Received: 12 March 2021 | Accepted: 30 July 2021

DOI: 10.1111/infa.12430

RESEARCH ARTICLE

INFANCY THE OFFICIAL JOURNAL OF THE INTERNATIONAL CONGRESS OF INFANT STUDIES WILEY

Linguistic and developmental influences on superordinate facial configuration categorization in infancy

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Funding information
This research was supported by grants from the National Institute of Mental Health (T32MH018931) to ALR, the University of Washington Royalty Research Fund (65-4662) to BMR, and the University of Washington Institute for Learning & Brain Sciences Ready Mind Project to ANM. The authors declare no conflicts of interest with regard to the funding source for this study

Abstract

Humans perceive emotions in terms of categories, such as "happiness," "sadness," and "anger." To learn these complex conceptual emotion categories, humans must first be able to perceive regularities in expressive behaviors (e.g., facial configurations) across individuals. Recent research suggests that infants spontaneously form "basic-level" categories of facial configurations (e.g., happy vs. fear), but not "superordinate" categories of facial configurations (e.g., positive vs. negative). The current studies further explore how infant age and language impact superordinate categorization of facial configurations associated with different negative emotions. Across all experiments, infants were habituated to one person displaying facial configurations associated with anger and disgust. While 10-month-olds formed a category of person identity (Experiment 1), 14-month-olds formed a category that included negative facial configurations displayed by the same person (Experiment 2). However, neither age formed the hypothesized superordinate category of negative valence. When a verbal label ("toma") was added to each of the habituation events (Experiment 3), 10-month-olds formed a category similar to 14-month-olds in Experiment 2. These findings intersect a larger conversation about the nature and development of children's emotion categories and

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highlight the importance of considering developmental processes, such as language learning and attentional/memory development, in the design and interpretation of infant categorization studies.

1 | INTRODUCTION

Emotions are complex social phenomena, expressed in variable ways across different situations. Despite this variability, humans perceive others' emotions in terms of categories, such as "happiness," "sadness," and "anger" (Barrett, 2017). To learn these complex conceptual emotion categories, humans must first be able to perceive regularities in expressive behaviors across individuals—such as whether multiple people are smiling or frowning. Much research has shown that infants in the first year of life are able to form these basic-level categories of facial configurations associated with different emotions (e.g., happy vs. fear; Bornstein & Arterberry, 2003; Ruba et al., 2017; White et al., 2019). However, a recent study suggests that older, 14- and 18-month-old infants do not spontaneously group these facial configurations into superordinate categories based on valence (e.g., positive vs. negative; Ruba et al., 2020b). This suggests that facial configuration categorization emerges in a "narrow-to-broad" fashion (Quinn et al., 2011), whereby infants form basic-level categories of facial configurations before forming superordinate categories based on valence. Much more research is needed in order to confirm this conclusion. In particular, very little is known about how facial configuration categorization develops and changes over the first two years of life alongside other developmental processes (Hoemann, Wu, et al., 2020; Oakes & Rakison, 2019; Ruba & Pollak, 2020). The current studies explore how infant age and language acquisition influences superordinate facial configuration categorization.

1.1 | Basic-level and superordinate facial configuration categorization in infancy

Nearly all research on infant facial configuration categorization has examined basic-level categories (for a review, see Ruba & Repacholi, 2020). In standard categorization studies, infants are habituated or familiarized to pictures of multiple people displaying one emotion (e.g., anger). Infants provide evidence of forming a basic-level category if they (a) do not recover looking time to novel people displaying the habituation emotion (e.g., anger) and (b) recover looking time to familiar people displaying a novel emotion (e.g., disgust). By 5–7 months of age, infants provide evidence of forming these basic-level categories across a variety of facial configurations (e.g., happiness vs. fear, anger vs. disgust; Bornstein & Arterberry, 2003; Ruba et al., 2017; White et al., 2019). These basic-level categories may be based on facial features (e.g., smiles vs. frowns), affective meaning (i.e., "happiness" vs. "sadness"), or some combination of the two—current paradigms used to assess infant facial configuration categorization are unable to differentiate between these possibilities (Madole & Oakes, 1999).

Much less is known about whether infants perceive that facial configurations also belong to broader, superordinate categories. Superordinate categories, based on more abstract features of emotion (e.g., positive vs. negative valence), may be more difficult for infants to form compared

to basic-level categories (Quinn et al., 2011; Waxman & Markow, 1995). To date, only one study has examined whether infants can form superordinate categories of facial configurations associated with different negative emotions (for an early study with positive emotions, see Ludemann, 1991). Ruba et al. (2020b) habituated 14- and 18-month-olds to three people posing two negative emotions: anger and sadness (*Anger-Sad* condition) or disgust and sadness (*Disgust-Sad* condition). At test, infants dishabituated to (a) a person not seen during habituation, posing one of the habituation emotions, and (b) a person seen during habituation, posing a novel negative emotion (e.g., anger in the *Disgust-Sad* condition). Thus, infants did not form a superordinate category of negative valence—they did not treat a "novel" category exemplar as "familiar." However, when a verbal label ("toma") was added to each event during the habituation trials, infants formed this superordinate category (in the *Disgust-Sad* condition only). No age differences were found in these studies. Similar to basic-level categories, infants' superordinate categories of facial configurations may be based on perceptual facial features. Yet, given the considerable perceptual variability in the stimuli to be categorized (e.g., multiple individuals displaying different types of emotions), infants may form superordinate categories of facial configurations based on more "abstract" affective features (i.e., emotional valence).

Together, these findings suggest that infants form "basic-level" categories of facial configurations before forming "superordinate" categories based on valence (i.e., a "narrow-to-broad" trajectory; Quinn et al., 2011). Although many developmental researchers have argued that preverbal infants have an innate or early-emerging ability to perceive facial configurations in terms of basic-level categories (Izard, 1994; Leppänen & Nelson, 2009; Walker-Andrews, 1997), there is much debate about whether this account fully captures the nature and development of children's emotion categories (Hoemann et al., 2020; Ruba & Repacholi, 2020a, 2020b; Shablack et al., 2020). In particular, some researchers have hypothesized that preverbal infants initially form superordinate, valence-based categories (e.g., positive vs. negative) that slowly differentiate into basic-level categories (e.g., happy vs. fear) over the first decade of life (Barrett, 2017; Hoemann, Wu, et al., 2020; Widen, 2013). Although Ruba et al. (2020) did not find support for this hypothesis, more research is needed to determine how superordinate facial configuration categorization develops and changes over the first two years of life alongside infant age and language acquisition.

1.2 | Developmental processes and superordinate facial configuration categorization

Categorization tasks place various demands on infants' cognitive abilities (Hoemann, Wu, et al., 2020; Oakes & Rakison, 2019; Ruba & Pollak, 2020). To form a category in habituation-categorization tasks, infants must detect, attend to, and remember the category exemplars seen during habituation and differentiate these from novel exemplars at test. Likely due to the memory and attentional capacities required to form such categories, much research has found differences in infants' object categorization abilities between the first and second years of life, whereby older infants form categories that younger infants do not (Casasola, 2005b; Casasola & Cohen, 2002; Cohen & Oakes, 1993; Oakes, 1994; Rose et al., 2001; Ross-Sheehy et al., 2003). Studies have also found that younger infants' categorization abilities are facilitated by task modifications that reduce memory and attentional demands. For example, presenting exemplars in pairs, rather than sequentially, reduces the memory demands involved in comparing the stimuli (Kovack-Lesh & Oakes, 2007) and, thus, facilitates object categorization for 4- to 10-month-olds (Oakes & Ribar, 2005; Younger & Furrer, 2003). Similarly, while 13- and 16-month-olds categorize objects

across a variety of tasks (e.g., sequential touching tasks), 10-month-olds benefit from tasks that focus their attention on the relevant features of objects (i.e., object examining tasks; Oakes et al., 1996). Taken together, these studies suggest that object categorization becomes more sophisticated across infancy alongside memory and cognitive development. Comparatively less is known about whether similar effects are seen with facial configuration categorization. Some studies have found that infants 7 months of age and younger show limited or no basic-level categorization of facial configurations, whereas infants older than 7 months are able to form these categories (Caron et al., 1985; Lee et al., 2015; Ludemann, 1991). Yet, little is known about how these abilities further develop and change in the second year of life, particularly with respect to superordinate categorization.

In addition to memory and attentional capacities, language also influences infants' categorization abilities. Prior work has found that presenting category exemplars with a single label (e.g., "vehicle") facilitates infants' categorization of objects (Balaban & Waxman, 1997; LaTourrette & Waxman, 2019) and spatial relations (Casasola, 2005a; Pruden et al., 2013). This effect has even been found for infants as young as 3 to 4 months of age, who do not yet have extensive experience with language (Ferry et al., 2010, 2013). One explanation for these effects is that verbal labels prompt infants to search for non-obvious commonalities between objects (Althaus & Mareschal, 2014), a process that is especially critical for superordinate categorization (Waxman & Markow, 1995). This constructive effect of labels is thought to be foundational for children's emotion categorization (Barrett, 2017; Hoemann et al., 2019). Much research has found that the inclusion of emotion labels in verbal facial configuration categorization tasks improves children's and adult's categorization accuracy (Nook et al., 2015; Widen & Russell, 2004), while reduced accessibility to emotion labels leads to slower and less accurate categorization (Gendron et al., 2012; Lindquist et al., 2014; Ruba et al., 2018). A similar effect has been reported in infants (Ruba et al., 2020), whereby 14- and 18-month-olds only form superordinate categories of facial configurations when a verbal label is paired with each habituation event. However, since infants in the second year of life have already begun to produce emotion labels (Ridgeway et al., 1985), it is unknown whether and how labels influence facial configuration categorization for infants who do not yet have emotion labels in their productive vocabularies. It is possible that infants' own language abilities influence their capacity to use linguistic information in categorization tasks (for similar findings in another domain, see Sommerville et al., 2005).

1.3 | Current studies

Although prior research suggests that infants form basic-level categories of facial configurations before forming superordinate categories based on valence (Ruba et al., 2020b; White et al., 2019), it also appears that infant age and language influence infant facial configuration categorization (Hoemann, Wu, et al., 2020; Oakes & Rakison, 2019; Ruba & Pollak, 2020). The current studies extend this research to explore how superordinate facial configuration categorization develops and changes over the first two years of life. Experiment 1 examined whether 10-month-old infants could form a superordinate category of negative facial configurations after habituation to a single person displaying anger and disgust. Experiment 2 tested 14-month-olds in the same task to determine whether and how superordinate facial configuration categorization changes between the first and second years of life. Experiment 3 examined how adding a single label (i.e., "toma") to the habituation events influenced 10-month-olds' superordinate facial configuration

categorization. This information is critical to determining how facial configuration categorization emerges and transforms throughout infancy.

2 | EXPERIMENT 1

Experiment 1 tested whether 10-month-olds could form a superordinate category of negative valence. This age was selected since infant superordinate facial configuration categorization likely undergoes developmental changes between the first and second years of life, alongside developing memory and attentional capacities (Oakes, 1994; Rose et al., 2001; Ruba & Pollak, 2020). Since superordinate facial configuration categorization has only been tested with infants in the second year of life (Ruba et al., 2020), studies with a younger age group are needed to map the developmental progression of this ability. Research also suggests that 10-month-olds are especially attentive to emotion in basic-level facial configuration categorization tasks (Ruba et al., 2017). This focused attention to emotion may enhance 10-month-olds' ability to form superordinate categories.

In Experiment 1, 10-month-olds were habituated to a single person displaying facial configurations associated with anger and disgust. These habituation trials differ from Ruba et al. (2020) in two critical aspects. First, Ruba et al. (2020) habituated 14- and 18-month-olds to *three* people displaying facial configurations associated with disgust and sadness or anger and sadness. In the current studies, anger and disgust were selected as the habituation emotions, since (a) these facial configurations have considerable perceptual similarity (Aviezer et al., 2008), (b) older, school-age children group these perceptually similar facial configurations together into a superordinate category of negative valence (for a review, see Widen & Russell, 2013), (c) infants as young as 10 months can perceptually discriminate and form basic-level categories of anger and disgust facial configurations (Ruba et al., 2017), and (d) little research has examined this comparison relative to other emotion pairs (e.g., anger vs. sadness; sadness vs. fear; Ruba et al., 2020b). Second, since object categorization is facilitated by presenting infants with fewer exemplars of a category (Casasola, 2005b; Cohen & Oakes, 1993; Oakes & Cohen, 1990), infants were shown a *single* person during habituation. These design changes were made to increase the likelihood that infants would form a superordinate category of negative valence. Importantly, we did not present multiple identities during the habituation trials given a pilot study suggesting that 10-month-olds were unable to track four events during habituation (i.e., two people displaying two facial configurations; see Supporting Information for more information).

After the habituation events, infants were shown four test trials. If infants formed a superordinate category, their looking time to a *negative familiar event* (the person and emotion seen during habituation; e.g., disgust) should not differ from their looking time to a *negative novel face* (a person not seen during habituation, displaying one of the habituation emotions; e.g., anger), and a *negative novel emotion* (the person seen during habituation displaying a novel, negative emotion; e.g., sadness). In other words, even though infants have not seen the two *negative novel* events before, their looking time should be equivalent to the *negative familiar event* (i.e., they should treat the *novel* events as *familiar*). If infants formed a superordinate category, their looking time to each of these three negative emotions should also be significantly shorter than their looking time to a *positive novel emotion* (the person seen during habituation displaying a novel, positive emotion, i.e., happiness). We hypothesized that 10-month-olds would exhibit this pattern of looking, that is, they would form a superordinate category.

2.1 | Methods

2.1.1 | Participants

The final sample consisted of 24 (12 female) 10-month-olds ($M = 10.01$ months, $SD = 0.22$ months, range = 9.67–10.36 months). A power analysis indicated that this sample size would be sufficient to detect reliable differences in a repeated-measures design with four test trials, assuming a medium effect size ($f = 0.25$, $\alpha = .05$, power = 0.80). This was pre-selected as the stopping rule for the study. All infants were healthy, full-term, of normal birth weight, and were primarily exposed to English at home. Across all studies, infants were primarily from middle/high-SES families with college-educated parents. There was no attrition in this study (i.e., all infants met the habituation criteria, described below). Parents identified their infants as Caucasian (75%, $n = 18$), multi-racial (17%, $n = 4$), Black (4%, $n = 1$), and Asian (4%, $n = 1$). Three infants (12%) were identified as Hispanic or Latino. All studies conducted according to guidelines laid down in the Declaration of Helsinki, with written informed consent obtained from a parent or guardian for each child before any assessment or data collection. All procedures involving human subjects in this study were approved by Institutional Review Board (IRB) at the University of Washington (Approval Number: 50377, Protocol Title: "Emotion Categories Study").

2.1.2 | Stimuli

Stimuli were created in iMovie, using static images from the Radboud Faces Database (for validation information, see Langner et al., 2010). Pictures of facial configurations associated with neutral affect, sadness, anger, disgust, and happiness were used (see Figure 1). Each event began with a female adult displaying neutral affect. After 1.5 s, a picture of the person's facial configuration associated with one of the emotions (e.g., anger) appeared. This static face was presented for 3.5 s before a black screen appeared, which lasted for 1 s. These 6 s events were looped five times, without pause, to create a 30 s video, which comprised a single trial in the study.

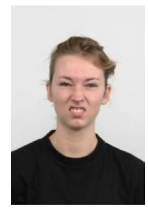
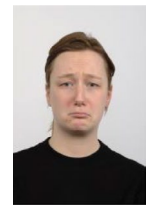
Habituation Stimuli	**Test Stimuli**			
	Negative Familiar Event (*anger*)	**Negative Novel Face** (*disgust*)	**Negative Novel Emotion** (*sadness*)	**Positive Novel Emotion** (*happiness*)
				

FIGURE 1 Sample habituation and test stimuli for all Experiments. Habituation events (and test events) were presented in a randomized order. Habituation stimuli for Experiment 3 were presented alongside a verbal label ("toma"). Pictures reprinted with permission from the creators of the Radboud Face Database. For validation information, see Langner et al. (2010)

2.1.3 | Apparatus

Each infant was tested in a small room, divided into two sections by an opaque curtain. In one half of the room, infants sat on their parent's lap approximately 60 cm away from a 48 cm color computer monitor and audio speakers. A camera was located approximately 10 cm above the monitor, which focused on the infant's face to capture their looking behavior. In the other half of the room, behind the curtain, the experimenter sat at a table with a laptop computer (connected to the testing monitor). A secondary monitor displayed a live feed of the testing session (from the camera focused on the infant's face), from which the experimenter observed and recorded infants' looking behavior during each trial. The experimenter used the Habit 2 software program on the laptop (Oakes et al., 2019) to present the stimuli, record infants' looking times, and calculate the habituation criteria (described below).

2.1.4 | Procedure

Infants were tested in a habituation-categorization procedure similar to Ruba et al. (2020). After obtaining parental consent, infants were seated on their parent's lap in the testing room. During the session, parents were asked not to speak to their infant or point to the screen. Before each habituation and test trial, an "attention-getter" (i.e., a blue flashing, chiming circle) directed infants' attention to the monitor. The experimenter began each trial when the infant was looking at the monitor and recorded the duration of infants' looking behavior during that trial. For a look to be counted, infants had to look continuously for at least two seconds. Each habituation and test trial played until infants looked away for more than two continuous seconds or until the 30-s trial ended.

Infants first saw a pre-test trial (i.e., plush cow toy rocking back and forth) designed to acclimate them to the task. In the subsequent habituation trials, infants saw one person displaying facial configurations associated with anger and disgust. These two habituation events were randomized and presented in blocks. The habituation trials continued until infants' looking time across the last three trials decreased 50% or more from their looking time during the first three consecutive habituation trials or until 18 habituation trials were presented. Only infants who met the habituation criteria were included in the final analyses.

After the habituation trials, infants were presented with four test trials. The trials were selected based on previous research with habituation-categorization paradigms (Ruba et al., 2020b). The presentation order of the test stimuli was randomized (see Figure 1), and the selected familiar/novel identities used in the habituation and test events were counterbalanced across participants. The following test trials were used in the current study. For the *negative familiar event* test trial, the person seen during habituation displayed one of the habituation emotions (e.g., anger). For the *negative novel face* test trial, a new person, not seen during habituation, displayed one of the habituation emotions (e.g., disgust). If infants included this novel person in their superordinate category, this would provide evidence that their category was based on emotion, rather than person identity. For the *negative novel emotion* test trial, the person seen during habituation displayed a novel, negative emotion, which was always sadness. Lastly, for the *positive novel emotion* test trial, the person seen during habituation displayed a novel, positive emotion, which was always happiness. The *negative novel emotion* and *positive novel emotion* test trials were of the familiar person (seen during habituation), so that infants' responses could be attributed to novelty of the emotion only.

2.1.5 | Scoring

Infants' looking behavior was live-coded by a trained research assistant. The coder was blind to which stimuli the infant was currently viewing during the habituation and test trials. A second research assistant, who was also display-blind, rescored 25% of the tapes ($n = 8$) offline. Reliability was excellent for duration of looking on each trial, $r = .96$, $p < .001$.

2.2 | Results

All statistical tests were two-tailed, and alpha was set at .05. Follow-up comparisons were paired *t* tests conducted using Bonferroni-Holm corrections (reported *p*-values are corrected). Data and analysis code can be found here: https://osf.io/d5amf/?view_only=3c6cd709c07d49bba7f3e84551b0ef36. The pattern and significance of the results remains the same when a log-transformation is applied to infants' looking times (Csibra et al., 2016).

2.2.1 | Habituation phase

A paired-samples *t* test found that 10-month-olds attended longer to the first three habituation trials (M = 19.86s, SD = 5.24) compared to the *negative familiar event* (M = 8.57s, SD = 6.71), $t(23) = 7.46$, $p < .001$, $d = 1.52$, $CI_{95\%}$ [8.16, 14.42]. This analysis confirmed that infants' looking significantly decreased from habituation to test.

2.2.2 | Test phase

A repeated-measures ANOVA (conducted with infants' looking time to each of the four test trials) revealed a significant effect of Test Trial, $F(3, 69) = 7.17$, $p < .001$, $\eta_p^2 = .24$. Follow-up comparisons revealed that infants looked significantly longer to the *negative novel face* compared to the *negative familiar event*, $t(23) = 4.51$, $p < .001$, $d = 0.92$, $CI_{95\%}$ [4.77, 12.85], the *negative novel emotion*, $t(23) = 2.92$, $p = .030$, $d = 0.60$, $CI_{95\%}$ [2.20, 12.88], and the *positive novel emotion*, $t(23) = 3.12$, $p = .024$, $d = 0.64$, $CI_{95\%}$ [2.30, 11.31]. There were no other significant comparisons (Figure 2). Critically, infants looking to the *negative familiar event* were not significantly different than their looking to the *negative novel emotion*, $t(23) = 0.70$, $p < .25$, $d = 0.14$, $CI_{95\%}$ [−2.50, 5.04], or the *positive novel emotion*, $t(23) = 1.36$, $p < .25$, $d = .28$, $CI_{95\%}$ [−1.50, 5.06], suggesting that infants formed a category of person identity, rather than a superordinate category of negative valence.

2.3 | Discussion

In contrast to our hypotheses, we found that 10-month-olds formed a category of person identity, rather than a superordinate category of negative valence. Specifically, 10-month-olds looked significantly longer at the *negative novel face* (i.e., a new person displaying one of the habituation emotions) compared to the other three test trials, which depicted the same person seen during habituation. Although unexpected, this failure of 10-month-olds to track both identity and emotion information converges with prior work. Ruba et al. (2017) found that, after habituation to

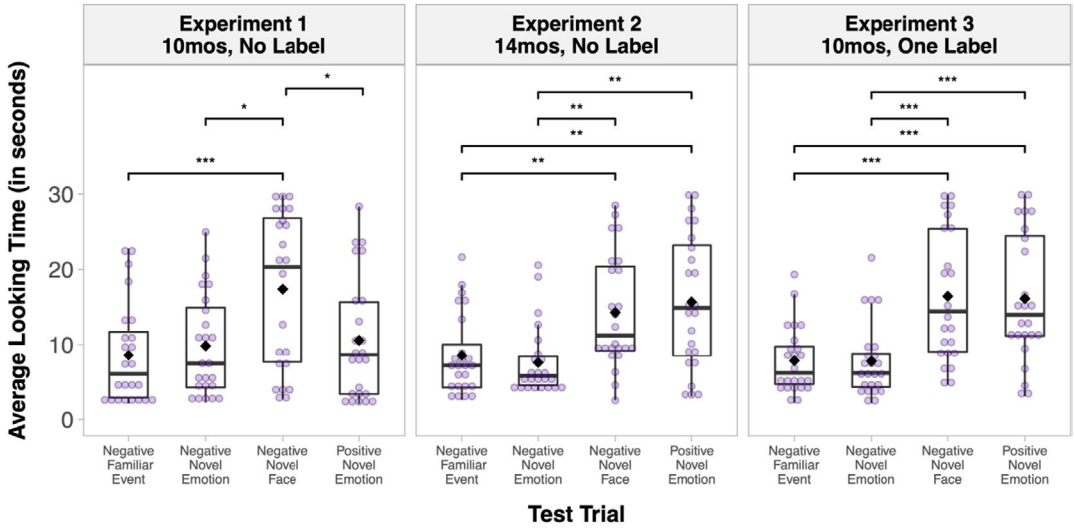


FIGURE 2 Average total looking times to each of the test trials, separated by Experiment. All comparisons between test trials were conducted with Bonferroni-Holm corrections. Statistically significant comparisons are marked, ***$p < .001$, **$p < .01$, *$p < .05$

four individuals displaying facial configurations associated with *one emotion*, 10-month-olds dishabituated to novel emotions, but not to novel identities. In the current study, after habituation to one individual displaying facial configurations associated with *two emotions*, 10-month-olds dishabituated to novel identities, but not to novel emotions. This suggests that 10-month-olds attend to whatever information is held constant during the habituation trials, possibly because infants at this age have not reached the level of memory and/or attentional development needed to concurrently track identity and emotion information (Cohen & Oakes, 1993; Oakes, 1994; Rose et al., 2001; Ross-Sheehy et al., 2003; Ruba & Pollak, 2020).

3 | EXPERIMENT 2

Experiment 2 tested whether older, 14-month-old infants would form a superordinate category of negative valence. In line with prior research (Casasola, 2005b; Casasola & Cohen, 2002; Ruba et al., 2017), we predicted that 14-month-olds would form a superordinate category of negative valence, whereby (a) infants' looking time to the *negative familiar event*, *negative novel face*, and *negative novel emotion* would not differ from one another, and (b) infants' looking times for each of these three negative emotion test trials would be significantly shorter than their looking times to the *positive novel emotion*.

3.1 | Methods

3.1.1 | Participants

The final sample consisted of 24 (12 female) 14-month-olds (M = 14.11 months, SD = 0.17 months, range = 13.81–14.47 months). An additional five 14-month-olds were tested but excluded from final analyses for failure to finish the study due to sustained infant crying ($n = 3$), fussiness/

inattentiveness during the study, leading to difficulties with accurate reliability coding ($n = 1$), or failure to meet the habituation criteria ($n = 1$). Exclusions made for fussiness and inattentiveness were initially made by the blind, online coder, who marked the tested infant as likely too fussy and/or inattentive for coding to be reliable. A second blind coder confirmed this decision during secondary offline reliability coding. Parents identified their infants as White (67%, $n = 16$) or Multi-racial (33%, $n = 8$). One infant (4%) was identified as Hispanic or Latino.

3.1.2 | Stimuli, apparatus, procedure, and scoring

The stimuli, apparatus, habituation, and scoring procedures were identical to Experiment 1. Reliability was excellent (25% of tapes rescored; $n = 8$) for duration of looking on each trial, $r = .98$, $p < .001$.

3.2 | Results

3.2.1 | Habituation phase

A paired-samples t test confirmed that 14-month-olds attended longer to the first three habituation trials (M = 19.96s, SD = 5.36) compared to the *negative familiar event* test trial (M = 8.55s, SD = 5.41), $t(23) = 10.13$, $p < .001$, $d = 2.07$, $CI_{95\%}$ [9.08, 13.74].

3.2.2 | Test phase

A repeated-measures ANOVA revealed a significant effect of Test Trial, $F(3, 69) = 10.80$, $p < .001$, $\eta_p^2 = .32$. Follow-up comparisons showed that infants' looking to the *positive novel emotion* was significantly greater than their looking to the *negative familiar event*, $t(23) = 3.64$, $p = .004$, $d = 0.74$, $CI_{95\%}$ [3.07, 11.19], and the *negative novel emotion*, $t(23) = 4.03$, $p = .003$, $d = 0.82$, $CI_{95\%}$ [3.95, 12.29]. Infants' looking to the *negative novel face* was also significantly greater than their looking to the *negative familiar event*, $t(23) = 3.91$, $p = .002$, $d = 0.80$, $CI_{95\%}$ [2.70, 8.77], and the *negative novel emotion*, $t(23) = 4.36$, $p = .001$, $d = 0.89$, $CI_{95\%}$ [3.53, 9.92]. There were no other significant comparisons (Figure 2). This suggests that 14-month-olds formed a category that included negative emotions displayed by the same person seen during habituation. However, infants did not form the hypothesized superordinate category of negative valence.

3.2.3 | Experiment 1 and 2 combined analysis

An additional analysis was conducted to determine whether there was a significant effect of age across the two experiments. A 2 (Age) × 4 (Test Trials) mixed-model ANOVA revealed a significant main effect of Test Trials, $F(3, 138) = 13.66$, $p < .001$, $\eta_p^2 = .23$, which was qualified by a significant Age × Test Trials interaction, $F(3, 138) = 3.68$, $p = .014$, $\eta_p^2 = .07$. This suggests that looking times were significantly different between the 10- and 14-month-olds across the two experiments (see "Results" of Experiment 1 and 2 follow-up comparisons). There was not a significant main effect of Age, $F(1, 46) < .01$, $p > .25$, $\eta_p^2 < .01$.

3.3 | Discussion

While 10-month-olds in Experiment 1 formed a category of person identity, 14-month-olds in Experiment 2 formed a category that included negative facial configurations displayed by the same person seen during habituation. Specifically, 14-month-olds attended less to the *negative familiar event* and the *negative novel emotion* compared to the *negative novel face* and the *novel positive emotion*. This suggests that infants formed a category of anger/disgust (i.e., *negative familiar event*) and sadness (i.e., *negative novel emotion*) modeled by the same person, and differentiated this category from (a) a new person displaying anger/disgust (i.e., *negative novel face*), and (b) the same person displaying happiness (i.e., *novel positive emotion*). Although this suggests that infants formed a category, the pattern of looking that would demonstrate superordinate categorization of valence across multiple individuals (i.e., equivalent looking to the three *negative emotions* that is significantly shorter than the *positive novel emotion*) was not found. Even so, these results suggest that developmental changes in categorization occur between the first and second year of life (Casasola, 2005b; Casasola & Cohen, 2002; Kovack-Lesh & Oakes, 2007). While 10-month-olds only tracked identity information (Experiment 1), 14-month-olds tracked both identity and emotion information (Experiment 2). This change is possibly due to maturing memory and/or attentional processes during this developmental period (Oakes, 1994; Rose et al., 2001; Ruba & Pollak, 2020).

4 | EXPERIMENT 3

Although 10-month-olds may not have reached the level of attentional/memory development necessary to form a superordinate category, prior research suggests that task modifications can reduce memory and attentional demands, thereby facilitating category formation (Kovack-Lesh & Oakes, 2007; Oakes et al., 1996; Oakes & Ribar, 2005; Younger & Furrer, 2003). Experiment 3 explored whether one such task modification—the inclusion of a label—would facilitate superordinate facial configuration categorization for 10-month-olds. Specifically, a novel verbal label (e.g., "toma") was presented alongside each of the habituation events. In line with prior research (Casasola, 2005a; Pruden et al., 2013; Ruba et al., 2020b; Waxman & Markow, 1995), we predicted that a label would help infants form a superordinate category of negative valence. In particular, we predicted that (a) infants' looking time to the *negative familiar event*, *negative novel face*, and *negative novel emotion* would not differ from one another, and (b) infants' looking times for each of these three negative emotion test trials would be significantly shorter than their looking times to the *positive novel emotion*.

4.1 | Methods

4.1.1 | Participants

The final sample consisted of 24 (12 female) 10-month-olds (M = 10.02 months, SD = 0.21 months, range = 9.67–10.32 months). Parents identified their infants as White (71%, $n = 17$), Multi-racial (21%, $n = 5$), or Asian (8%, $n = 2$). Two infants (8%) were identified as Hispanic or Latino. There was no attrition in this study. Parental report confirmed that their 10-month-olds did not yet

produce emotion labels. A minority of infants were reported to "understand" some emotion labels (see Table 1).

4.1.2 | Stimuli

The visual stimuli were identical to Experiment 1. However, a verbal label was added to each of the habituation events. The label was a pre-recorded nonsense word (i.e., "toma") spoken by a native English-speaking female in infant-directed speech. In each event, the novel word was spoken twice after the person's facial configuration shifted from neutral to the target emotion. The novel word was never presented immediately before or during the shift. This presentation increased the likelihood that infants would associate the novel word with the facial configurations and decreased the likelihood that infants would (a) associate the words with the facial movement or (b) make causal attributions (e.g., the word caused the person's facial configuration to change). This label was only attached to the habituation trials. The test trials were presented in silence, without labels.

4.1.3 | Apparatus, procedure, and scoring

The apparatus, habituation, and scoring procedures were identical to Experiment 1. Reliability was excellent (25% of tapes rescored; $n = 8$) for duration of looking on each trial, $r = .97$, $p < .001$.

TABLE 1 Number (and proportion) of 10-month-olds in Experiment 3 reported to "understand" (receptive) each of the listed emotion labels

Emotion label	Receptive vocabulary
Happy	6 (0.25)
Smile	10 (0.42)
Laugh	3 (0.12)
Sad	7 (0.29)
Cry	6 (0.25)
Tears	3 (0.12)
Pout	0 (0.00)
Frown	1 (0.04)
Upset	0 (0.00)
Unhappy	0 (0.00)
Angry/Mad	3 (0.12)
Scared/Afraid	0 (0.00)
Scary	1 (0.04)
Disgust(ed)	0 (0.00)
Yucky/Icky/Gross	6 (0.25)
Surprise(d)	5 (0.21)

Note: No infants were reported to "say" (productive) any of the listed emotion labels.

4.2 | Results

4.2.1 | Habituation phase

A paired-samples *t* test confirmed that 10-month-olds attended longer to the first three habituation trials (M = 26.32s, SD = 4.04) compared to the *negative familiar event* test trial (M = 8.42s, SD = 5.30), $t(23) = 16.83$, $p < .001$, $d = 3.43$, $CI_{95\%}$ [16.34, 20.92].

4.2.2 | Test phase

A repeated-measures ANOVA revealed a significant effect of Test Trial, $F(3, 69) = 15.90$, $p < .001$, $\eta_p^2 = .41$. Follow-up comparisons revealed that 10-month-olds showed the same pattern of looking as 14-month-olds in Experiment 2. Specifically, infants' looking to the *positive novel emotion* was significantly greater than their looking to the *negative familiar event*, $t(23) = 4.61$, $p < .001$, $d = 0.94$, $CI_{95\%}$ [4.59, 12.05], and the *negative novel emotion*, $t(23) = 4.50$, $p < .001$, $d = 0.92$, $CI_{95\%}$ [4.53, 12.23]. However, similar to Experiment 1, infants' looking to the *negative novel face* was also significantly greater than their looking to the *negative familiar event*, $t(23) = 5.27$, $p < .001$, $d = 1.08$, $CI_{95\%}$ [5.24, 12.02], and the *negative novel emotion*, $t(23) = 5.15$, $p < .001$, $d = 1.05$, $CI_{95\%}$ [5.20, 12.18]. There were no other significant comparisons (Figure 2). This suggests that 10-month-olds formed a category that included negative emotions displayed by the same person seen during habituation (similar to 14-month-olds in Experiment 2). However, 10-month-olds did not form the hypothesized superordinate category of negative valence.

4.2.3 | Experiment 1 and 3 combined analysis

An additional analysis was conducted to determine whether there was a significant effect of labels for 10-month-olds. A 2 (Label) × 4 (Test Trials) mixed-model ANOVA revealed a significant main effect of Test Trials, $F(3, 138) = 18.27$, $p < .001$, $\eta_p^2 = .28$, which was qualified by a significant Label × Test Trials interaction, $F(3, 138) = 3.24$, $p = .024$, $\eta_p^2 = .07$. This suggests that labels significantly impacted 10-month-olds' category formation across Experiment 1 and 3 by shifting infants' attention away from the identity information (see "Results" of Experiment 1 and 3 for follow-up comparisons). There was not a significant main effect of Label, $F(1, 46) = .10$, $p > .25$, $\eta_p^2 < .01$.

4.2.4 | Experiment 2 and 3 combined analysis

A final analysis was conducted to assess whether 14-month-olds (with no label) in Experiment 2 indeed formed similar categories to 10-month-olds (with a label) in Experiment 3. A 2 (Experiment) × 4 (Test Trials) mixed-model ANOVA revealed a significant main effect of Test Trials, $F(3, 138) = 26.20$, $p < .001$, $\eta_p^2 = .25$, but not a significant Experiment × Test Trials interaction, $F(3, 138) = .48$, $p > .25$, $\eta_p^2 = .01$. Follow-up comparisons with the combined sample were similar to the follow-up comparisons with the samples for each experiment. Infants' looking to the *positive novel emotion* was significantly greater than their looking to the *negative familiar event*, $t(47) = 5.85$, $p < .001$, $d = 0.84$, $CI_{95\%}$ [5.07, 10.38], and the *negative novel emotion*, $t(47) =$

6.08, $p < .001$, $d = 0.88$, $CI_{95\%}$ [5.52, 10.98]. However, infants' looking to the *negative novel face* was significantly greater than their looking to the *negative familiar event*, $t(47) = 6.48$, $p < .001$, $d = 0.94$, $CI_{95\%}$ [4.95, 9.41], and the *negative novel emotion*, $t(47) = 6.76$, $p < .001$, $d = 0.98$, $CI_{95\%}$ [5.41, 10.00]. There were no other significant comparisons. This suggests that 10-month-olds (with a label) and 14-month-olds (without a label) formed a category that included negative facial configurations displayed by the same person seen during habituation.

4.3 | Discussion

These results indicate that adding a novel verbal label to each habituation event modified 10-month-old infants' facial configuration categorization. In Experiment 1, 10-month-olds formed a category of person identity (i.e., longer looking at the *negative novel face* compared to the other three test trials). In Experiment 3, when a label was added to the habituation events, 10-month-olds formed a category of negative emotions for the person seen during habituation. Specifically, 10-month-olds attended less to the *negative familiar event* and the *negative novel emotion* compared to the *negative novel face* and the *novel positive emotion*. This suggests that infants formed a category of anger/disgust (i.e., *negative familiar event*) and sadness (i.e., *negative novel emotion*) modeled by the same person and differentiated this category from (a) a new person displaying anger/disgust (i.e., *negative novel face*) and (b) the same person displaying happiness (i.e., *novel positive emotion*). However, the pattern of looking that would demonstrate superordinate categorization of valence across multiple individuals (i.e., equivalent looking to the three *negative emotions* that is significantly shorter than the *positive novel emotion*) was not found.

Interestingly, this is the same pattern of looking as the 14-month-olds in Experiment 2, when a label was not included in the habituation events. Labels appeared to have an instructional, scaffolding effect, allowing 10-month-olds to form categories similar to those formed by 14-month-olds without labels. To form a superordinate category, infants not only have to continuously remember and compare multiple exemplars, but they also have to extract the common affective information (i.e., valence) across these exemplars. The addition of a verbal label may have prompted 10-month-olds to search for (and find) this common information (Waxman & Markow, 1995), shifting infants' focus away from the identity information (i.e., the person displaying the facial configuration), while drawing attention toward more shared, abstract features of the stimuli (i.e., their negative valence).

5 | GENERAL DISCUSSION

The current studies examined how infant age and language impacts superordinate categorization of facial configurations associated with different negative emotions. After habituation to one person displaying anger and disgust, we found that 10-month-olds formed a category of person identity (Experiment 1), whereas 14-month-olds formed a category of a single person's negative emotions (Experiment 2). When a label was added to each of the habituation events, 10-month-olds also formed a category of a single person's negative emotions (Experiment 3). These findings replicate and extend prior research indicating that infants' categorization abilities are influenced by (a) development across the first and second year of life, particularly with respect to attention and memory capacities (Casasola, 2005b; Casasola & Cohen, 2002; Oakes et al.,

1996; Ruba et al., 2017), and (b) the addition of language to categorization tasks (LaTourrette & Waxman, 2019; Ruba et al., 2020b; Waxman & Markow, 1995).

Yet, unexpectedly and across all experiments, infants did not form the hypothesized superordinate category of negative valence. This failure was driven by infants' sustained attention at test to the *negative novel face* (i.e., a person not seen during habituation, displaying the habituation emotion). Prior research has found that infants are sensitive to person identity when processing emotional information (Barrera & Maurer, 1981; Kahana-Kalman & Walker-Andrews, 2001; Montague & Walker-Andrews, 2002; Schwarzer & Jovanovic, 2010). In the current studies, infants' attention may have been further biased toward person identity since only one person was shown during the habituation events. As previously mentioned, only one person was used in the habituation trials after a pilot study suggested that 10-month-olds would be unable to track two people displaying two different emotions during habituation (see Supporting Information).

Research on object categorization also supports this interpretation. For example, when habituated to a single category exemplar, 3- to 14-month-olds fail to form abstract categories of spatial relations (Casasola, 2005b; Quinn et al., 2002, 2003). Similarly, Vukatana et al. (2015) found that 11-month-olds generalized a property (i.e., a sound) to new members of an object category, but only when presented with multiple category exemplars. Infants did not generalize the property when familiarized with a single category exemplar. Thus, some variation in category exemplars may be necessary for infants to form superordinate categories. The presentation of multiple category exemplars may promote a process of comparison, which highlights the relational commonalities (e.g., negative valence) between the exemplars (Gentner & Namy, 1999; Namy & Gentner, 2002). When provided with a single exemplar, infants may attend to features specific to that exemplar (e.g., person identity), rather than focusing attention to the abstract, shared feature (e.g., valence). This interpretation underscores the importance of considering how task features (e.g., stimuli selection) influence conclusions about infants' facial configuration categorization abilities.

The current studies also have important implications for ongoing discussions of children's emotion category development (Hoemann, Devlin, et al., 2020; Ruba & Repacholi, 2020a; Shablack et al., 2020). In support of the hypothesis that preverbal infants form superordinate categories of facial configurations (Barrett, 2017; Hoemann, Wu, et al., 2020; Hoemann et al., 2019; Lindquist & Gendron, 2013), we found that 10-month-olds (with labels, Experiment 3) and 14-month-olds (without labels, Experiment 2) formed a category of a single person's negative facial configurations. This provides some evidence that infants are sensitive to valence in facial configuration categorization tasks. However, outside of the laboratory, categories are a useful social tool because they can be generalized across a variety of individuals, situations, and displays of emotion. In the current studies, infants did not form the hypothesized superordinate category of negative valence across multiple individuals, even in a task designed to reduce cognitive demands (i.e., by using a small number of perceptually similar habituation events). These findings converge with Ruba et al. (2020b) to suggest that (a) infants between 10 and 18 months of age do not spontaneously form superordinate categories of facial configurations, (b) verbal labels facilitate facial configuration categorization, even for infants who do not yet produce emotion labels, and (c) facial configuration categorization emerges in a "narrow-to-broad" fashion (Quinn et al., 2011).

Yet, firm conclusions that infants cannot form superordinate categories of facial configurations are still premature. Categorization is a dynamic, task-dependent process, and some researchers have argued that infants' category boundaries are flexible and created "online" during the course of an experiment (Kovack-Lesh & Oakes, 2007; Madole & Oakes, 1999; Ribar et al.,

2004; Smith, 2000). In this way, facial configuration categorization tasks may measure the process and conditions by which infants respond to categorical distinctions, rather than infants' existing categorical representations (Jones & Smith, 1993; Oakes et al., 1997; Smith, 2000). Relatedly, while we favor a richer interpretation of infants' superordinate facial configuration categorization (i.e., based on valence or other affective meaning), it is not possible to rule out leaner interpretations—specifically, that infants formed categories based on some common perceptual feature. We view the leaner interpretation as unlikely, since salient facial features of the current stimuli varied considerably (e.g., the facial configurations associated with anger and sadness had closed mouths, whereas the facial configurations associated with disgust and happiness had open mouths).

A related possibility is that facial configuration categorization emerges in a "narrow-to-broad" fashion, while other aspects of emotion reasoning develop in a different manner. For instance, infants' ability to match different negative emotional expressions (e.g., anger vs. disgust) to specific eliciting events (Ruba et al., 2019, 2020a), as well as their ability to behaviorally respond to different negative emotional expressions (Walle et al., 2017), appear to develop in a "broad-to-narrow" fashion. In conjunction with the current findings, this illustrates the importance of clearly differentiating between individual components of infants' emotion reasoning abilities (i.e., categorization vs. event-emotion matching; see Ruba & Repacholi, 2020). Currently, little is known as to how these components relate to one another, particularly over the course of development (e.g., does infants' ability to categorize facial configurations predict their ability to behaviorally respond to others' emotions?). A more thorough examination of these developmental trajectories will elucidate how infants learn to infer, predict, and respond to other people's expressive behaviors.

Similarly, future research should also consider how developmental processes influence facial configuration categorization in infancy. One open question relates to whether attentional/memory development or other developmental process (e.g., social experience with emotions/faces) best account for the observed developmental differences in facial configuration categorization between 10- and 14-month-olds. One possibility is that infants are able to form superordinate categories of facial configurations, but only for faces with which they have prior social experiences (e.g., caregivers, siblings; Montague & Walker-Andrews, 2002) or only for emotions/facial configurations that infants have personally experienced or observed. In this way, it is important to consider how infants' prior social and emotional experiences influence their ability to categorize emotions. Another open question concerns the mechanism by which labels facilitate infants' facial configuration categorization. Complementary methods, such as eye tracking (Althaus & Plunkett, 2016), could examine whether and how labels change the visual processing of facial configurations. In addition, although research on object categorization shows that non-linguistic auditory stimuli (e.g., a tone) do not facilitate categorization in a similar way to labels (Balaban & Waxman, 1997; Ferry et al., 2010), studies are needed to extend these findings to facial configuration categorization.

Developmental psychologists should also continue to draw from perspectives in affective science in the conceptualization of future research. For example, the design of our study, like many studies of emotion, used posed stereotypes (i.e., facial configurations) of a few "basic" emotions, which likely fail to capture the diversity of children's emotional environments (Barrett et al., 2019; Ruba & Pollak, 2020). More research is needed to determine how dynamic, contextualized, and multimodal expressions of emotions influence infant facial configuration categorization. Taken together, these studies highlight the importance of considering developmental processes in the design and interpretation of infant facial configuration categorization studies. Only through

integration of these factors across multiple ages can researchers document a complete picture of emotional development in infancy and across the lifespan.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

How to cite this article: Ruba, A. L., Meltzoff, A. N., & Repacholi, B. M. (2021). Linguistic and developmental influences on superordinate facial configuration categorization in infancy. *Infancy*, 26, 857–876. https://doi.org/10.1111/infa.12430