THE COGNITIVE-EMOTIONAL FUGUE

Michael Lewis, Margaret Wolan Sullivan and Linda Michalson
Rutgers Medical School

> Fugue : The theme is first given out by one voice or part, and then, while that pursues its way, it is repeated by another at the interval of a fifth or a fourth, and so on, until all the parts have answered one by one, *continuing their several melodies and interweaving them in one complex and progressive whole, in which the theme is often lost and reappears.*

We have chosen the title "The Cognitive-Emotional Fugue" to stress the fact that cognition and emotion are neither separate nor independent aspects of behavior. Rather, both are elements of the same theme interwoven into a single composition. Both parts are continually chasing each other, like the parts of a fugue.

In this paper we will first characterize the relationship between emotion and cognition in terms of two traditional models. The first views emotion as a consequence of cognition and the second views emotion as an antecedent of cognition. Following this general discussion, attention will be given to an empirical investigation of the relationship between emotion and cognition in a simple learning task. The results of this study illustrate the central theme, namely, that emotion and cognition must be considered as parts of a complex and progressive whole in which both appear and disappear and each affects the other. Consequently, linear models that fail to capture this interplay are less satisfactory descriptions of the process than the model suggested by the fugue.

The relationship between cognition and emotion has been a topic of concern to many developmental theorists (Kagan, 1974 ; Lewis & Goldberg, 1969 ; McCall, 1972). Although recognizing that a certain level of cognitive development is necessary for the expression of complex emotions (e.g., guilt), these investigators suggest that early in development information processing is associated with emotional response. For example, the failure to assimilate an event is thought to produce wariness or fear, whereas mastery is likely to result in enjoyment (Kagan, 1974). In this model, emotion is the consequence of certain cognitive processes.

On the other hand, it is possible that emotion may precede cognitive processing. According to this model, emotion is a motive or drive with an action-producing or maintenance function (Darwin, 1872 ; Tomkins, 1962 ; Zajonc, 1980).

Editior's note : Dr. Michael Lewis is Professor of Pediatrics, Psychiatry and Psychology, Department of Pediatrics, Rutgers Medical School, New Jersey. In July, 1982 he visited RCCCD where he gave a lecture and held a colloquium with the staff and graduate students.

EMOTION AS THE CONSEQUENCE OF COGNITION

The role of cognition in emotion is complex and varied. It can be considered in terms of the relationship of cognition to each component of emotion, including elicitors, expressions, and experiences. The need to distinguish among these components is critical since the role of cognition in each may be quite different (Lewis & Michalson, 1983). The tendency of some investigators to blur these distinctions often does not permit one to understand fully the various roles that cognition may play in emotion.

The most general theories that view emotion as a consequence of cognition are those that regard emotion as nothing but "interpretive cognitive actions and arousal" (e.g., Mandler, 1975, 1980 ; Royce & Diamond, 1980 ; Schachter & Singer, 1962). These theories award no special status to interpretive cognitive acts other than that they appear to have a higher status than emotion, since emotion is considered to be nothing more than a mixture of arousal and interpretation. However, cognition may enter into the emotional life of the organism in many other ways. Some of these are more direct than others and will be considered in the following discussion as the role of cognition in each aspect of emotion is explored.

THE ROLE OF COGNITION AT THE LEVEL OF ELICITORS

Cognition may influence emotion by determining the effect of the eliciting event. For instance, past associations of one stimulus with a noxious outcome or of another stimulus with a pleasant outcome are cognitive acts that may affect the organism's subsequent emotional response to the stimulus. Memories and associations constitute the cognitive interface between events that may have had no emotional consequence and those that do. Watson and Rayner (1920) laid the groundwork for the literature on conditioned emotional responses. They demonstrated that by associating a rat with a sudden loud noise a young child who had previously shown only approach behaviors to the rat could be conditioned to fear it. This fear was long-lasting and generalized to similar animals and objects. In this example the influence of cognition on the meaning of elicitors is seen in terms of the immediate and automatic associational value acquired by certain stimulus events. These events occur so rapidly that associational links rather than interpretive mechanisms seem to be employed.

Cognitive processing may play a more direct role in the actual creation of emotion through the interpretation of the elicitor. Theories that propose that emotions arise from certain cognitive activities can be broken down into two types : appraisal theories and discrepancy theories. Both are concerned with the quality of the elicitor.

APPRAISAL THEORIES

Appraisal theorise are based on the hypothesis that emotion results from a cognitive appraisal of a stimulus situation. For example, Arnold's (1960, 1970) theory of emotion, although containing both neurophysiological and cognitive elements, has as its central construct the cognitive act of appraisal. Appraisal is defined as the immediate, automatic evaluation of anything encountered as either good (i.e., beneficial to one's well-being) or bad (i.e., harmful to one's well-being). This appraisal results in a tendency to approach that which is evaluated as "good" and to avoid that which is

"bad." What is judged as neither "good" nor "bad" is ignored.

The basis of most appraisals is memory. A new object will evoke a memory of the feeling associated with past experiences with similar objects. Imagination may also play a role in the emotional process to the degree that before people act, they may try to imagine whether the consequence of that action will be beneficial or harmful. Both the appraisal of the conditions and the possibility of action determine the nature of the emotional tendency (e.g., fear or courage). If conscious judgment and deliberate decision warrant, the feeling tendency will result in overt action. Otherwise, the emotional tendency may be revealed only in emotional expressions, such as exclamations of joy.

Another example of an appraisal theory is provided by Lazarus (1966, 1968 ; Lazarus, Averill, & Optin, 1970). In this theory emotions are also believed to originate in particular kinds of cognitive appraisals. Basic to the theory is the view that organisms are constantly in the process of appraising and reappraising stimuli with regard to their personal relevance and whether or not the organism can cope. Such appraisals lead to certain kinds of activities (physiological, cognitive, and behavioral) in an attempt to adjust to the appraised situation. Appraisals can be either benign or threatening. Benign appraisals result in either an automatic, emotionless adaptation to a situation, reappraisal if additional information warrants, or positive emotional states. Threatening appraisals, on the other hand, lead either to direct action in an attempt to remove the threat or, when no direct action is possible, to benign reappraisal. As the organism continues to appraise and reappraise objects and events, fluctuations in emotion will be observed.

DISCREPANCY THEORIES

In a second type of cognitive theory that involves cognitive processing at the level of the elicitor, emotions are regarded as a product of certain discrepancies or incongruities between external events and internal representations or schemas. Incongruity presupposes differentiation, since the schema of a familiar referent must exist in the organism's mind and also must be utilized in order for the recognition of the discrepancy to occur. Hebb (1946, 1949) was the first to relate incongruity to emotion by demonstrating that fear is evoked by events highly discrepant from previous experience. The detached head of a monkey shown to other monkeys produces extreme fear, Hebb reasoned, because of its incongruity.

Berlyne (1960) suggested that unfamiliar or novel events may evoke either fear or pleasure, contingent on the conditions. Pleasure is evoked when the stimulus is novel or curious "to the right degree" (Berlyne, 1970). Learning in general takes place through conflict or disequilibrium ; if the organism lacks information about a stimulus event, uncertainty is generated. To reduce the uncertainty, the organism may actively explore the event. Thus, Berlyne made some attempt to link learning as well as emotion to discrepancy. As such, the theory is not a pure example of cognition leading to emotion, since the model provides also for emotion (i.e., uncertainty) to lead to learning.

Kagan (1974, 1978) has more recently promoted the incongruity hypothesis. He suggests that the organism's first response to a discrepancy or an unexpected change

in the physical parameters of a stimulus event is characterized by an inhibition of motor activity and decreased heart rate. This state is not one of emotion but rather is viewed as a "special state" with different outcomes depending on the cognitive processes that follow. For example, if an event is easily assimilated into the organism's cognitive schema without much effort, the organism will return to baseline levels of response. No emotion (i.e., boredom) is likely to be observed in this case. Events that cannot be assimilated, or are assimilated only with great difficulty, may result in fear. A special cognitive competence, thought to emerge between seven and nine months of age in Western infants, has been hypothesized as playing a major role in the child's emotional reaction to discrepant events. This competence has been described both as the "activation of hypotheses" (Kagan, 1974) and as the ability to perform simultaneous comparisons (Schaffer, 1974).

A somewhat different version of discrepancy theory has been presented by Siminov (1970). In this model emotion is defined as the consequence of the organism's "need" for information with respect to reaching a goal multiplied by the difference between "necessary informtion" and "available information". Information is viewed as the possibility of reaching a goal as a function of a particular communication. Siminov perceives the human organism as continually striving to attain the behavioral and physiological state of satisfied needs. The quantity of information vis-a-vis the attainment of this goal determines the emotional response. A lack of information will prevent the organism from organizing itself appropriately ; in this case, the nervous system is activated in a way to produce negative emotions. Positive emotions, in contrast, result from a surplus of information over and above that which is necessary for the satisfaction of needs. Specific emotions are classified in terms of (1) the strength of the need, (2) the extent of the informational deficiency or redundancy, and (3) the specificitiy of the action aimed at satisfying the need.

There are problems with the incongruity hypothesis, however (Lewis & Brooks, 1974). Often it is used as a *post hoc* explanation of the data. Since it is difficult to determine *a priori* the similarity or congruity of a series of events, prediction of a specific response is difficult. Different organisms may have different categories for comparing internal schema and external events. Depending on what schema is used as the referent, different orders of similarity may be generated even in the case of only one organism. For example, I may order my mother, my nephew, and a strange adult female differently. If familial relationship is the referent, mother and nephew are similar, whereas if gender is the referent, mother and strange adult female are similar. Therefore, in predicting the emotional outcome, both the event and the organism's strategy must be taken into account.

Another inadequacy of the incongruity hypothesis is the failure of familiar events consistently to elicit boredom or withdrawal. For example, the mother at times may elicit highly positive emotions. Emotional preferences based on familiarity may be more salient to the organism (Hunt, 1961) than discrepancy. There can be no question that children enjoy and show positive affect to familiar events, the mother being the best example.

Other problems occur when the incongruity hypothesis is evoked to explain fear.

Can incongruity theory explain why a physical approach often is necessary to elicit positive and negative responses? The capacity of organisms to develop specific aversions to individuals may be better explained by previous experience than by discrepancy (Bronson, 1972). Infants may be fearful of babysitters because in their past experiences the sitter's arrival has meant that the parent is about to leave. This fear has less to do with incongruity than with past experience. In general, organisms may evoke internal representations of past experiences that were painful or frightening and associate them with current events to produce fear.

In a study on the acquisition and violation of expectancy, Lewis and Goldberg (1969) suggested that the chief function of violation of expectancy (i.e., discrepancy) is to alert the organism. This involves a general arousal. In this study, arousal was measured by observing surprise expressions on the faces of three-to four-year-old children. Thirteen out of fourteen cases of surprise occurred in response to a violation of expectancy. The positive emotional behavior (smiling) occurred *after* the initial surprise response. It would appear that the discrepancy served to arouse the child, thereby producing a general emotional response without any hedonic tone. The specific emotion may depend on the context of the violation and other cognitions of the child at that point. For example, a mother's putting on a mask may lead to a violation of expectancy for infants. This would lead to arousal. Whether infants laugh or cry depends on the context, the infants' specific cognitions, and the infants' adaptive strategies for dealing with increased arousal. Infants may cry if the mask is put on when the mother is about to read a bedtime story but laugh when it is put on during playtime. In both cases infants perceive the discrepancy. However, in one case it produces fear because they understand it to be unrelated to bedtime and in the other it produces delight because they understand it to be related to play. Thus, the discrepancy of the mask has only an arousing effect ; other cognitions may determine its hedonic value.

Control over a stimulus event is another factor determining the organism's emotional response in a particular situation (Lewis, 1980). Gunnar (1980) reports that when infants are allowed to control the actions of an arousing toy they exhibit significantly fewer distress responses and are more willing to approach and interact with the toy than when they have no control over the toy.

Although discrepancy theorists, like appraisal theorists, argue that emotion is produced by particular cognitive processes, exactly how cognitive or information processing leads to an emotion is not understood. One possibility is that the cognitive-emotional connection may be prewired into the nervous system. When activated by certain elicitors, cognition may "release" particular emotional states. Exactly how such evolutionary necessity controls the activation of emotional states is difficult to determine, however. Cognitive processing itself might be considered an elicitor of subsequent emotions. From this point of view, the failure to assimilate an event, the violation of an expectancy, or even the approach of a stranger may constitute cognitive elicitors of emotional states through their action on as yet undefined receptors.

On the other hand, one could argue that the effect of these events is a function of their past association with negative outcomes. If this is the case, then these events

produce emotions because of their associational connections as described previously. Discrepancy theories generally focus on perturbations in the process rather than on the content of thought. Gunnar's (1980) demonstration of the effects of control over the stimulus on distress responses forces one to consider not only perturbations (i.e., discrepancies) but their nature as they relate to other factors, including past experience, the content of knowledge, and subsequent emotional behavior. In these ways–either through learning or prewired connections and interpretive acts–cognitive processes might produce emotion.

THE ROLE OF COGNITION AT THE LEVEL OF EMOTIONAL EXPRESSIONS

The role of cognition in emotion is perhaps most prominent at the level of emotional expression. Emotional expressions have been viewed as the direct consequence of an emotional state (Darwin, 1872 ; Ekman, Friesen, & Ellsworth, 1972 ; Izard, 1971, 1977 ; Tomkins, 1962, 1963) or as the natural consequence of an emotional state and past learning (Lewis & Michalson, 1982, 1983). The first position maintains that fixed neurosomatic connections exist between internal state changes and facial expressions as well as select postural and vocal behaviors. These natural, biologically determined connections are hypothesized to exist on the basis of the reported universality of facial expressions across a number of vastly different cultures (Ekman, 1972). If, in fact, facial, postural, and vocal behaviors are universal and have a one-to-one correspondence with emotional states, the need to postulate a cognitive role associated with emotional expressions becomes superfluous.

In contrast to more biologically-oriented theories, socialization theories point out the fact that expressive behavior does not necessarily have a one-to one correspondence with internal states. Upon reflection, it should be obvious that although facial expressions might be biologically connected to internal states, how and when to express emotions are rules clearly learned through socialization experiences. It is easily demonstrated that people often express emotions incongruent with internal emotional states. This could be due to knowledge that the expression of a particular emotion is inappropriate (such as expressing anger toward one's boss) or to a refusal to acknowledge a particular emotion (e. g., denying anger when insulted). There are many reasons why emotional expressions and emotional states may not be congruous (Lewis & Michalson, 1983). In all cases the need to postulate some form of learning is evident, a need that suggests a role for cognitive processing in the expression of emotion.

Because of the influence of socialization on emotional expression, some theorists have argued that "purer" (i. e., biologically based) emotional expreesions can be observed better during the early part of the life cycle, prior to the learning of the rules for their expression (e.g., Izard & Buechler, 1979). However, maternal responsivity to infants' emotional expressions is already differentiated by the time the infants are three months old (Brooks-Gunn & Lewis, 1982). The fact that mothers are less likely to reinforce fretting and crying than smiling suggests that socialization practices probably exert differential impacts on emotional expressions from the beginning of life. A more complete discussion of this particular topic can be found in Lewis and Michalson (1983).

THE ROLE OF COGNITION AT THE LEVEL OF EMOTIONAL EXPERIENCES

Cognitive processes may affect emotional experience in at least two ways : (1) in the perception of unique physiological changes within one's own body or (2) in the cognitve interpretation and evaluation of a general arousal state. The first role for cognition is illustrated in James' (1884, 1890) theory of emotion. For James it is the *perception* of the bodily changes as they occur that constitutes the emotion. Crying makes one sad, trembling makes one angry, and smiling makes one happy. Emotional differentiation is a function of the occurrence and perception of different patterns of bodily changes unique to particular emotional states. All that is required cognitively on the organism's part is the perception of these internal changes in state. Tomkins (1962, 1963, 1970) also believes that differences in emotional experience originate from differential patterns of body responses (primarily facial) and that a minimal amount of cognitive processing is involved beyond the perception or registration of such changes. The awareness of these responses constitutes the experience of the emotion.

Another way cognition may enter into emotional experience is in the interpretation and evaluation of a general arousal state. For Schachter and Singer (1962) emotion consists of general physiological arousal rather than specific patterns of physiological changes. Since this general arousal state is common to all emotions, the organism cannot make distinctions in emotional experience based solely on differences in physiological cues. Rather some cognitive interpretation and evaluation of the arousal is necessary. This "cognitive context" is provided by cues external to the organism. From knowledge of the situation in which the arousal occurs, including the social behavior of other people, the organism creates, as it were, the emotional experience.

In Mandler's (1975, 1980) theory of emotion, cognition seems to play a dual role in emotion, first as an elicitor of an emotional state, then as an interpretive-evaluative act. For Mandler, the interruption of ongoing thought or behavior (a discrepancy or conflict) produces arousal. This arousal is quite general and is responsible only for the intensity of the experience ; it is not a specific emotional reaction. The specific quality of the emotion produced by the interruption depends on the accompanying cognitive evaluation of the internal state and the environment.

Although in Mandler's theory autonomic reactions only produce emotional experiences in conjunction with cognitive evaluations (that are usually previously acquired or assigned), cognitive evaluations and judgments may also occur in the absence of autonomic activity. Thus, one can talk about being happy or sad without the accompanying state of happiness or sadness. Buck (1980) reviews studies in which patients with spinal cord lesions (and thus without physical sensation) report they experience "a cognitive kind of emotion" in the absence of any emotional state. In Mandler's view there are also instances in which "pure" cognitive activity can generate autonomic activity and produce a "full-blown emotional reaction." The possibility of emotional experience being retrieved in this instance would depend on the retrieval of the appropriate context.

It is important to understand that whether a theory of emotion posits either a specific physiological state or a general state such as arousal, the interpretation of that state is what gives emotions their particular phenomenological quality. For theories

where general arousal is the internal state of emotion, specific emotional experiences are facilitated by the individual's interpretation, knowledge about, and direct observation of the situation in which arousal takes place. This can occur either through the observation of the expressions of others in the situation or through knowledge of what emotional state is "appropriate" to that particular situation (e.g., we know to feel sad at funerals and not when someone wins a lottery). For those theories in which emotional state is specific to a particular emotion, the interpretation of that state may rely less on external events and more on specific somatic, visceral, or neural responses. Making a face distinctive to a specific emotion may generate the corresponding emotional experience (Laird, 1974), presumably because the subject has produced a set of unique responses related only to that specific emotion.

Although cognitive theories of emotion stress the need to consider the role of appraisal as well as the role of physiological and situational cues that play a role in emotion, more work is needed in detailing the particular cognitive processes that affect various emotional responses and in specifying their antecedent conditions. However, there can be no doubt that the perception of the stimulus plus an evaluation of it with respect to its personal significance are contributing factors to some emotions.

COGNITION AS THE CONSEQUENCE OF EMOTION

The model that depicts cognition as the consequence of emotion parallels the model of emotion as the consequence of cognition. However, most theorists have addressed the topic somewhat differently. They ask whether it is possible to feel without thinking. More to the point is the issue of whether emotion can produce different ways of thinking or different cognitive processes.

There is at least one theory (although far from complete) that suggests that thought may be the consequence of certain feeling states. In ego development theory, the delay of immediate gratification and the resulting emotion force the organism to develop more mature thought processes. Cognitive structures are produced by delays through processes labeled "secondary thought" (Freud, 1960) or "elaborated thought" (e. g., Hartmann, 1958). For instance, when individuals cannot eat immediately when they are hungry, they may imagine themselves eating in order to feel good. Imagination is the consequence of an unfilled (i.e., negative) emotional state. The notion that emotion precedes cognition has recently resurfaced (Zajonc, 1980). Emotion may be viewed as preceding cognitions from three perspectives : as motive, marker, and instigator.

EMOTIONS AS MOTIVES

Since Darwin (1872), the notion of emotions as motives to act has been popular in many contemporary theories of emotion. Cognitive activity can be thought of as a subclass of the general category of action or behavior. In the following discussion, the general category of action is considered but the reader should understand that this discussion is meant to apply to cognitive actions as well. Theories that consider emotions as motives to explain action can be divided into two classes : (1) those that view emotion as a consequence of an action pattern and thereby reinforcing that

pattern and (2) those that view emotion as causing an action pattern based on the evolutionary history of the species.

The central issue of the hedonic tradition is the belief that people act (or think) in such ways as to produce pleasure and avoid pain. The emotional consequences of an action (or thought) are regarded as the primary cause of that action. Thought patterns that are likely to result in pleasure or to reduce pain will be taken ; thought patterns that are likely to lead to pain will not be taken (e. g., consider Festinger's [1957] notion of cognitive dissonance).

This view of emotions as motivating action through the emotinal consequences of that action appears reasonable. For example, students may study for examinations because it feels good to pass and it feels bad to fail ; children engage in symbolic play in order to experience the pleasures in solving a problem. It should be noted that this view of emotion considers behavior to be motivated by the *possibility* of its emotional consequence. Even though the emotional experience occurs after the action, it is believed that the reinforcement value of this experience serves to produce the same set of behaviors in order to re-experience the particular emotion. So although emotion is initially a consequence of action, the expectation or memory of the emotional state may precede and influence action.

If one thinks of emotion in this way, then emotions, especially feeling good and feeling bad, act as reinforcers to particular actions or thoughts. In many cases, these hedonic reinforcers seem to be unlearned. For example, it is unlikely that the good feeling produced by eating when hungry is learned. Rather, eating feels good because of an innate biological connection between food in the digestive tract and relief from hunger. On the other hand, some emotional reinforcers seem, at least at first glance, to be learned. There is no intrinsic reason that it should feel good to get an "A" on a French examination. The issue, however, becomes more complex when one moves from the particular event, such as doing well on a test, to its more general form, such as being competent. It may be the case that being successful in anything (depending on the cultural definition of success) is rewarding(i.e., produces a positive state). In this event, the developmental issue pertains only to specifying which particular actions will be associated with positive or negative states.

In the above discussion, we have focused on emotion as the reinforcing consequence of behavior. However, emotion may not be only the reinforcing outcome of action, but also its antecedent. This view of emotion is usually associated with biological explanations of emotion. Darwin (1872). the source of the evolutionary tradition in the study of emotion, argues that the process of evolution applies not only to anatomical structures but to intellectual and expressive behaviors as well. Emotions are by their nature associated with action patterns that the organism needs for survival. For example, the sight of a predator will elicit fear in the organism, the action pattern of which is to flee. Or, a baby's cry will elicit nurturance in the mother with a concomitant behavioral repertoire of nursing, holding, or retrieving the infant. Viewed in this way, emotion is both a state of the organism and a response that is basic to life and survival. In all cases of positive and negative emotions the emotional elicitor produces specific action patterns (including cognitions) as a part of the emotion.

Plutchik (1980) enumerates eight basic functional patterns of behavior that have adaptive significance for all organisms in their struggle for survival. The prototypic patterns include incorporation, rejection, destruction, protection, reproduction, reintegration, orientation, and exploration. These basic adaptive patterns are thought to be the functional basis for all emotions recognized in humans and animals. Eight emotions accompany the functional patterns : acceptance, disgust, anger, fear, joy, sadness, surprise, and expectancy. Although the specific behaviors that accompany these patterns may vary across different species, their survival function is common to all species.

Recently, Zajonc (1980) has offered a view similar to the evolutionary position. For Zajonc, some of the behaviors associated with an emotional state may have "hard wire" cognitive representations ; that is, they may be independent of cognitive systems, and in fact may precede perceptual and cognitive operations. Zajonc discusses the primacy of emotion with regard to preferences and attitudes, but his argument is essentially that emotion "accompanies all cognitions, that it arises early in the process of registration and retrieval...and it derives from a parallel, separate, and partly independent system in the organism" (p.154). In short, emotions may be associated with basic adaptive functions and have as their biological consequence a set of dispositions, including actions as well as thoughts.

EMOTIONS AS MARKERS

Much attention has been focused on the roles of "hot" versus "cold" cognitions. The general assumption underlying this thought is that many cognitive processes have different levels of efficiency or outcomes depending on whether these cognitive processes are tagged with specific emotional tones (see Zajonc [1980] for a comprehensive review of this topic). Tow effects of markers are briefly considered here. First, one might argue that certain cognitive processes marked with emotion might be more efficient than those not marked. For example, the retrieval of past events, from both short term and long term memory, is facilitated by affective markers (Norman & Rumelhart, 1975). It is reasonable to assume that information may enter memory not only as a function of the content or sequence of the material, but also as a function of the emotional tag. Clearly the schema of a man in a white coat is more likely to be remembered if it is associated with fear than the schema of a man in a white coat than is not marked with fear.

Second, markers may also be associated with the emotional content of events as they relate to the emotional state of the organism. For example, Bower's (1981) research indicates that emotions may have a powerful influence on cognitive processes, including free recall, imaginative fantasies, and social perception. Bower has found that people recall more events that are affectively congruent with their mood during recall. Here, emotions as markers refer not only to the emotional tag attached to the cognitive event but also to the emotional state of the subject as the subject interacts with the cognitive event.

EMOTIONS AS INSTIGATORS

The third role of emotion in cognition addresses the following question : Do certain feelings necessarily lead people to think in particular ways? One way to approach this issue is to consider thought in the same way that one might consider other action patterns as related to specific emotions. Emotions may not only lead in some biological fashion to action patterns (Plutchik, 1980) but in fact emotions may produce specific thinking patterns.

One aspect of this issue is related to the nature or the content of the thought. For instance, someone may tell you that your cousin was hit by a car, or someone may tell you that your cousin won the lottery. The emotions produced by the information about your cousin in these two cases might influence your subsequent thoughts.

SUMMARY

In the preceding section, two models of the relationship between cognition and emotion were considered in an attempt to review some of the major themes underlying empirical inquiry. From this discussion one soon realizes that no single unidirectional model is sufficient. Cognition leads to emotion and emotion leads to cognition. Cognition and emotion must be viewed as continual processes that are interwoven in a highly complex way such that to separate them is to distort the phenomenon. The continuous nature of these processes is such that to separate them into arbitrary temporal units in fact serves to create an artifical temporal and causal sequence. Although a unidirectional model is appealing from an empiricist's point of view, the artificial boundaries imposed by such a model not only restrict our perspective but also generate theories that are too simple, ones that assume the process begins with either a cognition or an emotion.

An alternative view can be derived from Hofsteader's (1980) book, *Gödel, Escher, Bach.* This alternative model depicts an interplay of these forces or themes without beginning or end. This view is illustrated in Escher's art, in much of Escher's work, the theme of movement without beginning and end is depicted. So, too, cognition and emotion can be conceived as a continuous interweaving of behavior without beginning or end.

AN EMPIRICAL INVESTIGATION OF EMOTION AND LEARNING

To explore the empirical relationship between cognition and emotion, we have chosen to look at infants in a simple contingency learning situation. In this situation the children must discover that their actions systematically result in a predictable outcome. Thus, the study involves simple motor behaviors that reflect learning. At the same time facial expressions occur that can be used to measure changes in assumed emotional states. By the joint measurement of learning and facial expressions, it is possible to observe the interconnections between cognition and emotion. Before presenting this data, however, we will briefly review what is known about the role of emotion in learning. The empirical studies to date almost exclusively view emotion as a consequence of learning.

EMOTION AND LEARNING : A REVIEW

Lewis and Goldberg (1969) described a theory of generalized expectancy, or "learning to learn," in which they proposed that competence develops over time as the result of various contingency experiences. Similar to Piaget's (1952) notion of circular reactions, contingency experiences may be defined as "if-then" relationships. For example, *if* the infant pulls on a string, *then* a mobile revolves. If specific behavioral responses to contingent outcomes increase with time, the infant is said to have learned the contingency. Continued experience with sources of contingent stimulation is hypothesized to result in a generalized expectation that one can act upon and manipulate the environment and a motivation to do so in novel situations. Such a motivation should manifest itself in increased exploratory behavior and positive affect.

The display of positive affect as a direct consequence of contingent stimulation was reported by Watson (1966, 1972). Over the course of a two-week experience with a rotating stabile, Watson reported increased incidence of smiling and cooing only among those infants for whom stabile activation was contingent upon pillow presses. Together with Lewis and Goldberg's(1969) work, the data suggest that a major consequence of contingent learning may be an emotional change. Infants who learn exhibit more positive social behavior.

A number of investigators have followed Watson's lead and have attempted to document changes in emotional behaviors (i.e., smiling, vocalization, and crying) during contingency experience (Sullivan, Rovee–Collier, & Tynes, 1979). Brinker and Lewis (1981) report increased smiling and vocalization and decreased crying in young, severely handicapped children in response to simple contingencies. Thus, there is some evidence of positive and negative affect changes concomitant with contingency experience.

This very brief review of the contingency literature indicates that emotional responses occur at some point during the learning process. When they occur–whether at the beginning, the end, or throughout the process–has not yet been determined. Smiling and vocalizing may be the consequence of learning and mastery (i.e., it feels good !). Alternatively, they may be a necessary prerequisite for learning (i.e., I cannot learn unless all is well). In still another view, positive emotions may not occur only at beginning or at end of the learning experience, but during both phases or even in between. Nor is it clear that only positive emotions accompany the learning process ; they are the only emotions that have been measured. What about negative feelings, such as stress and frustration, that accompany increased arousal ? Does the infant's ability to "cope" with stress affect learning and at what stage ?

The two theoretical positions–cognition leads to emotion or emotion leads to cognition–suggest several alternative models regarding emotion and the learning process :

1. Positive emotion occurs as a consequent behavior, indexing the realization of the contingency. As such, it is greatest when the response has peaked and it will decline as the infant becomes bored, satiated, or fatigued (see figure 1A).

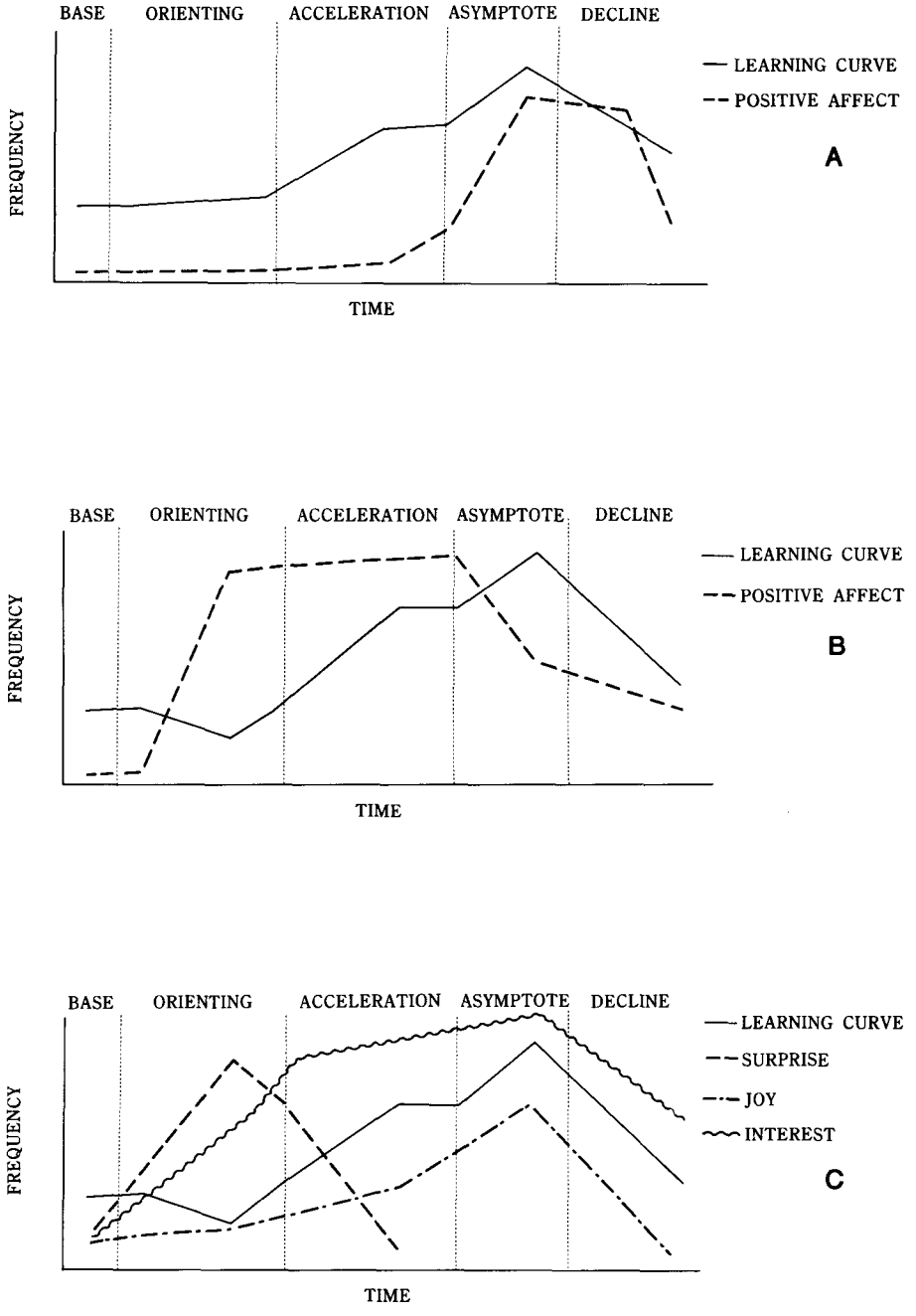

FIGURE 1 Models of learning and affect

2. Positive emotion occurs before the actual recognition of the contingency. It is not necessary to know what the contingency is before being pleased with the situation. Positive emotion and the corresponding absence of negative emotion signal the infant's pleasure at the stimulus situation–in other words, a like-dislike reaction made prior to any other cognition. Emotion will be elevated with respect to a base period early in the session prior to contingency perception and will decrease after the infant's response peaks (see figure 1B).

3. If, as we propose, emotion and cognition are interwoven, then we might expect that some emotions precede cognition, which in turn leads to new emotions and cognitions. For example, early aspects of learning may depend on increased interest and surprise that keep the infant engaged and oriented. The enjoyment and orientation lead to improved performance, which in turn leads to increased interest. Increased interest leads to further performance and mastery, which in turn leads to enjoyment. The interplay between these two processes and the differential timing and sequence of different emotional states is illustrated in figure 1C.

THE CONTINGENCY LEARNING STUDY

The subjects of the contingency learning study were among 60 infants who participated in a larger study of learning in the first six months of life. In this study infants sat in front of a contingency apparatus that was designed to deliver a three-second presentation of an audio-visual stimulus (a color slide of a happy baby accompanied by a recording of the *Sesame Street* theme song). Stimulus onset was contingent upon an armpull response by the infant. Armpull responses were automatically recorded by means of a ribbon connected to a velcro bracelet worn on the subject's wrist. Deflection of the ribbon activated a microswitch in a lever mounted above the subject. Subjects remained in the session as long as they continued to respond. Two minutes of inactivity or 30 seconds of fussy behavior or crying were the criteria for terminating the session. In addition to on-line recording of armpull responses, attention, smiling, and vocalizing behaviors were recorded and videotape recordings were made of facial expressions throughout the course of the experimental session.

From the sample of 60 infants five six-month-old infants (three boys and two girls) were selected randomly, with the only criteria being that they exhibited classic and well-differentiated learning curves. The temporal parameters of each learning curve were identified and each of the curves was segmented into the following phases :

Base : one minute of nonreinforcement (1).

Initial orientation to stimulus event : first minute following base (2). This minute is the infant's first encounter with the contingent stimulus.

Contingency awareness : one minute prior to response acceleration (3) (that point where armpull responses exceeded and stayed above base line) as well as the first minute following this point (4). Although some children's learning curves showed more rapid acceleration than others, the point of acceleration and the minute prior to and following this point were constant across subjects.

Response asymptote : one minute prior to the point of highest armpull response (5) as well as the first minute of the highest level (6).

Post-asymptote : first minute prior to decline in armpull response (7), first minute after the sustained decline (8), and the last minute of the session (9). Typically, responses dropped off quite dramatically during this period, although responding did not invariable return to base line level. The drop off in response may signify either habituation to the contingency problem or fatigue.

Because individual session lengths and rates of learning were variable, the length of each phase was also variable. However, by carefully marking the specific phases of each curve, comparable points of the learning curve were sampled and qualitatively similar moments during the learning experience were compared.

CODING OF FACIAL BEHAVIOR

Facial movements were coded from videotapes of the infants using the Maximally Discriminative Facial Movement Coding System, referred to as "Max" (Izard, 1979). Max was chosen because training manuals are available and it can be used reliably (Izard & Dougherty, 1982). In addition to coding facial movements, a number of other behaviors of particular interest in a contingency experiment were also recorded. Orientation of the head when other than a frontal full face served as an index of inattention to the contingency consequence. Infants might look away from the reinforcing stimulus either by casting their eyes down (which is codable in Max) or by looking to either side (which is not codable). Looks at hand is an interesting behavior in the contingency context since it suggests an awareness of the ribbon and possibly perception of the means-end contingency. Looks at hand was scored when both the subject's hand with the velcro bracelet and the subject's eyes were in view and the subject's gaze was oriented toward that hand.

Sucking lower lip, thumb sucking, and/or hand sucking were also coded for several reasons. First, their obstruction of the mouth clearly limits judgments of emotion to the rating of only the upper region of the face. It is useful to know the reason that an important emotional cue is missing. Second, sucking and other oral behaviors, although not emotional behaviors themselves, may be motivated by stress or boredom (i.e., they may serve pacifying, comforting, or self-stimulating functions). Finally, vocalizing, fussing, and crying were coded.

The coder sampled infants' facial behavior from the videotapes in three-second segments based on the predetermined phase of the learning curve : (1) one minute of base line, (2) the first 60 seconds of the contingency, (3) 60 seconds prior to response acceleration, (4) 60 seconds of initial acceleration, (5) 60 second prior to peak response, (6) first 60 seconds after peak response, (7) 60 seconds prior to sustained decline, (8) first 60 seconds of decline, and (9) last 60 seconds in the session. A total of nine minutes of facial behavior was coded for each subject.

During the coding, four passes were made through each tape. In the first three, with the volume off and in slow speed, brow, eye, and mouth regions of the face were coded. During the fourth pass, with the volume on and at normal speed, vocalization and fuss-cry were noted. To code facial expressions, the coder noted all codable movements in sequence for each three-second segment of behavior. One code per three-second segment was most common, although two to three facial changes occa-

sionally occurred, particularly during phases 2 and 3. If a facial movement began in one segment and persisted into the following segment, it was coded only for the interval in which it first appeared. Duration of appearance changes were not measured. In our experience it appeared that some facial expressions, such as interest, could be relatively enduring while others, such as enjoyment (i.e., smiling), were typically very brief. The dependent variable then is the number of three-second intervals in which a given expression was first visible without regard to its duration.

RESULTS

Figures 2, 3, and 4 present the mean number of expressed emotions as a function of the specific phases of the learning curve. It should be kept in mind that the temporal parameters associated with each phase are different for each subject. Nevertheless, the coding system allows for the observation of emotional responses by phase across subjects. Since three-second intervals across a minute of coding were used, the maximum number of facial expressions per minute is 20. However, since more than one facial expression might occur in a three-second period, each facial expression could occur a maximum 20 times per minute. Thus, the total number of different expressions per coded period can (and indeed sometimes does) total more than 20.

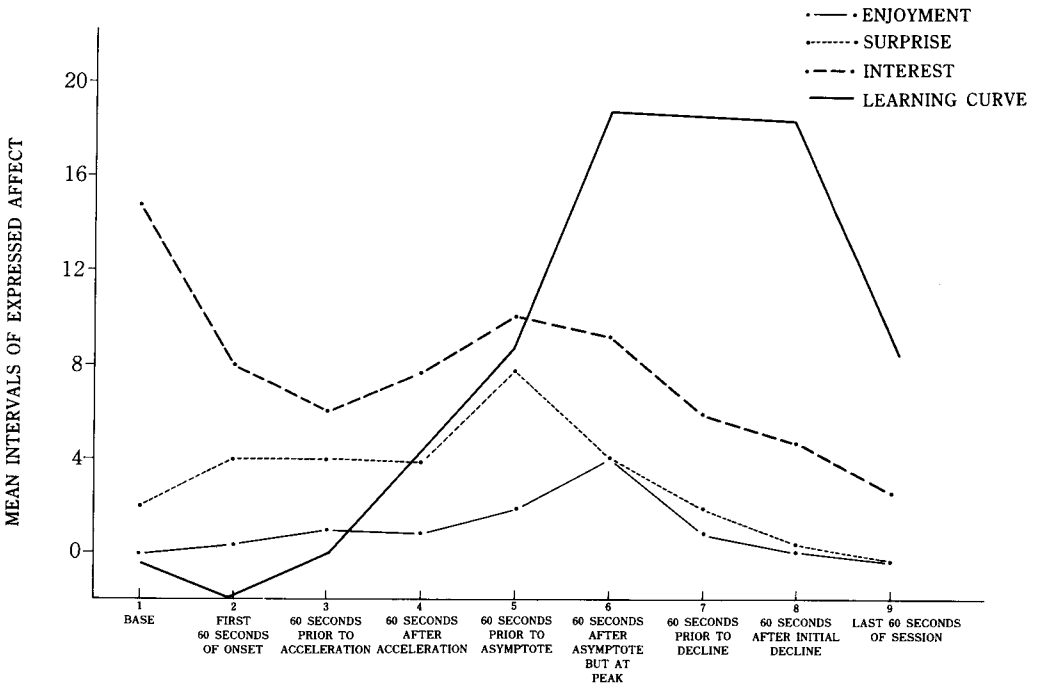

FIGURE 2 Positive affects: mean frequency across subjects

The positive emotions of interest, surprise, and enjoyment have distinct patterns in relation to the learning curve (see figure 2). During the base period (1), after the child has been placed in this new situation, interest is high while surprise and enjoy-

ment are quite low. In fact, only a small amount of surprise is observed. At the onset of the reinforcement (2), interest expressions decline markedly and surprise expressions increase slightly ; enjoyment remains low. The same pattern continues into the last phase of the orienting period (3). The acceleration phase of learning (4, 5) is characterized by an increase in interest and surprise and also a slight increase in enjoyment. This period is marked by the highest level of surprise and interest (except for the base period when interest was also high). In the asymptotic phase (6,7) interest and surprise decline but enjoyment peaks. Following this phase of learning, all positive expressions decline. This general pattern was shown for all five subjects. In four out of five subjects, surprise preceded enjoyment ; all five subjects showed a decline and then an increase in interest, and all showed a decline in positive expressions after learning.

The data reveal increases in positive expressions around the point of learning acquisition. Surprise and interest peak during the acquisition phase and enjoyment peaks at asymptote. Lewis and Goldberg (1969), discussing violation of expectancy, suggest that surprise and interest (more general emotions) should occur prior to the appearance of specific emotions such as joy or fear. The patterns found in the current study support the notion that surprise precedes enjoyment and thereby indicate that the process of acquiring information may be related to arousal with the final discovery related to enjoyment.

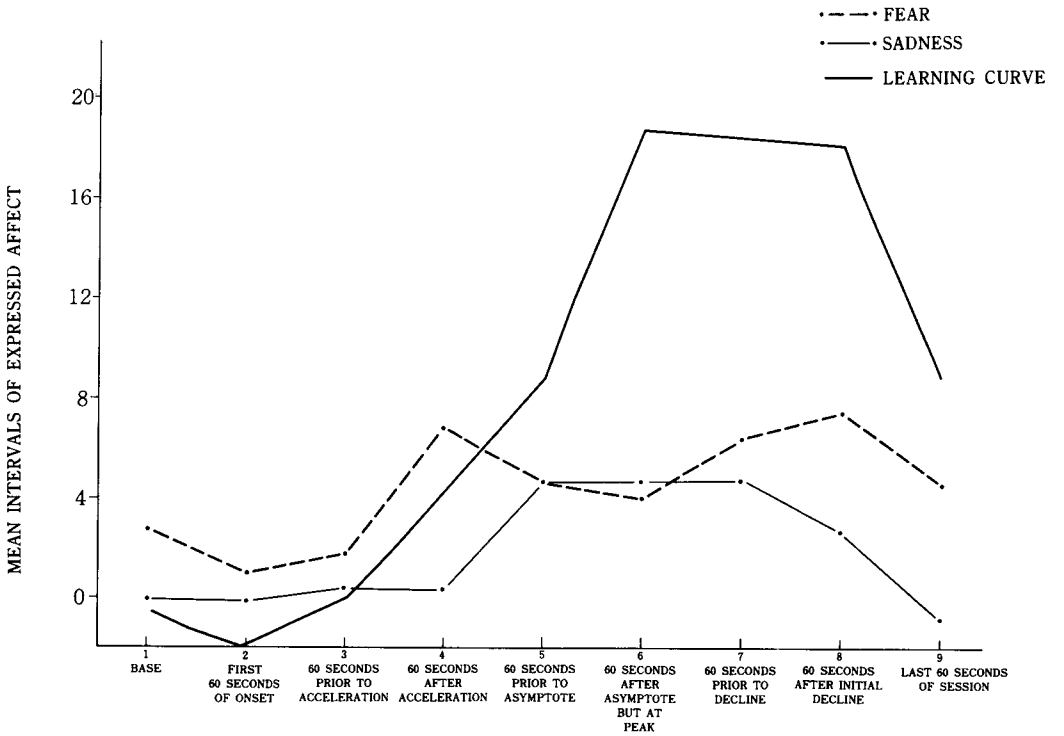

FIGURE 3 Negative affects : mean frequency across subjects

With regard to expressions of negative emotions, almost none are observed during base (1) (see figure 3). Negative expressions are most frequent during the

orientation phase (2 , 3), with fear reaching its highest level during this period. During the acquisition phase (4 , 5), fear declines and remains low thereafter. This pattern held for all five subjects. Sadness shows relatively little change across the learning process, except during the post-asymptotic period (8 , 9). At this point, as interest and other positive expressions decline, sadness reaches its highest point (perhaps indicating there are no new mountains to climb). Four out of five subjects showed this pattern. The negative facial expressions appear to be reciprocals of the positive expressions.

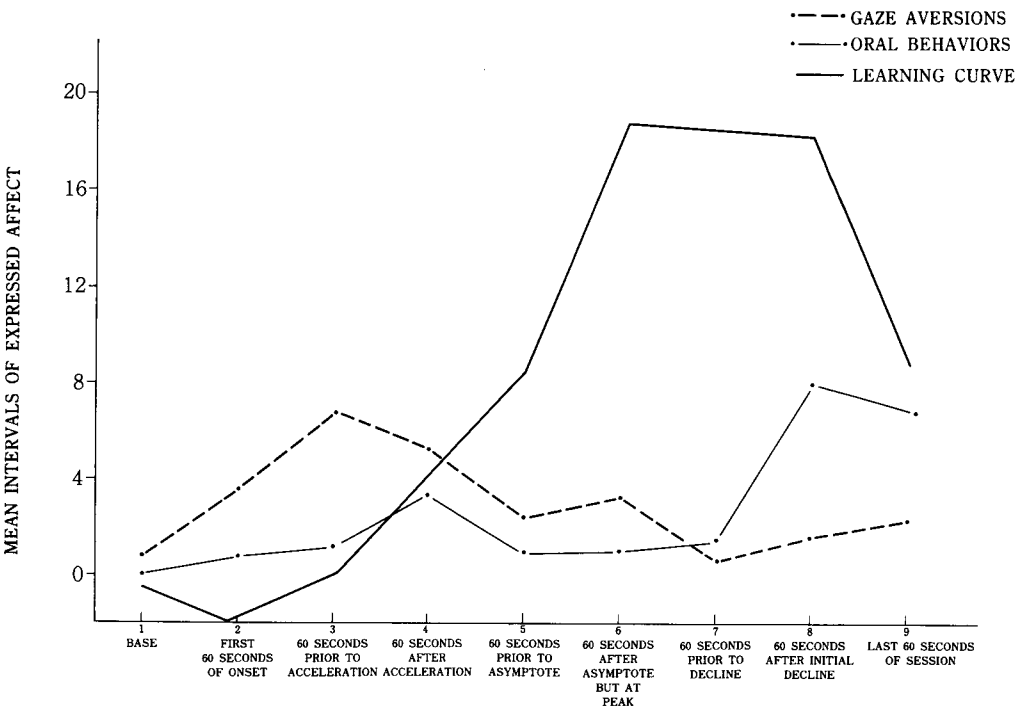

FIGURE 4 Regulatory behaviors: mean frequency across subjects

Figure 4 presents the sequence of appearance for the two self-regulating behaviors, gaze aversion and oral behavior. These behaviors follow still a different pattern of occurrence. Relatively little gaze aversion or oral behavior is observed during the base (1) or orienting (2 , 3) phases. Both classes of behavior increase markedly during the acceleration phase (4) and remain high throughout the rest of the session, although some decline can be seen during the last phase (9). Most notably, these behaviors increase at the time when negative expressions decline and positive expressions increase. However, they remain high during the asymptote and post-asymptote phases (6 , 7, 8, 9) when positive expressions decline. Although more individual variations occurred in these patterns compared to the others, however, four of the five subjects showed a decline in self-regulatory behavior in the last minute of the session (9).

Thus far, our discussion has focused on patterns of facial expressions with little attention given to the absolute levels of their occurrence. Without doubt, the most

frequent facial expression was interest. This is not surprising, since the task was designed specifically to interest children. The next most frequent responses were surprise and the control behaviors. Enjoyment, fear, and sadness were relatively infrequent expressions. In fact, in only one phase did enjoyment occur more than 20% of the time. Fear, on the other hand, occurred in three periods more than 20% of the time. The frequency of appearance of sadness was comparable to that of fear.

THE FUGUE

The results of the contingency learning study bear on several issues. First, consider the metaphor of a fugue of cognition and emotion. The infant is placed in a new situation. The fugue begins. Surprise is present and interest is high. The experiment starts ; reinforcement is delivered for an armpull response. For the infant, something new is happening ; surprise and fear increase, interest decreases. The activity level of the infant also decreases as armpulling declines below base line level. This dip in frequency of response may reflect the infant's thought : "Something is happening. What is going on ?" We label this period the orienting phase because of the infant's cessation of activity and increased vigilance and/or wariness. The increase in fear may reflect the infant's lack of information and control over the nex event.

The decline in activity serves to diminish the reinforcement. A response causes reinforcement to reoccur. During this phase, which is viewed as the end of orientation and the beginning of acceleration, the infant "begins to learn" the relationship between action and outcome. Fear decreases ; interest begins to rise. During the acquisition phase, interest and surprise continue to increase as fear declines. The infant continues to be aroused and it now becomes necessary to modulate this arousal. Self-regulatory behaviors (gaze aversion and oral activity)·appear for this purpose and occur at relatively high levels.

Learning is achieved by the asymptotic phase when enjoyment peaks. Fear remains low and self-regulatory behaviors remain high. Following the solution of the problem, armpulling responses decline along with many of the emotional expressions. This decline may reflect a drop in arousal. With the decline in arousal, the infant no longer has need for self-regulatory behaviors, which remained high until the beginning of the post-asymptotic phase. Cognitive solution brings enjoyment, a decline in arousal, and a decline in self-regulatory behavior.

During the post-asymptotic phase an interesting emotional expression appears, sadness. This expression may be a function of several factors. One possibility is that sadness is associated with fatigue and upset. If this is the case, however, one would also expect to see an increase in self-regulatory responses, particularly oral behavior. This did not occur. The large increase in sadness may be the consequence of a post-solution recoil. Such a process might be not unlike that described by adults who report depression following the successful completion of an activity (i.e., no more mountains to climb).

If the cognitive-emotional preocess is viewed in terms of well defined temporal bouts, each of which has a definite beginning and an end, then one would expect to observe a decline in all responses at the end of the experiment. The increase in

sadness at the end of the session, however, suggests that the end constitutes an artificial event imposed by the experimenter on the ongoing flow of emotion and cognition. One might imagine that this negative emotion serves as the first note of the next sequence in the cognitive-emotional fugue. In other words, the post-completion blues may be a vital factor in redirecting the individual to new tasks.

THE ORIENTING REFLEX

Another issue raised by the data has to do with the orienting response and learning. It has been argued that in order for learning to take place there must be a habituation of the orienting respose (Sokolov, 1963). Our data suggest that this is the case. The orienting reaction that occurs at the onset of reinforcement produces a complex set of responses. First, armpulling behavior declines as expected, since orienting results in the cessation of activity (Lewis, 1969). In addition, a fear response, perhaps a sign of wariness and/or vigilance, increases during the orienting phase only to decline shortly thereafter. It is following this orienting period that learning seems to occur. Once the subject's armpulling response returns to base line, armpulling gradually increases. In addition, once fear diminishes, interest begins to increase. It seems that the habituation of the orienting response consists of a decline in fear, a resumption of activity, and an increase in interest.

It should be noted that this change in emotional behavior accompanying the habituation of orienting has as a concomitant response an increase in self-regulatory behavior. The self-regulation may facilitate the emotion switch. Thus, for example, in order for the infant to become less fearful and more interested, it may be necessary that infants regulate themselves through self-stimulation. Although there are no data to support this view, the control of fear through self-regulation may allow an increase in interest and learning.

The habituation of the orienting respone appears to be comprised of emotional states nonconducive to learning. In this particular study, the cessation of activity was associated with wariness. Not until infants could respond did they learn the association between armpulling and outcome. Self-regulation served to reduce this wariness, thereby causing a reduction in the orienting reflex. Once the orienting reflex was habituated, behavior resumed. In this sense, the orienting reflex is envisioned not as a cognitive but as an emotional process.

INDIVIDUAL DIFFERENCES

Individual subject characteristics may also be implicated in the cognitive emotional process. Individual differences may include purely cognitive variables, such as the ability to recognize, store, and retrieve information about the cooccurrence of action and outcome. Of particular interest, however, are individual differences that may be related to the emotional components of this process. At each stage of learning, individual differences appeared in terms of the amount of emotion expressed, although relatively few individual differences were observed in the type of emotion expressed.

The variability among subjects was most pronounced on self-regulatory responses. Such individual differences may be related to what has been called

"temperament." Part of the child's task in the cognitive-emotional process is to regulate the level of negative emotion associated with the early phases of learning. This regulation may vary as a function both of (1) the amount of negative emotion initially produced and (2) the efficiency of the child's ability to regulate this negative emotion. Both may be features of the temperament dimensions of excitability and soothability (Thomas, Chess, Birch, Hertzig, & Korn, 1963). For infants with difficult temperaments, the intense emotion associated with orienting may overwhelm the infant and prevent habituation. These children may become increasingly fretful and ultimately drop out of the learning situation. Alternatively, other infants with difficult temperaments might take a prolonged period to regulate the orienting response, thereby demonstrating learning only much later. For some of these infants who gain control later, new state variables, such as fatigue, might appear prior to the learning phase and they too might drop out of the learning situation. From another point of view, lethargic children (sometimes considered to have easy temperaments) may not become sufficiently aroused to orient ; thus, they may not be able to initiate the learning process. Down's syndrome children may be a case in point. These children typically have low muscle tone, are lethargic, and are often reported to have easy temperaments. Their learning problems may in fact result from an inability to become activated.

One would expect that in the study of the cognitive-emotional interface, individual differences in the type of emotion as well as in the amount of emotion expressed would be found. Although the five subjects in the present study were remarkably similar in terms of the types of emotions expressed, there were some idiosyncratic facial appearances, which might be attributed to measurement error. It is not unlikely that individual differences exist in the cognitive-emotional interface. Indeed, with age individual differences in some of the minor threads of the process migh become even more visible, playing a major role in idiosyncratic behavior. Individual differences, however, should not trouble one. To invoke the metaphor of the fugue, "there are standard kinds of things to do but not so standard that one can merely compose a fugue by formula" (Hofstadter, 1981, p. 9).

In the present investigation we measured emotional expression, assuming a one-to-one correspondence exists between expression and internal emotional states. As we argued earlier, however, the relationship between expression and state is complex (Lewis & Michalson, 1983). Early facial expressions appear too differentiated vis-a-vis hypothesized internal states to allow one to assume a one-to-one correspondence between the two. Moreover, socializing agents soon teach children through a variety of means how to mask and alter facial expressions, and perhaps even when to display certain faces. Thus, a certain amount of caution must be taken in interpreting these data. It may be that emotional expressions rather than emotional states are the concomitants of learning.

We have used the metaphor of the fugue in an attempt to argue that (1) the separation of components, in this case cognition and emotion, may be an inappropriate way of viewing the relationship between elements and (2) a linear model of the relationship between these components is inadequate. In conceptualizing the relationship of cognition and emotion, neither should be described as causing the other ;

rather, each chases the other in an endless fugue.

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