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Cognitive Set and Coping Strategy Affect Mothers' Sensitivity to Infant Cries: A Signal Detection Approach

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We used Signal Detection methodology to examine how cognitive set affects mothers' response to an infant cry. We asked whether a cry from a "difficult" versus an "easy" infant would elicit a change in sensitivity or response bias in mothers' processing of these cries. Thirty-eight mothers of 4- to 6-month-old infants participated in a Signal Detection task in which they were asked whether they could detect differences between a standard cry and 1 of 4 cry variants. Cry variants differed from the standard cry in small, systematic changes in fundamental frequency. The task was conducted in 2 parts; each part constituted a condition wherein mothers received a cognitive set manipulation that labeled the identical cry as coming from either a "difficult" or an "easy" infant. An increase in mothers' sensitivity was associated with the "difficult" infant cognitive set. We examined as well how a coping strategy (illusion of control) affected cry signal processing. Mothers who exhibited high *illusory* control were least sensitive in detecting differences between cries. Two information-processing measures, response time and heart rate, were also collected and showed that greater sensitivity was associated with more efficient processing of the cry signal.

INTRODUCTION

For over 2 decades, studies generated from different theoretical perspectives have demonstrated the importance of a mother's responsiveness to her infant's signals for their developing relationship and the development of the child's social and cognitive competence (see Ainsworth, Bell, & Stayton, 1974; Bates, Maslin, & Frankel, 1985; Bornstein & Tamis-LeMonda, 1989; Donovan & Leavitt, 1978; Egeland & Faber, 1984; Isabella & Belsky, 1991). Given the central role of maternal sensitivity to developing reciprocity, it is noteworthy that research has not studied to what degree variation in maternal response is due to differences in signal processing (i.e., sensitivity at the sensory level) or due to differences in the response (decision-making) system.

In this study, we applied Signal Detection Theory (Statistical Decision Theory; Green & Swets, 1966; Macmillan & Creelman, 1991) methodology to separate these two measures of maternal performance—sensitivity and response bias. The first of these measures, sensitivity, reflects how well one is able to make correct judgments and avoid incorrect ones. The second measure, response bias, reflects the extent to which one favors one choice over another, independent of the sensory information available. If the response alternatives are perfectly clear, the decision problem is often trivial. However, real-life decision making usually involves some uncertainty. The sensory evidence on which perceptual decisions are made can be equivocal also. Perceptual errors may occur not only because of the poor quality or ambiguity of the stimulus, but also because of the internal state of the individual, which affects the processing and interpretation of information. One's motivational state, past learning experience, and cognitive set may determine the efficiency with which a person processes information and may also predispose one toward one type of response rather than another (Swets & Green, 1978). Human perception is fallible. A false alarm, thinking one detects a signal when one is not present, is not an unusual perceptual occurrence, and sometimes we "see" or "hear" the "wrong" thing. Because of this, there is the need for measuring sensitivity and response bias independently. The distinctive contribution of Signal Detection Theory is that it provides a means to separate these two potentially independent aspects of a discrimination task, sensitivity and response bias, by retaining the information contained in the false alarm rate which reveals as much about the decision process as do correct judgments.

The relevance of Signal Detection Theory to maternal responsiveness to infant signals lies in the fact that a good deal of what occurs during mother-infant interaction is concerned with choices. Does one respond? With what response? How quickly? And so on. For example, when responding to her infant's cry, a mother must acquire information quickly and then

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decide whether the cry requires immediate action, or whether it can or should tolerate some delay.

Responding to the cry signal is one of the first challenges faced by mothers. A common method of studying the effect of the cry on the caregiving environment has been to ask parents to rate their perceptions of the cry. Cries with a high fundamental frequency and an irregular temporal pattern (e.g., long pauses within cries) are judged to be unpleasant, annoying, or irritating (see Lester & Boukydis, 1985). Zeskind and Marshall (1988) report high positive correlations between ratings of cry aversiveness and measures of fundamental frequency. Duration, percent dysphonation, and power in low and high frequency bands may also contribute to cry ratings (Gustafson & Green, 1989). Applying the "goodness of fit" concept (Thomas & Chess, 1980), in which a "good fit" or match occurs when the infant's signals are accurately interpreted by the caregiver, Lester (Lester et al., 1995) has reported that a match between the acoustic characteristics of the infant's cry and the mother's perception of the cry predicts developmental outcome. For example, infants whose mothers rated a higher-pitched and more variable cry as more negative scored higher on measures of language and cognitive performance than did infants whose mothers failed to rate the higher-pitched cry as being negative.

Cries of infants perceived as more difficult are differentiated by the acoustic characteristic of higher fundamental frequency (Lounsbury & Bates, 1982) and are rated as more grating, arousing, piercing, and so on (Boukydis & Burgess, 1982). Moreover, infant temperament has been shown to influence the mother's response during social interaction (Crockenberg, 1986; van den Boom, 1991; Vaughn et al., 1992). Differences in maternal response to infant difficulty may be due to differences in processing the infant's signal, that is, in detecting information in the cry. Or differences may be due to differences in the decision to respond, that is, showing a preference for one response over another. In some instances, the signal information may be processed, but factors other than signal information (e.g., motivational state, past experience, or cognitive set) may be operating that affect behavioral response.

Research conducted within a social cognitive framework has documented the moderating role of cognitive set or attributions on information processing in adult-child interactions (Bugental, Blue, & Lewis, 1990; Dix & Grusec, 1985; Goodnow, 1988; Lewis, Bugental, & Fleck, 1991). A fruitful approach to studying the moderating effect of attributions has been to manipulate the mother's cognitive set through instructions provided to her. This approach entails observing a mother's response while she interacts with the child identified or "labeled" as differing reliably on the measure of interest. This experimental labeling approach has been used to study the effects of maternal response to "temperamental" differences (Donovan & Leavitt, 1985; Lounsbury & Bates, 1982), birth status (e.g., prematurity; Frodi et al., 1978; Stern & Hildebrandt, 1986), and infant's health status (Bisping, Steingrueber, Oltmann, & Wenk, 1990) differences, as well as differences in the older child's responsiveness (Bugental & Shennum, 1984; Lewis et al., 1991). In the present research, we employed this labeling technique to study the effect of perceived infant temperament on maternal response to infant crying.

A central issue addressed in this study is how mothers' style of coping with infant care corresponds to responsiveness to infant signals. We have found that mothers' behavioral response to infant signals is related to their assessment of their self-efficacy in coping with these signals (Donovan & Leavitt, 1989; 1994; Donovan, Leavitt, & Walsh, 1990). We have demonstrated in a simulated child-care task that when attempting to terminate an infant cry, mothers who responded by greatly overestimating their actual control (i.e., mothers with high illusory control) were less effective in managing other child-care tasks. They were more susceptible to helplessness following exposure to failure on a simulated child-care task (Donovan et al., 1990) and were more likely to have insecurely attached infants (Donovan & Leavitt, 1989). In a compliance task, toddler defiant behavior was associated with maternal high illusory control, the latter being associated with a socialization strategy involving negative control (Donovan & Leavitt, 1994). We have also found that, attitudinally, mothers with high illusory control are characterized by a less positive attributional style and depressed mood. Physiologically, aversive conditioning as well as less "attentive" responding are seen in these mothers as they respond to infant cries (Donovan & Leavitt, 1989; Donovan et al., 1990). Together, these behavioral, attitudinal, and physiological data suggest that high illusory control can be characterized as defensive responding and thus is limited in its effectiveness as a way of coping. Repressive/defensive coping (Weinberger, Schwartz, & Davidson, 1979) has been associated with altered sensory and perceptual processing (e.g., Kline, Schwartz, Fitzpatrick, & Hendricks, 1993); therefore, we predict that this defensive responding, characteristic of mothers with high illusory control, reflects an internal state of the individual that will interfere with effective processing of the cry signal.

The goals of our study were to: (1) assess maternal sensitivity to the infant cry signal independent of response bias using the methodology of Signal Detection Theory, (2) manipulate cognitive set to study infant temperament effects on maternal response, and (3) determine whether or not maternal coping strategy, that is, variation in illusory control, is associated with efficient signal processing.

METHOD

Participants

Thirty-eight mothers of 4- to 6-month-old infants participated in the study. Mothers' mean age was 32 years (*range* = 25–40 years). All mothers were white and married; 14 were primiparous. All had graduated from high school, 34 of 38 had attended college or technical school, 29 had graduated, and 13 had some postgraduate education or an advanced degree.

Instruments

In addition to collecting demographic information, mothers were administered two instruments prior to testing, an infant temperament questionnaire and a depression scale. The effects of temperament on maternal response could thus be studied via parental report as well as through the manipulation of cognitive set. Depression was assessed because of its consistent association with illusory control (Donovan & Leavitt, 1989; Donovan et al., 1990), a variable of interest in the present study. A third scale on which mothers rated the characteristics of the cry stimulus was administered as part of the experimental procedure.

Demographic data. Demographic information consisted of sex of infant, parity, mother's age, educational level, occupational status, family income, and the number of hours per week mother and father worked outside the home. Also, on a 7 point Likert-type scale, mothers indicated their degree of conflict over the decision to either remain at home or return to work.

Infant Characteristics Questionnaire (ICQ). Mothers completed the Infant Characteristics Questionnaire, which has established reliability and validity (Bates, Freeland, & Lounsbury, 1979). This scale consists of 24 items comprising four factors: Fussy-difficult, Unadaptable, Dull, and Unpredictable. Items are rated on 7 point Likert-type scales, with the rating of "1" describing an optimal temperamental trait and "7" a difficult temperamental trait, and were summed to yield a total temperament score.

Center for Epidemiological Studies Depression Scale (CES-D). Mothers also completed the CES-D, which is a 20 item self-report questionnaire with established reliability designed for the general population to measure level of depressive symptomatology within the last week (Radloff, 1977). Each item is scored on a scale of frequency of occurrence of the symptom from Rarely or None of the Time (0) to Most or All of the Time (3).

Cry Characteristics Scale (CCS). The Cry Characteristics Scale (Zeskind & Lester, 1978) consists of eight bipolar dimensions (e.g., urgent versus not urgent) arranged on 7 point Likert-type scales that assess the mother's perception of the cry. The remaining seven dimensions are: grating, sick, arousing, piercing, discomforting, aversive, and distressing.

Procedure

Mothers were asked to visit the laboratory twice to participate in a study on mothers' response to infant signals. During the first visit, they completed demographic information, the ICQ, and the CES-D. They then participated in a simulated child-care task, the Illusion of Control task, to assess their perception of control over the termination of an audiotaped infant cry. At the conclusion of the task, mothers completed the CCS. During the second visit, approximately 1 week later, mothers participated in the Signal Detection task, during which they were asked to differentiate infant cries that varied in fundamental frequency. Both tasks were conducted in a sound-attenuated chamber.

Illusion of Control Task

In this laboratory simulation of a child-care task, mothers responded to an audiotaped infant cry, their goal being the termination of the cry. The task is a CS-UCS paradigm with a light preceding an infant cry.

Cry stimulus and response apparatus. The cry stimulus and response apparatuses are identical to those used in earlier studies (Donovan & Leavitt, 1989; Donovan et al., 1990). The apparatus for CS presentation consisted of a white wooden stand-up platform on which a red light was positioned facing the mother. The UCS was a tape-recorded 80 db infant cry produced by a 5-month-old infant. The cry was loaded in a TASCAM 122MKII audio cassette deck, amplified by a Crown D60 power amplifier, and presented to the mother via an AR-4x speaker located within the testing chamber. The response apparatus consisted of a metal box on which a spring-loaded button was mounted in the center. A 486 IBM PC compatible computer controlled the CS-UCS presentation and recorded mothers' responses.

Procedure. Each mother received 30 30-s trials. Each trial was initiated by the onset of a 10 s red light (CS) followed by cry onset (UCS), with UCS onset simultaneous with CS offset. The intertrial interval ranged from 20 to 30 s, with a mean of 25 s. The mother was instructed that this was a learning task and that she was to determine whether or not her responses terminated the cry. Following the presentation of each cry, she had the option of either pressing or not pressing the button. Responses were followed by either cry termination at 5 s (success) or cry continuation for 20 s (failure). Following the 30 trials, the mother was asked to estimate how much control she thought she had (i.e., was one response more effective than the other) over the termination of the cry. Estimates of control were indicated on a scale in units of 5 with extreme values of 0 (labeled "no control") and 100 (labeled "complete control"). The task was designed as a zero contingency task in which neither response was more effective than the other in terminating the cry. Therefore, objective control (i.e., zero control) subtracted from perceived control constituted the mother's *illusion of control* score.

Data reduction—illusion of control categories. Because our past work has shown that some variables bear a linear relation (e.g., susceptibility to learned helplessness; Donovan et al., 1990), others a curvilinear relation (e.g., depression, attributional style; Donovan & Leavitt, 1989; Donovan et al., 1990), to the illusory control variable, we have found it best to analyze the effects of illusory control by grouping mothers into three illusion of control groups based on their perceived control scores from the Illusion of Control task. Mothers with an illusion of control score of 20 or less were categorized as *low* illusion (n = 11), mothers with a score of 21 to 50 were categorized as *moderate* illusion (n = 18), and mothers with a score of 50 or greater were categorized as *high* illusion (n = 9).

Physiologic response recording. Cardiac activity was monitored throughout the Illusion of Control task. To record cardiac activity, Beckman biopotential miniature electrodes were attached to the mother prior to giving the instructions for the task. Active leads were placed at the left ankle and right forearm, with the ground electrode at the right ankle. The signal was amplified by a Hewlett-Packard ECG monitor (07905A) and recorded as well as stored on an AT-class microcomputer for data analysis. The R-R intervals of the electrocardiogram were timed to the nearest millisecond and converted to heart rate in beats per minute for each second interval. The physiologic dependent measure was the mean cardiac change scores (i.e., deviation from prestimulus level) during the 10 s interval prior to the onset of the UCS.

Signal Detection Task

Mothers were presented the Signal Detection task in which they were asked to differentiate between infant cries that varied in fundamental frequency. The task entailed a cognitive set manipulation that identified an identical cry as coming from either a "difficult" or an "easy" infant.

Cry stimulus construction. The 6 s tape-recorded 5-month-old infant cry served as the standard cry. We used a Kay Elemetrics Model 5500 Digital Sona-Graph to make wide- and narrow-band spectrograms of the cry. The narrow-band (117 Hz bandwidth) was the most informative. Fundamental frequency was determined by measuring the frequency values of the tenth harmonic and dividing by the harmonic number (10). The cry was composed of three segments, each associated with an inspiratory and expiratory phase. The duration of the inspiratory phases ranged from 90 to 130 ms, with the duration of the expiratory phases ranging from 1,360 to 1,680 ms. The fundamental frequency contour of each of the expiratory phases was defined by a minimum value of 400 Hz and a maximum value of 444 Hz for the first, 420 Hz and 444 Hz for the second, and 415 Hz and 424 Hz for the third phase. The fundamental frequency of 90% of the total duration varied between 400 and 440 Hz, indicating that the phonatory portion of the cry was quite stable.

Four cry variants were then generated by editing this standard cry. For each of the three segments of the standard cry, the expiratory phase was edited by making small, systematic changes in the f_0 level and contour without changing the duration. The cry was resynthesized by LPC using the Kay Sona-Graph and related software. This software allowed us to ramp into the frequency change, hold the frequency to the desired level, ramp back down, and resynchronize with the original waveform. Thus, the changes were gradual, smooth, and natural sounding. The four cry variants constructed from the standard cry had 4.5%, 6%, 7.5%, and 9% increases in the fundamental frequency.

Apparatus. The stimulus apparatus for presentation of a warning light preceding each trial was the same apparatus used for the CS presentation in the

Table 1 Verbal Instructions to Mothers for the Cognitive Set Manipulation

Easy Infant Cognitive Set
Before we begin, I want to tell you that the cries you are about to hear are from a 4-month-old baby who is EASY to care for. The baby usually sleeps through the night and naps at regular times during the day. The baby eats well and is usually happy. It is easy to tell when it is the best time for the baby's nap, feeding, or diaper change.

Difficult Infant Cognitive Set
Before we begin, I want to tell you that the cries you are about to hear are the cries of a 4-month-old baby who is DIFFICULT to care for. The baby often wakes up crying two or three times a night. The baby eats well sometimes and other times does not. The baby is often fussy. It is hard to tell when it is the best time for the baby's nap, feeding, or diaper change.

Illusion of Control task—a white wooden stand-up platform on which a red light was positioned facing the mother. The digitized cries were presented by an IBM ACPA (Audio Capture Playback Adaptor) board in the 486 microcomputer. The sounds were again amplified by the Crown D60 power amplifier and played through the AR-4x speaker.

The response apparatus consisted of a box with six spring-loaded buttons with two response buttons mounted across the top labeled "different" and "same" and four certainty buttons at the bottom labeled "different certain," "different uncertain," "same uncertain," and "same certain." The same computer that controlled the cry presentation controlled the warning light presentation and recorded the mothers' responses.

Procedure. The task was conducted in two parts; each part constituted a condition wherein mothers received the designated cognitive set manipulation. Each part (i.e., condition) contained two sessions with 85 trials in each session. Thus the entire task had a total of 340 trials. For each trial, the warning light was presented for 1 s, followed by the 6 s standard cry, a 2 s pause, and the 6 s test cry. The test cry for each trial was either the same cry as the standard cry or a different cry (cry variant). The particular variant selected as the test cry for each trial was determined at random, with the restriction that the four variants be presented an equal number of times. The same cry and each variant were thus presented 17 times per session. Each presentation of the two cries was followed by an intertrial interval of 5 s during which the mother gave her response. The mother was instructed to indicate whether she thought the test cry was the same or different from the standard cry by pressing the appropriate button. Response time from test cry offset to button response was collected to the nearest millisecond. Immediately following her initial response, she then indicated how confident she was in her response by pressing one of the certainty buttons in the bottom row of the response apparatus.

Cognitive set manipulation. All mothers received both cognitive sets. The cognitive set manipulation entailed telling the mothers that the cry was from an "easy" infant or from a "difficult" infant (see Table 1). One-half of the mothers were randomly assigned to receive the Difficult Infant manipulation first, and the other half of the mothers received the Easy Infant manipulation first. The stimuli for each condition were, in fact, identical. The mothers were given a 30 min break between conditions, during which time they were given a form to complete that was unrelated to aspects of the cognitive set manipulation. Upon completing the entire task, mothers were informed that the cries labeled as "easy" and "difficult" in the two conditions were identical.

Data reduction—sensitivity and response bias measures. Four conditional probabilities are generated from the *same* and *different* responses, two of which are necessary for calculating the sensitivity and response bias measures. They are: (1) the probability of responding with *different* given *cry variant* [P(D/d) or Hits], and (2) the probability of responding with *different* given *same cry* [P(D/s) or False Alarms] (see Figure 1). Thus for each mother we calculated a hit rate, that is, the number of times she responded by saying that the standard cry and the test cry were different when in fact they were different, and a false alarm rate, that is, the number of times she responded by saying that the standard cry and the test cry were different when in fact they were identical.

To calculate sensitivity, a Receiver Operating Characteristic (ROC) curve with P(D/d) on the abscissa and P(D/s) on the ordinate was plotted for each cry variant. The mother's certainty button responses indicating her degree of confidence gener-

		Response: different	Response: same
Stimulus	cry variant	HITS	
	same cry	FALSE ALARMS	

Figure 1 The two combinations of stimulus and response events that generate the conditional probabilities necessary for calculating sensitivity and response bias.

ated the three points for the ROC curve for each of the cry variants. The proportion of the area beneath the ROC curve, P(A), defines sensitivity for that cry variant (see Figure 2). To obtain the sensitivity threshold for a particular session and condition from these four P(A)s, the sensitivity P(A) for each cry variant was plotted against its corresponding fundamental frequency change level, and a logistic psychometric function was fitted to these data with the sensitivity threshold for a particular session and condition defined as the fundamental frequency change value, where P(A) = 75% intercepts the fitted function (Allen & Wightman, 1994) (see Figure 3). Following this procedure, our particular task yielded four sensitivity scores for each mother, one for each of the two sessions of 85 trials under the Easy condition and another two under the Difficult condition. However, for the analysis-of-variance techniques, each mother contributed a single sensitivity score for each condition, hereafter referred to as a mother's sensitivity score for that particular condition. This sensitivity score for each condition was represented by the mother's best performance of the two sessions for the respective condition.[1] For correlational analyses, a single sensitivity score was used, an average of these two best performance scores, hereafter referred to as a mother's average sensitivity score. This average appears to adequately and meaningfully represent mothers' sensitivity because the correlation between the two best performance scores is .87.

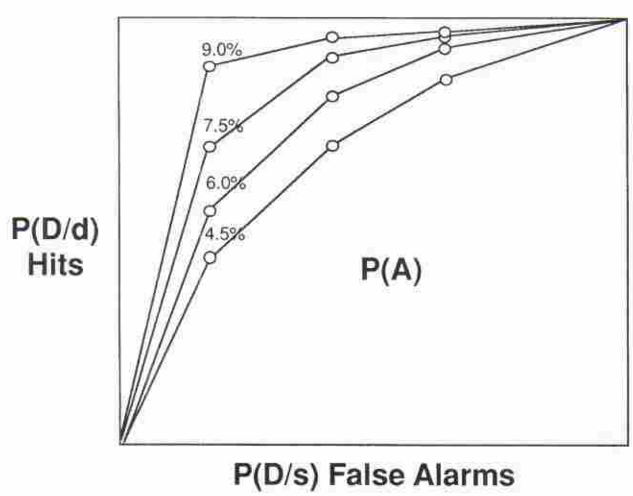

Figure 2 Hypothetical ROC curves defining P(A) for each of the four fundamental frequency change levels.

To calculate response bias in equal probability tasks, the response bias criterion point that maximizes correct decisions is defined as the point on the mother's rating scale at which she is equally disposed to *same* and *different* responses. However, in our task, *same cry* and *cry variant* had different probabilities of occurrence, P(s) = 1/4 P(d). Therefore, a bias value was calculated by alternative means (F. Wightman, personal communication, February 9, 1996). For each of the 12 points on the ROC curves, the P(D/d) was summed with its respective P(D/s). Because P(D/d) + P(D/s) = 1 indicates no bias, values that were less than 1 were categorized as "strict" which represent keeping false alarms at a minimum and values that were greater than 1 were categorized as "lax" which represent maximizing hits. Values that equaled 1 were eliminated from the analysis. A likelihood ratio was calculated by dividing the number of lax values by the number of strict values. For each mother, there were four likelihood ratios, one for each session of 85 trials under the two conditions; again, as with the sensitivity scores, the likelihood ratio from a single session under each condition was selected for analysis. The session selected corresponded to the session that represented mothers' sensitivity score (i.e., their best performance score) under that condition. Likelihood ratios were logarithmically transformed for use in the analysis.

1. For five mothers, it was not possible to calculate a sensitivity score because they did not reach the above chance sensitivity threshold of 75% at even the highest fundamental frequency change level of 9%. Sensitivity scores of 13 were assigned to these mothers. The basis for assigning this value was as follows: The highest extrapolated value from the fitted function attained from this sample differed from the 9% cry variant by 2. Thus, the extrapolated value of 11 was increased by an increment of 2, yielding a score of 13 as a conservative estimate for these mothers. Of these five mothers, two were in the low illusion group and three were in the high illusion group.

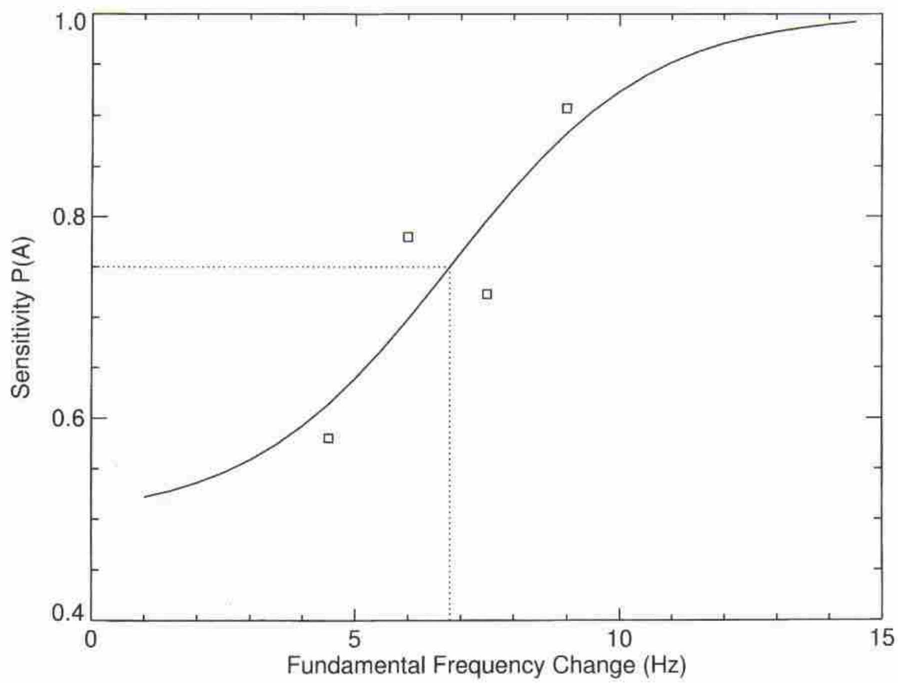

Figure 3 Logistic psychometric function of hypothetical data defining sensitivity threshold as the fundamental frequency change value, where P(A) = 75% intercepts the fitted function.

RESULTS

Illusion of Control, Demographic, and Questionnaire Data

Group differences as a function of illusion of control were examined in a series of one-way ANOVAs with illusion group as the independent variable and demographic and questionnaire data as the dependent variables. Mothers were categorized as having low, moderate, or high illusory control based on their perception of control in the Illusion of Control task. Correlations between demographic and questionnaire data were explored as well.

Univariate ANOVAs indicated that mothers in the three illusion groups were similar on the demographic variables ($ps > .10$), including age, education, parity, and sex of infant. The groups did not differ in the distribution of easy versus difficult infants assessed by the ICQ or in their ratings of the cry during the simulated child-care task. Illusion groups did differ with respect to maternal depression, with a significant main effect, $F(2, 35) = 5.00$, $p < .01$, and a significant quadratic effect, $F(1, 35) = 7.93$, on the means: Low ($M = 9.9$, $SD = 5.79$), Moderate ($M = 6.7$, $SD = 5.80$), and High ($M = 14.2$, $SD = 6.18$). Greater depression was associated with working fewer hours outside the home, $r(36) = -.32$, $p < .05$, more conflict over the decision to stay at home or return to work, $r(36) = .50$, $p < .001$, and lower family income, $r(36) = -.27$, $p < .05$.

Signal Detection Data

The Signal Detection data are presented in two sections, performance data and information processing. In the first section, we examine sensitivity and response bias performance measures from the Signal Detection task as a function of illusion of control. The effects of infant temperament on these two performance measures are also examined via the cognitive set manipulation as well as a self-report of the mother's own infant's temperament. In the second section, we report on two measures, response time and heart rate, indices of signal processing, to enhance our understanding of the behavioral performance data.

Performance Data

Sensitivity. Differences in mothers' sensitivity to fundamental frequency changes in the cry signal were determined in a 3 (illusion of control) × 2 (infant temperament) × 2 (cognitive set) repeated-measures analysis of covariance (ANCOVA). Except for maternal age, none of the demographic variables correlated with sensitivity (i.e., the average of the sensitivity scores obtained under each condition). Older mothers were less sensitive, $r(36) = .27, p < .05$; thus age was entered as a covariate in the analysis. Illusion of control was entered as a between-subjects variable. Because of its systematic relation to illusory control, depression scores were entered as a second covariate in the analysis. Infant temperament was entered as the second between-subjects variable, with mothers being grouped on their perception of their infants as being either easy or difficult based on a mean split of scores on the ICQ ($M = 2.63, SD = 0.59$). The cognitive set manipulation of "easy" versus "difficult" infant was a within-subjects variable, with the dependent variable being each mother's sensitivity score from each condition. Sensitivity scores represent the percent change in fundamental frequency at which mothers could detect a difference between cries; therefore, lower values indicate greater sensitivity.

Group differences in sensitivity as a function of illusion of control were represented by a significant main effect, $F(2, 30) = 3.35, p < .05$. Polynomial contrasts were used to analyze mean differences. A quadratic effect, $F(1, 30) = 3.80, p < .06$, indicated that mothers with moderate illusory control were the most sensitive ($M = 5.76\%$ frequency change, $SD = 2.11$). A linear effect, $F(1, 30) = 3.26, p < .08$, indicated that mothers with high illusory control were the least sensitive ($M = 8.36\%$ change, $SD = 3.64$). Scores of mothers with low illusory control were intermediate ($M = 7.05\%$ change, $SD = 3.60$).

A main effect for cognitive set, the within-subjects variable, was significant, $F(1, 32) = 4.83, p < .04$, in that mothers showed greater sensitivity under the Difficult Infant as compared to the Easy Infant cognitive set manipulation. More specifically, mothers were able to detect smaller changes in fundamental frequency when they were told the cry was coming from a difficult infant ($M = 6.22\%$ change, $SD = 2.95$) rather than when they were told the cry was from an easy infant ($M = 6.75\%$ change, $SD = 3.10$). There were no main or interaction effects for the second between-subjects variable, the mother's perception of her own infant's temperament.

Sensitivity, which was measured during the Signal Detection task, was also related to cry ratings on the Cry Characteristics Scale, which were assessed during the Illusion task. These ratings were collected during the first task to allow us to determine the association between sensitivity and perception of the cry independent of any labeling effects due to the manipulation. Using mothers' average sensitivity score (i.e., an average of the scores obtained under each condition), mothers who were more sensitive had rated the cry as more grating, $r(36) = .41, p < .01$, and more piercing, $r(36) = .32, p < .05$.

Response bias. Correlational analyses indicated that response bias was not related to any of the demographic or questionnaire variables. Response bias was then entered as the dependent variable in a 3 (illusion of control) $\times$ 2 (infant temperament) $\times$ 2 (cognitive set) ANCOVA. Because sensitivity must be held constant when making response bias comparisons (McNicol, 1972), we entered it as a covariate in the analysis. Because of its systematic relation with illusory control, depression was also entered as a covariate. This analysis yielded no significant effects for response bias.

Information Processing

Two measures of information processing were recorded—response time and heart rate. Response times were collected as mothers performed the Signal Detection task and heart-rate data were collected during the Illusion of Control task.

Response time measure. The response time measure indexed processing efficiency, faster times indicating more efficient processing. For each of the four fundamental frequency change levels under each of the two conditions, response times were averaged over trials for each of the two response choices, *same* or *different*. Note that mothers responded correctly if they said *different* when in fact the two cries were different, and they were incorrect when they responded with *same*. This yielded 16 response times that were subjected to a logarithmic transformation for analysis.

Confirming our use of response time as an index of processing efficiency in this paradigm, we found that, when responding correctly, as the stimulus difference became more apparent (i.e., the change in frequency increased), mothers responded more quickly. And, inefficient processing was evident when mothers were incorrect in that response time slowed as the stimulus difference became more apparent, reflecting a hesitancy in a deliberation process that resulted in a wrong decision. This was supported statistically when response times were subjected to four repeated-measures ANOVAs (correct and incorrect responses under each of the two conditions) across the four fundamental frequency change levels. Significant linear components indicated that for correct responses, response time was faster as fundamental frequency change increased under both the Easy Infant, $F(1, 37) = 5.95$, $p < .02$, and the Difficult Infant, $F(1, 37) = 11.72$, $p < .002$, conditions. Conversely, response time slowed as fundamental frequency change increased for incorrect responses under both the Easy Infant, $F(1, 37) = 10.63$, $p < .002$, and the Difficult Infant, $F(1, 37) = 4.78$, $p < .04$, conditions.

To look at the relation between the response time measure of efficient processing (i.e., when they responded correctly) and demographic, questionnaire, and laboratory performance variables, we collapsed over fundamental frequency level to calculate an average response time when responding correctly under each manipulation condition. Only sensitivity correlated with response time: Higher sensitivity scores were related to faster response times under both the Easy Infant, $r(36) = .56$, $p < .001$, and the Difficult Infant, $r(36) = .53$, $p < .001$, conditions.

Heart-rate data. The dependent variable for heart-rate analysis was the mean second-by-second change scores (i.e., deviation from prestimulus level) during the 10 s CS interval preceding the cry in the Illusion of Control task. Heart-rate data were analyzed for differences in the phasic components of cardiac response during this CS period. A typical phasic response of the CS period consists of an initial brief decelerative component, followed by an accelerative "arousal" component, and a second decelerative "attentive" component, and is based on data that identify them as correlates of signal processing activity (Bohlin & Kjellberg, 1979). Response habituation of these phasic components is associated with more efficient processing (Siddle, 1985).

Mothers were divided into three groups of equal size based on their sensitivity scores collected during the Signal task. Because a single score per mother was required for this grouping procedure, we again used the average sensitivity score. To repeat, this score was an average of the sensitivity score obtained under each of the two conditions. Mothers in the least sensitive group had scores (fundamental frequency change levels) that ranged from 7.29 to 13, mothers in the intermediate group had scores from 5.10 to 7.23, and mothers in the most sensitive group had scores from 2 to 4.52. Resting heart rate recorded at the beginning of the session did not differentiate mothers in the three groups, $F(2, 35) = 0.21$, $p > .80$. In a repeated-measures ANOVA with sensitivity level as the between-subjects variable, trends across the first nine trials (blocked by three) of the second-by-second trends were the dependent variable. Differences between the three groups were evidenced by a significant linear-trials-by-quadratic-seconds effect, $F(2, 35) = 4.97$, $p < .01$, and a quadratic-trials-by-quadratic-seconds effect, $F(2, 35) = 3.82$, $p < .03$. Visual inspection of the data suggested that only the most sensitive mothers exhibited habituation to the impending cry, in that the acceleratory component decreased in a linear fashion across trials (see Figure 4). This was supported statistically by significant differences in trends between mothers who were most sensitive and those who were least sensitive, a linear-trials-by-quadratic-seconds effect, $F(1, 24) = 4.94$, $p < .04$, and those of intermediate sensitivity, a linear-trials-by-quadratic-seconds effect, $F(1, 23) = 8.06$, $p < .01$. Mothers in the latter two groups failed to habituate across trials. The quadratic-trials-by-quadratic-seconds effect was accounted for by different patterns of modulation exhibited by mothers in the least versus the intermediate sensitivity group, $F(1, 23) = 5.73$, $p < .03$.

DISCUSSION

In this study, the ability of mothers of young infants to discriminate between patterns of infant cry features (i.e., small changes in fundamental frequency) was assessed using the methodology of Signal Detection Theory. The value of Signal Detection Theory in decision-making situations is that it separates two useful measures of performance, sensitivity and response bias. Our application of Signal Detection Theory to the study of maternal response to infant signals has allowed us to measure sensitivity at the sensory/perceptual level independently of factors that are known to influence response bias. Measures of information processing, response time and heart rate, correlated with the first of these measures, sensitivity. Greater sensitivity was associated with faster response time (i.e., more efficient processing). Greater sensitivity was also associated with habituation of heart-rate response. Heart rate was collected during the Illusion task because the collection of heart rate during the Signal Detection task would have made the length of that task prohibitive. Despite the time lapse between tasks, the association between cardiac habituation and greater sensitivity suggests that characteristic physiologic patterns are an index of more efficient signal processing in general.

Cry ratings were also collected during the Illusion task, which was free of any manipulated cognitive set, enabling us to determine the association between sensitivity and perception of the cry independent of any labeling effects due to the manipulation. Mothers with greater sensitivity were more likely to have rated the cry in the earlier task as more grating and piercing. This indicates that the affective valance attached to an infant cry influences its perception. In some situations, childcare may be facilitated as a re-

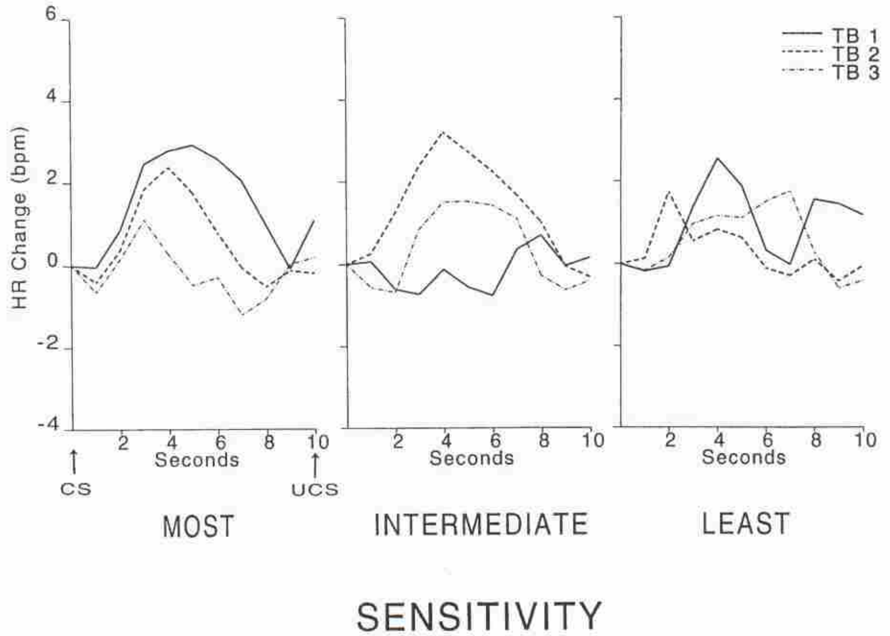

Figure 4 Mean second-by-second changes in heart rate during the CS period of the first nine trials, blocked by three, as a function of sensitivity.

sult of this influence: when the infant is perceived to be in need of special handling and the parents are attuned to provide the appropriate care. Personality traits, attributions of intentionality, and belief systems (cognitive sets) of the caregiver may alter not only the perceived aversiveness to the cry but also her sensitivity to it. Our experimental manipulation of labeling the cry affected mothers' sensitivity, that is, how well the mother was able to make correct judgments and avoid incorrect ones, but did not affect response bias, that is, her preference for one response over another. Mothers were able to detect smaller variations in fundamental frequency when the cries they were asked to discriminate had been labeled as coming from a "difficult" rather than from an "easy" infant. These data are important in that they demonstrate that the mother's cognitive set or belief system, which serves as a perceptual filter (Bugental & Shennum, 1984), significantly guides her reception and interpretation of her infant's signals and behavior.

The finding that sensitivity is affected by our cognitive set manipulation agrees with the work of others who emphasize the key role that the caregiver's "representations" or cognitive and affective mediational sets play in directing the interaction process (Parkes, Stevenson-Hinde, & Marris, 1991). To the degree that mediational sets are as important as or more important than objective stimuli, it becomes necessary to determine conditions that foster the development of positive versus negative mediational sets that can either facilitate or impede the interaction process. Although our particular manipulation affected the sensitivity measure only, future research is needed to determine those conditions that affect response bias. Identification of conditions that differentially affect these two response components will have important practical implications for both preventive intervention with parents and infants who have been identified as being at risk and for therapeutic intervention when the interaction process has become destructive in nature.

Sensitivity was also related to maternal coping strategy. The illusory control phenomenon, a mother's perception of her own control over terminating an infant cry, was systematically related to her ability to discriminate between patterns of cry features. Mothers with high illusory control in the present study were the least sensitive to small fundamental frequency changes in the cry. We have shown in previous studies that mothers with high illusory control have responded less effectively during childcare, and even defensively (Donovan & Leavitt, 1989, 1994; Donovan et al., 1990). The link between high illusory control and lowered sensitivity converges with a growing body of evidence suggesting that a repressive / defensive coping style (Weinberger et al., 1979) predicts an alteration in sensory and perceptual processing (e.g., Kline et al., 1993; Schwartz, 1990; Wexler, Warrenburg, Schwartz, & Jamner, 1992). The present data suggest that the less efficient coping strategy of mothers with high illusory control is due in part to less efficient processing of the cry signal. We have also found that mothers with this ineffective coping style are more likely to be paired with insecurely attached infants (Donovan & Leavitt, 1989) and to employ a socialization strategy of negative control during childcare that is related to less competent (i.e., defiant) toddler behavior (Donovan & Leavitt, 1994). Thus, without addressing the issue of cause and effect, we note that behaviors associated with high illusory control, such as reduced maternal sensitivity, child defiance, and defensive and ineffective maternal coping, become a self-sustaining system.

In this study, we have assessed mothers' response to cries from an infant other than their own. We have found in other studies that mothers' laboratory response to such infant cries predicts everyday interaction with their own children (Donovan & Leavitt, 1989, 1994). Furthermore, using this laboratory simulation of mother-infant interaction, we have demonstrated a mechanism by which cognitive factors such as mothers' expectations based on infant temperament can affect behavioral sensitivity. Our data describe an adaptive mechanism by which parental concern about their infant leads to increased sensitivity to the infant's signals, allowing parents to intervene (to parent) in a manner attuned to the needs of their child. Our findings provide direction as well for clinical interventions to promote optimal parent-infant interaction and child development. For clinicians in search of intervention strategies to enhance parental sensitivity to infant signals, these data highlight key points of attack. With the knowledge that mothers' perceptions (and expectations) of their infants' behavioral style affect their sensitivity to infant signals, our data provide support for clinical interventions that attempt to reframe parents' cognitive set in processing infant signals. The data also support clinical interventions that attempt to modify parents' coping strategies in confronting the challenges of everyday childcare.

In summary, attending to their crying infant is a major challenge faced by parents in their early everyday life with a new baby. The ability to discriminate between patterns of cry features that inform the caregiver of the infant's state of distress is an essential first step in learning to manage infant crying. We applied Signal Detection methodology to the study of maternal response to infant cries to separate the measure of sensitivity from response bias. We were able to demonstrate that a mother's ability to discriminate between infant cries (maternal sensitivity) was affected by her cognitive set: She was more sensitive when she thought the cries came from a "difficult" rather than an "easy" infant. Maternal coping, assessed by measuring mothers' perception of control over terminating an infant cry, was also related to maternal sensitivity to infant signals. Mothers with high illusory control, those who have been shown in other studies to be less effective in their coping, were least sensitive to changes in the fundamental frequency of the cry signal.

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