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Infant Sensitivity to Emotional Behaviour Derived from Human Biological Motions

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Abstract: It has been reported that young infants recognise and discriminate human emotional expressions. They seem to prefer to look at facial expressions that are accompanied by matching vocal emotional expressions (Walker-Andrew, Montague, & Kahana-Kalman, 2000). Infants as young as 3.5 months are also sensitive to the moving figure of walking point light display-Biological Motions (Bertenthal, Proffitt, & Cutting, 1984). Whether or not infants' sensitivity to such human moving figures extends to emotional aspects of human behaviours was investigated. This study reports the preliminarily results on early understanding of human emotional behaviours inferred from Biological Motions presented on the screen monitor. Infants aged between 4 to 20 months were tested using a multimodal preferential looking paradigm in which two different Biological Motions, which depicted "happy" and "sad" were presented simultaneously with vocal expressions of either "happy" or "sad". Data collected so far suggest that infants seem to look longer at the Biological Motion that was congruent with the "happy" vocal expression. However, when infants heard the "sad" vocal expression, they preferred to look at the incongruent Biological Motion. The results were discussed with reference to the salience of Human Motion that might have triggered infants' sensitivity beyond their inferential understanding of human emotion from such Motion

Key words: intentionality, multimodal matching, biological motions

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INTRODUCTION

The growing interest in the study of human infants has advanced our knowledge of human development in various aspects. It is now accepted that infants have a sophisticated understanding of both the physical and social worlds at very early ages.

With respect to infant social understanding, a large body of studies suggests that infants are: sensitive to the direction of human eye gaze (Farroni, Massaccesi, Menon, & Johnson, 2007; Farroni, Massaccesi, Pividori, & Johnson, 2004; Farroni, Menon, & Johnson, 2006); able to perceive multimodal information derived from unfamiliar adult and child faces (Bahrick, Netto, & Hernandez-Reif, 1998); and are sensitive to social contingency and able to attend to preverbal communicative interactions with other human beings (Tronick, Als, Adamson, Wise, & Brazelton, 1978).

In order for human beings to communicate with one another, one needs to understand or at least to infer what the other is intending. Young infants' sophisticated social understanding identified in the recent studies could be regarded as precursors to such communicative skills.

Early understanding of emotion

Infants are also sensitive to emotional expressions of a familiar person such as their parents as early as 3.5 months of age (Montague & Walker-Andrews, 2002). Infants prefer to look longer at their mother with a happy face in concordance with a happy emotional voice when compared with an unfamiliar person displaying similar emotional facial and vocal expressions. Moreover, they found that infants prefer to look longer at the happy expression compared with the negative emotional expression; when infants were presented with other emotional expressions such as fear and surprise side by side, they showed no preference between them even though a familiar person was displaying such emotional expressions. They argue that contextual information derived from the familiar person facilitated infants understanding emotion. To confirm this claim, Walker-Andrews and her collaborators (Kahana-Kalman & Walker-Andrews, 2001; Montague & Walker-Andrews, 2002) tested this familiarity effect by comparing the infant's mother and father with unfamiliar male and female facial expressions. They found that generally infants prefer to look at their mothers' happy expressions than those of their fathers or an unfamiliar person. It was also found that the infants looking time when presented with their fathers' expression was positively correlated with amount of parental involvement in daily activities. Although a series of studies demonstrated early sensitivity to emotional expression in multimodal perception, one of the remaining questions that need to be addressed is why happy expressions were recognized easily and others were not. According to several studies, the amount of interpersonal experience that infants experience (= which is happy emotional expression) may have facilitated such recognition. However, another study (Caron, Caron, & MacLean, 1988) that investigated infants' ability to recognize emotional expressions suggest that it was not until 5 months of age that did infants were able to discriminate between naturalistic expressions of happiness and sadness. It was also found that even 7 months old infants could not discriminate emotional expressions between happiness and anger without multimodal information such as vision and voice. These results suggest that multimodal information may be vital for young infants in recognising and differentiating emotional expressions.

The implications of these studies are that the development of emotion understanding seems not to be straightforward and the amount of information available to infants (including familiarity) may influence how far they can understand emotional expressions in humans.

Human sensitivity to Biological Motion

Humans are seen to be very sensitive to Biological Motion. Since Johanson (1976) demonstrated that biological motions could be perceptually recognized accurately from point-light motion, numerous studies have advanced our understanding of human perception of information derived from biological motions for different sexes, emotional expressions, affects and personal identities (Loula, Prasad, Harber, & Shiffrar, 2005; Mather & Murdoch, 1994; Pollick, Lestou, Ryu, & CHo, 2002; Troje, Westhoff, & Lavrov, 2005). With reference to human perception of emotion displayed in the biological motion, Atkinson, Sittrich, Gemmell, and Young (2004) compared a full body expression of different emotions (happiness, sadness, disgust, fear, and anger) in point-light and full-light displays. Human perception of the emotion for disgust, fear and anger differ depending on lighting conditions but happiness and sadness were not dependent on lighting conditions. Moreover, the effect of movement quality in terms of exaggeration also differed depending on the type of emotion; the correct recognition of all emotions, excluding sadness, increased when the movement was exaggerated. These finding suggest that human perception of emotion involves different degree of salience for each emotion expression.

From a developmental perspective,Bertenthal, Proffitt, Spetner, and Thomas (1985) found that infants as young as 3 to 5 months are able to perceive biological motions presented in a point-light manner as something meaningful. More recently, Spencer, O'Brien, Johnston, and Hill (2005) found that infants of 4 to 8 months old are able to discriminate facial motions between individuals using biological motion cues. As seen in these studies, human sensitivity to biological motions seems to be in place very early in infants.

The present study was concerned with infant's emotional understanding of biological motions. If infants have a sophisticated socio-emotional understanding and a sensitivity to perceive biological motions at an early age, they may be able to perceive emotional expressions of biological motions from point-light motions. It was hypothesised that infants may be able to understand emotional expression in such biological motions at the same time when they start to perceive other people as emotional and psychological beings like themselves-which is often referred to as the beginning of understanding the intention of others. Thus this study addresses if infant are able to perceive and differentiate emotional expressions in biological motions around the same time as they develop their understanding of intention.

Experiment 1

METHOD

Participants

Thirty-five infants participated in the study. They fell into two age groups. Those infants whose ages ranged from four to nine months were grouped into a younger-age group (M=5.9 months, SD=1.4) and those aged ranged from 10 to 19 months were grouped into an older-age group (M=13.5 months, SD=3.7).

Production and validation of biological motion stimuli

Biological motions were produced from

video clips of a person who made overt motions of crying, jumping and skipping. In order to capture clear movements of the person, the actor wore small pieces of reflective tape that were attached to the body in a point-light manner. The video recoding took place in an infrared light mode in a semi dark room. The movie editing software Final Cut Pro (Apple inc.) was used to process the video recordings into the point-light action movies with a black background.

In order to validate these movie stimuli, each of the movies was presented to 64 female university students. Using the semantic differential method (Osgood, Suci, & Tannenbaum, 1957), the students were asked to rate impressions derived from each movie with 14 pairs of opposing adjectives along a 6 point-scale. The validation sessions took place in two groups. The order of the stimuli presentation was counterbalanced for each session. After rating the impressions derived from biological motions, they were also asked to infer what kind of motions the person was making. The results from this semantic differential method for the three biological motions will be reported in the results section.

The experiment consisted of two blocks. For each block, the stimuli presentation was initiated by showing a fixation figure in the centre of the screen with emotional voices for either crying or laughing. This lasted for 5 seconds and was followed by the simultaneous presentation of the biological motions for crying (="sad") and jumping (="happy") on either side of the screen. This presentation of the testing stimuli lasted for 20 seconds. After the first block of the experiments ended, there was a 5 second refreshing period in which an animated picture unrelated to the test stimuli was presented, before beginning the second block of the experiment (Figure 1).

The presentation of the biological motions on either side of the screen and the order in which the emotional voices accompanying with the visual stimuli were played were counterbalanced. The order of administering these two blocks was also counterbalanced. All phases of the stimuli presentation were controlled using a Keynote software.

The experiment was run on a PC (MacBook Pro, Apple inc.) with a 20-inch colour monitor. One video camera (Sony HDR-HC3 for NTSC) was used to record the infant's face and it was mounted on the top centre of the monitor. The video camera was connected to another PC (MacPro, Apple inc.) so that the infants face could be captured and monitored throughout the experiment as it was recorded. A chair for the child's parent was placed 70cm away form the monitor. Two room-partitioning screens (1.4m side and 1.5m tall) were placed on both sides of apparatus to minimise distraction for the infant. A full-length mirror was placed in a position to enable the camera to simultaneously capture a direct image of the infant's face and the reflection in the mirror of the screen image

Procedure

The experimental sessions took place when the infants were alert. An infant sat on their parent's lap facing the screen that was placed 70 cm away from the infant. Their parents were instructed not to speak to their infants, but to look at the centre of the screen so that the infants were not influenced or disturbed.

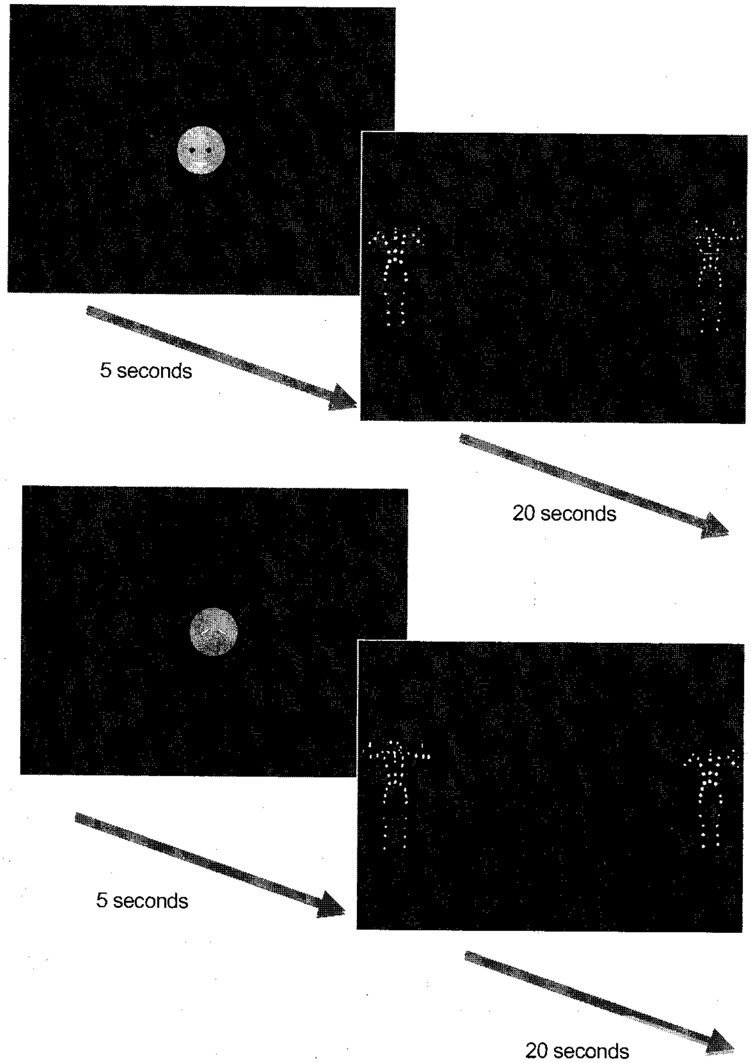

Figure 1. Schematic diagrams for the experimental stimuli apparatus

Before starting the experiment the infants were shown cartoon animations.

Data analysis

The infant's gaze directions were assessed frame by frame from the video recordings. If the infants averted their gaze from the monitor for more than 3 seconds, it was regarded as the point at which the infants were no longer interested in the stimuli and further recording frames were not included in the data analysis. The total number of valid frames was counted and the proportion of frames for which the infant gazed at each biological motion was calculated.

RESULTS AND DISCUSSION

Validation of biological motions for emotional sentiments

Mean ratings for each of the biological motions are summarised in Figures 2, 3, and 4. In order to evaluate the differences in the

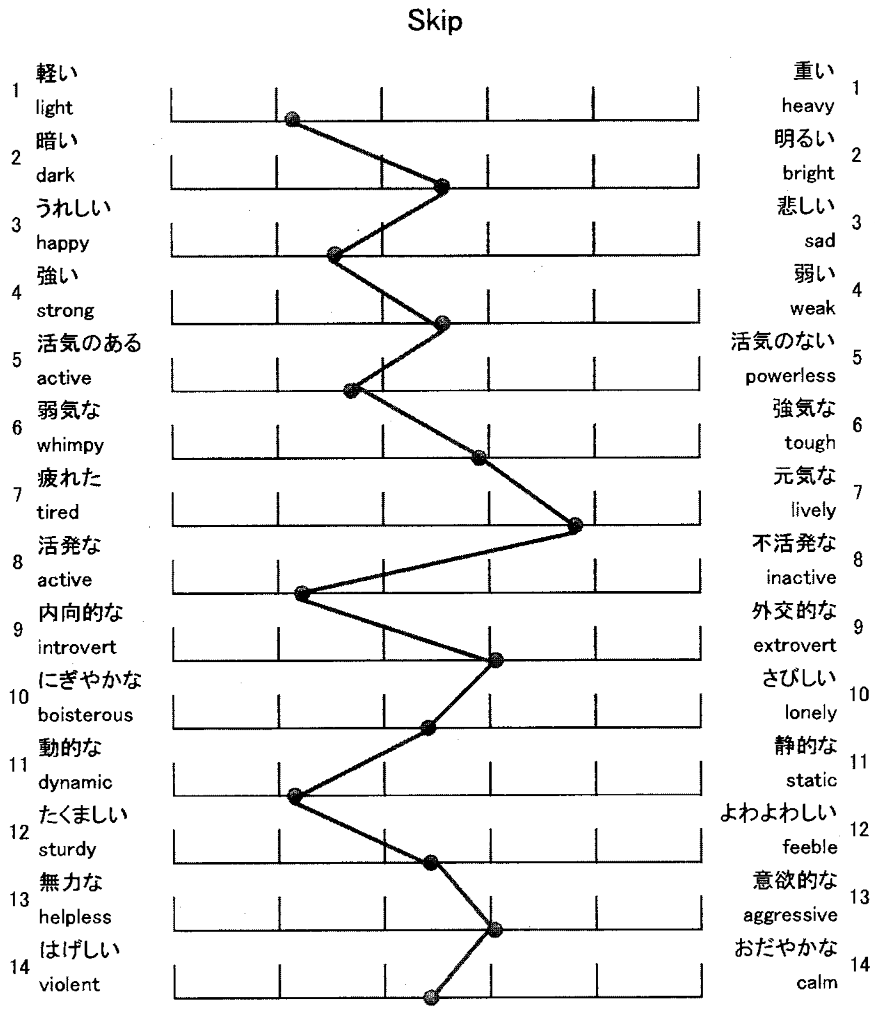

Figure 2. Impression from the biological motion for "Skipping"

students rating of impressions for three biological motions, an ANOVA of the three biological motions as repeated measures was carried out for the 14 pairs of opposing adjectives. For all adjective pairs, there were significant differences in the student ratings for the biological motions. Table 1 summarises the results of ANOVAs. These results indicate that each biological motion derives semantically different impressions. The biological motion for jumping appeared to show strong, active and happy impressions whereas the crying motion appeared to show dark, quiet and sad impressions. The skipping biological motion appeared to be located in between the other two motions.

Infant preference for biological motions as a function of emotional voices

In order to evaluate an infant's understanding of an emotional motion that corresponds to emotional voices, the infant's proportionate looking time at each biological motion was compared between the types of biological

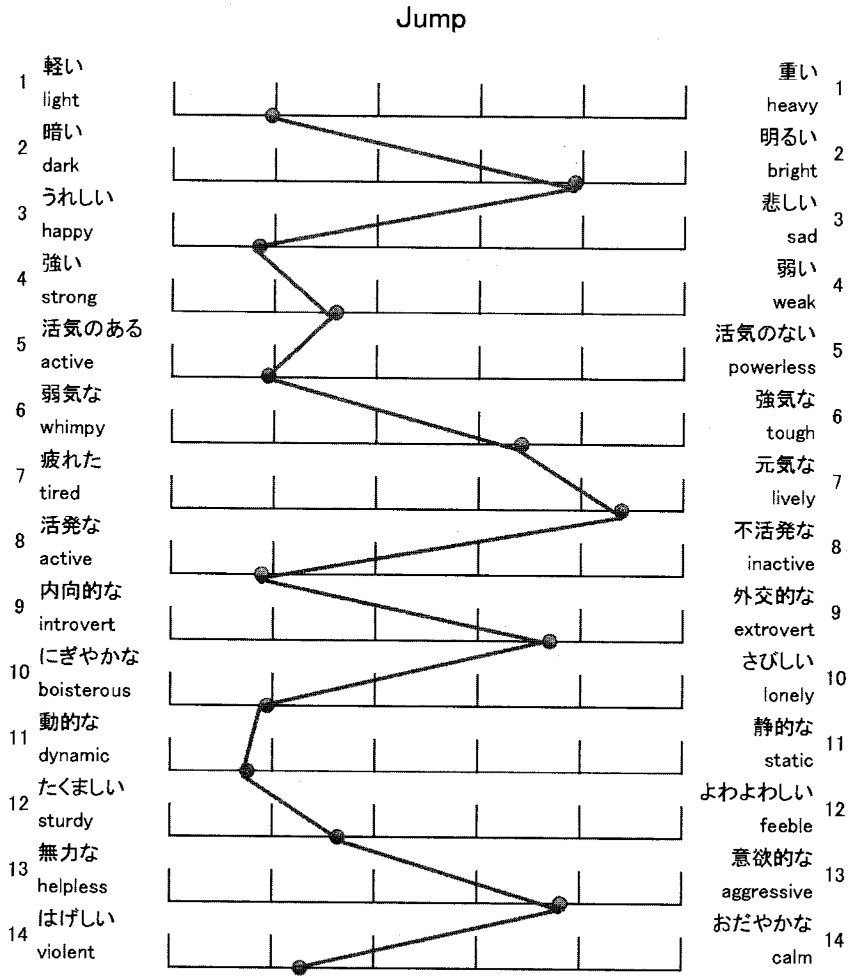

Figure 3. Impression from the biological motion for "Jumping"

motions and the emotional voices as a function of age. A mixed-design ANOVA for 2 (age groups) × 2 (biological motions: crying, jumping) × 2 (emotional voices: sad, happy) was carried out. Descriptive statistics are summarised in Table 2.

There was no significant main effects for voices: F (1, 33) = .43, n.s. but for actions: F (1, 33) = 28.37, p<.0001, ηp^2 = .46. There was no significant age group effect: F (1, 33) = .79, n.s. There was a significant interaction between voice and motion: F (1, 33) = 4.03, p = .053. However, there were no other significant two-way or three-way interactions involving motion type, age group and voice. With reference to the significant interaction between voice and motion type, simple effects were examined using the Bonferroni method. A significant interaction was due to a significant difference in infant looking time between the two motion conditions regardless of the accompanying emotional voices. These results suggest that, on the whole, infants from both age groups showed similar trends for looking preference;

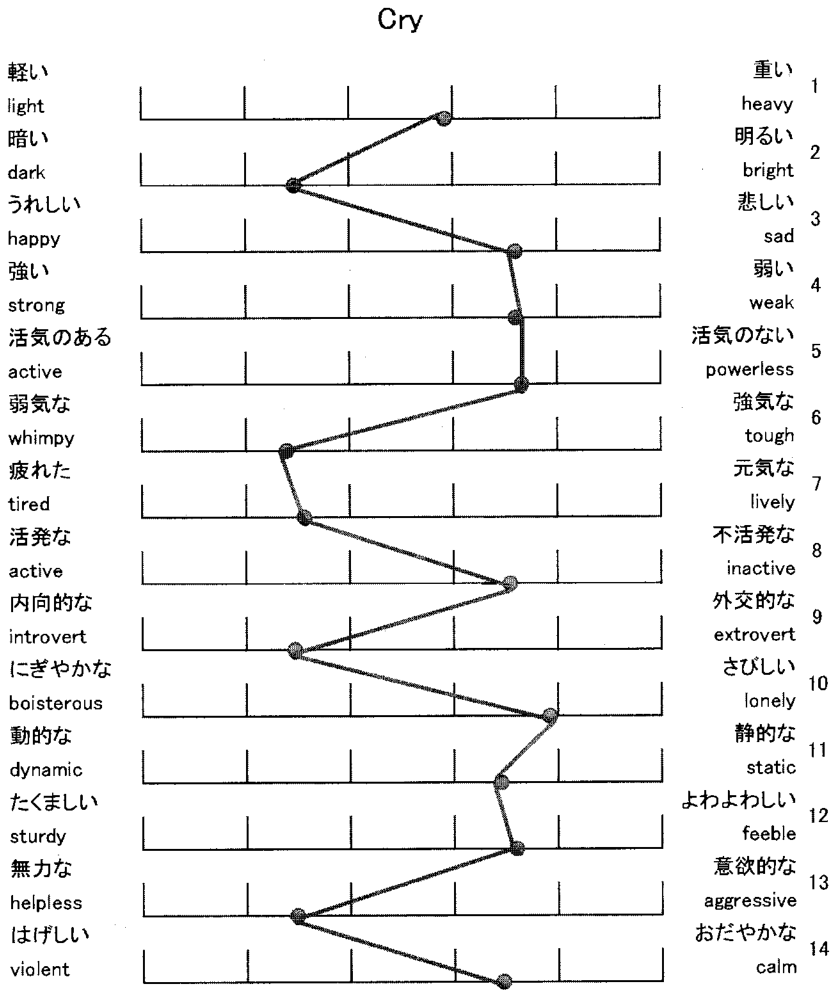

Figure 4. Impression from the biological motion for "Crying"

infants tended to look longer at the jumping motion rather than the crying motion when they heard either sad or happy voices. This indicates that the infants did not respond, as reflected in their looking preference, to the multimodal congruence between biological motions and appropriate emotional voices. There may be a possibility that infants were merely interested in the salience in the movement of biological motions.

Experiment 2

In order to test the possibility that infants prefer to look at biological motions that are more salient, the infants looking time for the skipping biological motion was compared with that for the jumping motion. Given that the adult ratings of impressions with reference to these two biological motions were significantly different, whether or not infants show a preference under the accompanying emotional voice is of interest. The experiment was carried out in a same way as experiment 1.

Table 1. Summary of the ANOVA results for Semantic Differentiation of three biological motions

1	軽い light	Jump		Skip	*	Cry	重い heavy	1	$F_{1.707, 107.54}=84.43$ $p<.0001$
2	暗い dark	Cry	*	Skip	*	Jump	明るい bright	2	$F_{2,126}=97.6$ $p<.0001$
3	うれしい happy	Jump	*	Skip	*	Cry	悲しい sad	3	$F_{2,126}=140.22$ $p<.0001$
4	強い strong	Jump	*	Skip	*	Cry	弱い weak	4	$F_{2,126}=63.16$ $p<.0001$
5	活気のある active	Jump	*	Skip	*	Cry	活気のない powerless	5	$F_{2,126}=127.88$ $p<.0001$
6	弱気な wimpy	Cry	*	Skip		Jump	強気な tough	6	$F_{2,126}=74.44$ $p<.0001$
7	疲れた tired	Cry	*	Skip	*	Jump	元気な lively	7	$F_{2,126}=140.09$ $p<.0001$
8	活発な active	Jump	*	Skip	*	Cry	不活発な inactive	8	$F_{2,126}=132.05$ $p<.0001$
9	内向的な introvert	Cry	*	Skip	*	Jump	外交的な extrovert	9	$F_{2,126}=86.13$ $p<.0001$
10	にぎやかな boisterous	Jump	*	Skip	*	Cry	さびしい lonely	10	$F_{2,126}=137.09$ $p<.0001$
11	動的な dynamic	Jump	*	Skip	*	Cry	静的な static	11	$F_{2,126}=130.69$ $p<.0001$
12	たくましい sturdy	Jump	*	Skip	*	Cry	よわよわしい feeble	12	$F_{2,126}=67.58$ $p<.0001$
13	無力な helpless	Cry	*	Skip	*	Jump	意欲的な aggressive	13	$F_{2,126}=85.86$ $p<.0001$
14	はげしい violent	Jump	*	Skip	*	Cry	おだやかな calm	14	$F_{2,126}=70.21$ $p<.0001$

Note *: significant difference was observed in the paired t-test comparisons using a Bonferonni method

Table 2. Descriptive statistics for proportionate infant looking time for biological motions (crying and jumping) as a function of age and emotional voices

Emotional voice	Biological Motion	AGE group	N	Mean	SD
Sad	Cry	Younger	18	0.203	0.185
		Older	17	0.322	0.234
		Total	35	0.260	0.216
	Jump	Younger	18	0.764	0.185
		Older	17	0.658	0.235
		Total	35	0.713	0.215
Happy	Cry	Younger	18	0.321	0.288
		Older	17	0.357	0.217
		Total	35	0.338	0.253
	Jump	Younger	18	0.654	0.296
		Older	17	0.626	0.219
		Total	35	0.641	0.258

METHOD

Participants

Twenty-four infants participated in the experiment. They fell into two age groups. Those infants whose ages ranged from four to nine months were grouped into a younger-age group (M=5.7 months, SD=1.9) and those aged from 10 to 19 months were grouped into the older-age group (M=14.2 months, SD=4.2).

Stimuli and apparatus

The stimuli presentation is identical to Experiment 1 except that the biological motion for crying was replaced by the skipping motion. The apparatus used for the Experiment 2 was identical to the Experiment 1.

RESULTS AND DISCUSSION

Infants' proportionate looking time for each type of biological motion was calculated and the descriptive statistics are summarised in Table 3. In order to evaluate an infant's understanding of the emotional motion that corresponds to emotional voices, the infants' proportionate looking time at each biological motion was compared between the two types of biological motions and the emotional voices as a function of age. A mixed-design ANOVA for 2 (age groups) × 2 (biological motions: skipping, jumping) × 2 (emotional voices: sad, happy) was carried out. There were no significant main effects or interactions involving age groups, voice and motions. The main effects for voice: $F(1, 22)=.18$, n.s., for motion: $F(1, 22)=.67$, n.s., and for age group $F(1, 22)=.79$, n.s. The interactions between voice and motion: $F(1, 22)=1.76$, n.s., between voice and age: $F(1, 22)=2.5$, n.s., between motion and age: $F(1, 22)=.00$, n.s., and the three-way interaction between age, motion and voice: $F(1, 22)=.51$, n.s. These results suggest that infants made no preference for the biological motions of skipping and jumping under the condition of accompanying emotional voices for either "sad" or "happy". Experiment 2 was carried out to examine the possibility that infants preferred to look longer at the biological motion that included salient features rather than to look at motions that are congruent with emotional voices. According to the

Table 3. Descriptive statistics for proportionate infant looking time for biological motions (skipping and jumping) as a function of age and emotional voices

Emotional voice	Biological Motion	AGE group	N	Mean	SD
Sad	Skip	Younger	12	0.535	0.305
		Older	12	0.592	0.218
		Total	24	0.563	0.261
	Jump	Younger	12	0.424	0.308
		Older	12	0.370	0.223
		Total	24	0.397	0.264
Happy	Skip	Younger	12	0.498	0.346
		Older	12	0.422	0.162
		Total	24	0.460	0.267
	Jump	Younger	12	0.485	0.342
		Older	12	0.526	0.155
		Total	24	0.506	0.260

adult rating, the skipping and jumping motions were rated as generally more positive and active than the crying motion. Infants seemed to attend to both the active motions similarly but not to the crying motion that appeared negative, inactive and clearly different from the former motions. This result is congruent with a previous study (Kahana-Kalman & Walker-Andrews, 2001) that reported infants' sensitivity to different emotional faces. Positive emotions displayed by a familiar person were perceived easily by very young infants, whereas negative emotions were not as easily recognised. An infants' ability to perceive emotional expression may be related not only to familiarity but also to the movement of facial features. Biological motions that contain large movements may be more likely to elicit awareness of a perceiver, even if one did not have an emotional representation underlying such motions.

GENERAL DISCUSSION

This study examined infants' sensitivity to emotional expressions derived from biological motion cues using the point-light motion movies. When infants heard the happy emotional voice, they preferred to look longer at the "happy" motion. However, when infants heard the sad emotional voice, they did not prefer to look longer at the "sad" motion; on the contrary, they preferred to look longer at the "happy" motion. These results suggest that infants might have preferred to look at the more active motions irrespective of matching emotional voices. This speculation was supported by the finding in Experiment 2. No clear evidence for multimodal matching for emotional expressions was found in the present study. This suggests two implications.

Firstly, in order to match emotional information derived from two modalities, one needs to have a form of emotional representation. On this criterion, it is possible to say that young infants who were in the middle of their second year have not yet developed sufficient emotional understanding. In the present study, emotional information derived from multimodal stimuli presented on the screen was not synchronized to prevent infants from relying on synchrony cues rather than emotional information. Under this condition, the infants' ability to match emotional information in a multimodal manner was tested. In this respect, we need to be cautious about what has been reported in the literature with reference to young infants' ability to perceive social information in the experimental setting. Infants are seen to be sensitive to changes in given information; occasionally this ability is much better than in adults'. However, infants' behaviour in responding differently to paired stimuli that are related to social milieu does not show that infants have a full-fledged social understanding. Previous findings that demonstrated young infant ability could be limited to certain information in real life. Therefore, when infants' ability to perceive emotion was examined, familiarity might have been a significant factor particularly when the infants are young. As to the question, when are infants able to perceive emotional information, no clear conclusions can be drawn from the current results. It is possible to say that a more sophisticated understanding of emotion may be developed later than some studies have reported.

Secondly, task difficulty needs to be taken into account when comparing the current results with those of previous studies. The main objective of the present study was to test infants' ability to perceive emotion using the point-light motion cues. As indicated above, multimodal matching of emotional information requires a certain level of representation; in addition, by presenting biological motions in a point-light manner, familiarity cues were taken away from the infants. With reference to human sensitivity to biological motions, despite the well-known and widely accepted phenomenon, this has been questioned in a recent study (Hiris, 2007). When carefully controlled stimuli were used to compare biological motions with non-biological, which was translated from biological motions, human perception was not highly sensitive to biological motions. When non-biological motions were presented with an underlying form, which biological motions normally have, and both the biological and non-biological motions were masked equally with random motions, human subjects performed better at detecting biological motions than non-biological motions. Thus, the early finding that human sensitivity to biological motion can be extended to early infancy may be overestimating infants' ability in this respect.

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