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Two Temperamental Characteristics, Approach and Inhibition/fear, and Saccadic Responses in Infancy

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Abstract

To examine early development of two aspects of individual differences in temperament, we assessed the saccadic eye movements of infants. As for the approach tendency (surgency), we examined the general speed of saccades. To study behavioral inhibition or fear, we examined the speed at which infants reorient their attention to a previously attended location (inhibition of return: IOR). Temperament was assessed by the Infant Behavior Questionnaire Revised (IBQ-R). Innate and learned fear scores were developed from IBQ-R fear scores. While a quick approach tendency was positively related to the extent of surgency across ages, no relationship was observed between fear or behavioral inhibition and IOR. However, the response numbers indicated some different effect of fearfulness in younger and older infants.

Key words: temperament, saccade, surgency, fear, inhibition of return.

Resumen

En el presente estudio se evaluaron los movimientos sacádicos de los ojos en bebés a fin de examinar el desarrollo temprano de dos aspectos de las diferencias individuales en temperamento. Se examinó la velocidad general de las sacadas como en la tendencia a la aproximación (extraversión). Para estudiar la inhibición conductual o miedo, examinamos la velocidad a la que los bebés reorientaban su atención a una localización atendida previamente (inhibición de retorno: IOR). El temperamento se evaluó mediante el Infant Behavior Questionnaire Revised (IBR-R). A partir de las puntuaciones IBR-R de miedo se desarrollaron puntuaciones de miedo innato y aprendido. Mientras que una rápida tendencia a la aproximación se relacionó positivamente a la extraversión a través de la edad, no se observaron diferencias entre miedo o inhibición conductual e IOR, Sin embargo, el número de respuestas indicó algun efecto diferencial de miedo en los bebés más jóvenes y en los mayores.

Palabras clave: temperamento, movimientos sacádicos, extraversión, miedo, inhibición de retorno.

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From birth, each infant has its own distinct characteristics and disposition that can be discerned and reported by parents as individual differences in temperament. Studies have found clear differences in extraversion or surgency in 2- to 4-month-old infants. Positive affect/surgency in infancy is reportedly predictive of extravert tendencies in seven-year-olds (Rothbart, Derryberry, & Hershey, 2000).

Later in the first year, immediate approach movements were replaced by periods of hesitation that signify a more or less prolonged reluctance to make contact with unfamiliar stimuli (Schaffer, Greenwood, & Parry, 1972). This relative increase in the elapsed time before contact might mark the beginning of wariness or fear response. The onset of wariness is considered to reflect the growing influence of the visual system and memory store in the processing familiarity. Fear-related inhibition reportedly shows at least a moderate continuity across childhood and is, to a certain extent, also related to certain aspects of adult personality (Kagan & Fox, 2006).

A theoretical single dimension extends from a rapid to a slower approach to inhibition or withdrawal as described in the approach-withdrawal dimension of Thomas and Chess (1977). However, based on Gray's constructs of behavioral inhibition and activation systems (BIS and BAS) (Gray, 1982), Rothbart posited two theoretical dimensions of behavior variability. One is the child's approach tendency, while the other is the inhibition of approaching or behavioral inhibition. In a longitudinal sample of infants (Rothbart, 1988) at 6.5 months, the speed of reaching out for two toys under high- and low-intensity/novelty conditions is considered to be primarily under the control of the approach component. Moreover, infants who approached sooner tended to generally express more positive affect. Near the end of the first year, the latency of an onset of approach was slower for high-novelty/intensity toys than for familiar low-intensity toys, with infants grasping the former more slowly, and with greater hesitation.

Regarding the independence of these two temperamental dimensions, Putnum and Stifter (2005) found that in toddlers a failure to approach together with negative affect might indicate strong activity of the inhibition system (BIS), whereas a nonapproach without fearful negativity could indicate a low-approach tendency. Likewise, an approach combined with positive affect could be a sign of an overactive behavioral activation system (BAS), whereas an approach in the absence of positivity might indicate a mild approach tendency and low inhibition. As a result of confirmatory factor analysis, they indicated a 3-dimensional model of positivity, negativity, and behavioral approach-inhibition. Moreover, among a sample of preschool-age children (mean age: 3.57±.3), Laptook *et al*. (2008) reported that a low approach which characterizes behavior inhibition is context-dependent and limited to novel situations, while such an approach with low positive affect is evident across most contexts regardless of the level of familiarity

In neuroscience, a broad approach dimension linked to positive affect could be related to the general function of dopamine activity (Panksepp, 1998). A likely neural substrate for fear is the amygdala (Ledoux, 1990), a structure possibly linked to the inhibition of approach (Kagan & Fox, 2006). Moreover, in recent behavioral genetic studies, an association between dopamine D4 receptor (DRD4) gene and the personality trait of novelty seeking (extraversion) (Golimbet, Alfimova, Gritsenko, & Ebstein, 2007), and one between a serotonin transporter promoter region polymorphism (5-HTTLPR) and fear and anxiety-related traits (Hayden *et al*., 2007) were reported. Furthermore, the interaction between alleles of the DRD4 and 5HTTLPR genes was reported in studies of both adults and infants (Lakatos *et al*., 2003). Since negative emotionality might have beneficial effects during tasks requiring controlled processing (Strobel *et al*., 2007), one of the genes involved in the phenotype of behavioral inhibition might constitute the first major temperamental control system over reactive approaches and actions.

While it is easy to measure approaches and inhibitions in voluntary behavior, such is not the case in studies of very young infants. In the present study, we therefore focused on the saccadic eye movement latency by which young infants often approach an unfamiliar stimulus. Hand movements come under attentional control later than eye movements (Posner & Rothbart, 1980). If eye movements reflect the same type of individual differences as reaching, individual differences in the speed of saccades might be negatively related to surgency as measured by parental reports.

IOR is a type of inhibition observable early in infancy (Posner & Cohen, 1984), one which produces a bias against reorienting attention to a recently attended location. When a spatial cuing paradigm is used, IOR is reliably observed when targets appear between 300 and 1300 ms after the onset of a peripheral cue. Facilitation of detection and saccades toward the cued location occurs when the target stimulus is presented very shortly after the cue offset. IOR, which is present even in newborns (Valenza, Simion, & Umilta, 1994) involves the superior colliculus (Sapir, Soroker, Berger, & Henik, 1999). Since the superior colliculus is involved in the generation of motor programs rather than being limited only to eye movements (Dringenberg, Dennis, Tomaszek, & Martin, 2003), it is reasonable to assume that it would play a role in the inhibition found in reaching for novel objects. That suggests two possibilities: more fearful children might exhibit more or less IOR depending on how they treat a return to the already intended area. If they regard it as a secure place they might be more likely to return and show less IOR, whereas if they are generally more inhibited they might be less likely to do so. Our study is directed toward determining which of these proves to be experimentally confirmed.

Since fear develops late, we might expect to observe inhibitions against approach only in older infants (Rothbart, 1988). On the other hand, Panksepp (1998) has noted the innate fear observed in children under 2 years who exhibit the greatest fear in response to sudden noises, strange objects, pain, and the loss of physical support. Although all such fears decline steadily with age, others develop only as the children mature, i.e., they only gradually develop a fear of strangers, animals, etc. Based on Panksepp (1998), we proposed two scores from the fear scale of a Revised Infant Behavior Questionnaire (IBQ-R: Gartstein & Rothbart, 2003), the revision of a widely-used parent-reported measure of infant temperament (IBQ: Rothbart (1981)). Although a limiting factor in the use of parent-reported questionnaires has been often pointed out, fear assessed in the laboratory proved significantly correlated with the fear score derived from parental reports on the IBQ-R (Gartstein & Marmion, 2008). Since item 94 (How often during the last week did the baby startle at a sudden change in body position?) and item 99 (How often during the last week did the baby startle upon a sudden or loud noise?) might represent innate fear, we calculated both the innate fear and learned fear scores.

Therefore, we first reanalyzed the fear scale scores of our Japanese IBQ-R data.

Here, we used the cross-sectional method to examine the phenomena of development. We predicted that infants rated higher in the broad dimension of surgency might show generally faster saccades, a tendency observed at both younger and older ages. On the other hand, learned fear could be applicable to fear which develops by the end of the first year of life and might be exhibited as an inhibition toward motor approach, while innate fear might emerge as an early individual difference. We hypothesized that infants who rated higher on the fear scale would exhibit more or less IOR depending on how they react to a previously attended cued side. Thus, if individual differences in fearful inhibition emerge in early infancy, some relationship should be observed between temperamental innate fear and IOR at a younger age. However, if fearful inhibition is well developed by the end of the first year, some relationship between temperamental learned fear and the latency of saccades would likely be discerned only in the older-age group. We used the innate fear scale at both younger and older ages, while reserving the learned fear scale only for the older age.

We also decided to use the number of responses to cued and non-cued sides as a dependent variable. We speculated that response numbers might be somehow related to infant reactivity, e.g., response numbers may well have decreased because of subsequent dropped responses, e.g., trials during which the infant was not looking at the centering stimulus when cues or targets appeared, eye movements not made directly to a target, etc. We considered that infant reactivity such as specific motor acts (hyperextensions, bursts and arching the back) and crying or fretting (Moehler *et al*., 2008) could be reasons for dropping responses or for lower response numbers in the present study.

Method

Participants

All Japanese samples resided in Nagoya, which is Japan's third largest industrial metropolis, is located near the center of Japan. Criteria for enrollment in the study were no known birth deficiencies or other kinds of complications, full term (more than 37 weeks gestation), and normal (2500 g- 4000 g) birth weights. Informed consent was obtained from parents. These studies were approved by the Ethics Committee of Nagoya City University and complied with the ethical standards specified in the 1964 Declaration of Helsinki.

Temperamental Scores on IBQ-R

This scoring instrument of 191 items assesses the frequency over the prior one week of the occurrence of temperament-related behaviors on a 7-point Likert scale ranging from never to always. Fourteen sub-scales were designed to measure the following dimensions: approach, vocal reactivity, high intensity pleasure, smile and laughter, activity level, perceptual sensitivity, sadness, distress to limitations, fear, falling reactivity, low intensity pleasure, cuddliness, duration of orienting, and soothability.

Concerning surgency, we applied its broad dimension, which is defined by approach, vocal reactivity, high-intensity pleasure, smiling and laughter, activity level, and perceptual sensitivity (Putnam, Ellis, & Rothbart, 2001).

We reanalyzed scores of the fear scale of our Japanese IBQ-R data from a sample of 284 Japanese infants distributed over three age groups. We tentatively divided 16 Fear items into 2 subscales: innate fear (items 94 and 99) and learned fear (the remaining fear scale items). After obtaining scores for these two subscales over the three age groups (Table 1), ANOVA was applied to the factors of age (3: 3-6 months, 6-9 months, 9-12 months) and type of fear (2: innate, learned). The main effects of types of fear and age proved significant (F (1,281)= 888.0, p <.001; F (2,281)= 16.0, p <.001), as did their interaction (F (2,281)= 20.8, p <.001), i.e., innate fears were almost equally high across ages, though learned fears only developed with age, while the two subscales were not correlated in any age group.

Table 1. Mean score of fear subscales (SD).

Temperamental Scale	Subtype	Age (months)		
		3-5 (N= 97)	6-8 (N= 79)	9-11 (N= 108)
Fear	Innate	5.43 (1.23)	5.34 (1.21)	5.45 (1.02)
	Learned	1.96 (1.08)	2.74 (1.10)	3.33 (1.26)

General procedure

After arrival at the experiment room, the research director explained the general procedure to the caregivers, while a research assistant handed the infants some warm-up toys to play with. When the infants seemed accustomed to both the room and the assistant, they were taken to a semi-dark area surrounded by a blackout curtain.

In that area, each infant was seated in a baby chair 65 cm from the color monitor of an AV tachistoscope (IS-702). The director outside monitored the participant's eye movements through a video camera focusing on the baby's face, and controlled the stimulus presentation with a microcomputer (FMV-S167). The fixation stimuli in the center of the monitor were comprised of brightly-colored moving abstract figures that were subtended at a 5-degree visual angle. The figure display was accompanied by sounds. Once the infant focused on the fixation stimulus, the director pressed a key that initiated the presentation of the cue (a yellow diamond of 3 degrees) on one of the two sides. The peripheral target was composed of colored moving abstract shapes, both sides of which were always identical. They were reflected in a first-surface mirror on one of the two sides so as to be presented at approximately 30 degrees distant from the central fixation point. The experiment comprised a total of 32 trials, with 16 left and 16 right cues presented in pseudo-random order.

The stimuli so presented were superimposed synchronously on video images of the infants' eye movements (For-A, MF-310), which were recorded for later analysis. During the experiments, the mother remained close by the infant but out of sight. At the

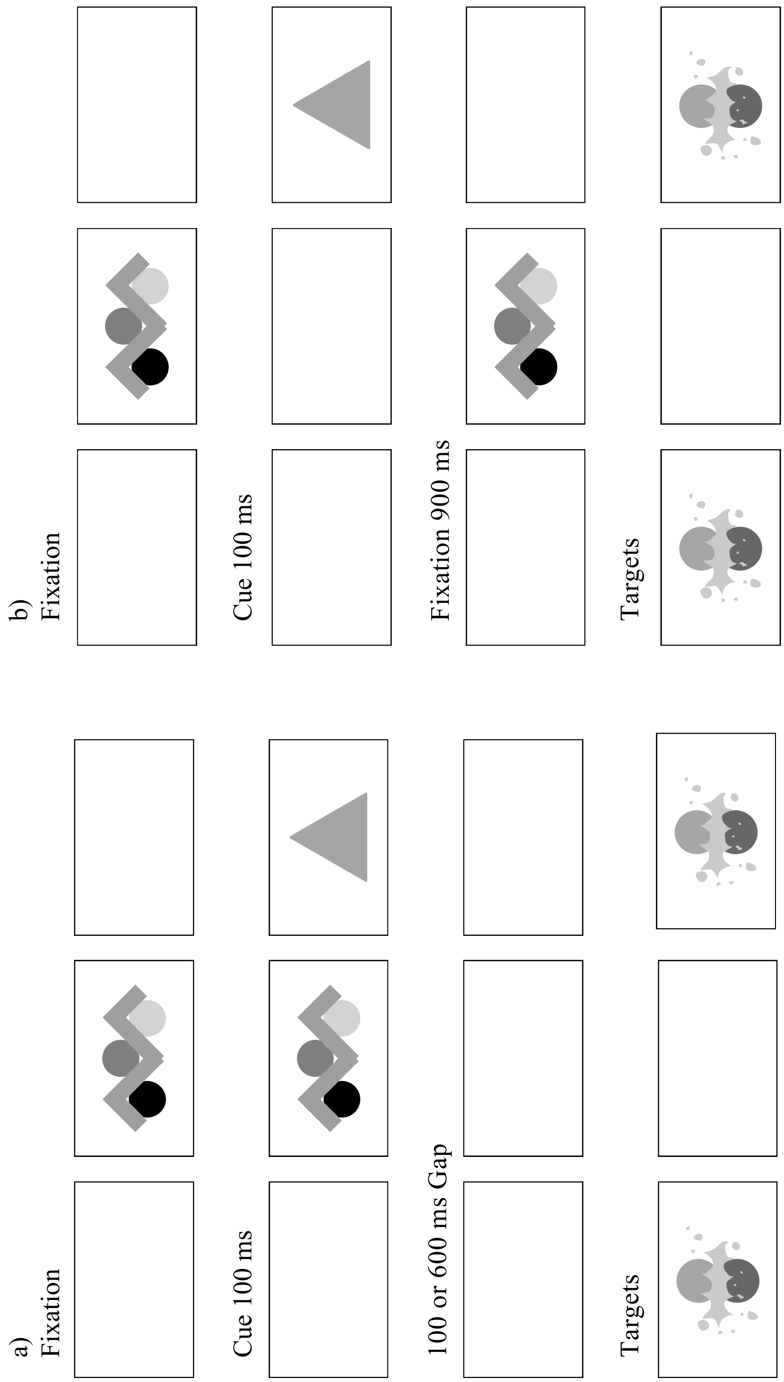

Figure 1. The stimulus sequence used in a) Experiment 1 and b) Experiment 2.

end of the session, the mother was given the Japanese IBQ-R (Nakagawa & Sukigara, 2005) and asked to complete and return it.

Experiment 1

Methods

Participants and procedure

Sixteen 4-month-old infants (11 male, 5 female) and ten 9-month-old infants (6 male, 4 female) were tested in the spatial cuing paradigm. Participants were recruited through newspaper advertisements. The data from the other six 4-month-olds and four 9-month-olds were not included because they failed to complete even half the visual task trials.

The task procedure (Figure 1a) followed that of Johnson and Tucker (1996). The peripheral cue was presented for 100 ms at the same time as the central fixation. Following offsets of both the central stimulus and peripheral cue, there was either a 100-ms or a 600-ms gap before presentation of the bilateral target (corresponding to SOAs of 200, or 700 ms, respectively). The SOA of 200 ms may be short enough to produce facilitation, while that of 700 ms may be long enough to produce inhibition.

Those trials in which the infant's gaze moved directly from fixation to one of the target locations were analyzed regarding the direction of the saccade (cued and non-cued) and the reaction time (RT; in video frames, with each frame lasting 33 ms) that was recorded based on the first frame in which an eye movement to a target was detected. The reliability between the two coders was tested based on 96% agreement of as to whether or not the trial was adequate.

Results

Following Johnson and Tucker (1996), reaction times (RTs) of saccades over 2 s or under 200 ms were excluded from the data analysis. The number of scorable trials was 12.3 ±3.64 for 4-month-olds and 12.6±3.02 for 9-month-olds.

The respective average surgency scores for the younger- and older-age groups were 3.57±.54 and 4.98±.32. The average innate fear scores for those groups were 4.96±1.33, and 5.15±1.10, whereas the respective average learned fear scores for those groups were 1.97±1.15 and 2.67±.86. Each age group was divided into two subgroups according to the mean scores of surgency, innate fear and learned fear of each applicable age group based on our previous large samples. The mean latencies of each group divided by the surgency and innate fear are presented in Tables 2 and 3.

ANOVA was then applied to the reaction times based on the following factors: age (2), surgency (2), side (2), SOA (2). Age and surgency were between-subject factors, while side and SOA were within-subject factors. As a result, the significant main effects of side and the interaction of age x side were observed (F (1,13)= 4.76, p <.05; F (1,13)= 7.89, p <.05) i.e., response to the cued side was faster, with post-hoc analysis

Table 2. Mean latencies of saccades (SD) for high and low surgency infants in Experiment 1 (frame).

Side	*SOA*	*Surgency*	*Age (months)*			
			4 (*N*= 10)		9 (*N*= 7)	
Non-cued	200 ms	High	20.40	(9.64)	13.15	(2.38)
		Low	16.01	(5.91)	25.00	(13.43)
	700 ms	High	22.05	(3.03)	16.30	(5.76)
		Low	22.18	(10.06)	14.50	(3.53)
Cued	200 ms	High	12.65	(4.95)	11.80	(2.91)
		Low	16.51	(7.74)	14.62	(0.53)
	700 ms	High	12.15	(6.11)	16.00	(3.82)
		Low	15.65	(8.74)	29.50	(2.12)

Table 3. Mean latencies of saccades (SD) for high and low innate fear infants in Experiment 1 (frame).

Side	*SOA*	*Fear*	*Age (months)*			
			4 (*N*= 10)		9 (*N*= 7)	
Non-cued	200 ms	High	22.12	(10.20)	20.91	(11.91)
		Low	15.59	(5.38)	13.25	(2.53)
	700 ms	High	21.68	(3.37)	13.91	(4.21)
		Low	22.40	(9.02)	17.18	(5.66)
Cued	200 ms	High	12.18	(5.59)	12.16	(2.42)
		Low	16.18	(6.97)	12.93	(3.30)
	700 ms	High	12.18	(7.05)	18.91	(8.03)
		Low	15.04	(7.95)	20.56	(7.95)

revealing that 4-month-old infants showed a significantly faster RT to the cued than to the non-cued target (F (1,13)= 17.1, p <.01). The interaction of side x surgency was only marginally significant (F (1,13)= 3.56, p= .082), while that of age x SOA x side was clearly significant (F (1,13)= 9.14, p <.05). Simple-effect analysis revealed that 9-month-olds showed slow responses to the cued target at the longer SOA (F (1,13)= 16.43, p <.01). The interaction of age x SOA x side x surgency was significant (F (1,13)= 6.15, p <.05). The main effect of surgency was marginal (F (1,13)= 3.27, p= .094), with more surgent children appearing to display a tendency toward faster responses. The same ANOVA was applied to the response numbers. Significant main effects of SOA and the interaction of SOA x side were observed (F (1,22)= 39.51, p <.01; F (1,22)= 15.97, p <.01), i.e., infants showed more responses at a short SOA. On the cued side more responses were elicited at a shorter SOA, while on the non-cued side more responses were evoked at a longer SOA.

Next, to examine the effect of innate fear, ANOVA was applied to the reaction times based on the following factors: innate fear (2), side (2), and SOA (2). Innate fear and age were between-subject factors, while side and SOA were within-subject factors. The significant main effects of side and the interaction of age x side were observed (F

(1,13)= 9.47, *p* <.01; *F* (1,13)= 8.53, *p* <.05). The interaction of innate fear x side was significant (*F* (1,13)= 4.96, *p* <.05), i.e., there was a significant difference between RTs to the cued side and those to the non-cued side in infants showing more innate fear (*F* (1,13)= 12.07, *p* <.01); the interaction of age x SOA x side was only marginally significant (*F* (1,13)= 3.67, *p*= .077). ANOVA was also applied to the response numbers. Significant main effects of SOA and interaction of side x SOA were observed (*F* (1,22)= 39.79, *p* <.001; F (1,22)= 17.96, *p* <.001). The interaction of age x innate fear also proved significant (*F* (1,22)= 4.64, *p* <.05), in that, at a younger age, the higher the innate fear scores, the fewer responses they evoked (*F* (1,22)= 3.28, *p*= .083). On the other hand, in the older age group, no clear trend was observed.

We then applied the learned fear scores to older infants. ANOVA was applied to the reaction times based on the following factors: learned fear (2), side (2), and SOA (2); we found no significant differences. ANOVA was also applied to the response numbers. The main effect of SOA and the interaction of SOA x side were significant (*F* (1,8)= 8.86, *p* <.05: *F* (1,8)= 10.97, *p* <.05). SOA x learned fear proved only marginally significant (*F* (1,8)= 3.73, *p*= .089).

Discussion

Our data based on innate fear indicated that younger infants who were rated as more fearful were found more readily to return. Moreover, younger fearful infants showed a tendency to give fewer responses, suggesting that they might be more reactive. This is reminiscent of the findings of Kagan and Snidman (1991) who observed that infants more motorically reactive 4 months later showed increased behavioral inhibition. While the main effect of surgency was marginal.

Experiment 1 failed to provide support for our predicted relationship, possibly because its spatial cueing procedure readily produced very rapid saccades to a cue in some 4- and many 9-month-olds. We excluded these rapid responses from the above analysis. In Experiment 2, to discourage saccades toward the peripheral cue or to provoke saccades after the target presentation, we added central refixation following the cue presentation. Moreover, to focus on the responses of IOR, we used only one longer interstimulus interval (Figure 1, b). Applying the corneal reflection method, we attempted to conduct a quantitative analysis of the latency of infant eye movements (Nakagawa & Sukigara, 2007).

Experiment 2

Method

Participants and Procedure

Twenty-nine infants recruited through local maternity groups were divided into two age groups: eleven 3- to 7-month-olds (5 male, 6 female) and eleven 8- to 11-month-olds (6 male, 5 female). Data from the other seven infants were not included because they failed to complete even half the visual task trials.

Infant eye movements were recorded by the corneal-reflection method. To measure head movements, a tiny chrome steel ball bearing (4.75 mm) was affixed to the middle of the participant's forehead. Beams of invisible infrared light (LED: SLR-938C) were directed at the participant's eye from the upper right. The reflected images of corneas and the chrome ball bearing were captured by a near-infrared CCD camera (Hamamatsu Photonics, C3077-78) set up at the participant's lower left side. The TV signal was digitized to a two-dimensional scale by an XY-tracker unit (Hamamatsu Photonics, C3162). Only the horizontal component (X-axis) was analyzed from a two-dimensional coordination (horizontal and vertical outputs). We defined latency as the elapsed period between the sampling time at the target presentation and the moment of maximum acceleration of eye movements for each trial of each infant.

Inhibition-of-return task. The inhibition-of-return task procedure (Figure 1b) followed that of Butcher, Kalverboer, and Geuze (1999). The cue was presented for 100 ms with no central fixation. Once the cue disappeared, the central stimulus reappeared for 900 ms. Following the offset of the central stimulus, a bilateral target was presented.

Results

Based on the superimposed recordings, two observers not directly involved in the experiment judged whether or not the trial had proved adequate for our analysis. Only responses occurring after the target onset were included. Reliability between the two coders was .98 for whether trials should be rejected.

The average numbers of responses directed to the side opposite the cue were 12.0 (*SD*= 5.29) for the younger-age group and 8.50 (*SD*= 3.43) for the older-age group; those average numbers directed to the cued location were 9.76 (*SD*= 5.06) for the younger-age group and 7.70 (*SD*= 4.69) for the older-age group.

Each age group was divided into two subgroups in the same way as Experiment 1. Mean surgency scores for the younger- and older-age groups were 3.85±.83 and 4.50±.58, while average innate fear scores for those groups were 4.80±1.39, and 4.72±1.61. As for learned fear scale scores, respective means for the younger- and older-age group were 2.61±1.01 and 3.15±1.23. The mean latencies of each group divided by the surgency and innate fear are presented in Table 4.

ANOVA was applied to the RT based on the following factors: side (2), age (2), and surgency (2). Only side was found to be a within-factor, the main effect of which was marginal (F (1,18)= 3.99, p= .061), i.e., the average latency to the non-cued side was faster than that to the cued side. The main effects of surgency and age were significant (F (1,18)= 7.63, p <.05; F (1,18)= 5.64, p <.05). Thus, more surgent or older children showed a tendency toward faster responses. This analysis was also applied to the response numbers. The main effect of age was marginal (F (1,19)= 4.08, p= .058), i.e., younger infants seemed to respond more often.

ANOVA was then applied to the RT with the following factors: side (2), age (2), and innate fear (2). Whereas the main side effect was marginal (F (1,18)= 3.82,

Table 4. Mean latencies (SD) of saccades during IOR task in Experiment 2 (ms).

Temperamental Scale	Level	Side	Age (months) 3-7 (*N*= 13)		8-11 (*N*= 9)	
Surgency	High	Non-cued	517.2	(89.9)	446.2	(122.9)
		Cued	613.3	(125.9)	499.9	(89.3)
	Low	Non-cued	599.1	(28.3)	576.2	(124.7)
		Cued	708.6	(149.4)	581.6	(102.5)
Innate Fear	High	Non-cued	534.1	(86.9)	482.1	(67.3)
		Cued	630.7	(135.7)	545.1	(81.0)
	Low	Non-cued	597.4	(39.9)	563.8	(193.3)
		Cued	714.2	(152.1)	545.5	(134.8)

p= .066), the main effect of age was significant (F (1,18)= 4.79, p <.05). ANOVA was also used for a number of responses. The main effect of age proved to be marginal (F (1,19)= 3.41, p =.080).

ANOVA was then applied to the RT of older infants with the following factors: side (2) and learned fear (2). No effect was found significant. ANOVA was also used for the number of responses. The main effect of learned fear was significant (F (1,19)= 17.18, p <.01). The average response numbers (*SD*) for higher and lower fearful infants were 21.8 (4.54) and 10.60 (3.97), respectively. At an older age, fearful infants seemed to turn away less readily from the central stimuli before target presentation.

General Discussion

The present study used infant saccades as a behavioral measure to examine two temperamental dimensions, i.e., the approach (surgency) and the behavioral inhibition during the first year of life. As a result, we concluded that a quick approach tendency was positively related to the extent of surgency across all ages, which is consistent with a previous study (Rothbart, 1988). Ours is the first study confirming the relationship between surgency and the latencies of saccades. On the other hand, the results did not support a predicted relationship of ours between IOR and parental reports of fear at an older age.

The present data provided no evidence of a link between IOR and fearfulness or behavioral inhibition. This may have been because the present participants were infants up to their first year, so that any possible neural link between them may have been still immature; or from the beginning, there may never have been any relationship between IOR and fearfulness. Since there is also a report that patients with obsessive-compulsive and/or anxiety disorders, as well as a healthy control group, displayed a comparable time-course pattern of IOR (Moritz & Mühlenen, 2005), IOR appears to be a robust effect, independent of individual differences in emotional variables.

To assess the fear during early infancy, we tentatively proposed the use of both innate and learned fear scores based on our previous IBQ-R data. Although innate stimuli for fear have been indicated in humans, such as sudden loss of support and loud noises, recent neuroscience studies confirm that humans possess innate fear as well as learned fear (Lobue & DeLoache, 2008). Corcoran & Quirk (2007) also disclosed a previously unsuspected difference between the neural circuits responsible for learned versus innate fear.

In Experiment 1, parent-rated infants whose score was higher on the innate fear scale generally showed fewer responses in early infancy. However, such individual differences in innate fear among young infants were not replicated in Experiment 2. Although fearful older infants showed more responses in Experiment 2, this was not the case in Experiment 1. One reason for that discrepancy might be a difference in the procedure used (Figure 1). In Experiment 2, to discourage saccades toward the peripheral cue, we added central refixation following the peripheral cue presentation and we used only one longer interstimulus interval. Thus, since two time intervals (100- or 600-ms interval) were involved before the bilateral presentation of targets, the temporal pattern of visual stimuli in Experiment 1 might be relatively more complex. This may imply the possibility of a link between innate fear and stimulus conditions, but any discussion regarding the nature of innate or learned fears is beyond the scope of the present study.

On the other hand, in Experiment 2, older infants who scored higher on the learned fear scale generally showed more responses. Central fixation disappeared within 100 ms of the cue presentation, and to discourage peripheral orientation, the fixation was presented again after the cue had disappeared. The results of Experiment 2 showed that the decline in the total number of responses increased with age. It is possible that the duration of 900 ms for refixation was too long for all but the younger infants. Children in the older-age group seemed bored with continuing to refocus upon the simple colorful moving stimuli. Thus, in situations where it is not necessarily easy to continue to fixate, fearful children late in the first year seemed to rivet their attention on the fixation and to respond accordingly. We thought that at an older age, less fearful infants were more easily distracted from the central stimuli, while more fearful ones showed more controlled behaviors. This is consistent with the results of Sheese, Rothbart, Posner, White, and Fraundrof (2008), who found that fear, as measured by the duration of distress and the number of mask trials completed, was positively related to the infants' number of correct anticipatory looks. Their results suggest close relations between early developing fear and later self-regulation.

In the present study, our goal of demonstrating behavioral evidence from saccadic latencies for two dissociable emotional systems was not achieved. However, it seems very possible that there is insufficient variability in the present sample to claim that some babies are actually more fearful than others. Nevertheless, more surgent children showed a tendency toward faster responses, and we could find no effect of age on the positive affect/surgency. Meanwhile, our response-number data suggest that, by the end of the first year, fear may function as some kind of control system, while at the beginning it might appear as a general reactive tendency. Further research is warranted to verify our preliminary findings.

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