Constructing Emotion Categorization: Insights from Developmental Psychology Applied to a Young Adult Sample

Ashley L. Ruba*, Makeba Parramore Wilbourn, Devin M. Ulrich, & Lasana T. Harris[1]

Duke University

*Ashley L. Ruba is the corresponding author
[1]Lasana T. Harris is now at University College London

Abstract

Previous research has found that the categorization of emotional facial expressions is influenced by a variety of factors, such as processing time, facial mimicry, emotion labels, and perceptual cues. However, past research has frequently confounded these factors, making it impossible to ascertain how adults use this varied information to categorize emotions. The current study is the first to explore the magnitude of impact for each of these factors on emotion categorization in the same paradigm. Participants (*N*=102) categorized anger and disgust emotional facial expressions in a novel computerized task, modeled on similar tasks in the developmental literature with preverbal infants. Experimental conditions manipulated (a) whether the task was time-restricted, and (b) whether the labels “anger” and “disgust” were used in the instructions. Participants were significantly more accurate when provided with unlimited response time and emotion labels. Participants who were given restricted sorting time (2s) and no emotion labels tended to focus on perceptual features of the faces when categorizing the emotions, which led to low sorting accuracy. In addition, facial mimicry related to greater sorting accuracy. These results suggest that when high-level (labeling) categorization strategies are unavailable, adults use low-level (perceptual) strategies to categorize facial expressions. Methodological implications for the study of emotion are discussed.

Keywords: emotion categorization, labels, mimicry, processing time, perceptual cues

Introduction

Emotional facial expressions[1] are powerful non-verbal forms of communication; a simple smile or a furrowed brow can quickly communicate one's inner thoughts and feelings. Some scholars argue that humans' ability to quickly and accurately categorize facial expressions (i.e., linking homogeneous inferences of 'happy', sad', or 'angry' to facial expressions conveying these emotions) is universal (Ekman, 1992; Izard, 1971) and evolutionary advantageous (Shariff & Tracy, 2011). Support for this perspective comes from research demonstrating that humans' facial expression categorization occurs (1) automatically via a facial mimicry mechanism (Dimberg, Thunberg, & Elmehed, 2000) and (2) quickly under cognitive stress (Tracy & Robins, 2008). In contrast, other scholars contend that emotion categorization is constructed from a variety of factors, such as culture, socialization, and language (e.g., Lindquist & Gendron, 2013). This perspective is driven by research demonstrating that categorization of facial expressions is drastically impacted when emotion labels (Carroll & Russell, 1996) and/or perceptual cues (e.g., amount of teeth shown in a smile; Caron, Caron, & Myers, 1985) are manipulated in the task.

Taken together, it appears that facial expression categorization is influenced by a variety of factors, including cognitive load, facial mimicry, emotion labels, and perceptual cues. However, since these factors have typically been studied in isolation (or confounded with other factors), their relative contributions to facial expression categorization remain unclear. By drawing on insights from developmental psychology, the current study explores how these factors influence emotion categorization in adults.

Early Emotion Categorization

[1] Hereafter, "emotional facial expressions" will be referred to as "facial expressions." For the purposes of this paper, we only discuss emotion expressions that are expressed facially, rather than vocally or through body posture.

While the vast majority of research on emotion categorization has been conducted with adults and older, verbal children, much can be learned about emotion categorization from preverbal infants. Unlike adults and older children, preverbal infants cannot sort facial expressions into categories using emotion labels. Instead, most studies on infant emotion perception utilize strictly perceptual tasks, which do not require infants to label or attribute affective meaning to the facial expressions (e.g., Quinn et al., 2011). For example, to determine whether infants can perceptually discriminate between two facial expressions, infants are repeatedly shown one facial expression (e.g., happy) and tested with a contrasting expression (e.g., fear; Kotsoni, de Haan, & Johnson, 2001). If infants look longer at the contrasting expression, it is concluded that infants discriminated between the expressions. Most studies utilizing this paradigm have found that infants, younger than 7-months, can discriminate between positive and negative facial expressions, such as happy and fear (e.g., Bornstein & Arterberry, 2003), and between different negative facial expressions, such as anger, sadness, and fear (e.g., Parker & Nelson, 2005). Thus, before their first birthday, infants are able to perceptually detect differences between various facial expressions.

However, it appears that young infants are highly sensitive to salient perceptual features of the faces when making these discriminations. For instance, infants have difficultly forming categories of facial expressions when the expressions vary on a salient feature, like the amount of teeth shown in a smile (e.g., Caron et al., 1985). Furthermore, while infants are able to discriminate between facial expressions on familiar adults (i.e., parents), they struggle to do so on strangers' faces (Montague & Walker-Andrews, 2002). Other studies have found that infants can only discriminate between pairs of facial expressions when habituated to one expression (e.g., happy) but not when habituated to the other expression (e.g., fear; Kotsoni et al., 2001;

Parker & Nelson, 2005). Overall, this research suggests that infants may process the facial expressions on a perceptual level, rather than appreciating the affective, conceptual meaning behind these expressions (Quinn et al., 2011). As infants develop, these perceptual categories likely become enriched by more abstract information (Quinn & Eimas, 1997), such as language.

In particular, research in developmental psychology has long argued that conceptual categories, especially perceptually variable categories, are anchored with words or labels (e.g., Waxman & Markow, 1995). In fact, language is thought to be the driving force behind infants' acquisition of concepts (Vygotsky, 1962). This hypothesis has been extended to suggest that children gradually acquire emotion concepts alongside emotion labels (Widen & Russell, 2008). Specifically, research has shown that as children acquire more emotion words, they become more accurate at categorizing facial expressions (Widen, 2013). One explanation for this improved categorical perception is that verbal labels smooth over perceptual variability in faces that share the same category membership (e.g., Barrett, Lindquist, Gendron, 2007). For instance, the word "anger" could describe faces with furrowed eyebrows that either do or do not show teeth. In this way, verbal children and adults view facial expressions as psychologically meaningful stimuli, rather than simple clusters of perceptual features (Fugate, 2013). In fact, studies have found that decreasing language accessibility actually impairs facial expression categorization (for a review, see Lindquist, Satpute, & Gendron, 2015).

Emotion Categorization in Adults

Given the crucial role of language plays in emotion categorization, the vast majority of studies exploring categorization abilities have utilized emotion labels. For instance, studies often ask participants to sort facial expressions into labeled categories (e.g., "happy" vs. "sad") or to choose from emotion words on a list (Pochedly et al., 2012; Widen & Russell, 2008). However, using emotion labels in these tasks limits researchers' ability to isolate the specific skills adults recruit when categorizing facial expressions. For example, Tracy and Robbins (2008) explored how processing speed and cognitive load impacted adults' facial expression categorization. In their task, participants were asked to categorize facial expressions under specific time constraints using emotion labels (e.g., "Is this *anger*?"). The findings revealed that for some facial expressions, like anger, participants were significantly more accurate when given 8000ms to respond than when given 1000ms. Yet, for other expressions, like disgust, more processing time did not improve categorization. While these findings provide valuable insights into the interrelation between emotion-specific semantic categories (e.g., "anger" faces) and processing speed, it remains unclear as to whether the relation between categorization accuracy and processing speed is similar when emotion labels are not included in the task. Put another way, it is possible that both processing speed and accuracy are impaired when (1) labels are not provided or (2) semantic categories are not available/accessible, as is the case with preverbal infants and dementia patients (Lindquist, Gendron, Dickerson, & Barrett, 2013). However, to date, important questions still remain as to whether emotion labels are necessary for emotion categorization in healthy adults.

In addition, emotion labels may also impact the relation between facial mimicry and emotion categorization in humans. Research has shown that perceiving others' facial expressions evokes instantaneous and measurable facial muscle responses in the perceiver (Dimberg, 1982). These automatic responses, in turn, elicit the perceived emotion in the perceiver (Niedenthal, 2007). Ultimately, this elicited emotion provides insight into others' emotional states (Niedenthal, 1992), thereby facilitating humans' ability to quickly recognize emotions in others (Stel & Knippenberg, 2008). This theory of embodied cognition has been validated with a variety of methodologies (Pitcher, Garrido, Walsh, & Duchaine, 2008).

While facial mimicry has been studied extensively, research has yet to establish a reliable link between facial mimicry and emotion categorization (Blairy, Herrera, & Hess, 1999; Hess & Blairy, 2001). To date, evidence exists both supporting and refuting the facilitative effect of facial mimicry on facial expression recognition (e.g., Oberman, Winkielman, & Ramachandran, 2007; Neal & Chartrand, 2011; Rives Bogart & Matsumoto, 2010). It is possible that these conflicting results are due to variations in the context and demands of the task. For instance, research has shown that facial expression mimicry is stronger when the perceiver agrees with the expresser's political positions (Bourgeois & Hess, 2008) or when the perceiver and expresser are cooperating (Lanzetta & Englis, 1989). Again, much of this research has relied on experimental paradigms where participants must categorize or rate facial emotions based on labeled categories (e.g., Blairy et al., 1999; Oberman et al., 2007; Neal & Chartrand, 2011), making it difficult to disentangle the impact of context versus semantic categorization on adults' facial expression mimicry. How does the inclusion of emotion labels influence the cognitive demands for adults in an emotion categorization task? In addition, how does semantic categorization (i.e., use of emotion labels) influence the relation between facial mimicry and emotional expression categorization in healthy adults?

Current Study

The current study addresses these questions by examining adults' emotion facial expression categorization in order to pinpoint (1) the specific skills recruited during emotion categorization, and (2) the conditions under which these skills are recruited. Drawing from infant research, the current study explores how adults utilize perceptual information to categorize facial expressions depending on whether (1) labels are present in the task, and/or (2) processing time is restricted, thereby manipulating cognitive load. Since previous research has often confounded the role of language with the roles of perceptual cues and cognitive load, it remains unclear as to the magnitude of impact for each of these factors on emotion categorization.

For the current study, a new computerized task was adapted the infant categorization paradigms (e.g., Ruba et al., in press). These paradigms allow infants to visually form perceptual categories of facial expressions without the use of language or semantic information. Thus, by modifying this paradigm, the current study could manipulate the role of language in the task. Specifically, in this task, adult participants were asked to sort anger and disgust facial expressions into their respective categories. Anger and disgust facial expressions were chosen as the visual stimuli since older children and adults frequently misidentify disgust expressions as anger (e.g., Pochedly, Widen, & Russell, 2012; Widen & Russell, 2013). One possible reason for this confusion is that anger and disgust facial expressions are perceptually similar. In particular, both expressions involve lowered or furrowed eyebrows, although disgust is typically defined by the "nose scrunch" (Ekman & Friesen, 1978). As a result, we expected that these facial expressions would evoke variability in categorization accuracy. Furthermore, since these expressions were perceptually similar, the current study could more stringently examine whether/how adults used perceptual facial cues when categorizing the emotions.

During the task, facial EMG was recorded in order to determine how processing time and emotion labels impact facial expression mimicry during emotion categorization. Participants were assigned to one of three experimental conditions: *Timed-No Label, Untimed-No Label,* and *Timed-Label*. These conditions manipulated (1) the amount of time allowed to sort each face (i.e., 2000ms or no time limit), and (2) whether the faces were explicitly labeled during the instructions (i.e., "you will sort facial expressions" or "you will sort *anger* and *disgust* facial expressions").

We hypothesized that adult participants would recruit higher-level emotion categorization strategies (i.e., language), rather than lower-level perceptual strategies more commonly recruited in infancy (e.g., teeth versus no teeth; Caron et al., 1985; Montague & Walker-Andrews, 2002). However, participants' recruitment of these higher-level strategies would likely vary as a function of experimental condition. Based on previous research (Tracy & Robins, 2008; Russell & Widen, 2002), we predicted that participants would have more accurate emotion categorization when given unlimited sorting time (*Untimed-No Label* condition) and provided with emotion labels (*Timed-Label* condition). We hypothesized that if participants were cognitively taxed by restricted sorting time and having no emotion labels (*Timed-No Label* condition), they may be more likely to recruit lower-level, perceptual categorization strategies (Cohen, Chaput, & Cashon, 2002). Ultimately, we predicted that this would result in lower accuracy. In addition, we hypothesized that facial expression mimicry would also be impacted by the task demands. As a result, we predicted that reducing cognitive demands (e.g., increased sorting time and providing emotion labels) would increase participants' facial mimicry, which, in turn, may increase accuracy.

Methods

Participants

Adult participants were undergraduate students recruited through a psychology course subject pool at a southeastern university in the United States. The final sample consisted of 102 students (67 females, M = 19.5 years, SD = 1.0 years, range = 18.0 years – 24.6 years). Five additional participants were excluded from the final analyses for extremely low total accuracy scores (i.e., < 3 SD below the mean, n = 3) and computer errors (n = 2). All participants received research credit for their participation.

Stimuli

Still images of facial expressions were selected from the Karolinska Directed Emotional Faces database (Lundqvist, Flykt, & Öhman, 1998) and used as stimuli. A total of 80 emotion facial expressions (40 anger, 40 disgust) were selected, with still images of both adult men and women (40 each). Critically, these images varied in terms the amount of teeth displayed for each emotion. Half of the disgust facial expressions displayed teeth, while the other half of these expressions did not display teeth. The same was true for the anger expressions. This ensured that participants could not use one particularly salient feature (i.e., mouth or teeth) to accurately categorize the expressions. Participants' reliance on this perceptual feature was further analyzed in the results.

Apparatus

Participants completed the task using a 13-inch computer monitor connected to a PC. On this computer, E-Prime 2.0 software presented the stimuli and recorded participants' accuracy and reaction times for each trial. Participants used the computer keyboard to sort each expression into their respective groups or "piles" (e.g., anger v. disgust). These piles were displayed at the bottom of the screen by cartoon facial expressions of emotion (see Table 1). These cartoon facial expressions eliminated the need for emotion labels during the task (e.g., "anger" and "disgust"), which have been shown to boost facial expression categorization performance (Russell & Widen, 2002). Cartoon expressions were also used so participants could not perceptually match the anger and disgust expressions to a human face, as is sometimes done in emotion categorization tasks (Widen, 2013). Notably, however, the anger cartoon face had an open mouth (and could show teeth), while the disgust cartoon face had a closed mouth and no teeth. Thus, it is still possible that participants could attempt to perceptually match to the cartoon faces in this way. Since the human facial expressions used throughout the task varied in the amount of teeth shown, perceptual matching would have been an ineffective strategy for categorizing these facial expressions.

An adjacent monitor and Mac Mini recorded the facial EMG data with AcqKnowledge 4 software. Facial EMG was sampled at 1000Hz for the corrugator supercilii (brow) and levator labii (nose) muscles. The corrugator supercilii would be activated for mimicked anger facial expressions (lowered brow), while the levator labii would be activated for mimicked disgust facial expressions (scrunched nose; Ekman & Friesen, 1978). For each participant, the skin was prepped with NuPrep gel, and pairs of 4mm electrodes were placed on each muscle. A ground electrode was also placed on the participant's wrist bone. Electrode-skin contact impedance was measured, and in the case of high impedance (above 20Ω), the electrodes were removed, and the skin re-prepped. The electrodes were then connected to a BioPac MP150 Data Acquisition System, which linked to the AcqKnowledge software program. Using a line of code within the E-Prime script, a "pulse" was sent to the EMG stream to mark the beginning and end of each trial.

Procedure

Participants were tested individually. After obtaining informed consent, participants read several instruction screens. The content of the instructions varied based on the participant's experimental condition. For the *Timed-No label* condition, participants were told that they would have two seconds to sort "facial expressions." If participants did not make a selection within this 2-second time frame, an "Incorrect/No Response" was recorded. For the *Untimed-No label* condition, participants were told that they would have unlimited time to sort "facial expressions". Note that for both of the "*No Label*" conditions, the instructions specifically omitted the emotion words "anger" and "disgust." Experimenters also did not use these emotion words at any point during the study. Conversely, for the *Timed-Label* condition, participants were told that they would have two seconds to sort "anger and disgust facial expressions." Furthermore, the cartoon faces corresponding to "anger" and "disgust" were explicitly labeled on the instruction (but not testing) screen. Labels were never presented after the instructions (during the task), as to provide a more conservative test of the role of language in emotion categorization. During the task, participants sorted emotion facial expressions across four rounds of trials (total of 80 trials). Accuracy scores were calculated as a percentage and averaged across the four rounds of sorting. After the study, participants completed a follow-up survey where they were asked to (1) provide a word that "best described" each of the cartoon faces, and (2) describe the "strategy" they used to sort the facial expressions during the task.

Results

Manipulation Check

In order to determine whether the experimental manipulation significantly impacted participants' use of emotion labels in the task, we analyzed participants' responses to the survey at the end of the study. First, we examined participants' freely produced labels for the cartoon faces using a chi-squared test. Results revealed that the proportion of participants who labeled the cartoon anger expression as "anger" did not differ across conditions, χ^2 (2, N=102) = 1.93, p = .38 (Table 1). Likewise, the proportion of participants who labeled the cartoon disgust expression as "disgust" did not differ across conditions, χ^2 (2, N=102) = 2.83, p = .24. In fact, most participants labeled the cartoon anger expression correctly (84%) and the cartoon disgust expression correctly (82%) at the end of the study, regardless of whether they had been told the labels before the task (i.e., *Timed-Label* condition).

However, this finding does not reflect whether or how participants utilized these labels during the task. To probe this question, the "strategies" participants reported using during the task were also examined. These strategies were classified in one of three ways. *Perceptual feature* strategies comprised participants who reported focusing on specific perceptual features of the face when categorizing the expressions (e.g., "I sorted based on whether or not the *mouth* was open or how squinted the *eyes* were."). Participants using these strategies did not mention or use the words, "anger" or "disgust" in any way. Conversely, *emotion label* strategies comprised participants who reported sorting the faces into "anger" and "disgust" categories, specifically (e.g., "For the *disgust* pile, I looked for uneven, scrunched faces. For the *anger* pile, I looked for furrowed brows." "I sorted based on whether the faces looked *disgusted* or *angry*.") Lastly, the *other associated* strategies category captured all other responses (e.g., "I sorted what felt right." "I didn't have a strategy.")

A chi-squared analysis revealed participants' strategies significantly differed across experimental conditions, χ^2 (4, N=102) = 11.60, p = .02 (Table 2). Follow-up analyses revealed that participants' strategy use differed across both *No Label* conditions (i.e., *Timed vs. Untimed*). More specifically, the proportion of participants in the who used an *emotion label* strategy (56%) vs. a *perceptual feature* strategy (35%) in the *Timed-No Label* significantly differed from the proportion of participants who used an *emotion label* strategy (88%) vs. a *perceptual feature* strategy (12%) in the *Untimed-No Label* condition, χ^2 (1, N=65) = 6.34, p = .01. Furthermore, participants' strategy use differed across both *Timed* conditions (i.e., *Label vs. No Label*). Specifically, the proportion of participants in the *Timed-No Label* condition who used *emotion label* vs. *perceptual feature* strategies significantly differed from the proportion of participants in the *Timed-Label* condition who used an *emotion label* strategy (73%) vs. a *perceptual feature* strategy (15%), χ^2 (1, N=61) = 3.69, p = .05. Taken together, these results suggest that participants in the *Timed-No Label* condition generated different strategies than participants in the *Timed-Label* and *Untimed-No Label* conditions. Without the aid of emotion labels, imposed time constraints (i.e., *Timed-No Label* condition*)* increased participants' reliance on perceptual strategies.

Emotion Labels and Perceptual Cues

To examine how language (emotion labels), perceptual cues (teeth shown on the stimuli), and processing time influenced participant accuracy when sorting anger and disgust facial expressions, a 3 (Condition: Timed-No label vs. Untimed-No label vs. Timed-Label) x 2 (Emotion: Anger vs. Disgust) x 2 (Teeth: No teeth shown vs. Teeth shown) mixed-methods ANOVA was conducted. A significant main effect of Condition, $F(2, 99) = 15.45$, $p < .001$, $\eta_p^2 = .24$, revealed that participants were significantly less accurate in the *Timed-No Label* condition ($M = 69.25$, $SD = 17.46$) compared to both the *Untimed-No Label* condition ($M = 86.11$, $SD = 14.15$) and *Timed-Label* conditions ($M = 84.29$, $SD = 6.79$), all $ps < .001$. Accuracy did not differ between the *Untimed-No Label* condition and the *Timed-Label* condition, $p > .05$.

Moreover, a significant main effect of Emotion, $F(1, 99) = 15.68$, $p < .001$, $\eta_p^2 = .14$, revealed that participants were significantly more accurate sorting disgust expressions ($M = 83.53\%$, $SD = 15.30$) compared to anger expressions ($M = 76.32\%$, $SD = 20.69$). However, these results were qualified by a significant Condition x Emotion x Teeth interaction, $F(2, 98) = 4.91$, $p = .01$, $\eta_p^2 = .09$. To explore this interaction, separate 2 (Emotion) x 2 (Teeth) repeated-measures ANOVAs were conducted for each condition (Figure 1).

Timed-No Label condition. For the *Timed-No Label* condition, a significant main effect of Emotion, $F(1, 33) = 16.39$, $p < .001$, $\eta_p^2 = .33$, revealed that participants were significantly more accurate sorting disgust expressions (M = 77.15, SD = 18.74) compared to anger expressions (M = 61.54, SD = 22.44). This result was qualified by a significant Emotion x Teeth interaction, $F(1, 33) = 4.29$, $p = .05$, $\eta_p^2 = .12$. Follow-up comparisons revealed that for anger expressions, participants were significantly *more accurate* at sorting anger faces with teeth (M = 67.35, SD = 19.59) than anger faces without teeth (M = 55.72, SD = 33.89), $t(33) = 2.09$, $p = .04$, 95% CI [.31, 22.93]. However, the inverse was true for disgust expressions. With disgust expressions, participants were marginally *less accurate* at sorting disgust faces with teeth (M = 73.97, SD = 24.30) than disgust faces without teeth (M = 80.50, SD = 17.79), $t(33) = 1.85$, p = .07, 95% CI [-.07, 13.71].

Untimed-No Label condition. For the *Untimed-No Label* condition, a significant main effect of Emotion, $F(1, 33) = 4.02$, $p = .05$, $\eta_p^2 = .11$, revealed that participants were significantly more accurate with disgust expressions (M = 89.14, SD = 14.49) compared to anger expressions (M = 83.16, SD = 18.91). However, this result was qualified by a significant Emotion x Teeth interaction, $F(1, 33) = 5.65$, $p = .02$, $\eta_p^2 = .15$. Follow-up comparisons revealed the same pattern of results as the *Timed-No Label* condition. Again, for anger expressions, participants were significantly *more accurate* at sorting anger faces with teeth (M = 87.42, SD = 15.72) than anger faces without teeth (M = 78.03, SD = 27.38), $t(33) = 2.31$, $p = .03$, 95% CI [1.11, 17.67]. In contrast, for disgust expressions, participants were marginally *less accurate* at sorting disgust faces with teeth (M = 87.12, SD = 19.88) than disgust faces without teeth (M = 91.23, SD = 10.66), $t(33) = 1.83$, $p = .08$, 95% CI [-.47, 8.68]. Thus, across both No-Label conditions, the presence of teeth improved sorting accuracy for anger expressions, but decreased sorting accuracy for disgust expressions.

Timed-Label condition. For the *Timed-Label* condition, while significant main effects did not emerge, all *ps* > .05, a significant Emotion x Teeth interaction did, $F(1, 33) = 5.54$, p = .03, $\eta_p^2 = .14$. In contrast to the previous two conditions, follow-up comparisons revealed an opposite pattern of results. More specifically, for anger expressions, participants were significantly more accurate at sorting anger faces *without* teeth (M = 87.65, SD = 11.23) than anger faces *with* teeth (M = 80.88, SD = 14.01), $t(33) = 2.81$, p = .01, 95% CI [1.87, 11.66]. However for disgust expressions, participants' accuracy did not differ when sorting disgust faces *without* teeth (M = 83.59, SD = 12.14) compared to disgust faces *with* teeth (M = 85.00, SD = 9.45), $t(33) = .673$, p = .51, 95% CI [-5.67, 2.85]. Thus, when constrained by time, but given an emotion label (i.e., *Timed-Label condition*), the absence of teeth *improved* participants' accuracy for anger expressions, but had no clear effect for disgust expressions.

Taken together, these findings indicate that participants were more accurate sorting facial expressions when given unlimited processing time (*Untimed-No Label* condition) or when given emotion labels (*Timed-Label* condition). Moreover, regardless of how much processing time they were provided, participants relied on particular perceptual features of the cartoon faces (i.e., anger faces with teeth, disgust faces without teeth) significantly less when they were provided with language/labels (*Timed-Label* condition) than when they were not (*Timed-No Label* and *Untimed-No Label*). These results are displayed in Figure 1.

Facial mimicry. To determine if and how the experimental conditions impacted facial mimicry, participants' facial EMG data was examined. Before conducting the analyses, the raw facial EMG data were integrated, rectified, and log transformed. Data for three participants were removed from these analyses for missing/corrupt data files (n = 2) or extremely high facial muscle activity (i.e., +3 SD above the mean, n = 1).

To examine whether the facial EMG data varied as a function of the emotion sorted or the experimental condition, a 3 (Condition) x 2 (Emotion) x 2 (Muscle: Corrugator v. Levator labii) mixed-methods ANOVA was conducted. A significant main effect of Condition, $F(1, 96) = 21.84$, $p < .001$, $\eta_p^2 = .31$, revealed that participants exhibited significantly less facial EMG activity in the *Timed-No Label* condition ($M = -4.93$, $SD = .29$) relative to both the *Untimed-No Label* condition ($M = -4.63$, $SD = .18$) and the *Timed-Label condition* ($M = -4.59$, $SD = .22$), *ps* $< .001$. However, facial EMG activity did not differ between the *Untimed-No Label* and *Timed-Label* conditions, $p > .05$. A significant main effect of Muscle, $F(1, 96) = 21.84$, $p < .001$, $\eta_p^2 = .31$, revealed significantly more activity for the corrugator/brow ($M = -4.59$, $SD = .35$) compared to the levator labii/nose ($M = -4.84$, $SD = .29$). No other significant main effects or interactions emerged. Interestingly, there were no significant interactions between Emotion and Muscle, all *p*s $> .05$, suggesting that participants did not experience more corrugator (brow) activity in response to anger expressions or more levator labii (nose) activity in response to disgust expressions.

To explore whether these facial EMG differences also related to differences in sorting accuracy, multiple regressions were conducted with corrugator and levator labii activity administered as the predictor variables. For overall accuracy, the model was significant, $F(2, 96) = 6.24$, $p = .003$, $R^2 = .12$. Interestingly, while corrugator activity did not significantly predict overall accuracy, $B = .02$, $t(98) = .15$, $p = .88$, levator labii activity was a significant predictor of overall accuracy, $B = .33$, $t(98) = 2.81$, $p = .01$.

To determine whether these results were similar for the specific emotions, multiple regressions were conducted separately for anger and disgust expressions. For anger expressions, the model was significant, $F(2, 96) = 4.93$, $p = .01$, $R^2 = .09$. Similar to the overall accuracy analyses, while corrugator (brow) activity did not significantly predict anger accuracy, $\beta = .11$, *t*(98) = .90, *p* = .37, levator labii (nose) activity was a marginally significant predictor of anger accuracy, β = .23, *t*(98) = 1.93, *p* = .06. For disgust expressions, the model was also significant, *F*(2, 96) = 4.14, *p* = .02, R^2 = .08. Similar to the previous analyses, while corrugator (brow) activity did not significantly predict disgust accuracy, β = -.10, *t*(98) = -.85, *p* = .40, levator labii (nose) activity was a significant predictor of disgust accuracy, β = .33, *t*(98) = 2.75, *p* = .01. Thus, levator labii (nose) activity alone appeared to be the most significant predictor of overall and emotion-specific sorting accuracy. When the accuracy analyses were conducted separately by Condition, no significant effects emerged, all *ps* > .05.

Discussion

The current study examined adults' categorization of anger and disgust facial expressions when (1) emotion labels were provided, and/or (2) sorting time was restricted, thereby increasing cognitive load. In order to manipulate the role of language in the task, the current study used a novel computerized paradigm, adapted from the infant literature (e.g., Ruba et al., in press). While previous research has often confounded the role of language with the roles of perceptual cues and cognitive load (e.g., Tracy & Robbins, 2008), the current study examined the magnitude of impact for each of these factors on emotion categorization. The study also investigated whether facial expression mimicry was influenced by the manipulation of processing time and language/semantic accessibility.

Emotion Labels and Perceptual Cues

As predicted, participants who were given unlimited sorting time (*Untimed-No Label* condition) or provided with emotion labels (*Timed-Label* condition) were significantly more accurate at sorting anger and disgust facial expressions compared to participants who had only two seconds to respond, without the benefit of emotion labels (*Timed-No Label* condition).

Taken together, these findings provide additional evidence to suggest that both processing time (Tracy & Robbins, 2008) and language/semantic representation (Barrett et al., 2007; Lindquist et al., 2015) facilitate emotion categorization. This finding also provides support for other views in emotion theory suggesting that cognitive resources are necessary for humans to experience emotion (Hoffman & Van Dillen, 2012; Van Dillen, Heslenfeld & Koole, 2009).

It is important to note that participants in *Timed-Label* condition were primed with emotion labels only during the instructions and *not* throughout the task. Nevertheless, adding these labels during the instructions had a powerful facilitative effect on participants' sorting accuracy. By limiting the use of emotion labels in this way, the current study provides a far more stringent test of the role of language/labels in emotion categorization than has previously been reported in the literature. Although only participants in the *Timed-Label* condition were explicitly given these emotion labels in the instructions, during the manipulation check at the end of the task, participants in all three conditions were equally likely to correctly label the cartoon faces as "anger" and "disgust" (Table 1). Thus, participants clearly used emotion labels differently during the task compared to the end of the task. Moreover, when asked what "strategy" they used during the task, participants in the *Timed-No Label* condition were significantly less likely to report sorting the facial expressions into "anger" and "disgust" categories (Table 2).

In contrast, nearly all participants in the *Untimed-No Label* condition (i.e., unlimited time, but not primed with emotion labels) reported using an "emotion labeling strategy" after the task. This suggests that participants in the *Untimed-No Label* condition self-generated these labels throughout the course of the task. It is likely that this self-generation process required additional processing time and cognitive capacity, which explains why participants in the *Timed-*

No Label condition could not generate these labels during the timed task. Instead, participants in the *Timed-No Label* condition were more likely to report using lower-level “perceptual feature strategies.” It is likely that these lower-level strategies were more cognitively accessible to participants when faced with time constraints. Although participants in the *Timed-Label* condition faced similar time pressure, they tended to rely on the emotion labeling strategies primed by the instructions. This suggests that adults may be biased to categorizing facial expressions with higher-level emotion labeling strategies.

Additional analyses confirmed and extended this interpretation. In particular, significant Emotion x Teeth interactions emerged for all three conditions. For instance, in the two *No Label* conditions (*Timed* and *Untimed*), participants were more accurate at sorting anger expressions when the faces showed teeth. Participants were also more accurate at sorting disgust expressions when the faces did not show teeth. This pattern of results aligns with the cartoon faces used as category anchors (Table 1). Specifically, while the anger cartoon face depicts an open mouth (and could show teeth), the disgust cartoon face depicts a closed mouth and no teeth. In other words, participants in these conditions more accurately sorted the human facial expression stimuli when the faces matched the perceptual features of the cartoon faces. These cartoon faces were chosen as category anchors in order to *discourage* participants from this type of perceptual matching. Nevertheless, it appears that participants in the *No Label* conditions did use perceptual cues (e.g., mouth) when sorting the stimuli. In addition, although participants in the *Untimed-No Label* condition reported using “emotion labeling” strategies, it is clear that they also relied on perceptual cues to some extent.

Interestingly, these interactions were not the same for the *Timed-Label* condition. While accuracy with disgust expressions did not differ based on whether or not teeth were shown, participants were more accurate at sorting anger expressions when the faces *did not show* teeth. This latter finding suggests that participants were not perceptually matching the human expression stimuli to the cartoon faces. It also suggests that participants relied less on perceptual cues (of the cartoon faces) when emotion labels were provided. This pattern of results aligns with participants' self-reported emotion labeling strategies in the manipulation check.

Facial Mimicry

To measure how cognitive load and access to emotion labels impacted facial expression mimicry, facial EMG was recorded during the task. Participants in the *Timed-No Label* condition demonstrated less facial EMG activity for both muscle sites than participants in the other two conditions (*Timed-Label, Untimed- No Label*). One explanation for these findings is that the cognitive load in the *Timed-No Label* condition led to decreased facial mimicry. Another possibility is that reliance on language (as measured by self-reported strategies) in the *Timed-Label* and *Untimed-No Label* conditions led to increased facial mimicry. Overall, these results suggest that facial expression mimicry can be influenced by contextual factors, such as language and processing time (for similar contextual results, see Cannon, Hayes, & Tipper, 2009; Van Dillen, Harris, Van Dijk, & Rotteveel, 2014).

The findings also revealed that facial EMG activity positively predicted sorting accuracy; however, it appears that levator labii (nose) activity drove this finding. Perhaps the involvement of the corrugator (brow) in expressing both anger and disgust facial expressions made this muscle superfluous during the emotion categorization task. This pattern of results was the same regardless of whether anger or disgust facial expressions were sorted. Studies suggest that facial expression mimicry provides a "faster route" to accessing information about another person's emotions (Stel & van Knippenberg, 2008). This faster route would be especially helpful for participants who were given limited time to categorize the facial emotions (i.e., *Timed* conditions). However, participants in the *Timed-No Label* condition displayed less facial activity during the task compared to the other two conditions. Further, when the accuracy analyses were conducted separately by condition, no significant effects emerged. Thus, facial EMG activity did not appear to provide a “faster route” to emotion categorization in the *Timed-No Label* condition. Even so, it is possible that these new analyses were underpowered (n = 34 per condition).

It is important to note that participants did not display more corrugator (brow) activity in response to anger expressions or more levator labii (nose) activity in response to disgust expressions. Thus, while facial EMG activity did predict sorting accuracy, the sorted facial expressions did not elicit specific patterns of muscle activity.

Constructing Emotion Categorization

Taken together, these findings suggest that adults construct their categorization of emotional facial expressions depending on the context of the task. As a result, we propose a constructionist model of emotion categorization similar to information-processing models proposed in the infant literature. Specifically, Cohen and colleagues (2002) argue that infants are biased to process information at the highest, most sophisticated level available (e.g., language). However, if higher-level strategies are not available, then lower-level strategies (e.g., perceptual cues) are recruited. For infants, higher-level strategies often become unavailable when the cognitive system is overloaded (e.g., taxed working memory). Based on the findings of the current study, it appears that this levels-of-processing framework (Cohen et al., 2002) for infants can be extended to emotion categorization in adults.

The results suggest that adults are biased to categorizing facial expressions with higher-level emotion labeling strategies. Thus, once a person detects a facial expression, they may automatically generate a label to describe that expression, and then use that label to categorize the emotion. In the current study, participants in the *Timed-No Label* condition likely bypassed this label generation step in order to respond within the allotted time, which resulted in less accurate emotion recognition. On the other hand, since participants in the *Untimed-No Label* condition had unlimited time to respond, they likely had time to generate the appropriate labels. Furthermore, since participants in the *Timed-Label* condition were primed with the emotion labels, they likely generated the appropriate labels quicker during the task, and thus facilitating their ability to accurately respond in the allotted time. Put another way, priming participants with emotion labels likely reduced the processing time needed to access the labels, thereby reducing cognitive load during the task and allowing for faster responses. This may explain why, when prompted with emotion labels, adults can quickly recognize facial expressions, even under cognitive stress (Tracy & Robbins, 2008).

The current findings have important methodological implications for the study of emotion categorization. First, the role of emotion labels/language in studies must be more explicitly defined and examined. In the current study, simply changing *one line* in the instructions (i.e., “sort facial expressions” vs. “sort *anger* and *disgust* facial expressions”) significantly increased participants’ sorting accuracy (i.e., *Timed-Label* condition). Since most emotion categorization studies utilize some degree of emotion language/labels (e.g., “is this person happy?”) and unlimited processing time, participants may have an unintentional cognitive processing boost. Thus, depending on the research questions, researchers may consider removing language from their tasks or explicitly measuring its effect.

Ultimately, we can revisit the theoretical debate about the nature of emotional expressions. The current study finds that facial expression categorization is influenced by a variety of factors, including perceptual cues, verbal labels, and cognitive load. This provides support for a constructed view of emotional expressions. Nevertheless, participants demonstrated high accuracy at categorizing these expressions under cognitive constraints, and facial mimicry led to improved accuracy. This may be taken as evidence for a more universal, evolutionary-based view of emotional expressions. However, these adult participants may have learned through considerable life experience how to identify emotional expressions quickly and accurately. Thus, studying such an age range may not provide answers to this particular debate in affective science. Future studies may consider the development of emotion categorization across the lifespan. The current study was informed by studies with preverbal infants (e.g., Ruba et al., in press; Quinn et al., 2011), demonstrating that infants could discriminate and categorize facial expressions without the use of language. Comparing and contrasting preverbal infants with verbal children and adults could provide valuable insights into the nature of emotional expressions, and to how emotion categorization abilities change over time, particularly in relation to language.

Tables and Figures

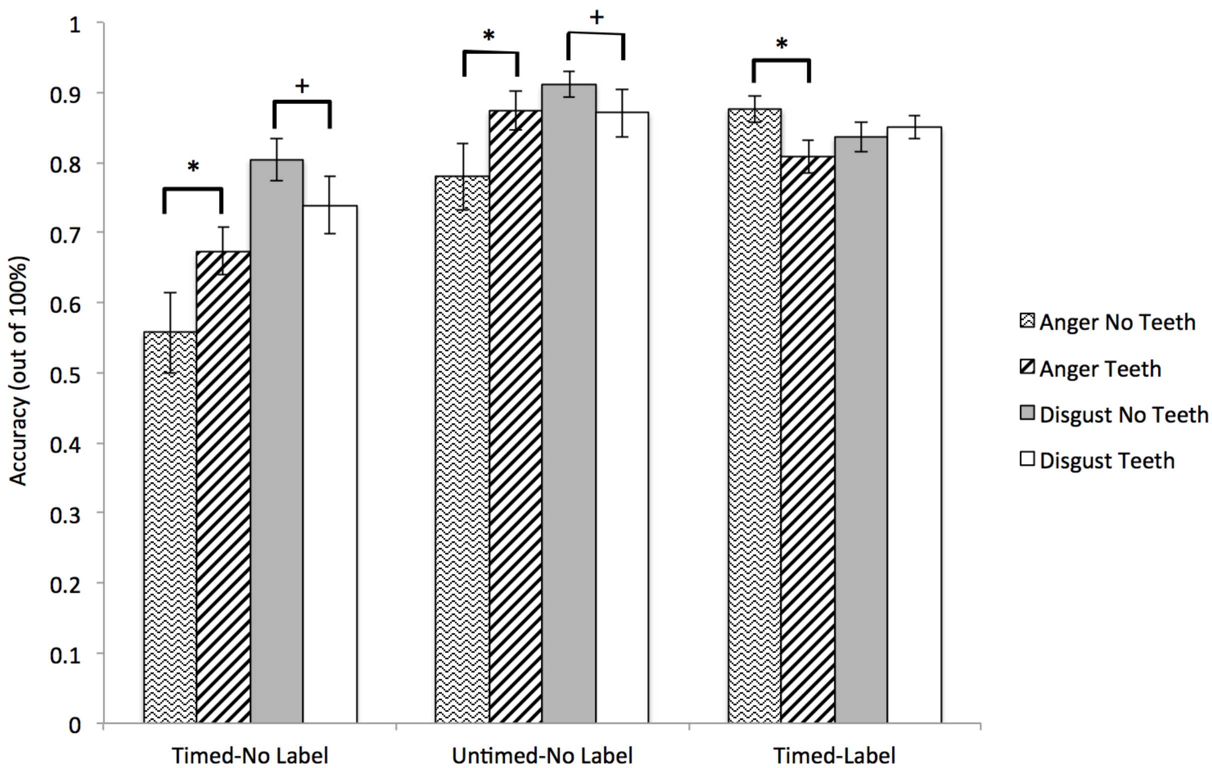
Table 1. *"What label best describes this face?" Number and percentage of participants in each condition who provided the correct response. N = 102; n = 34 for each condition*

Face and Correct Label		**Condition**			**Total**
		Timed-No Label	Untimed-No Label	Timed-Label	
	"Anger"	27 (.79)	31 (.91)	28 (.82)	86 (.84)
	"Disgust"	26 (.76)	31 (.91)	27 (.79)	84 (.82)

Table 2. *"What strategy did you use to sort the faces?" Number and percentage of participants in each condition who reported using certain strategies during the task. N = 102; n = 34 for each condition*

Strategy	**Condition**			**Total**
	Timed- No Label	Untimed- No Label	Word- Label	
Emotion Labeling	19 (.56)	30 (.88)	25 (.73)	74 (.72)
Perceptual Feature	12 (.35)	4 (.12)	5 (.15)	21 (.21)
Other Assorted	3 (.09)	0 (.00)	4 (.12)	7 (.07)

Figure 1. *Average sorting accuracy (and standard errors) split by experimental condition and type of face sorted; *p < .05, +p < .10*



References

Barrett, L. F., Lindquist, K. A., & Gendron, M. (2007). Language as context for the perception of emotion. *Trends in Cognitive Sciences*, *11*(8), 327-332. doi: 10.1016/j.tics.2007.06.003

Blairy, S., Herrera, P., & Hess, U. (1999). Mimicry and the judgment of emotional facial expressions. *Journal of Nonverbal Behavior*, *23*(1), 5-41. doi: 10.1023/A:1021370825283

Bornstein, M. H., & Arterberry, M. E. (2003). Recognition, discrimination and categorization of smiling by 5-month-old infants. *Developmental Science*, *6*(5), 585-599. doi: 10.1111/1467-7687.00314

Bourgeois, P. & Hess, U. (2008). The impact of social context on mimicry. *Biological Psychology*, *77*(3), 343-352. doi: 10.1016/j.biopsycho.2007.11.008

Cannon, P. R., Hayes, A. E., & Tipper, S. P. (2009). An electromyographic investigation of the impact of task relevance on facial mimicry. *Cognition and Emotion*, *23*(5), 918-929. doi: 10.1080/02699930802234864

Caron, R. F., Caron, A. J., & Myers, R. S. (1985). Do infants see emotional expressions in static faces? *Child Development*, *56*(6) 1552-1560. doi: 10.2307/1130474

Carroll, J. M., & Russell, J. A. (1996). Do facial expressions signal specific emotions? Judging emotion from the face in context. *Journal of Personality and Social Psychology*, *70*(2), 205-218. doi: 10.1037/0022-3514.70.2.205

Dimberg, U. (1982). Facial reactions to facial expressions. *Psychophysiology*, *19*(6), 643-647. doi: 10.1111/j.1469-8986.1982.tb02516.x

Dimberg, U., Thunberg, M., & Elmehed, K. (2000). Unconscious facial reactions to emotional facial expressions. *Psychological Science*, *11*(1), 86-89. doi: 10.1111/1467-9280.00221

Ekman, P. (1992). An argument for basic emotions. *Cognition & Emotion*, *6*(3-4), 169-200. doi: 10.1080/02699939208411068

Ekman, P., & Friesen, W. V. (1978). *Facial action coding systems*. Palo Alto, CA: Consulting Psychologists Press.

Fugate, J. M. (2013). Categorical perception for emotional faces. *Emotion Review*, *5*(1), 84-89. doi: 10.1177/1754073912451350

Hess, U., & Blairy, S. (2001). Facial mimicry and emotional contagion to dynamic emotional facial expressions and their influence on decoding accuracy. *International Journal of Psychophysiology*, *40*(2), 129-141. doi: 10.1016/S0167-8760(00)00161-6

Hofmann, W., & Van Dillen, L. (2012). Desire The New Hot Spot in Self-Control Research. *Current Directions in Psychological Science*, *21*(5), 317-322.

Izard, C. E. (1971). *The face of emotion.* New York, NY: Appleton-Century-Crofts.

Kotsoni, E., de Haan, M., & Johnson, M. H. (2001). Categorical perception of facial expressions by 7-month-old infants. *Perception, 30*(9), 1115-1125. doi: 10.1068/p3155

Lanzetta, J. T., & Englis, B. G. (1989). Expectations of cooperation and competition and their effects on observers' vicarious emotional responses.*Journal of Personality and Social Psychology*, *56*(4), 543-554. doi: 10.1037/0022-3514.56.4.543

Lindquist, K. A., & Gendron, M. (2013). What’s in a Word? Language Constructs Emotion Perception. *Emotion Review, 5*(1), 66-71. doi: 10.1177/1754073912451351

Lindquist, K. A., Gendron, M., Barrett, L. F., & Dickerson, B. C. (2014). Emotion perception, but not affect perception, is impaired with semantic memory loss. *Emotion*, *14*(2), 375-387. doi: 10.1037/a0035293

Lindquist, K. A., Satpute, A. B., & Gendron, M. (2015). Does language do more than communicate emotion? *Current Directions in Psychological Science*, *24*(2), 99-108. doi: 10.1177/0963721414553440

Lundqvist, D., Flykt, A., & Öhman, A. (1998). The Karolinska directed emotional faces (KDEF). (*Available from Department of Clinical Neuroscience, Psychology Section, Karolinska Institutet*).

Montague, D. P., & Walker–Andrews, A. S. (2002). Mothers, fathers, and infants: The role of person familiarity and parental involvement in infants' perception of emotion expressions. *Child Development*, *73*(5), 1339-1352. doi: 10.1111/1467-8624.00475

Neal, D. T., & Chartrand, T. L. (2011). Embodied emotion perception amplifying and dampening facial feedback modulates emotion perception accuracy. *Social Psychological and Personality Science*, *2*(6), 673-678. doi: 10.1177/1948550611406138

Niedenthal, P.M. (1992). Affect and social perception: On the psychological validity of rose-colored glasses. In R.F. Bornstein & T.S. Pittman (Eds.), Perception without awareness. New York: Guilford Press.

Niedenthal, P. M. (2007). Embodying emotion. *Science*, *316*(5827), 1002-1005. doi: 10.1126/science.1136930

Oberman, L. M., Winkielman, P., & Ramachandran, V. S. (2007). Face to face: Blocking facial mimicry can selectively impair recognition of emotional expressions. *Social Neuroscience*, *2*(3-4), 167-178. doi: 10.1080/17470910701391943

Parker, S. W., & Nelson, C. A. (2005). The impact of early institutional rearing on the ability to discriminate facial expressions of emotion: An event- related potential study. *Child Development*, *76*(1), 54-72. doi: 10.1111/j.1467-8624.2005.00829.x

Pitcher, D., Garrido, L., Walsh, V., & Duchaine, B. C. (2008). Transcranial magnetic stimulation disrupts the perception and embodiment of facial expressions. *Journal of Neuroscience*, *28*(36), 8929-8933. doi: 10.1523/JNEUROSCI.1450-08.2008

Pochedly, J. T., Widen, S. C., & Russell, J. A. (2012). What emotion does the “facial expression of disgust” express? *Emotion, 12*(6), 1315-1319. doi: 10.1037/a0027998

Quinn, P. C., Anzures, G., Izard, C. E., Lee, K., Pascalis, O., Slater, A. M., & Tanaka, J. W. (2011). Looking across domains to understand infant representation of emotion. *Emotion Review*, *3*(2), 197-206. doi: 10.1177/1754073910387941

Quinn, P. C., & Eimas, P. D. (1997). A reexamination of the perceptual-to-conceptual shift in mental representations. *Review of General Psychology*, *1*(3), 271-287. doi: 10.1037/1089-2680.1.3.271

Rives Bogart, K., & Matsumoto, D. (2010). Facial mimicry is not necessary to recognize emotion: Facial expression recognition by people with Moebius syndrome. *Social Neuroscience*, *5*(2), 241-251. doi: 10.1080/17470910903395692

Ruba A., Johnson, K., Harris, L., & Wilbourn, M. (in press). Developmental changes in infants’ categorization of anger and disgust facial expressions. Accepted for publication in *Developmental Psychology*.

Russell, J. A., & Widen, S. C. (2002). A Label Superiority effect in children's categorization of facial expressions. *Social Development, 11*(1), 30-52. doi: 10.1111/1467-9507.00185

Shariff, A. F., & Tracy, J. L. (2011). What are emotion expressions for?. *Current Directions in Psychological Science*, *20*(6), 395-399. doi: 10.1177/0963721411424739

Stel, M., & van Knippenberg, A. (2008). The role of facial mimicry in the recognition of affect. *Psychological Science*, *19*(10), 984-985. doi: 10.1111/j.1467-9280.2008.02188.x

Tracy, J. L., & Robins, R. W. (2008). The automaticity of emotion recognition. *Emotion*, *8*(1), 81-95. doi: 10.1037/1528-3542.8.1.81

Waxman, S. R., & Markow, D. B. (1995). Words as invitations to form categories: Evidence from 12-to 13-month-old infants. *Cognitive Psychology*, *29*(3), 257-302.

Widen, S. C. (2013). Children's Interpretation of Facial Expressions: The Long Path from Valence-Based to Specific Discrete Categories. *Emotion Review, 5*(1), 72-77. doi: 10.1177/1754073912451492

Widen, S. C., & Russell, J. A. (2008). Children acquire emotion categories gradually. *Cognitive Development*, *23*(2), 291-312. doi: 10.1016/j.cogdev.2008.01.002

Widen, S. C., & Russell, J. A. (2013). Children's recognition of disgust in others. *Psychological Bulletin, 139*(2), 271-299. doi: 10.1037/a0031640

Van Dillen, L. F., Harris, L. T., van Dijk, W. W., & Rotteveel, M. (2014). Looking with different eyes: The psychological meaning of categorisation goals moderates facial reactivity to facial expressions. *Cognition and Emotion*. doi: 10.1080/02699931.2014.982514

Van Dillen, L. F., Heslenfeld, D. J., & Koole, S. L. (2009). Tuning down the emotional brain: an fMRI study of the effects of cognitive load on the processing of affective images. *Neuroimage*, *45*(4), 1212-1219.

Vygotsky, L. (1962). *Thought and Language*. Cambridge: MIT Press (Original Publication in 1934).