emotions of interest expressed by infants using the pacifier or with the mouth area obscured would be rated as less intense than when they were expressed by infants with their full face visible. In addition, ratings of emotions in the pacifier condition could be higher or lower than in the square condition. These predictions were tested with two planned orthogonal contrasts.

Smiling infants with the full face visible were rated as expressing more happiness ($M = 7.60$, $SD = 0.67$) than the same infants with their mouth obscured by a square ($M = 7.03$, $SD = 0.97$) and with pacifiers ($M = 7.16$, $SD = 0.96$). Contrast 1 (full face = 2, square = −1, pacifier = −1) was significant, $F(1,16) = 4.47$, $p = .05$, $\eta_p^2 = .22$, whereas Contrast 2 (0, 1, −1) was not, $F(1, 16) = 1.52$, $p = .24$, $\eta_p^2 = .008$, suggesting that the effects of pacifier and square on happiness ratings were similar. Full faces of sad infants were judged as more sad ($M = 7.75$, $SD = 0.33$) than faces of infants with the mouth area covered ($M = 5.25$, $SD = 0.84$) or faces of infants sucking a pacifier ($M = 5.75$, $SD = 0.68$). Contrast 1 (2, −1, −1) was statistically significant, $F(1,\ 16) = 14.59$, $p = .01$, $\eta_p^2 = .35$, whereas Contrast 2 (0, 1, −1) was not, $F(1,\ 16) = .07$, $p = .93$, $\eta_p^2 < .001$. These differences were not significant for ratings of anger and sadness in response to faces of angry infants (all $ps > .350$, all η_p^2 s $< .05$), nor for ratings of neutrality in response to photos of neutral infants (both $ps > .85$, η_p^2 s $< .005$).

Ratings of emotions were then submitted, separately for each facial expression, to a 3 (condition: full, square, pacifier) × 4 (emotion rated: happiness, sadness, anger, neutrality) repeated measures ANOVA. Where necessary Greenhouse-Geisser corrections were applied, in which case corrected p values and uncorrected degrees of freedom are reported. Results showed a significant interaction for sad faces, $F(6, 96) = 2.72$, $p = .04$, $\eta_p^2 = .14$, and a marginally significant interaction for happy facial expressions, $F(6, 96) = 2.78$, $p = .07$, $\eta_p^2 = .16$, suggesting that the effect of covering the mouth with a pacifier and a square varied across emotions. The interaction was not significant for angry and neutral infants (both $Fs < 1$, η_p^2 s $< .05$). Thus, ratings of these facial expressions were not significantly affected by any obscuring of the mouth. Only judgments of happiness and sadness were compromised by the presence of the pacifier or by covering the mouth of the infant.

Finally, we tested for correlations between emotional ratings and facial mimicry to happy faces across the three viewing conditions. However, no significant relationships could be found, all $rs(15) < .30$, $ps > .250$,

[2]We since replicated the findings of the present study in a larger between-subjects design involving 164 participants. Details of the method and raw data are available upon request.

probably due to the relatively small number of observations, and thus low power.

DISCUSSION

The present study extends the work by Niedenthal and colleagues (2012), which documented negative effects of pacifier use on the pacifier users' emotional competence. In that research, duration of pacifier use was found to be negatively predictive of spontaneous facial mimicry, perspective taking, and self-reported emotional intelligence in boys. Our experiment shows effects of pacifiers on the *perceiver* of a pacifier user, which can be potentially detrimental for child–caregiver interactions. We tested the effects of pacifier use and obscuring the mouth on mimicry and judgments of facial expressions of infants. EMG recordings showed that the Zygomaticus muscle was less activated in response to smiling faces when the mouth was obscured, either by a pacifier or a white square. The lack of significant differences between the pacifier and the square condition suggests that the reduced mimicry in the pacifier condition is due to the obscuring of perceptual information from infants' faces rather than to adults' negative beliefs toward pacifier use.

Similarly, activation of the Corrugator muscle in response to sad and angry faces was reduced when participants viewed infants with pacifiers or with obscured mouths, compared to whole faces. These differences, however, did not reach statistical significance. As illustrated by the error bars in Figure 3, this may partly be due to relatively high variance in EMG recordings across participants. Alternatively, the weaker effect may be due to the fact that the Corrugator, which is prominent in several negative emotions including sadness and anger, is located on the upper face and is not obscured by the pacifier (or the presence of a white square). Obscuring of the mouth may affect the processing of expressions involving the Corrugator to a lesser degree than it affects expressions involving the Zygomaticus. Such an explanation is consistent with research findings showing that the mouth region is critical for categorizing happiness and disgust but not sadness and anger (Calder, Young, Keane, & Dean, 2000; Smith, Cottrell, Gosselin, & Schyns, 2005).

Activations of the Depressor muscle, typically involved in displays of sadness, were not mimicked. This null result may be due to the overall weak activation of this muscle in the present study (see Figures 2 and 3).

Of interest, and consistent with the EMG findings, subjective ratings of happiness in response to the smiling expressions were reduced to the same extent when the mouth was either covered by a pacifier or was obscured with a white square. A similar effect was observed for ratings of sadness to sad faces. Obscuring the mouth with either the pacifier or the white square did not affect, however, ratings of anger and sadness in response to angry faces.

The fact that pacifiers influenced mainly the mimicry of the smile is consistent with the recent findings of Ponari, Conson, D'Amico, Grossi, and Trojano (2012, Study 1) who observed poorer recognition of happiness and disgust expressions when blocking mimicry in the lower half of perceivers' faces and poorer recognition of anger expressions when blocking mimicry of the upper face. Both manipulations decreased the recognition of fear, whereas the recognition of neither surprise nor sadness was affected. More relevant to the present research, Fischer and colleagues (Fischer, Gillebaart, Rotteveel, Becker, & Vliek, 2012) examined how covering the lower half of women's faces with a niqab affects emotion perception and perceivers' attitudes. The study did not show marked differences between the conditions where faces were obscured by a niqab and digitally covered. Covering the lower part of the face—either with a niqab or with a black rectangle—led to perceptions of women as more expressive of negative and less of positive emotions compared to the condition in which full faces were visible. Moreover, the perception of more negative emotion mediated the negative attitude toward wearing niqabs. Thus, previous empirical evidence (Calder et al., 2000; Fischer et al., 2012, Ponari et al., 2012; Smith et al., 2005) and the present findings link lower face processing with the perception, mimicry, and judgments of smiles.

Our findings are also consistent with other results implicating the lower face muscles, and specifically the Zygomaticus major, in the motor mimicry of a smile (Korb, Grandjean, & Scherer, 2010; Sato & Yoshikawa, 2007); the recognition of happiness (Kerstenbaum, 1992; Oberman, Winkielman, & Ramachandran, 2007); and, more generally, the processing of positive conceptual information (Niedenthal, Winkielman, Mondillon, & Vermeulen, 2009). It should be noted, however, that we observed some disturbance of mimicry on the upper part of the face. Specifically, participants' Corrugator muscle was less active in response to infants depicted with the mouth obscured. This was only a trend, possibly due to the variability of responses in the full face condition, but the result warrants further research attention. Future experiments will aim to clarify the impact of pacifier use on the processing of infants' negative facial expressions, such as anger or sadness, and test whether covering the infants' mouths results in more negative observers' attitudes, consistent with the previous research (Fischer et al., 2012).

In the present study, effects of pacifiers on the perception of emotion in babies' faces suggest that perceivers may find interactions with infants using a pacifier less enjoyable and less stimulating. Participants perceived less happiness in infants' smiles and less sadness in sad faces. Smiles are powerful social rewards (Shore & Heerey, 2011), and sadness, despite its negative valence, elicits talk, play, and supportive behavior of adults (Buss & Kiel, 2004; Huebner & Izard, 1988). Indeed, expressions of happiness and sadness can be the most adaptive for infants. Therefore, changes in the perception of facial expressions due to the obscuring of the mouth by the pacifier could have important consequences for the emotional development of the user. Resonance with adult perceivers allows infants to gain emotional understanding and develop mentalizing abilities (Fonagy & Target, 1997). These skills are key components of emotional intelligence (Salovey & Mayer, 1990) and are positively associated with life satisfaction (Palmer, Donaldson, & Stough, 2002), social network size (Austin, Saklofske, & Egan, 2005), and health and well-being (Slaski & Cartwright, 2002). Our previous research shows that long-term pacifier use is associated with lower levels of emotional intelligence in boys (Niedenthal et al., 2012), and another study (Gale & Martyn, 1996) showed a negative association between pacifier use and levels of general intelligence, controlling for demographic variables.

The full implications of pacifier use need to be further explored. For example, to understand whether and how pacifiers affect facial mimicry of children and adults, we need to know precisely which facial muscles are recruited by a pacifier. It is thus necessary to separate the long-terms effects of pacifier use from its momentary impact. We also need to understand when exactly the judgments of emotional expressions of pacifier users will be guided by facial mimicry and embodied simulation, and when they will result from adults' beliefs about pacifiers. Such relationships may be explored in future experiments testing whether the effects of pacifier use on observers' judgments are mediated by facial mimicry. Future research could also use different types of stimuli, including dynamic videos, eliciting more facial responses than photographs (Rymarczyk, Biele, Grabowska, & Majczynski, 2011; Sato & Yoshikawa, 2007).

Future studies should also address the causal pathways underlying pacifier use, such as characteristics of the child or of the caregivers. For example, an infant's agitation and fussiness or a caregiver's personality or attachment styles can be predictive of long-term pacifier use. Consistently, pacifier use has been linked to maternal-infant distance, sensitivity to infant crying, and lack of self-confidence in the mother (Victora, Behague, Barros, Olinto, & Weiderpass, 1997). Another important question concerns the impact of pacifier use on adults' judgments of infants' emotional competence, and the extent to which adults' expressive behavior can compensate for the potentially negative effects of pacifiers.

Taken together, the present findings are important not only because they reveal additional mechanisms—this time concerning the perceiver—by which pacifiers can negatively influence the developing emotional competence in the pacifier user but also because they provide further evidence for the conditions under which emotional resonance between individuals can be disrupted.

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