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When Frustration Is Repeated: Behavioral and Emotion Responses During Extinction Over Time

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Abstract

Persistence of instrumental responding and negative facial expressions in response to repeated goal blockage was studied in 53 4-month-old infants. All participants experienced 2 sessions comprising baseline (no stimulation), contingency (stimulation resulting from infant action), and extinction (no stimulation) on consecutive days. Performance criteria identified 2 groups of infants, those who learned in Session 1 (Learning Group 1) and those who learned in Session 2 (Learning Group 2). Individual differences in instrumental responses and facial expression during extinction were compared as a function of learning group. Across sessions, the repetition of extinction for Learning Group 1 was associated with both a persistent instrumental response and anger expressions. The level of instrumental response and anger expression was equivalent to that observed for Learning Group 2 but only in Session 2, the day on which that group learned. Sadness and anger/sadness blended expressions were initially more common in Learning Group 2, but these expressions were attenuated given another exposure to the contingency in Session 2. Implications for the relations among infant emotion, cognition, and behavior are discussed.

Keywords

infant facial expressions; goal blockage; anger

In children and adults, an initial increase in responding at the outset of the removal of a reward or goal is known as an “extinction burst”. It is a predictable feature of extinction (Miller, 1996). One cognitive explanation for the extinction burst is that, when access to an expected reward or a goal is blocked, violation of the individual’s expectation leads to increased behavior to regain the goal. Similarly, an emotional/motivational account suggests that blockage in goal approach situations leads to increased efforts to overcome the blockage and the action pattern of anger (Harmon-Jones, 2003). Indeed, a number of studies now show that when an infant’s access to a contingency is blocked during extinction, increased instrumental behavior and predominantly facial expressions of anger result (Alessandri, Sullivan, & Lewis, 1990; Lewis, Sullivan, Ramsay, & Alessandri, 1992; Sullivan & Lewis, 2003; Sullivan, Lewis, & Alessandri, 1992). Although increased sadness is also observed at this time in some individuals, anger is the predominant expression and sadness appears related to perceptions of noncontingency or loss of the stimulus as opposed to loss of the contingency per se (Lewis et al., 1992; Sullivan & Lewis, 2003). Infants’ extinction response and concurrent negative facial expression are

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therefore consistent with the view of emotional responses as action patterns of increased approach in response to goal blockage (Lewis & Ramsay, 2005).

An approach/withdrawal model of emotion treats infant facial expressions as one component of brain-based emotional processes that underlie affective response styles (Davidson, 2004; Lewis & Michalson, 1983). Approach and withdrawal were described as organized behavioral systems by Schnierla (1959); Darwin (1965); Carver (2004) and others. Panksepp (1998) has described the approach or “seeking” system as one of the basic neuroaffective systems in the mammalian brain. Research indicates that, although biologically based, expressions indexing approach or withdrawal are sensitive to environmental contingencies and are affected by cognition in context (Lewis et al., 1992; Sullivan & Lewis, 2003).

Approach is marked by increased activity toward goals, increased ANS activity, decreased cortisol response, and facial expressions of interest and other expressions and postures marking movement toward stimulation, such as anger, described above. In contrast, withdrawal is marked by low activity toward goals, increased cortisol response, and facial expressions of sadness, fear or behaviors related to withdrawal from a stimulus (Buss et al., 2003; Lewis, Hitchcock, & Sullivan, 2004; Lewis, Ramsay, & Sullivan, 2006). Anger during extinction is related to approach motivation. It occurs infrequently during contingency learning and increases when the contingency is removed or disrupted (Lewis et al., 1992; Sullivan & Lewis, 2003). Unlike anger, sad expressions in response to extinction do not appear to be an action pattern of increased approach. Rather, they are more related to response cessation and do not mirror anger expression during extinction (Lewis & Ramsay, 2005; Sullivan & Lewis, 2003). Sad expressions in response to contingency goal blockage might reflect temperament (i.e., a tendency to be less active or easily aroused) or variation in contingency perception per se. Although temperament has not typically been associated with differences in contingency learning (Alessandri et al., 1990; Fagen & Ohr, 1990), differences in emotional response to extinction have been related to temperament, in particular distress to novelty (Fagen & Ohr, 1990). Thus, temperament differences must be considered in assessing the meaning of responses to goal blockage.

The approach/withdrawal model of infant emotion is particularly applicable to the context of contingency learning. Although it differs somewhat from two theoretical views of emotion expression typically discussed in the infant literature (Differential Emotions Theory (Izard, 2007) and Dynamical Systems Theory (Camras, Malatesta, & Izard, 1991; Camras et al., 2007), it integrates some aspects of both views. The approach/withdrawal model does not assume one to one correspondence of expression to a discrete emotion state, nor does it require specificity of expression to a particular elicitor. Coactivation of approach and withdrawal action tendencies in a context is regarded not only as possible, but very likely, resulting in both multiple emotions in a given individual within a specific context, and blended expressions. Moreover, an approach/withdrawal model is not especially concerned with how individual facial movements self-assemble to form recognizable facial expressions, as in DST (Camras et al., 1991). Rather, the model is concerned with how approach and withdrawal action tendencies vary over time and in response to perceived contextual change and how individuals may vary in their tendencies to approach and withdraw from specific stimulus contexts. Anger and sadness expressions typically observed in contingency learning studies are of particular interest because the model predicts that the pattern of approach and withdrawal action tendencies should vary over time, depending on experience with a specific context. If anger and sadness expressions index activation of the same emotion or motivational processes (either approach or withdrawal), they should change in parallel. If they reflect different emotion or motivational processes (approach vs. withdrawal), they should diverge with repeated experience.

To date, change in extinction responses and negative emotion over time has not been studied in infant contingency research as infant extinction responses are typically observed during one session. A notable exception is the infant memory work of Rovee-Collier and associates. Their work has examined infant learning and extinction over multiple sessions and after periods of two weeks or longer (e.g., Rovee-Collier & Hayne, 2000; Sullivan, Rovee-Collier & Tynes, 1979). Excellent retention of contingency learning has been reliably shown, with sustained response levels during a baseline period 24-hr following extinction, providing an index of retention or persistence of behavioral responding (Rovee-Collier & Fagen, 1981; Rovee-Collier & Hayne, 2000). Extinction responses gradually decline over session as infants repeatedly are unable to access rewards. That is, with repeated experience, infants adapt to extinction with decreased responses (hence, its name). Given that anger has been found to be the predominant facial expression during extinction, anger expression also would be expected to decrease during repeated extinction episodes as infants learn to expect that the contingency sometimes will not work. Conversely, if infants remember the contingent goal specifically, instrumental response and anger may persist when extinction is repeated. That is, infants may be more likely to remember the previous specific goal rather than the brief goal blockage, at least initially. We hypothesize, then, that anger (but not sadness) expressions, as a component of the approach action pattern, are likely related to behavioral persistence in a contingency learning task, defined as continued instrumental responses directed toward engaging or regaining the blocked goal.

The current study examined changes in instrumental arm response (pulling) and facial expressions across two consecutive contingency learning/extinction sessions in order to observe whether infants alter their behavior and emotions once they have prior experience with extinction in that context. We also assessed whether infants, having learned the contingency in Session 1, remembered the pulling response (as indexed by baseline responding in Session 2) and whether their pulling and anger expressions persisted during their second exposure to extinction. If infants adapt rapidly to extinction, infants should respond differently in Session 2. That is, dampened instrumental response and less negative emotion should occur since infants have previously experienced that they cannot reinstate the contingency. If, however, the extinction responses and anger reflect persistent behavioral approach, then infants should continue to show both the sustained extinction responses and anger.

Because some infants learn more slowly than others (Fagen & Ohr, 1990), we also examined whether extinction responses were comparable as a function of *when* infants actually learned (i.e., in the first or second session). If persistent arm responses (or an extinction burst) and anger responses occur *only when infants learn* and are equivalent regardless of when that learning occurs, then anger is related to perceived goal blockage rather than individual differences in the rate of learning. For those infants who show no evidence of contingency learning in Session 1, affect during that “mock” extinction (due to the absence of contingency learning) can be attributed to the removal of stimuli only. Finally, maternal reports of temperament were also examined in relation to initial and repeated extinction experience in order to continue to explore the relation of temperament to affect during extinction.

Method

Participants

Fifty-three infants aged 3 1/2 to 4 1/2 months ($M = 119.77$ days, $SD = 8.5$; range = 104–139 days) completed this study (27 females, 26 males). Infants were Asian ($n = 4$), Caucasian ($n = 48$), and Hispanic ($n = 1$). Ten additional subjects were excluded because of inability to complete facial coding because of poor video quality ($n = 6$) or fussy behavior during baseline ($n = 2$).

Infants were full term at birth, with no history of birth complications or sensory/neurological deficits, and they were healthy at the time of the two sessions. Parents were recruited through follow-up telephone calls subsequent to contact made in the maternity ward at a regional university teaching hospital.

Apparatus

Infants were tested in a three-sided booth while sitting in a reclining infant seat. The seat faced an 18-cm square rear-projection screen mounted in the rear wall of the booth and was 45 cm from the screen. A cassette player placed behind the screen provided auditory feedback at a level of 50 dB. We attached a ribbon to each infant's right wrist by tying it to a terrycloth elastic wristband that was placed around the infant's wrist. The ribbon was connected to a leaf switch (Zygo Industries, CM-2) mounted behind the booth. When pulled in any direction, the string activated a 3-s presentation of an infant's smiling face (in color), accompanied by a recording of children's music.

Infant pulls were continuously recorded with a Laser 128 Apple-compatible computer. During the sessions, the infant's face was continuously monitored in close-up by a Burle TC292 color video camera, mounted just below the screen. Sessions were videotaped (Hi8) and concurrently encoded with a digital readout of time in seconds.

Procedure

The two experimental sessions each lasted 10 min and were scheduled on consecutive days at an alert/play time, as designated by the parent. Upon arrival, infants were seated in the apparatus and the ribbon was attached to their right wrist. Length of the string was adjusted so that hand-to-mouth behavior would not activate stimulus presentation. Parents sat behind the infants throughout the entire contingency session, out of the child's view.

Each session was identical and consisted of three phases: baseline, learning, and extinction. On each day, the baseline phase involved a 2-min period of nonreinforcement during which the initial rate of arm pulling was recorded. The learning phase was 6 min of contingent stimulation, during which arm pulling activated the audiovisual stimuli. Previous research utilizing both contingent and noncontingent controls determined that this interval was sufficient for observing learning in the majority of cases but short enough to avoid boredom or fussiness (Alessandri et al., 1990; Hitchcock & Rovee-Collier, 1996; Lewis, Sullivan, & Brooks-Gunn, 1985). The extinction phase consisted of a 2-min period of extinction that was procedurally identical to the baseline phase (i.e., no stimulation of any kind, contingent or noncontingent was provided).

Parents (primarily mothers) completed the Infant Behavior Questionnaire (IBQ; Rothbart, 1981) to assess their infants' temperament during their first visit to the lab. Ratings yield scores on the following scales: activity, pleasure, fear (distress to novelty), interest, anger (distress to limits), and soothability.

Response Measures

Arm response rate—Arm responses were recorded continuously throughout the experiment. The number of pulls per minute was automatically calculated. To be included in the final sample, each subject was required to meet a minimum learning criterion during either of the two sessions. This criterion was a mean pulling rate, across all 6 learning minutes, equal to or greater than 1.15 times the mean baseline rate in Session 1. Previous work established that infants meeting this criterion exceed the responding of subjects exposed to noncontingent stimulation (Sullivan & Lewis, 2003). The Session 1 baseline rate was used to determine the day on which each infant mastered the contingency, because the Session 2 baseline could reflect

both baseline responses and the previous day's responding. All infants completing the procedure met criterion in at least one session.

Learning groups—The learning criterion was used to divide infants into two groups: those who learned the contingency in the initial session (Learning Group 1) and those who learned in the second session (Learning Group 2). There were 45 infants in Learning Group 1 ($M = 120.8$ days old, $SD = 8.6$; 45% male) and 8 in Learning Group 2 ($M = 114.1$ day, $SD = 5.3$; 50% male). In addition, there were no differences in temperament between the two learning groups, with two exceptions. Mothers of Learning Group 2 infants rated them as significantly more soothable than those of Learning Group 1, $t(18.2) = 2.15, p < .05$,¹ and reported a trend toward more distress to limitations compared to Learning Group 1, $t(51) = 1.96, p < .06$. Thus, Learning Group 2 was rated as somewhat more easily distressed but more soothable than Group 1.

Facial expressions—Facial movements were coded from the videotaped sessions using AFFEX (Izard, Dougherty, & Hembree, 1983), an adaptation of the Maximally Discriminative Facial Movement Coding System (MAX; Izard, 1977, 1992, 1995), which allows the face to be scored as a unit in a single pass through the videotape. We trained two coders initially using MAX training tapes as well as precoded slides of infants from earlier learning studies using the same contingency procedure and the standard MAX coding techniques. They achieved 85% reliability on each facial region during the training phase. Thus, coders were reliable in their scoring of all MAX movements before using AFFEX in this study. The AFFEX method was chosen to increase coding efficiency, as the use of AFFEX reduces coding time by at least 50% compared with MAX. Faces were viewed for coding in slow motion, second by second, and codes were assigned on the basis of MAX formulae.

Coders noted the occurrence of the expressions of anger (25–33-00/54/55), sadness (23–33-00/56), and anger/sadness blends (25–33-56 or 23–33-54/55). These expressions were the focus of study because the infant expression literature suggests that anger expressions tend to co-occur with sad and blended expressions (Alessandri et al., 1990; Camras et al., 1991). The frequency of each expression was tabulated for each 30-s period of the session. We assessed reliability of coding the study tapes by computing kappa statistics on a random sample of 9 subjects (16%), scored by the two coders. The average kappa coefficient for the ratings of all five facial expressions combined over the total session was .90 (anger, $\kappa = .87$; anger/sadness blends, $\kappa = .91$; sadness, $\kappa = .93$). All kappas indicated above chance agreement for all expressions scored.

Results

Plan of Data Analyses

Data were averaged across consecutive 2-min intervals to yield the mean rates for baseline, the first 2 min of learning, the middle 2 min of learning, the last 2 min of learning, and extinction for pulling and each facial expression measure. The learning data are first presented to show the differing performance of each group during the contingency and extinction phases over the two sessions. However, the main goal was to compare the trajectories of each measure across the successive days' baseline and extinction phases to determine how behavior and emotion expressions changed as a function of repeating the extinction in Session 2. The main research questions were as follows: (a) Did a second extinction experience for Learning Group 1 affect their behavior and facial expressions in reaction to the re-encountered goal blockage? (b) Do

¹When the assumption of equality of variance was violated (Levene's test), t tests using adjusted degrees of freedom (i.e., those with decimals) were used to correct for the violation.

similar patterns of extinction response and anger expressions appear regardless of when initial learning occurred (i.e., are the first extinction for Learning Group 1 and the second extinction for Learning Group 2 the same)?

Alpha levels were set at .05 for all analyses, and within-subjects effects are reported using Geisser–Greenhouse-adjusted values, unless otherwise indicated. Because there were no significant main effects for child gender, data were collapsed across gender for all analyses.

Preliminary Analyses of Learning

Figure 1 shows the pulling rates of the two learning groups, averaged in 2-min blocks across the two sessions. These data are presented to demonstrate that learning group assignment, based on a general, predetermined index of individual, initial performance, produced two distinct groups that maintained different learning trajectories over the two sessions. This evidence is necessary to support our premise that Session 2 is a repeated extinction experience for Learning Group 1 and an initial extinction experience for Learning Group 2. As can be seen in Figure 1, the groups differed in Session 1, but by Session 2, Learning Group 2 increased responding across the session as expected. Repeated measures analyses of variance (ANOVAs) (learning group by session by 2-min time block) confirmed these group differences. In Session 1, differences were not evident initially but rather emerged over the course of the session; $F(3, 157) = 4.77, p < .01$, partial $\eta^2 = .09$. Learning groups did not differ in baseline during Session 1, nor did they differ during the first 2 learning minutes (baseline and the first learning phase in Figure 1A), but Group 1 infants pulled at significantly higher rates than Group 2 infants did in each of the remaining intervals in Session 1 (the second and third learning phases and extinction phase in Figure 1A), $t(51) = 2.68, 3.56$, and 2.43 , respectively, $ps < .05$.

In Session 2, Learning Group 1 started out pulling more and increased rapidly beyond the previous day's asymptote. In contrast, Learning Group 2 showed the expected pulling increase so that by the end of the contingency phase, they were pulling at rates comparable with those of Group 1, $t(51) = 0.15$ (mean $ns = 8.69$ and 8.94 , respectively; $SDs = 2.36$ and 4.64 , respectively), and they were pulling at rates significantly above their own Session 1 and 2 baseline rates, $t(7) = 9.60$ and 4.05 , respectively, $ps < .01$. Learning Group 2 increased pulling rapidly in Session 2, in contrast to their previous performance; Wilks's $F(4, 4) = 6.57, p < .05$, partial $\eta^2 = .87$. All these changes were expected and consistent with the learning group assignment, confirming that Learning Group 2 infants required an extra day to show the expected changes in pulling rate by phase.

Baseline differences within learning group—Because interpretation of any changes in affect observed in Session 2 for Learning Group 1 is predicated on a repeated contingency experience, we briefly summarize below the key contrasts focusing on the changes in pulling during baseline over sessions within each learning group. We sought evidence in these analyses for memory of the contingency by Group 1 and, conversely, no evidence of response carryover in Group 2 (because the contingency had not yet been mastered). Group 1 pulled at a higher rate during the Session 2 baseline than they had during the Session 1 baseline, $t(44) = 4.83, p < .001$ ($Ms = 7.92$ and 4.72 , respectively; $SDs = 4.95$ and 1.89 , respectively). Moreover, their pulling rate during the Session 2 baseline did not differ statistically from the rate during the final learning minutes of Session 1, $t(44) = .94, ns$ ($M = 8.51, SD = 3.83$), demonstrating memory for the previous day's contingency. In contrast, Learning Group 2 pulled at roughly the same baseline rates in both sessions, $t(7) = .09, ns$ ($Ms = 5.12$ and 5.06 , respectively; $SDs = 1.98$ and 2.27 , respectively), suggesting no carryover from the first session.

In summary, these preliminary learning analyses show that infants changed their instrumental behavior as expected over phases, although they initially learned on different days. Learning Group 1 learned the contingency in a single session and remembered it over a 24-hr period of

time, responding at stable, above-baseline rates in Session 2. In contrast, Learning Group 2 required the second session to show a similar increase in response rate and showed no change in the Session 2 baseline. Therefore, Group 1 learners had 2 days of experience with extinction, whereas Group 2 learners had only one (Session 2). Because Learning Group 2 did not learn the contingency in the first session, extinction in Session 1 was not functionally a goal blockage for this group. Instead, it represented only the cessation of stimulation, *not* the blockage of a contingency. However, by the second session, because both groups had learned and were performing similarly during the contingency and extinction phases, Session 2 extinction constituted a goal blockage experience for both groups. For Learning Group 1, it was a *repeated* goal blockage experience, but for Learning Group 2, it was functionally their *initial* goal blockage. We next review within group changes in instrumental response and affect over the key phases of baseline and extinction in each session.

Instrumental Responses to Extinction as a Function of Experience

Having shown that groups differed in their learning performance, we next examined instrumental responses across the non-stimulation minutes in each session as a function of experience with extinction. Table 1 presents mean infant responses to the consecutive nonreinforcement periods, baseline and extinction, in Sessions 1 and 2. For Learning Group 1, a follow-up repeated measures ANOVA was conducted with session (2) and baseline/extinction phase (2) as repeated measures. There were linear increases in pulling across phase and session and an interaction between the two, Wilks's $F_s(1, 44) = 34.58, 13.67$, and 6.55 , respectively, all $p_s \leq .01$. Recall that the baseline in Session 2 served as a memory probe. Despite memory for the contingency in Session 2 (Session 2 baseline > Session 1 baseline, t test reported earlier), Group 1 learners' pulling responses in the Session 2 extinction phase showed persistent instrumental responding. The number of pulls increased from baseline to extinction and from the Session 1 extinction phase to the Session 2 baseline, but the greatest increase in pulling occurred between Baseline 1 and Baseline 2, with no difference between the two extinctions. In fact, during their second extinction experience, the mean trend was that Group 1 learners actually pulled more, rather than less, than during the Session 1 extinction, which is suggestive of an extinction burst.

In contrast, Learning Group 2 showed no difference across Session 1 baseline, Session 2 baseline, and the Session 1 extinction phase, but response in the Session 2 extinction phase was greater than that in the Session 1 extinction phase, $t(7) = 3.50, p < .05$. Response in the Session 2 extinction phase for Learning Group 2 was equivalent to that for Learning Group 1, $t(51) = .41, ns$. Thus, all infants, regardless of the day on which initial learning took place, showed an equivalent extinction response in the session that the contingency was learned. Moreover, when the extinction (or goal blockage) was repeated, response decrement did not occur. Rather, if infants responded with increased instrumental response in Session 1, they were likely to do so again in Session 2.

Temperament and extinction response—Because the learning groups differed significantly with respect to soothability, analyses also were conducted with soothability included as a covariate. There were neither main effects of soothability nor interactions of any factor with soothability on instrumental responses during learning or extinction. The pattern of significant effects also remained the same. Thus, soothability did not influence instrumental responses over phase on either day. Next, we turn to the question of whether the facial expressions associated with the extinction burst declined over sessions for Learning Group 1 and whether Learning Group 2 showed parallel anger expressions when they learned.

Facial Expression Analyses

Changes over phase and session—Anger, sadness, and blended anger/sadness expressions were each examined separately in planned repeated measures ANOVAs, with session (2) and phase (5) as repeated measures and learning group (2) as the between-subjects factor. All three expressions increased from baseline to extinction in each session, and the greatest change in expression was observed during extinction. Significant main effects of phase were observed for anger, $F(2, 121) = 31.23, p < .001$, partial $\eta^2 = .38$; sadness, $F(2, 101) = 8.76, p < .001$, partial $\eta^2 = .15$; as well as anger/sadness blends, $F(2, 87) = 7.36, p < .01$, partial $\eta^2 = .13$, with expressions increasing across phase. Anger was the only expression to show differences by session, occurring more often in Session 2 than Session 1, $F(1, 51) = 5.71, p < .05$, partial $\eta^2 = .10$ ($M_s = 2.42$ and 1.57 , respectively; $SE_s = .32$ and $.30$, respectively). No other significant main effects or interactions were observed for anger or anger/sadness blends.

For sad expressions, the main effect for phase was qualified by significant interactions between session and phase, $F(2, 106) = 7.00, p = .001$, partial $\eta^2 = .12$; and session, phase, and learning group, $F(2, 106) = 3.10, p < .05$, partial $\eta^2 = .06$. Separate analyses conducted by group indicated that only Group 1 learners had a main effect for phase (linear increase in sad expressions across phases), $F(2, 107) = 6.77, p = .001$, partial $\eta^2 = .13$; and a marginal interaction between phase and session, $F(2, 91) = 2.64, p = .10$, partial $\eta^2 = .06$. That is, the linear increase in sad expressions was present only in Session 1 for infants who learned on the first day.

Table 1 presents mean infant expressions during the consecutive nonstimulus periods, baseline and extinction, in Sessions 1 and 2. Although each of the emotion expressions increased in frequency from Session 1 baseline to Session 2 baseline— $t_s(52) = 2.63, 2.21$, and 2.68 for anger, sadness, and anger/sadness blended expressions, respectively, $p_s < .05$ —there were no differences in baseline by learning group for any expression. Because the greatest increases in negative expression were observed during extinction as opposed to the contingency phases, in planned group comparisons (Learning Group 1 vs. Learning Group 2), we focused on changes in each expression by baseline versus extinction phase and session (1 vs. 2) to observe the effects of repeated experience on emotion expressions (see Figure 2). Repeated measures analyses were conducted with and without soothability included as a covariate and are detailed later. There were no significant main effects of soothability, nor were there interactions of any factor with soothability in any of the analyses.

Anger expressions as a function of extinction experience—Figure 2A shows the change in anger expressions in each learning group as a function of session and phase. Anger expressions increased during extinction similarly, regardless of the day infants learned. The only significant effect was for phase, Wilks's $F(1, 51) = 70.54, p < .001$, partial $\eta^2 = .58$. Thus, anger was similar across learning groups and sessions for both baseline and extinction but increased from baseline to extinction, regardless of session or day learned. A second extinction experience did not affect the anger expressions of Learning Group 1. Moreover, anger during extinction of Learning Group 2 in the second session was equivalent to the anger response of Learning Group 1 in the first session.

Sad expressions as a function of extinction experience—Figure 2B shows the change in sad expressions in each learning group as a function of session and phase. Increases in sad expressions occurred between baseline and extinction overall, Wilks's $F(1, 51) = 12.07, p < .01$, partial $\eta^2 = .19$; and decreased between Session 1 and Session 2 overall, Wilks's $F(1, 51) = 5.36, p < .05$, partial $\eta^2 = .09$. However, these effects were qualified by a significant interaction among session, phase, and day learned, Wilks's $F(1, 51) = 4.21, p < .05$, partial $\eta^2 = .08$. That is, Learning Group 2 showed a greater increase in sad expressions in Session 1 and showed a greater number of sad expressions overall in extinction than did Learning Group

1. However, there were no group differences in Session 2. Baseline levels of sad expressions did not differ between Sessions 1 and 2 in either group. Thus, Learning Group 2 showed more sadness to extinction initially, but once they learned the contingency, the number of sad expressions during extinction was similar to that of Group 1 learners.

Blended expressions as a function of extinction experience—Figure 2C shows the change in anger/sadness blended expressions by phase and session for each learning group. The pattern of effects was similar to that for sad expressions. Although anger/sadness blends during extinction were significantly higher than the baseline phase overall, Wilks's $F(1, 51) = 12.46, p = .001$, partial $\eta^2 = .20$; this was qualified by an interaction between session and phase, Wilks's $F(1, 51) = 3.95, p < .05$, partial $\eta^2 = .07$; and by an interaction among session, phase, and day learned, Wilks's $F(1, 51) = 4.42, p = .05$, partial $\eta^2 = .08$. Analyses by learning group indicated that the numbers of anger/sadness blends were similar in Sessions 1 and 2 for Learning Group 1. Baseline levels in each session did not differ, and blends subsequently increased from baseline to extinction in both sessions. In contrast, for Group 2 learners, anger/sadness blends increased significantly in Session 1 but showed little change in Session 2. Baseline levels did not differ by session, and blends in the second baseline were not significantly lower than those in the previous extinction phase. In summary, consistent with sadness expressions, increases in anger/sadness blended expressions occurred in both sessions, but the amount of increase between baseline and extinction was greater in Session 1, particularly for Learning Group 2. Unlike sad expressions, however, blends increased again during the second extinction phase and remained above the first baseline level, with no differences during the second extinction phase as a function of day learned.

Summary—Examining the pattern across negative expressions, Learning Group 1 showed increased anger and blends in extinction in both sessions, whereas Learning Group 2 showed increases in all three expressions in Session 1. More total negative affect was shown in Session 1 by the group that did not learn initially, despite the absence of initial differences in expression. By Session 2, these differences were no longer significant. One possible explanation for the greater mixture of negative expressions shown by Group 2 learners is that they were crying more vigorously during extinction. The greater mix of negative expressions may therefore be a function of their higher arousal. We therefore examined whether Group 2 learners were more likely to cry continuously during the Session 1 extinction phase than Group 1 learners were. They were not; 32% of Group 1 learners and 34% of Day 2 learners cried continuously during the extinction phase in Session 1. A multivariate analysis of expressions by continuous cry (yes vs. no) and day learned (1 vs. 2) confirmed that continuous crying was associated with more anger and more blended expressions but not with more sad expressions; $F_s(1, 51) = 15.40$ and 14.6, respectively, $p < .01$. There was neither a main effect of learning group nor an interaction. Thus, continuous crying during extinction did not account for the learning group differences in the pattern of negative expression.

Temperament and expression change during extinction—Because the observed group differences in facial expressions in the Session 1 extinction phase could reflect differences in maternal reported temperament, we also examined the correlations of soothability and distress to limitations with the change in facial expressions observed during extinction over sessions. Distress to limits was not significantly related to change in facial expressions or total negative expressions in either session for either learning group. Table 2 presents the results for soothability and supports the mean findings. Soothability was unrelated to facial expression change among Group 1 learners in either Session 1 or Session 2. Among Group 2 learners, soothability was significantly related to sad expressions as well as total negative expressions in Session 1. In Session 2, however, these correlations were attenuated.

Discussion

Infants in the present study were exposed to a contingency learning procedure on 2 successive days. Each session ended with a 2-min extinction period, constituting a goal blockage. Infants demonstrating learning on the first day persisted in their responding and facial expressions during the repeated extinction. Levels of both instrumental and expressive behavior were comparable with those observed during Session 1. Memory of contingency across a minor disruption led to persistence of previously effective behaviors. Learning Group 1's repeated exposure to extinction was insufficient to elicit the response decline that is characteristic of prolonged or repeated extinction phases in the animal literature and in conjugate contingency work. Such a decline in pulling would be functionally equivalent to "giving up" or to memory of the previous day's extinction.

Persistence of instrumental responding across two brief extinction periods is perhaps not surprising when considered in the context of the young infants' robust contingency memories, as well as their likely experience with intermittent rewards. Much of infant experience with real-world contingencies is based on intermittent rewards (see Watson, 1997). An experimental context in which a previously effective strategy works after a brief period of contingency disruption is likely consistent with such experiences and may well foster the development of behavioral persistence. Crying and increasing efforts to regain a lost toy may not always be successful but will often enough result in regaining the toy or intervention by a caregiver that it is a reliable strategy. The intermittent nature of "extinctions" in the real world and infants' memory of contingent actions and goals thus may be mechanisms supporting behavioral persistence.

Perhaps surprising is that anger expressions to goal blockage also persisted. Despite reliable findings of behavioral decline in the animal learning literature in response to extinction, and the likelihood of a concurrent decline in affect expression, infants who had previously learned a contingency demonstrated similar levels of anger expression in the face of a second extinction. Moreover, like instrumental behavior, the anger expressions observed in the repeated extinction did not differ from those of infants who learned initially in Session 2 (Learning Group 2). Instead, anger expressions appeared to index an individual difference associated with learning and action tendencies directed toward regaining the goal. This pattern (predominant anger expressions and behavioral persistence across a repeated extinction) is consistent with a model of early emotion processes organized around approach or withdrawal. Recent conceptualization of anger as an approach emotion is consistent with this hypothesis (Harmon-Jones, 2003; Harmon-Jones, Leuck, Fearn, & Harmon-Jones, 2006). Neuroscience models of the approach or stimulus-seeking system also propose that weak activation of the anger system is an aspect of frustrated approach (Panksepp, 1998). In fact, nonstimulation recruited anger expressions predominantly only when the contingency had been perceived. Anger expressions during extinction may thus index motivated efforts to reinstate the contingency or are elicited when the infants' increased efforts are thwarted. Sequential analyses of anger expressions and pulling would be of interest in this regard.

Individual infants varied in how rapidly they learned, with some only demonstrating their contingency mastery and the expected extinction response in the second session. However, there was little that differentiated the early from the later learners at the outset of the study. Apart from the differences in rate of learning that emerged during the study, the only other significant differences observed between the learning groups were their behavioral differences during extinction, differential patterns of negative affect, and maternally reported differences in soothability. However, behavioral changes and anger during extinction were unrelated to temperament. Anger expressions were generally unrelated to specific subscales, and soothability had no effect on the results when included in the analyses. Such findings confirm

earlier reports that contingency learning is unrelated to maternal reports of temperament (Fagen & Ohr, 1990). Despite individual differences in rate of learning and temperament, contingency appears to be a powerful approach context.

Although heightened anger expressions appeared with the loss of contingency for those who had learned in the first session, greater total negative expressions appeared at extinction for infants who did not learn initially. In particular, sad expressions showed an interesting interactive effect. They were not prominent in extinction responses of Learning Group 1, and during their second exposure to extinction, Learning Group 2 showed fewer sad expressions. In contrast, Learning Group 2 showed heightened sad expression during the initial session, when extinction was functionally stimulus withdrawal rather than contingency blockage. In Session 2, when they did learn, this group showed a lower, stable level of sad expressions. Moreover, in this study at least, the patterns for blended anger and sadness expressions in each learning group followed the same trajectory as sad expressions. Like sad expressions, blends were less likely after the perception of contingency, although specific processes accounting for the occurrence of these blended expressions, as well as their meaning, remain ill understood.

Although learning group differences in sadness and blended expressions may be an artifact of the small *N* for Learning Group 2, several factors suggest that continuing to explore relations between affect during initial extinction response and individual differences in temperament may be worthwhile. First, the small number of infants who did not learn the contingency within the first session does not appear to be an aberrant group. All were full term and apparently healthy, normally developing infants. Follow-up through 18 months did not reveal any undetected developmental issues. Second, Learning Group 2 did not show an affect pattern similar to infants who experience noncontingent stimulation after learning. Whether learners or nonlearners, infants exposed to noncontingent stimulation rather than extinction showed low amounts of sadness expression (Sullivan & Lewis, 2003). Third, Learning Group 2 in the present study did not represent extremes of temperament. Maternal IBQ ratings identified only differences in maternal reports of soothability between the learning groups during extinction. Group 2 learners were not reported to be less active than Group 1 learners on the IBQ, and baseline activity did not differ between the groups. Mothers did report that Group 2 learners showed a nonsignificant tendency toward more distress to limits, a dimension that may be interpreted as either greater proneness to anger or negative emotion. However, Group 2 learners did not express more anger; rather they showed a nearly identical pattern of results to those shown by the Group 1 learners in session one with regard to anger.

Were mothers wrong about their infants' temperaments? Probably not. Group 2 learners did show more sadness and blended expressions than the other group in Session 1. However, these differences were not maintained once they learned in Session 2. Greater distress appeared in this group, but only on the day that they did not learn. Mothers reported on the IBQ that Group 2 infants were significantly more soothable, suggesting that their negative emotion was amenable to appropriate intervention and that they were not more "difficult" infants. The present results therefore seem to validate mothers' reports that Group 2 learners may be more easily distressed but were more soothable. Clearly, these temperament findings are exploratory, given the small number of Day 2 learners. However, they raise the hypothesis that infants who initially show more sadness expressions, relative to anger expressions, may be perceived as more soothable by their mothers. It is not unreasonable to assume that, when infants respond to contingent care with decreased negative emotion, mothers perceive this as soothability. Here, the interesting finding is that a reduction in negative expression in response to contingency experience in soothable infants came about through reduced sadness and blended expressions, presumably withdrawal affect, but not anger. In fact, rises in cortisol, but not heart rate, are differentially related to sadness as opposed to anger expressions during infant response to extinction, supporting the interpretation of sad expressions, as opposed to anger, as an indicator

of distress emotion in the contingency/goal blockage context (Lewis et al., 2006). Thus, contingency not only seems to promote approach behavior and the approach emotion of anger but also may help suppress withdrawal and distress emotions indexed by sad expressions, perhaps by promoting feelings of control (Sullivan & Lewis, 2003).

Although the findings suggest that infants did not rapidly adapt either instrumental behavior or emotion to the extinction episode with a second exposure, how long the accompanying negative expressions would persist is unknown. Continued experience with extinction appears to gradually lead to the expected instrumental response decrement (Rovee-Collier & Fagen, 1981). Presumably, anger expressions would also decline; however, longitudinal research is needed to address this issue. If, when, and how extinction experience results in evidence of down-regulation of behavior and negative emotion and the relation of these processes to behavioral persistence in later developmental periods may prove to be important measures of individual differences in motivation and emotion regulation. However, it appears that examination of changes in instrumental behavior and expressions over time in response to repeated extinction or goal blockage can reveal individual differences in behavioral and motivational processes.

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A Session 1: Pulling by 2 Min Interval and Learning Group

B Session 2: Pulling by 2 Min Interval and Learning Group

Figure 1.

Mean arm responses (i.e., pulling rates) per 2-min intervals across baseline (B), contingency learning (L1–through L3) and extinction (Ex) phases in Session 1 (Panel A) and Session 2 (Panel B) as a function of learning group. Diamonds represent Learning Group 1, and squares represent Learning Group 2.

A Anger Expressions by Experience **B Sad Expressions by Experience** **C Anger/Sad Blends by Experience** **Figure 2.**

Mean number of anger (A), sadness (B), and anger/sadness blended (C) expressions in 2-min intervals of baseline and extinction in Session 1 and Session 2 as a function of learning group.

Table 1
Mean Facial Emotion Expressions (and Standard Deviations) per 2-Min Interval
by Session, Phase, and Learning Group

Infant reaction	Learning Group 1	Learning Group 2
Mean pulling responses at:		
Session 1 baseline	4.72 (1.89)	5.12 (1.98)
Session 1 extinction	9.06 (4.78)	4.75 (3.41)
Session 2 baseline	7.92 (4.95)	5.06 (2.27)
Session 2 extinction	9.59 (4.37)	8.94 (2.37)
Mean anger expressions at:		
Session 1 baseline	0.28 (0.95)	0.62 (0.92)
Session 1 extinction	3.98 (3.86)	4.25 (4.28)
Session 2 baseline	0.84 (1.13)	1.56 (2.60)
Session 2 extinction	4.33 (2.91)	5.25 (5.18)
Mean sadness expressions at:		
Session 1 baseline	0.06 (0.22)	0.06 (0.18)
Session 1 extinction	0.78 (1.49)	2.25 (4.09)
Session 2 baseline	0.20 (0.55)	0.50 (0.71)
Session 2 extinction	0.39 (0.75)	0.50 (0.60)
Mean anger/sadness blends		
Session 1 baseline	0.02 (0.15)	0.00 (0.00)
Session 1 extinction	0.68 (1.52)	1.75 (2.99)
Session 2 baseline	0.18 (0.44)	0.37 (0.69)
Session 2 extinction	0.88 (1.46)	0.62 (1.09)

Table 2
Correlations of IBQ Soothability and Distress to Limitations With Changes in Negative Emotion During Extinction/Goal Blockage by Learning Group

Soothability and change in emotion	Learning Group 1 (<i>n</i> = 45)	Learning Group 2 (<i>n</i> = 8)
Soothability with Session 1 change in:		
Anger	-.13	.43
Sadness	.03	.65 [*]
Anger/sadness blend	.03	.57 [†]
Total negative expression	-.07	.61 [*]
Soothability with Session 2 change in:		
Anger	-.10	.05
Sadness	-.03	.39
Anger/sadness blend	-.06	.17
Total negative expression	-.10	.37

Note. IBQ = Infant Behavior Questionnaire.

[†]
p < .10.

^{*}
p < .05, one-tailed.