Physiological reactivity to fear in children: effects of temperament, attachment & the serotonin transporter gene

Gilissen, R.

3 Parent-Child Relationship, Temperament, and Physiological Reactions to Fear-Inducing Film Clips: Further Evidence for Differential Susceptibility

Abstract

Recent studies have supported the intriguing hypothesis that highly reactive infants are most susceptible to the effect of parenting. This study replicates and extends an earlier study on 4-year-olds concerning higher susceptibility of more fearful children to the quality of the relationship with their mother, as shown by their physiological reactions to fear-inducing film clips. Two groups of children (4- and 7-year-olds) were shown the same fear-inducing and neutral film clips. During the film-clips, their skin conductance and heart rate variability were measured. Both 4- and 7-year-olds responded to the fear-inducing film clip with increases in skin conductance and decreases in heart rate variability. A secure relationship affected the reactivity to fearful stimuli in temperamentally more fearful children but not in less fearful children irrespective of children's ages. Our findings add to the growing literature showing that children high in negative emotion are more susceptible to positive as well as negative rearing influences for better *and* for worse.

Gilissen, R., Bakermans-Kranenburg, M. J., Van IJzendoorn, M. H., & Van der Veer, R. (2008). Parent-child relationship, temperament, and physiological reactions to fear-inducing film clips: Further evidence for differential susceptibility. *Journal of Experimental Child Psychology, 99*, 182-195.

Introduction

Several recent studies have indicated that children may vary in their susceptibility to parental rearing. More specifically, Belsky (1997, 2005) hypothesized that not all children are similarly susceptible to the effects of parenting. Belsky suggested that children within a family may vary in their susceptibility to rearing influences for evolutionary reasons. According to evolutionary theory, variation in human characteristics is needed to maximize an individual's reproductive success. If the future is inherently uncertain, parents would benefit from raising children who differ in their susceptibility to environmental influences so that at least some of their offspring would survive even in a drastically changing social or ecological context. Thus, Belsky (2005) suggested that the variations in susceptibility are a product of natural selection. Boyce and Ellis (2005) argued that variations in susceptibility are due to individual differences in biological sensitivity to early environmental stimuli. Prenatal influences and parental rearing are suggested to create variations in susceptibility depending on an individual's biological sensitivity.

Intriguingly, children with a "difficult" temperament seem most susceptible to effects of rearing. A difficult temperament typically involves frequent negative emotions, low adaptability, high activity level, and low emotion regulation (Gallagher, 2002). Various designations of difficult temperament have been used in studies on differential susceptibility, including negative emotionality, high reactivity (physiological or psychological), high inhibition, and high fearfulness. However, regardless of the terms used, interaction effects between temperament and parenting have consistently been found in several studies. For example, Suomi (1997) found that highly reactive infant rhesus monkeys were more susceptible to parenting than were normative reactive infant monkeys. He showed that highly reactive infants reared by foster mothers caring in the normal range showed expected deficits in their development, whereas highly reactive monkeys reared by highly sensitive foster mothers appeared to have relatively normal, or even optimal, long-term developmental trajectories. Kochanska, Aksan and Joy (2007) demonstrated that temperamentally more fearful children, experiencing high levels of paternal power assertion, showed more cheating behavior during games than did temperamentally less fearful children. Furthermore, Klein Velderman, Bakermans-Kranenburg, Juffer, and Van IJzendoorn (2006) showed that highly reactive children were more susceptible to changes in their mothers' sensitivity during interventions. Children with a difficult temperament thus appear to be more susceptible to environmental influence, with both negative outcomes (when they are raised in a less supportive environment) and positive outcomes (when they are raised in a supportive environment) (Belsky, 2005; Boyce & Ellis, 2005). This is in contrast to the cumulative risk hypothesis (Seifer, Sameroff, Baldwin, & Baldwin, 1992), which states that risk factors such as fearfulness only increase the probability of negative outcomes (Bakermans-Kranenburg & Van IJzendoorn, 2007).

Gilissen, Koolstra, Van IJzendoorn, Bakermans-Kranenburg, and Van der Veer (2007) found additional evidence for the differential susceptibility hypothesis. In their study, 4-year-old children were shown two brief film episodes; one fear-inducing and one emotionally neutral. Their skin conductance and heart rate variability were recorded simultaneously. Physiological responses to stressors often are characterized by sympathetic activation (an increase in skin conductance), parasympathetic withdrawal (a decrease in heart rate variability), or a combination of both (e.g., Berntson, Cacioppo, & Quigly, 1991). The 4-year-olds responded to the fear-inducing film clip with significantly more increases in skin conductance and more decreases in heart rate variability compared with their responses to the neutral film clip. Furthermore, temperamentally fearful children were more susceptible to the quality of their relationship with their parent, as evident from their highest scores for skin conductance reactivity to fearful stimuli when their relationship with their parent was less harmonious. This finding provided evidence for Belsky‘s (1997, 2005) differential susceptibility hypothesis and is replicated in the current study in a group of 7-year-olds. The two groups of children (4- and 7-year-olds) were shown the same fear-inducing and neutral film clips. In addition, the different age groups present the opportunity to compare the children’s fright reactions induced by television across age.

The purpose of the current study was twofold: (a) to compare the impact of television-induced fear on 7-year-olds with the impact on 4-year-olds and (b) to replicate an earlier study on 4-year-olds concerning higher susceptibility of more fearful children to the quality of their relationships with their mothers, as shown by their physiological fear reactions to the fear-evoking film clips. On the basis of studies conducted previously, we expected to find an interaction effect between attachment and temperamental fearfulness, with temperamentally more fearful children being more dependent on the quality of their attachment relationship when coping with fear-inducing film clips.

Method

Participants

Participants were 78 4-year-olds (mean age = 3.8 years, *SD* = 0.3) and 92 7-year-olds (*M* = 7.4 years, *SD* = 0.3). All participants were born in The Netherlands. The group of 4-year-olds consisted of 38 boys and 40 girls. The families were recruited with the use of town hall records. The mean age of their mothers was 35.9 years (SD = 3.9), and the mean age of their fathers was 38.3 years (*SD* = 5.2). On average, the mothers of the 4-year-olds had completed 15.9 years (*SD* = 3.9) of education and the fathers had completed 16.3 years (*SD* = 3.7).

The 7-year-olds were the first-born children of twin pairs. Twins were recruited with the help of the Netherlands Twin Register (Boomsma, Orlebeke, & Van Baal, 1992). Of the 92 twins, 45 were monozygotic and 47 were dizygotic. All pairs were same-sex. The group of 7-year-old children consisted of 43 boys and 49 girls. The mean age of the mothers of the 7-year-olds was 38.8 years (SD = 3.4), and the mothers had completed an average of 14.4 years (*SD* = 3.1) of education. The mean age of the fathers was 41.1 years (*SD* = 4.7), and the fathers had completed an average of 15.4 years (*SD* = 3.3) of education.

Some of the twins (42%) had participated in previous research at 12 months of age (Bokhorst et al., 2003). The additional group of children was not different from the children who had participated in previous research on gender, $\chi^2(1, N = 92) = 1.37$, $p = .24$, maternal age, $t(87) = -1.68$, $p = .10$, or paternal age, $t(86) = -.81$, $p = .42$). None of the children had serious medical problems. Permission for the study was obtained from the medical ethics committee of Leiden University Medical Centre and the ethics committee of the Faculty of Social and Behavioral Sciences of Leiden University.

Procedure

Mothers and children of both age groups were invited for a session in the laboratory. The session, for both 4- and 7-year-olds, consisted of two parts: one where film-clips were shown and one where the quality of the mother-child relationship was measured (Gilissen et al., 2007).

Mothers of twins came to the laboratory with both twin children at the same time. Twin children were separated from each other and switched after finishing one part of the session to participate in the second part. Both children of each twin pair were tested. However, we restricted the analyses to the oldest child of each twin pair to avoid dependent data. We opted for the first-born children because they are known to have fewer perinatal problems and, therefore, resemble the normal population. In addition, in our procedure the oldest twin siblings always started with the film clips, in contrast to the youngest children who began with the assessment of the attachment representations and saw the film clips approximately 1 h later. Thus, the physiological data of the first-born twins were less liable to influences from other assessments. The room in which the film clips were shown contained a 20-in. television-video set and two video cameras placed in opposite corners. A large one-way mirror provided visual access to this room. The room in which attachment representations were measured contained a table with two chairs. All procedures were videotaped.

Film Clips

The same film clips were shown to both age groups (Gilissen et al., 2007). Each child was seated in a chair, 1.5 m in front of the TV set, and was instructed to watch the film clips. The children watched a baseline clip that was followed by either a neutral or fear-inducing film clip. After this, a baseline fragment was shown again (to decrease possible arousal) and an episode finished with either a fear-inducing or neutral clip (Gilissen et al., 2007). The order of presentation was counterbalanced for the fear-neutral condition.

All film clips included movies categorized as suitable for all ages by ”Kijkwijzer/Nicam”, a Dutch classification system that gives age recommendations for television programs, cinema movies, and videos (Valkenburg, Beentjes, Nikken, & Tan, 2002). The baseline clip had been selected from ”Tik Tak 15” (Lenssens, 2000). This 1.5-min clip showed stars and slowly turning shapes in different colors (mandalas). After the baseline clip, a neutral or fear-inducing video clip was shown (counterbalanced) interspersed with a 1.5-minute baseline clip. The fear-inducing video clip was a 1-minute fragment of the film ”Dinosaur” (Marsden, 2000), an animation production of *Walt Disney*. This fragment showed various big dinosaurs chasing each other. These images, in combination with the threatening music, are likely to be fearful to children of both age groups. The duration of the neutral film clip was 1 min, and showed colorful objects (balls and ducks) moving in a slow rhythm, (”Tik Tak 15”; Lenssens, 2000). All stimuli were matched for average sound level, which was 60 dB at the point of the child’s head during the tests.

Physiological measures

Skin Conductance was measured to assess the sympathetic influence of the autonomic nervous system. The apparatus used was an ambulatory system called the Ambulatory Monitoring System (AMS; version 36, Vrije Universiteit, Department of Psychophysiology, Amsterdam, NL; e.g., Christie & Friedman, 2004). To measure skin conductance, two small Ag/AgCl electrodes were placed on the volar surfaces of the index finger and middle finger of the child's right hand. Electrodes were applied with a small amount of Unibase paste (Fowles, Christie, Edelberg, Grings, Lykken, & Venables, 1981) and taped onto the fingers with Leukoplast.

To asses the parasympathetic influence, root mean of the squared successive differences (RMSSD) was measured by placing three disposable electrocardiogram (ECG) electrodes on the child's chest in a triangular arrangement. RMSSD was used to index heart rate variability (Groot, de Geus, & de Vries, 1998; Task Force of the European Society of Cardiology the North American Society of Pacing Electrophysiology, 1996).

The combination of an event marker button on the AMS and the recording of time allowed us to synchronize the physiological reactions to the film clips. At specific time points on the video, before and after the film clips were presented, the experimenter pushed the button. The AMS recorded the specific time points, and the beginning and end of each film clip were marked with labels.

Temperamental Fearfulness

Children's temperamental fearfulness was measured by the combined scores on Shyness (13 items, $\alpha_{4\text{-year-olds}} = .87$, $\alpha_{7\text{-year-olds}} = .91$), Fear (12 items; $\alpha_{4\text{-year-olds}} = .62$, $\alpha_{7\text{-year-olds}} = .78$), and Discomfort (13 items; $\alpha_{4\text{-year-olds}} = .64$, $\alpha_{7\text{-year-olds}} = .77$) of the Children's Behavior Questionnaire (CBQ; Rothbart, Ahadi, & Hershey, 1994). These three scales -Shyness, Fear, and Discomfort- are most characteristic for anxiety proneness and fearfulness (Fowles & Kochanska, 2000). Each mother indicated on a 7-point rating scale how well a statement described her child. The Shyness scale contained items such as "My child is comfortable in situations where s/he will be meeting others" (reversed). The Fear scale included items such as "My child is afraid of the dark". The Discomfort scale contained items such as "My child is likely to cry when even a little bit hurt". The 38 items were averaged into one overall score for parent-reported temperamental fearfulness (for the summary measure of the 38 items, $\alpha = .76$ for the 4-year-olds and $\alpha = .87$ for the 7-year-olds).

Attachment

The quality of the relationship of the 4-year-olds with their mothers was measured with the Emotional Availability Scales (EAS, third edition; Biringen, Robinson, & Emde, 1998). The EAS is an observational scale that evaluates two maternal dimensions (sensitivity and nonintrusiveness) and two child dimensions (responsiveness to mother and involvement of mother) (for a complete description of the scales, see Biringen et al., 1998) Two independent coders, who were unaware of the physiological and temperamental data, rated the mother-child dyads during a 10-min free play episode of mother and child. The coders were reliable with an expert coder on a set of 24 mother-child free play episodes. Intraclass correlations ranged between .74 and .87. In addition, the two coders achieved interrater reliability on an extra set of 15 free play episodes. Intraclass correlations were .88 for parental sensitivity, .82 for parental nonintrusiveness, .85 for child responsiveness, and .77 for child involvement. Because the separate standardized scores for parent and child were strongly intercorrelated (α = .88) and principal component analyses pointed to one underlying factor (factor loadings .72-.92), the standardized scores were averaged into one global emotional availability score to indicate the quality of the parent-child relationship (M = 0.00, SD = 0.86). A median split was used to distinguish more secure dyads (n = 39) from more insecure dyads (n = 39).

For the 7-year-olds, the quality of the relationship was measured with the Attachment Story Completion Task (ASCT; Verschueren & Marcoen, 1994; based on Bretherton, Ridgeway, & Cassidy, 1990; Cassidy, 1988). Using a child and mother doll, children were asked to complete five attachment-related stories (for a complete description of the stories, see Verschueren, Marcoen, & Schoefs, 1996). Each story was coded as either *secure*; *insecure-avoidant, insecure-bizarre/ambivalent,* or *secure/insecure*. Stories classified as secure contained descriptions of positive feelings and harmonious interactions between the child and the mother without any negative, unclear, or bizarre subjects or issues. Stories that showed negative, hostile, or bizarre interactions with the mother figure were classified as insecure-bizarre/ambivalent. Stories with minimal interaction between the mother and the child, avoidance of the topic, or reluctance to complete the story were classified as insecure-avoidant. If the child did not tell clearly secure or insecure stories, these stories were classified as secure/insecure.

Five independent coders, who were unaware of the physiological and temperament data, rated the verbal transcripts of the children’s stories. Coders were trained and reliable on a set of 40 stories coded by Karine Verschueren (Leuven University).

Intraclass correlations for the five coders on 40 stories ranged between .90 and .95. To reduce the possibility of an incorrect classification, all stories were coded twice by different coders. In cases of disagreement, a third coder decided. On the basis of the classification of the five stories, each child received an overall attachment classification of secure or insecure. Reliability of the five stories was modest at α = .59 (for comparable alpha values of the stories, see Verschueren & Marcoen, 1999).

Both the ASCT and the EAS have proven to be related to infant attachment security assessed with Ainsworth's (1978) Strange Situation Procedure (EAS: Easterbrooks, Biesecker, & Lyons-Ruth, 2000; Ziv, Aviezer, Gini, Sagi & Koren-Karie, 2000; ASCT: Bretherton et al., 1990). Story stems, such as the ASCT, also have been associated with the separation-reunion procedure for preschoolers (Oppenheim, 1997) and the Attachment Q-sort (Vaughn & Waters, 1990; Bretherton et al., 1990). The EAS also have been shown to be related to maternal Adult Attachment Interview classifications (Biringen, et al., 2000).

Analyses

Skin conductance data were available for all 170 children. However, heart rate data for 9 children were missing due to technical failures. Furthermore, 1 child showed unacceptable heart rate variability values (i.e., RMSSD maxima > 200 ms; Groot et al., 1998). Missing and unacceptable values were replaced with the mean heart rate variability values for the subgroup matched for child gender and child age. In addition, seven outliers ($z > 3.29$; five in skin conductance data and two in heart rate variability data) were found. These values were changed into the next most extreme scores (Tabachnick & Fidell, 2001).

Responses during the 60-s film clips (either fear-inducing or neutral) were calculated by subtracting the means during the first baseline of an episode from the means during the film clips, leading to reactivity scores for both heart rate variability and skin conductance (e.g. Christie & Friedman, 2004; El-Sheikh, 2007; Osborn & Endsley, 1971). Thus, the reactivity scores show positive values when heart rate variability or skin conductance activity was higher during the film clips than during baseline and show negative values when heart rate variability or skin conductance activity was lower during the film clips than during baseline (Christie & Friedman, 2004; Osborn & Endsley, 1971). Physiological responses to fear often are characterized by an increase in skin conductance and a decrease in heart rate variability (Thayer & Lane, 2000) that would show in positive values for skin conductance reactivity and in negative values for heart rate variability reactivity.

Results

Impact of television-induced fear on 4- and 7-year-olds

Table 1 presents descriptive data of parent and child variables and their correlations with heart rate variability and skin conductance reactivity. No order effects were found for neutral-fear and fear-neutral (skin conductance: $F(1,168) = 3.02$, $p = .08$; heart rate variability: $F(1,168) = 2.54$, $p = .11$). Also, gender did not have any influence on the physiological reactions (skin conductance: $F(1,168) = .52$, $p = .47$; heart rate variability: $F(1,168) = 2.82$, $p = .10$).

Table 1

Descriptive Data of Parent and Child Variables, and Correlations with Heart Rate Variability (RMSSD) and Skin Conductance Level (SCL) Reactivity Watching a Fear-Inducing Film Clip.

	4-year-olds				7-year-olds			
	M	*SD*	*RMSSD*	*SCL*	*M*	*SD*	*RMSSD*	*SCL*
Age of child (yrs)	3.8	0.3	-.06	-.16	7.4	0.3	-.14	-.13
Male children (%)	48.7		.12	.17	46.7		.10	-.20
Age of mother (yrs)	35.9	3.9	-.19	-.04	38.8	3.4	.14	-.11
Education mother (yrs)	15.9	3.9	-.24	-.14	14.4	3.1	-.08	.07
Temp fearfulness (CBQ)	3.3	0.7	.11	.07	3.3	0.7	.05	-.08
Shyness	3.3	1.0	.01	.04	3.4	1.2	-.04	-.03
Fear	3.3	1.0	.10	.08	3.3	0.9	.09	-.17
Discomfort	3.5	0.9	.15	.04	3.2	0.8	.08	.04
Secure children (%) (EAS / ASCT)	50.0		-.00	.26	54.3		.05	.13

To compare the impact of television-induced fear on 4-year-olds with the impact of the same fragments on 7-year-olds, and to examine whether the fear-inducing film clip of *Dinosaur* had more impact than the neutral film clip in both age groups, a repeated measures analysis was conducted with the type of film clip as the within subjects factor and age group as the between-subjects factor. Children of both age groups responded to the fear-inducing film clip with significantly greater increases in skin conductance and greater decreases in heart rate variability during the fear-inducing film clip compared with during the neutral film clip, as shown in Table 2. No significant differences were found between 4- and 7-year-olds in skin conductance reactivity; the skin conductance reactivities to the fear-inducing and neutral film-clips were similar in both age groups (F (1, 168) = 0.10, $p = .76$). However, 7-year-olds showed higher scores on heart rate variability reactivity in both conditions (fear-inducing and neutral film clip), *F* (1, 168) = 4.67, *p* = .03.

Table 2

Physiological Effects of Fear-Inducing and Neutral Film Clips Watched by 4- and 7-Year Olds.

	Measure	*N*	Film clips				*F*
			Fear		Neutral		
			M	*SD*	*M*	*SD*	
4-year-olds	SCL (μS)	78	1.81	3.80	0.30	3.53	7.55**
	RMSSD	78	-5.06	11.55	0.66	12.69	20.09***
7-year-olds	SCL (μS)	92	1.98	2.67	0.35	2.30	22.55***
	RMSSD	92	-2.47	16.68	8.12	24.24	23.49***

** *p* < .01, *** *p* < .001

Temperament and attachment as predictors of physiological reactions to fear

In an attempt to replicate the prediction of skin conductance reactivity from the interaction between temperamental fearfulness and the quality of the relationship found in our previous study with 4-year-olds, a hierarchical multiple regression analysis was conducted on skin conductance reactivity with age as the predictor in the first step, attachment security and temperamental fearfulness as predictors in the second step, and the interaction between attachment security and temperamental fearfulness (centered before their product was computed) in the third step (Table 3). The overall regression was significant, *F* (4,165) = 3.07, *p* = .02. Age did not contribute significantly to the regression equation, (*β* = .04, *p* = .64), and fearfulness did not contribute significantly either (*β* = .02, *p* = .82). Greater attachment security predicted less skin conductance reactivity (*β* = -.20, *p* = .01). Furthermore, the interaction of attachment security and temperamental fearfulness was significant (*β* = .18; *p* = .02), in line with our prediction. In addition, we tested whether the interaction effect differed between the two age groups. The interaction effect of attachment security by temperamental fearfulness by age was not significant (*β* = .01; *p* = .89), indicating that the interaction of attachment security and temperamental fearfulness was independent of age.

Table 3

Regression Analysis for Skin Conductance Reactivity to Fear-Inducing Film Stimuli with Age, Temperamental Fearfulness, Attachment, and the Interaction between them as Predictors.

	R	R^2	R^2Ch	*F*	*Df*	*Beta*[1]	*p*
Step 1	.00	.00	.00	0.00	(1,168)		.98
Age						.04	.64
Step 2	.20	.04	.04	2.24	(3,166)		.09
Attachment						.20	.01
Temperamental Fearfulness						.02	.82
Step 3	.26	.07	.03	3.07	(4,165)		.02
Attachment* Temperamental Fearfulness						.18	.02

[1]Betas were derived from the final block of the regression model.

Post-hoc analyses were conducted to clarify the interpretation of the significant interaction effect (Aiken & West, 1991; Dearing & Hamilton, 2006). Four groups were created based on a median split for temperamental fearfulness (as had been done for attachment security) and attachment quality, resulting in temperamentally less fearful children with a more secure attachment relationship (Group 1); temperamentally more fearful children with a more secure attachment relationship (Group 2); temperamentally less fearful children with a less secure attachment relationship (Group 3); and temperamentally more fearful children with a less secure attachment relationship (Group 4). We hypothesized that more fearful children (Groups 2 and 4) would be more susceptible to the quality of the relationship with their parent in their reactivity to fear-inducing film stimuli.

An analysis of variance (ANOVA) showed a significant difference in skin conductance reactivity, F (3, 166) = 3.55, p = .02. Contrasting more fearful children with a less secure relationship (Group 4) with the three other groups, we found a significant contrast, t (166) = 2.75, $p < .01$). These children (more temperamentally fearful, less secure relationship) showed the highest skin conductance reactivity. Furthermore, contrasting Group 2 children (more temperamentally fearful, more secure relationship) with the other three groups, the contrast was also significant, $t(166)$ = 2.49; p = .01. Group 2 children showed the lowest skin conductance reactivity (Figure 1).

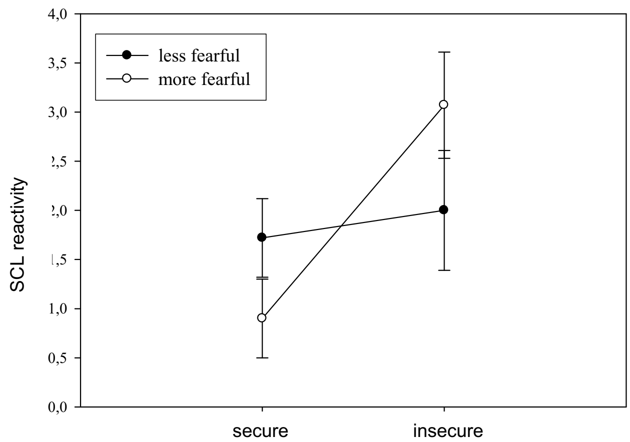

Figure 1. Relation between attachment and skin conductance reactivity to fear-inducing stimuli for temperamentally less fearful and more fearful children

Temperamentally more fearful children thus appeared to be more susceptible to the quality of the relationship with their parent in their reactivity to fear-inducing film stimuli. Analyses with the continuous variables confirmed these results. For temperamentally less fearful children, the correlation between the standardized continuous attachment score and skin conductance reactivity was non-significant, *r* (85) = .06 (*p* = .61), whereas for more fearful children, the correlation was significant, with more secure children showing less skin conductance reactivity, *r* (85) = -.48 (*p* <.01). These correlations differed significantly (Z_{diff} = 3.70, $p < .01$). Thus, secure relationships affected the reactivity to fearful stimuli in temperamentally more fearful children but not in less fearful children.

We repeated the hierarchical multiple regression analysis with heart rate variability reactivity as the dependent variable. The overall regression was not significant, *F* (4, 165) = 0.60, *p* = .66. None of the predictors contributed significantly to the prediction of heart rate variability, and the interaction between fearfulness and relationship quality did not add significantly to the prediction of heart rate variability to the fear-inducing film stimuli (β = .05; *p* = .50).

Discussion

In this study we found (a) that the impact of television-induced fear on 4-year-olds was comparable to the impact on 7-year-olds and (b) that more fearful children were more susceptible to the quality of their relationships with their mothers irrespective of their ages.

Impact of television-induced fear

Both 4- and 7-year-olds responded to the fear-inducing film clip with increases in skin conductance (sympathetic activation) and decreases in heart rate variability (parasympathetic withdrawal). The skin conductance reactivities to the fear-inducing and neutral film-clips were similar in both age groups, showing no difference in reactivity between 4- and 7-year-olds in the two conditions. However, 7-year-olds showed higher scores on heart rate variability reactivity to the fear-inducing and neutral film clips, indicating less parasympathetic withdrawal than that of 4-year-olds. In the 7-year-olds, heart rate variability reactivity during the neutral film clip even showed positive values, representing higher heart rate variability during the neutral film clip than during baseline. It seems that 7-year-olds experienced more fear during baseline episodes than during the neutral film clip. Baseline clips were shown just after children were told that they would see different kinds of film clips. Reactivity scores were calculated by subtracting the means during this baseline from the means during the film clips. Maybe the idea of the coming film clips was more arousing (expressed only in parasympathetic activity) for 7-year-olds than for 4-year-olds because they were better able to imagine the possibly exciting fragments. Perhaps older children became more relaxed during the neutral clip because they are more accustomed to this type of entertainment.

Differential susceptibility

Our study provided additional evidence for the intriguing concept of differential susceptibility (Belsky, 1997, 2005) by showing that temperamentally more fearful children were more susceptible to the quality of their relationships with their mothers than were less fearful children. This finding indicates that rearing influences are more important for more temperamentally fearful children. Furthermore, the results of our study show that temperamentally more fearful children were more susceptible to *both* secure and insecure attachment relationships (more temperamentally fearful children with a less secure relationship showed the highest skin conductance reactivities to the fearful film clip, whereas comparable children with a more secure relationship showed the lowest skin conductance reactivities), providing more evidence for the differential susceptibility hypothesis and contradicting the concept of cumulative risk (Belsky, 2005).

As in our previous study (Gilissen et al., 2007), none of the predictors, nor the interaction, contributed significantly to the prediction of heart rate variability. Apparently, the interaction between temperamental fearfulness and attachment predicts only sympathetic reactivity. The difference between sympathetic and parasympathetic activity may account for the lack of prediction of (parasympathetic) heart rate variability. The two branches, which reflect different processes of the autonomic nervous system (e.g., Fox & Card, 1999), showed only a weak correlation (r = -.10, p = .22). Furthermore, responses of the two branches are not always reciprocal (Berntson, et al., 1991), and neural circuits seem to be matched to specific environmental risks (Porges, 2003).

Limitations and Implications.

The main limitation of this study concerns the different measures used to measure the quality of the mother-child relationship. It might be argued that the ASCT (Verschueren & Marcoen, 1994) measures somewhat different aspects of the mother-child attachment relationship compared with the EAS (Biringen et al., 1998). Beyond infancy, no ”gold standard” measures of attachment security have been developed and validated (Solomon & George, 1999). However, several studies have found relations between attachment security in infancy and story stem techniques such as the ASCT (Page, 2001) as well as the EAS (Bretherton, 2000). Both types of methods have proven to be associated with more thoroughly validated measures of the parent-infant attachment relationship and of maternal attachment representations.

In spite of this limitation, our findings add to the growing literature showing that children high in negative emotion are more susceptible to positive as well as negative rearing influences, for better *and* for worse. Our results thus support the differential susceptibility hypothesis, which states that some children are more susceptible to effects of rearing, with both more negative and more positive outcomes than emotionally robust children (Belsky, 2005). Being more susceptible with possibly optimal outcomes implies that being temperamentally more fearful is not a risk factor per se. As Belsky (2005) suggested, children within a family may vary in their susceptibility to rearing influences for evolutionary reasons because parents would benefit from raising children who differ in their susceptibility so as to maximize their reproductive success in different ecological niches.

Previous research showed an important role of genetics in temperamental reactivity. Bokhorst and colleagues (2003) found that 77% of the variance in temperamental reactivity was explained by genetic factors, with 23% of the variance being explained by unique environment and measurement error. This raises the possibility that children are differentially susceptible to the quality of the mother-child relationship depending on their genetic make-up, in particular concerning polymorphisms in genes related to temperamental reactivity. Differential susceptibility has indeed been shown on the level of functional genetic polymorphisms related to the dopamine system. Bakermans-Kranenburg and Van IJzendoorn (2006) showed that children were differentially susceptible to parental rearing depending on the presence of the DRD4 7-repeat allele. Children with the DRD4 7-repeat allele receiving less sensitive care showed more externalizing behavior than did children without the 7-repeat allele. Furthermore, children with the 7-repeat allele receiving sensitive care showed the least amount of externalizing behavior. In another study, Van IJzendoorn and Bakermans-Kranenburg (2006) showed that the risk for attachment disorganization was higher for children with the DRD4 7-repeat allele exposed to maternal unresolved loss or trauma than for children without this 7-repeat allele and that it was lowest for children with this allele but not raised by mothers with unresolved loss or trauma.

Further research is needed to test the contention that children are differentially susceptible to environmental influences dependent on their genetic make-up as related to temperamental fearfulness. The study of endophenotypes (measurable components along the pathway between genotype and phenotype, Bearden & Freimer, 2006) related to fear, such as the neural systems underlying attention bias to threat (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van IJzendoorn, 2007) and functional aspects of the ventral prefrontal-amygdala circuitry that have been suggested to be affected by the quality of maternal care (Fox, Hane, & Pine, 2007), may provide more insight into the intricate interplay of child characteristics and parenting in the prediction of physiological reactions to fear-inducing stimuli.