Categorization and understanding of facial expressions in 4-month-old infants[1]

TOSHINORI KANESHIGE[2]* and ETSUKO HARYU   *University of Tokyo*

Abstract: This study examined whether 4-month-olds ($N = 40$) could perceptually categorize happy and angry faces, and show appropriate behavior in response to these faces. During the habituation phase, infants were shown the same type of facial expressions (happy or angry) posed by three models, and their behavior in response to those faces was observed. During the test phase immediately after the habituation phase, infants saw a novel emotional expression and a familiar expression posed by a new model, and their looking times were measured. The results indicated that, although 4-month-olds could perceptually categorize happy and angry faces accurately, they responded positively to both expression types. These findings suggest that, although infants can perceptually categorize facial expressions at 4 months of age, they require further time to learn the affective meanings of the facial expressions.

Key words: infant, facial expression, categorization, affective meaning.

Facial expressions can indicate a person's inner emotional states and intentions (Kotsoni, de Haan, & Johnson, 2001). For example, an adult smiling at an infant may be willing to take care of the infant. In contrast, another adult with a sad facial expression may not be ready to take care of others. In this respect, the understanding of facial expressions may play an important role in interacting with others, particularly for infants, as they do not yet use language to communicate (Caron, Caron, & Myers, 1982; de Haan & Nelson, 1998; Kestenbaum & Nelson, 1990; Ludemann & Nelson, 1988; Nelson, 1987; Nelson & Dolgin, 1985). However, to effectively use facial expressions in interaction with others, infants require the following two abilities: (a) perceptual discrimination between facial expressions that have different affective meanings and (b) identification of the affective meaning of each facial expression. Therefore, the development of infants' understanding of others' facial expressions has been investigated focusing on these two aspects.

Regarding the ability to discriminate between different facial expressions, it is now well known that even neonates notice changes in the facial expressions of an individual (Field et al., 1983; Field, Woodson, Greenberg, & Cohen, 1982). However, for effective use of facial expression, the ability to discriminate between the different facial expressions of an individual is insufficient. Infants need to categorize the same type of facial expression posed by different individuals. Several studies have observed that infants can generalize a facial expression across multiple individuals by at least 7 months of age (Caron et al., 1982; Ludemann & Nelson, 1988; Nelson & Dolgin,

1985; Nelson, Morse, & Leavitt, 1979; Serrano, Iglesias, & Loeches, 1992, 1995). Bornstein and Arterberry (2003) reported that 5-month-olds who were habituated to the smiling faces of several different individuals showed a preference for a fearful face over another smiling face posed by a new model in the test phase. Serrano et al. (1995) observed that 4- to 6-month-old infants could discriminate happy faces from angry faces, concluding that infants at 4 months can perceptually categorize facial expressions.

However, the conclusions drawn by Serrano et al. (1995) seem unwarranted based on their analysis of data on 4- to 6-month-olds inclusively. Only the older infants might have contributed to these positive results. This seems likely when considering the findings of Caron et al. (1982), who observed that 4.0-month-olds failed to discriminate happy faces from surprised faces whereas 5.5-month-olds succeeded in the same task. To determine whether 4-month-olds can categorize happy and angry expressions, we must test only 4-month-old infants' ability to discriminate happy from angry faces.

The other ability that infants need in order to use facial expressions effectively in interactions with others is identification of the affective meanings of expressions. According to Serrano et al. (1995), 4- to 6-month-old infants showed positive behavior more frequently than negative behavior in response to happy faces. Furthermore, the infants produced positive behavior more frequently in response to happy faces than angry faces. Conversely, they showed negative behavior more frequently in response to angry faces than happy faces. Based on these results, Serrano et al. (1995) stated that infants at 4 months can identify the affective meanings of these expressions. However, given that the age group tested comprised 4- to 6-month-olds, whether 4-month-olds understand the meaning of happy and angry expressions remains unclear.

Focusing exclusively on 4-month-old infants, the present study investigates whether they can perceptually categorize happy and angry faces, and further identify the affective meanings of these facial expressions. More specifically, the infants were presented with the same type of facial expression (happy or angry) posed by three models during the habituation phase. During the test phase immediately after the habituation phase, two facial expressions, one the same as the habituation phase and the other different, were posed to the infant by a new model. The length of time that the infants looked at each of these facial expressions was measured. Furthermore, to examine their understanding of either a positive or negative meaning, we observed the infants' behavior in response to the presented facial expressions during the habituation phase.

Looking significantly longer at an expression in the test phase that differed from the expression presented in the habituation phase should indicate that 4-month-olds can perceptually categorize happy and angry faces. Additionally, if the infants reacted differently to happy and angry faces, and their responses matched the valence of those facial expressions, this would support the view of Serrano et al. (1995) that infants at 4 months of age can perceptually categorize facial expressions as well as respond in consonance with the valence of those expressions. If infants did not show differing reactions to happy and angry faces despite looking longer at the different facial expression in the test phase, this would support the view proposed by Quinn et al. (2011) that infants first perceptually categorize facial expressions and then learn the affective meanings of those expressions. If the 4-month-olds neither looked longer at different expressions in the test phase nor responded differently to happy and angry faces, this would suggest that infants at 4 months neither categorize facial expressions nor identify the affective meanings of those facial expressions.

Method

Participants

Forty healthy, full-term 4-month-olds (20 boys and 20 girls, M = 4 months and 16 days, SD = 8 days) participated in the experiment, with half of the infants (10 boys and 10 girls)

assigned to the happiness condition, and the other half to the anger condition. An additional six 4-month-olds were excluded from the analysis because of fussiness (4 infants) and experimenter error (2 infants). Infants were recruited through public notices or our internet page and given a token for participation. All the participants lived in Tokyo.

Stimuli
Ten colored pictures of facial expressions were used as stimuli (see Appendix), consisting of two facial expressions, happiness and anger, posed by five female models (aged 23–29 years; $M = 25$ years). As the infants in our sample were reared by Japanese caregivers, we used pictures of Japanese female models. To avoid the problem of infants discriminating between facial expressions depending on the presence of teeth, the models were instructed to pose with their mouths closed. Furthermore, they were instructed to remove their earrings and glasses, but their hair was not excluded from the stimuli. Before depicting the facial expressions, the models were shown samples of happy and angry faces taken from the study of Ekman and Friesen (1975), and they practiced these expressions in front of a mirror. To ascertain the validity of the stimuli, 10 mothers (aged 30–41 years) whose infants had participated in other experiments, were asked to select, for each picture, the closest emotional label from three options (happy, neutral, and angry), and to evaluate the emotional valence of the facial expressions in each picture using a 7-point Likert scale (1 = *very negative*; 7 = *very positive*). All five happy faces used in the experiment were labeled as "happy" over 80% of the time (range = 80–100%), and all the angry faces were labeled as "angry" over 80% of the time (range = 80–100%). As for the evaluation of emotional valence, the average scores were calculated for each of the happy and angry expressions, and five *t*-tests were conducted to compare the evaluation of a happy expression with that of an angry expression for each model. These tests revealed that a happy face was evaluated as being more positive than an angry face for all models (ps < .01). The happy

and angry faces used as stimuli therefore clearly differed from one another in their affective meanings.

Apparatus and procedure
Infants were shown the stimuli while sitting in a baby sling worn by their caregivers, who sat in a chair in a fixed position in the experimental room. Caregivers were instructed not to interact with their infants. The stimuli were presented on a 17-in. display at a distance of approximately 60 cm from the infants' faces, using Habit X 1.0 software (Cohen, Atkinson, & Chaput, 2000) on a Macintosh computer. All the faces were approximately 16 cm high and similar in size to an adult face, and were displayed against a gray background. A digital video camera underneath the display recorded infants' responses during stimulus presentation at 30 frames per second and, through this camera, the experimenter could observe the infants' behavior from an adjacent room.

We used an infant-controlled habituation procedure. Infants were randomly assigned to one of the two conditions, the happiness condition or the anger condition. In the happiness condition, infants were presented with the happy faces of three females (models 1, 2, and 3), shown one at a time in each trial during the habituation phase. The infants in the anger condition were habituated to angry faces of the same three models in the same manner as in the happiness condition. In both conditions, the three faces were presented in a randomized block design. Each trial ended when infants looked away from the stimuli for a minimum of 2 s or when the trial had lasted for a period of 20 s. The criterion of habituation was that the average looking times in three consecutive trials decreased to less than 50% of those in the most attentive three trials. All the infants met the criterion before reaching the 20th habituation trial. Immediately after the infants had met this criterion, the test phase began. During the test phase, infants saw a happy and an angry expression posed by a fourth female model whom they had not seen during the habituation phase. During the test phase, half of the infants in the happiness and anger conditions saw the

happy and angry faces of model 4, and the other half saw those of model 5. Stimuli were presented one at a time, and the order of presentation of the two facial expressions was counterbalanced across the infants. On the same test trial, infants in the happiness condition saw the happy facial expression posed by a new model, and infants in the anger condition saw the angry facial expression posed by a new model. On a different test trial, infants in the happiness condition saw the angry expression posed by a new model, and infants in the anger condition saw the happy expression posed by a new model. The same model was used in both the same and different test trials.

Coding

Infants' looking times and behavior were coded off-line by an observer who was blind to the facial expressions being presented to the infants. More specifically, looking times were calculated for each habituation and test trial by counting the number of frames that the infant attended to the stimuli. Infants' behavior during the habituation phase was coded as positive or negative according to the criteria of Serrano et al. (1995). That is, infants' behavior was coded as positive when they showed a smile (defined as narrowed eyelids and retracted lip corners) and/or moved toward the monitor with their head, trunk, or hands. Avoidance behavior, such as leaning backward and frowning, was coded as negative behavior. The number of frames in which the infants produced the target behavior was also counted. A positive behavior score was determined by calculating the number of frames in which infants showed positive behavior divided by the total number of frames in which infants attended to the visual stimuli during the habituation phase. The score for negative behavior was calculated in the same manner.

To establish inter-observer reliability, a second observer also judged infants looking and behavior off-line for approximately 20% of the participants. The correlation coefficients were $r = .99$ for looking times and $r = .93$ for both the positive and negative behavior scores.

Results

Preliminary analyses did not observe any significant effects for participant gender, model, or order of presentation during the test phase. Data were then collapsed over these variables.

Looking times during the habituation phase

Four-month-olds in the happiness condition had become habituated in an average of 9.00 trials ($SD = 3.49$) and those in the anger condition in an average of 9.75 trials ($SD = 4.39$). A two-tailed t-test to compare differences in mean score was conducted, and found no significant difference, $t(38) = 0.60, p = .55$, and $d = 0.10$. The mean total looking times during the habituation phase were 64.66 s ($SD = 31.55$) in the happiness condition and 85.47 s ($SD = 54.40$) in the anger condition. A further two-tailed t-test indicated that the difference was not statistically significant ($t(38) = 1.48, p = .15, d = 0.23$).

Looking times during the test phase

Figure 1 shows the looking times for 4-month-olds averaged across the last three habituation
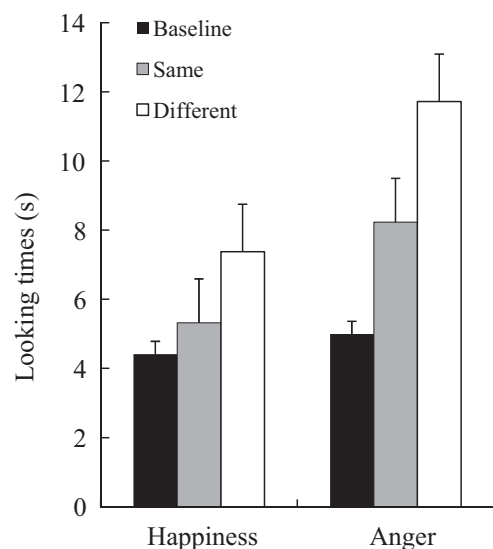

Figure 1 Infants' looking times on the baseline, the same test trial, and the different test trial (mean + *SE*).

trials (the baseline), and those on the different and same test trials. The looking times were submitted to a 2×3 analysis of variance (ANOVA) with condition (happiness, anger) as a between-participants factor and trial (the baseline, the same test trial, the different test trial) as a within-participants factor.

The ANOVA revealed the main effect of condition, $F(1, 38) = 6.35$, $p < .05$, $\eta_p^2 = .14$, and the main effect of trial, $F(2, 76) = 11.64$, $p < .01$, $\eta_p^2 = .24$. A condition × trial interaction did not reach statistical significance, $F(2, 76) = 1.61$, $p = .18$, $\eta_p^2 = .05$. The main effect of condition indicated that the infants in the anger condition showed longer looking times than the infants in the happiness condition. What was more important, however, was the main effect of trial. Post hoc pairwise comparisons using Ryan's method revealed that 4-month-olds showed longer looking times on the different test trial compared with the baseline and the same test trial (ps < .05). The difference between the looking time on the same test trial and that on the baseline was not significant ($p < .10$).

Infants' behavior during the habituation phase

Before analyzing the data, scores for the duration of each behavioral category were transformed into percentages of the total looking time in the habituation phase (Figure 2). The percentages were submitted to a 2×2 ANOVA with condition (happiness/anger) as a between-participants factor and type of behavior (positive/negative) as a within-participants factor.

The analysis found only a main effect of type of behavior, $F(1, 38) = 12.74$, $p < .01$, $\eta_p^2 = .25$. Neither the main effect of condition nor the interaction, $F(1, 38) = 0.46$, $p = .50$, $\eta_p^2 = .01$, and $F(1, 38) = 1.04$, $p = .31$, $\eta_p^2 = .03$, respectively, reached statistical significance. The main effect of behavior type showed that the 4-month-olds in both conditions produced more positive than negative behaviors. That is, they were more likely to respond positively to human faces regardless of facial expression.

Discussion

The present study investigated whether 4-month-olds could perceptually categorize happy and angry faces, and respond to those facial expressions appropriately. Regarding the ability to categorize happy and angry faces perceptually, the results indicated that 4-month-olds do have this ability. That is, 4-month-olds who were habituated to three happy faces looked longer at an angry face posed by a fourth model than at another happy face during the test phase. Similarly, those who saw angry faces during the habituation phase showed longer looking times at a happy face than at another angry face in the test phase. The present research thus confirmed that 4-month-olds perceptually categorize facial expressions.

However, these findings are not consistent with two other studies that indicated 4-month-olds could not generalize facial expressions to a new model. One such study by Caron et al. (1982) found that 4-month-olds did not form a category of happy faces that contrasted with a category of surprised faces. The discrepancy between Caron et al. (1982) and the present study suggest that it is easier for 4-month-olds to discriminate happy versus angry expressions
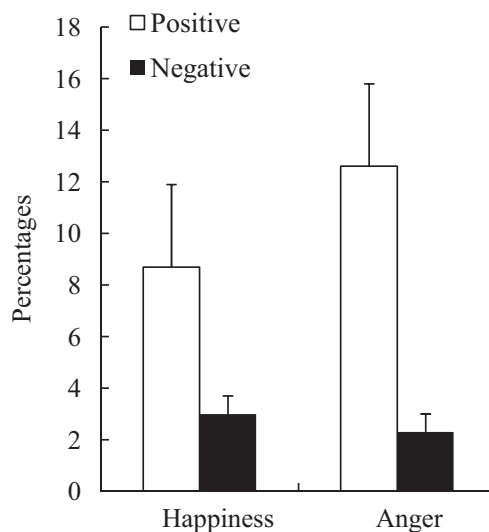

Figure 2 Percentage of target behaviors during the habituation phase (mean + *SE*).

than to discriminate happy versus surprised expressions. In fact, Yamada (1993) suggested that the perceptual contrast between happy and angry faces is steeper than that between happy and surprised faces. On happy faces, the outer ends of eyebrows and eyes are pulled down, while at the same time, the lip corners are lifted. On angry faces, the outer ends of eyebrows and eyes are lifted upward, and the lip corners are slanted downward. Thus, facial elements are moved in opposite directions in happy and angry faces. However, surprised faces are perceptually discriminated from happy faces just through the degree of openness of facial elements. Eyes and mouth are opened more widely on surprised faces than on happy faces. Such perceptual discriminability between facial expressions may influence the time at which infants begin to develop the ability to discriminate between those facial expressions.

Another study showing inconsistencies with the present findings is that of Phillips, Wagner, Fells, and Lynch (1990). This study demonstrated a failure to discriminate between happy and angry faces among 7-month-olds. However, their method using pictures of facial expressions posed by eight models including males and females is likely to account for the results, as other studies using a maximum of five models have successfully demonstrated that 7-month-old infants can categorize facial expressions (Caron et al., 1982; Ludemann & Nelson, 1988; Nelson et al., 1979; Nelson & Dolgin, 1985; Serrano et al., 1995). The great variety in facial models in the study by Phillips et al. (1990) might have made it more difficult for infants to find the core features of the facial expression. Whether an infants' ability to perceptually categorize facial expressions is detected might therefore depend partly on both the experimental method adopted by researchers and the contrast of emotion in the expressions presented.

In the current study, 4-month-olds in both conditions produced more positive than negative behaviors. This might suggest that infants understand the affective meaning of happy faces, but not that of angry faces. However, given that the infants did not show different behavioral responses to different facial expressions, we cannot exclude the possibilities that infants at this age just behave positively to human faces regardless of their facial expressions, or that infants fixed on their caregivers' bodies with a baby sling felt some comfort during the experiment. Given that infants did not respond differently to the two types of facial expressions, the present results suggest that 4-month-olds did not identify the meaning of facial expressions of anger or happiness. This contrasts with the study of Serrano et al. (1995) that tested 4- to 6-month-olds as a group and found that the infants responded differently to happy and angry faces. The infants in their study showed positive behavior more frequently than negative behavior in response to happy faces, and produced negative behavior as frequently as positive behavior in response to angry faces. These results, however, might have been obtained because Serrano et al. (1995) tested and analyzed 4- to 6-month old infants as a group. In the current study, focusing only on 4-month-olds, we revealed that they might not have learned the affective meanings of happy and angry faces.

The results showed that 4-month-olds succeeded in perceptually discriminating happy faces from angry faces, although they failed to respond differently to either expression. These results converge with the proposal that infants first learn how to categorize facial expressions perceptually and then develop more conceptual discrimination through various experiences with perceptual categories (Quinn et al., 2011). These researchers regarded categorization of facial expressions as an example of object categorization. Studies examining infants' object categorization have shown that even within the first 3–5 months of life, infants can categorize objects perceptually, for example animals and vehicles, without any former experience or knowledge of them. Indeed, 3- to 7-month-olds successfully categorized cats and dogs, although they do not know that cats like to eat tuna and bear kittens (Mareschal & Quinn, 2001; Quinn, 2008). Infants may first learn how to categorize facial expressions perceptually, and then how to respond to different types of facial expressions

through experience, as is the case with object categorization.

In the present study, we focused on the distinction between happy and angry faces, and observed that infants as young as 4 months of age could perceptually discriminate between these two facial expressions. However, discrepancies between this and other findings, such as those of Caron et al. (1982), may reflect the order and developmental trajectory in which infants can recognize the facial expressions of various emotions. Future research should focus on contrasts between facial expressions of different emotions to better ascertain factors affecting infants' categorization of facial expressions. Furthermore, the present research observed that 4-month-olds did not react differently to happy and angry faces. Future research should test infants aged 5 months or older to find the age at which infants begin to show the ability to identify the meanings of facial expressions.

References

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

Caron, R. F., Caron, A. J., & Myers, R. S. (1982). Abstraction of invariant face expressions in infancy. *Child Development*, *53*, 1008–1015.

Cohen, L. B., Atkinson, D. J., & Chaput, H. H. (2000). *Habit 2000: A new program for testing infant perception and cognition* [Computer software]. Austin, TX: University of Texas.

de Haan, M., & Nelson, C. A. (1998). Discrimination and categorization of facial expressions of emotion during infancy. In A. Slater (Ed.), *Perceptual development: Visual, auditory and language development in infancy* (pp. 287–309). London: UCL Press.

Ekman, P., & Friesen, W. V. (1975). *Unmasking the face: A guide to recognizing emotions from facial clues*. Englewood Cliffs, NJ: Prentice-Hall.

Field, T. M., Woodson, R. W., Cohen, D., Greenberg, R., Garcia, R., & Collins, K. (1983). Discrimination and imitation of facial expressions by term and preterm neonates. *Infant Behavior and Development*, *6*, 485–489.

Field, T. M., Woodson, R., Greenberg, R., & Cohen, D. (1982). Discrimination and imitation of facial expressions by neonates. *Science*, *218*, 179–181.

Kestenbaum, R., & Nelson, C. A. (1990). The recognition and categorization of upright and inverted emotional expressions by 7-month-old infants. *Infant Behavior and Development*, *13*, 497–511.

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

Ludemann, P. M., & Nelson, C. A. (1988). Categorical representation of facial expressions by 7-month-old infants. *Developmental Psychology*, *24*, 492–501.

Mareschal, D., & Quinn, P. C. (2001). Categorization in infancy. *Trends in Cognitive Sciences*, *5*, 443–450.

Nelson, C. A. (1987). The recognition of facial expressions in the first two years of life: Mechanisms of development. *Child Development*, *58*, 889–909.

Nelson, C. A., & Dolgin, K. G. (1985). The generalized discrimination of facial expressions by seven-month-old infants. *Child Development*, *56*, 58–61.

Nelson, C. A., Morse, P. A., & Leavitt, L. A. (1979). Recognition of facial expressions by seven-month-old infants. *Child Development*, *50*, 1239–1242.

Phillips, R. D., Wagner, S. H., Fells, C. A., & Lynch, M. (1990). Do infants recognize emotion in facial expressions?: Categorical and "metaphorical" evidence. *Infant Behavior and Development*, *13*, 71–84.

Quinn, P. C. (2008). In defense of core competencies, quantitative change, and continuity. *Child Development*, *79*, 1633–1638.

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*, 197–206.

Serrano, J. M., Iglesias, J., & Loeches, A. (1992). Visual discrimination and recognition of facial expressions of anger, fear, and surprise in 4- to 6-month-old infants. *Developmental Psychobiology*, *25*, 411–425.

Serrano, J. M., Iglesias, J., & Loeches, A. (1995). Infants' responses to adult static facial expressions. *Infant Behavior and Development*, *18*, 477–482.

Yamada, H. (1993). Visual information for categorizing facial expressions of emotions. *Applied Cognitive Psychology*, *7*, 257–270.

Appendix

Facial stimuli used in the present study

HAPPINESS

ANGER

Model 1   Model 2   Model3   Model 4   Model 5