Early Childhood Predictors of Adult Anxiety Disorders

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This paper considers the influence of temperamental factors on the development of anxious symptoms in children and adolescents.

About 20 percent of healthy children are born with a temperamental bias that predisposes them to be highly reactive to unfamiliar stimulation as infants and to be fearful of or avoidant to unfamiliar events and people as young children. Experiences act on this initial temperamental bias and, by adolescence, about one-third of this group is likely to show signs of serious social anxiety. These children are also likely to have one or more biological features, including a sympathetically more reactive cardiovascular system, asymmetry of cortical activation in EEG favoring a more active right frontal area, more power in the EEG in the higher frequency range, and a narrower facial skeleton. The data imply that this temperamental bias should be conceptualized as constraining the probability of developing a consistently fearless and spontaneous profile rather than as determining an anxious or introverted phenotype. Biol Psychiatry 1999;46:1536–1541 © *1999 Society of Biological Psychiatry*

Key Words: Anxiety, inhibition, temperament

Introduction

One feature that distinguishes European-American conceptualizations of psychological variation during most of this century with the views of physicians and philosophers in ancient Athens, Rome, and Alexandria is the stigma the former group attributes to individuals who are excessively apprehensive over physical harm, task failure, or unfamiliar social settings. Citizens in ancient societies regarded anger, not anxiety, as the more harmful emotion that individuals should try to control. The contemporary judgment that chronic anxiety is a greater obstacle to adjustment than chronic anger, boredom, or sexual frustration is the product of historical factors. Conformity to authority and to the values of the local community were adaptive in early societies; worry over the evaluative judgments of others is easier if one is vulnerable to apprehension. These anxiety states are a burden in modern society because assuming risk, defending an unpopular opinion, engaging strangers, and meeting difficult obligations serve effective adaptation. Thus, the current concern with, and intensive study of, anxiety and its symptoms are understandable.

Current hypotheses regarding the causes of variation in susceptibility to this family of feelings have cycled back to the views of Hippocrates and Galen who claimed that some individuals inherited a constitutional vulnerability to anxious states, a quality called "temperament" by modern authors.

The suggestion by Thomas and Chess (1977) that temperamental factors render some children especially susceptible to fear and anxiety was followed by elegant discoveries in neuroscience laboratories that made it possible for scientists to speculate on the possible biological substrates for vulnerabilities to fear and anxiety. It took less than 50 years after the first Chess and Thomas publication to persuade the psychiatric and psychological community that some children inherited a biology that made it easier for them to feel uncertain, tense, or apprehensive to unfamiliarity and challenge and, as a result, to be more vulnerable to one or more of the anxiety disorders.

This paper summarizes what scholars have learned about these temperamental biases. My colleagues and I—especially Nancy Snidman, Doreen Arcus, J. Steven Reznick, and Mark McManis—have been studying this interesting problem for almost 20 years and much of the evidence to be summarized comes from my laboratory. Before presenting the data, however, it is necessary to make a methodological point.

The primary information in the work to be described came from direct observations rather than parental descriptions of children. Investigators who rely only on parental descriptions assume that these verbal reports correspond closely to what would be detected by direct behavioral observations. Unfortunately, the degree of correspondence between the two sources of information is modest at best; therefore, generalizations based only on parental descriptions have a special meaning and validity (Spiker et al 1992; Seifer et al 1994; Rosicky 1993; Klein 1991; Perrin and Last 1992; Kagan 1998).

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Table 1. Differences between High Reactive and Low Reactive Infants from 14 Months to 7.5 Years

Variable	High Reactive[a]	Low Reactive[a]	
Mean fear at 14 months	4.2 (2.4)	2.5 (1.6)	$t(286) = 11.1, p < .001$
Mean fear at 21 months	3.4 (2.5)	2.0 (1.9)	$t(243) = 4.67, p < .001$
Mean spontaneous comments at 4.5 years	40.7 (39.3)	53.7 (47.5)	$t(191) = 1.96, p < .05$
Mean smiles at 4.5 years	17.8 (15.3)	27.7 (19.3)	$t(191) = 3.69, p < .01$
Percent inhibited with peers at 4.5 years	46%	10%	
Percent uninhibited with peers at 4.5 years	27%	67%	$\chi^2(1) = 35.5, p < .001$
Mean spontaneous comments at 7.5 years	19.6 (27.9)	32.8 (30.3)	$t(109) = 2.37, p < .01$
Mean smiles at 7.5 years	14.4 (18.2)	22.0 (21.5)	$t(109) = 1.97, p = .05$
Percent with anxious symptoms at 7.5 years	45%	15%	$\chi^2(2) = 12.8, p < .01$

[a]Numbers in parentheses are standard deviations.

Reactivity in Infancy

Research with animals reveals that the amygdala is responsive to unfamiliar events and, in addition, is a necessary structure for the acquisition of conditioned reactions that imply a fear state when aversive events, like shock, are the unconditioned stimuli (Davis et al 1995; Blanchard and Blanchard 1988; LeDoux 1996). The amygdala contains receptors for a large number of neurotransmitters and neuromodulators that are relevant to the display of fearful behavior, including GABA, opioids, norepinephrine, and corticotropin releasing hormone (Amaral et al 1992). The basolateral area of the amygdala sends projections to the ventral striatum and excitation of this structure induces limb movement in animals (Rolls 1992). Second, the amygdala is the origin of the amygdalofugal pathway whose projections to the central gray and anterior cingulate modulate distress cries. Thus, infants born with a low threshold in the amygdala and its projections should display vigorous limb movements and become easily distressed to unfamiliar stimulation. Further, as young children, these infants should be avoidant of, or fearful to, unfamiliar events. These children are called inhibited. In contrast, infants born with an amygdaloid neurochemistry that raised the threshold of these structures should display minimal motor activity and minimal crying to unfamiliar stimulation and should be minimally fearful to, or avoidant of, unfamiliar events. These children are called uninhibited.

The Consequences of Variation in Infant Reactivity

A sample of 462 healthy, Caucasian, middle-class, four-month-old infants were administered a battery of visual, auditory, and olfactory stimuli (Kagan 1994). About 20% of the sample showed a combination of frequent vigorous motor activity, including arching of the back, combined with fretting and crying. These infants were called high reactive. About 40% of the sample showed the opposite profile of low motor activity and minimal distress to the same battery and these children were classified as low reactive. The remaining infants belonged to other temperamental groups.

Almost 80% of the sample of children returned to the laboratory when they were 14- and 21- months old and encountered a variety of unfamiliar social and nonsocial events. The unfamiliar events included: interacting with an unfamiliar examiner, placement of heart rate electrodes and a blood pressure cuff, an unfamiliar liquid being placed on the child's tongue, and the appearance, in different episodes, of a stranger, a clown, and an odd-looking robot made of metal combined with requests by an adult to approach each of these discrepant objects. Each episode was scored for the display of an unambiguous fear reaction, where fear was defined strictly as a display of fretting or crying to any of the unfamiliar incentives or failure to approach the stranger, clown, or robot despite a friendly invitation to do so. The mean number of fears was 2.6 at 14 months and 2.7 at 21 months and about 30% of the sample showed 4 or more fears at both 14 and 21 months. The high reactive infants displayed significantly more fears than the low reactives and were more likely to show four or more fears at both ages (Table 1).

A majority of the high and low reactive children were evaluated again when they were 4.5 years of age. We assumed that inhibition of speech in an unfamiliar social setting is analogous to an animal's freezing in an unfamiliar context and, therefore, expected that the high reactive infants would be far less talkative than low reactives while interacting with an unfamiliar adult. Further, because the high reactive infants smiled less often during the evaluations at 14 and 21 months and spontaneous smiling in a social interaction requires a low level of uncertainty, we expected that high reactives should smile less often with the examiner than low reactives. The videotapes of a 60 min battery involving the child and an unfamiliar female examiner were coded for the number of spontaneous comments and smiles. In addition, between 3 and 6 weeks after the laboratory session, the child and parent returned for a play session with two other unfamiliar children of the same age and gender. The three parents sat on a couch in a large playroom while the three children played with age-appropriate toys.

The 4.5-year-olds who had been high reactive infants displayed significantly fewer comments and smiles with the examiner and, in addition, were more likely than the low reactives to be classified as shy/inhibited when playing with the unfamiliar peers (Table 1). Only 4% of the entire sample (9 children) displayed a profile at 4.5 years that was inconsistent with their original 4 month temperament. Three high reactive infants were spontaneous and sociable and 6 low reactive infants were shy. The majority of the children, both high and low reactive, were neither extremely inhibited nor uninhibited at 4.5 years (Kagan et al 1998).

Development of Signs of Anxiety

A group of 164 of the original sample of 462 children were evaluated again when they were 7.5 years old. Initially, all mothers were sent a questionnaire and asked to rate their child on a 3-point scale for descriptions of age-appropriate behavior. Twelve of the questions dealt with anxious symptoms (for example, “My child becomes quiet and subdued in unfamiliar places,” “My child is afraid of thunder and lightning,” “My child is afraid of animals,” “My child has nightmares”). A score of 1 was assigned to the child if the mother said that the anxious behavior was sometimes true of the child, a score of 2 was assigned if the mother said the behavior was often true of her child. Children with a total score of 9 or more across the 12 questions were regarded as potential members of a category of anxious children. The mothers of these potentially anxious children were interviewed on the telephone and asked to provide specific examples to support their descriptions. These interviews often revealed that some mothers had exaggerated the seriousness of their child’s behavior and these children were eliminated from the potentially anxious group. The teachers of the remaining children were interviewed on the telephone. Each teacher, who had no knowledge of the child’s prior behavior or the purpose of the interview, described and then ranked the child with respect to all children of the same gender in that classroom for the qualities of shyness and fearfulness.

The maternal questionnaire and the subsequent interviews with the mother and the teacher were then discussed by a trio of investigators. If all three agreed that the evidence indicated the child met criteria for anxious symptoms, the child was categorized as anxious (42 children or 26% of the group met that criterion). We selected 107 control children from the rest of the sample who did not meet criteria for any symptom and brought all 164 children to the laboratory where each was administered a variety of procedures. As at 4.5 years, the frequency of spontaneous comments and smiles was coded from videotapes.

More high than low reactive infants had acquired anxious symptoms—45% of high reactives but only 15% of low reactives and 21% of all remaining children were classified as possessing anxious symptoms. Further, the high reactives displayed fewer spontaneous comments and smiles than the low reactives while interacting with an unfamiliar female examiner (Table 1). Only a modest proportion of children were consistently inhibited or consistently uninhibited on all assessments from 14 months to 7.5 years. Only 18% of the high reactives showed a combination of high fear scores at 14 and 21 months, inhibition with the examiner and inhibited behavior with same gender peers at 4.5 years, and, in addition, display of anxious symptoms at 7.5 years. Not one high reactive infant developed the complementary profile of low fear at 14 and 21 months, uninhibited behavior at 4.5 years, and no anxious symptoms at 7.5 years. Thus, the classification high reactive constrained the likelihood that a child would develop a consistently uninhibited phenotype. Most high reactive infants developed a profile in the average range (Kagan et al 1999).

The 23 high reactives who had anxious symptoms differed from the 27 high reactives who did not show signs of anxiety. More members of the former group had a narrow facial skeleton, higher sitting diastolic blood pressure, and a greater magnitude of cooling of the temperature of the fingertips while listening to a series of digits they were asked to remember. The latter 2 variables imply that these children had greater sympathetic influence on the cardiovascular system.

The predictive value of the facial skeleton was not a surprise. We had discovered earlier that the 14- and 21-month-old children who had a narrow facial skeleton were more inhibited than those with broad faces (Arcus and Kagan 1995). We interpret these results as implying that the genes that control the growth of the maxilla, which is a derivative of the neural crest and, therefore, ectodermal in origin, are correlated with the genetic factors that contribute to inhibited behavior. It is relevant, therefore, that an allelomorph of the agouti gene, located on chromosome 2 in mice, is linked to craniofacial anomalies (Asher et al 1996). Both melanocytes, whose activity is modulated by the agouti gene, and facial bone are derivatives of the neural crest. Mice and rats who are homozygous for the recessive form of the agouti gene (called non-agouti) have all black fur and are tamer and less fearful than animals with the agouti gene (Cottle and Price 1987; Hayssen 1997).

Other data affirm an association between high reactivity as an infant and greater sympathetic activation of cardiovascular targets at 7.5 years. For example, an asymmetry in skin temperature between the fingertips of the index fingers of the left and right hand is a result of differential constriction of arteriovenous anastomoses. The index fingers typically have larger asymmetries than the middle or ring fingers (average asymmetry of +0.3°C favoring a cooler left hand). When the distribution of asymmetries was divided into terciles, significantly more high than low reactives were either in the top or the bottom tercile (80% vs. 58%), and girls with large asymmetries were more likely to have anxious symptoms than girls with smaller asymmetries.

EEG Asymmetry

Davidson (1992) and Fox and Davidson (1988) have suggested that children who are avoidant of or fearful to unfamiliar events show greater desynchronization of alpha frequencies over the right frontal compared with the left frontal area under resting conditions (Davidson 1995). In addition, high reactives showed greater activation of the right frontal area when they were 9- and 24-months-old, whereas low reactives showed greater activation over the left frontal area (Fox et al 1994). Because neural activity in the amygdala is transmitted to the frontal lobes via cholinergic fibers projecting from the basal nucleus of Meynert, it is possible that greater desynchronization of alpha frequencies in the right frontal area reflects greater activity in the right amygdala (Kapp et al 1994; Lloyd and Kling 1991). We have begun to evaluate the children from this longitudinal sample at 10 years of age. At the time of this writing, 28 high reactives and 24 low reactives have been measured and significantly more high than low reactives are showing greater EEG activation under resting conditions over the right frontal area (30% vs. 8%) whereas more low reactives are showing greater activation over the left frontal area (55% vs. 25%) (chi square = 4.0, $p < .05$). This replication of Fox and Davidson findings lends robustness to this empirical association. In addition, more high than low reactives had greater power in the 14- to 30-Hz range than in the 8- to 13-Hz range at frontal sites (eyes opened and relaxed) (chi square = 4.1, $p < .05$). This result suggests greater cortical arousal in the children who had been high reactive infants.

Inhibition in Children of Panic Disorder Parents

An early study on a small sample suggested that children with a panic parent were more likely than controls to show inhibited behavior in a laboratory setting (Rosenbaum et al 1988). A subsequent collaboration involved an evaluation of two larger samples of Caucasian, middle-class children (65 4.5-year-olds and 83 6.5-year-olds), who had a parent with panic disorder or panic combined with depression. We compared the behavior and physiology of these children with that of 42 4.5-year-old and 36 6.5- year-old Caucasian children from middle-class families with no psychiatric symptoms. Each child was administered a battery by an examiner who was blind to the diagnostic status of the parent.

More panic than control children were emotionally subdued as they interacted with the unfamiliar female examiner. Nineteen percent of children with a panic parent, but only 5% of control children, had values in the lowest quartile of the distributions for both spontaneous smiles and comments while interacting with the female examiner. These behavioral differences between the panic and control children were clearer if the parent reported onset of panic disorder before 21 years of age.

The autonomic variable that best differentiated the panic from control children was a large temperature asymmetry (≥1°C) between the right and left index fingers while the child was watching film clips. It will be recalled that this sympathetically mediated measurement also differentiated high from low reactives in the longitudinal sample.

Thus, about 1 in 5 middle-class, Caucasian children living with a parent who had panic disorder was likely to become an inhibited child, compared with a probability of 1 in 20 for matched control children. If one adds the large temperature asymmetry as a diagnostic marker, then 1 in 10 children with a panic parent, but only 1 in 100 control children combined a subdued style of interaction with this sign of sympathetic lability.

A group of 10 girls living with a panic parent (15% of all girls) were extremely subdued—they displayed fewer than 10 spontaneous comments and 10 smiles across the battery. These extremely subdued girls were qualitatively different from the remaining girls living with a panic parent who were emotionally more spontaneous with the examiner. The 10 extremely subdued girls had higher resting heart rates, were more likely to have a very cool right compared with left index finger, and more likely to have very light blue eyes. These 3 features are more characteristic of extremely inhibited children in the larger longitudinal sample (Kagan 1994).

Implications

The major implication of this work is that high reactive infants, many of whom show an inhibited profile to unfamiliar events and situations in the second year, are at slightly higher than normal risk for the later development of some form of anxious symptomatology. This suggestion is affirmed by longitudinal study of an independent sample of 79 13-year-olds, who had been classified as inhibited or uninhibited in the second year of life (Kagan et al 1988b). These adolescents were interviewed by Carl Schwartz, a child psychiatrist, who had no knowledge of their initial temperamental classification or later laboratory behavior. More of the adolescents who had been classified as inhibited rather than uninhibited in the second year had symptoms of social anxiety (61% vs. 27%) (Schwartz et al, in press). These inhibited children were not more likely to have developed specific target phobias or separation anxiety, implying that inhibited children might be at special risk for the development of social phobia during the adolescent and adult years. College students who reported high levels of social anxiety remembered being very shy when they were young children (Mick and Telch 1998; van Ameringen et al 1998).

It is possible that inhibited children are especially susceptible to anxiety or PTSD after threatening events. Only 10 children from a large group of school children who were kidnaped and terrorized for 2 days developed post-traumatic stress disorder (Terr 1979); these 10 might have been temperamentally inhibited children. In 1984, a sniper in a building across the street from a Los Angeles elementary school fired at the children on the playground killing 1 and injuring 13 children. One month later a group of psychologists and psychiatrists who interviewed the victims of this event judged 38% of the group to be anxious. A primary quality that differentiated the anxious from the nonanxious children was a prior avoidant personality among the former group (Pynoos et al 1987).

It is important to appreciate, however, that the majority of inhibited children probably will not become anxiety disorder patients in later life. Given the frequency of anxiety disorder in the population, a variable that correctly predicted 90% of individuals with adult anxiety disorder and eliminated 90% of those who would not, would be correct in only one-third of the cases.

The Notion of Constraint

It will be recalled that only 18% of the high reactive infants were consistently inhibited at every evaluation, but not one member of the group was consistently uninhibited from 1–7 years of age. This fact suggests that the relation between infant reactivity and the later development of a consistently inhibited style is real, but modest. When the probability of one event following another is low, say the correlation is less than 0.4, it is likely that the relevant antecedent event is affecting the consequent either indirectly, only at extreme values, or in combination with other factors. Under these conditions, it is more accurate to use the verb "constrain" rather than "determine" to describe the relation between the earlier and later event. For example, consistent nurturance of young children during the first five years of life does not predict, with a high level of confidence, the quality of one's marriage, amount of education, or degree of professional accomplishment. Early nurturant care probably constrains, in a significant way, the likelihood that children raised in such families will become criminals. Because no high reactive infant became a consistently uninhibited child, it is more accurate to write that a high reactive temperament constrains the probability of the child becoming consistently uninhibited, rather than to claim that high reactivity determines the development of an inhibited or anxious profile. The replacement of the word "determine" with "constrain" is not idle word play for the connotations surrounding the two words are different.

Summary

The evidence and ideas presented in this paper support the usefulness of combining biological and behavioral evidence. During the first half of this century, psychiatrists and psychologists ignored the modest but significant contribution of temperament to personality profiles. The child's social history determines the meaning he or she will impose on an event; the combination of temperament and history determines the ease with which the event activates limbic structures and the subsequent emotional response. The fact that only a small proportion of high reactive infants became consistently fearful, anxious children implicates an important role for the environment. We must now search for the integrated profiles that emerge from particular temperamental dispositions encountering varied life histories and resist the desire to simplify the problem by proceeding as if we could eventually have a quantitative estimate of the separate contributions of temperament and life events.

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