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ABSTRACT

This paper presents an integrative perspective on infant development (based on a consideration of developmental data) which focuses on the function of the smile. From the earliest spontaneous smiles of the newborn period to mature smiling and laughter, a central role was revealed for an excitation (tension)-relaxation process in producing smiles. This notion is complementary to social and cognitive theories of smiling but is more basic in pointing to the function of the smile for the infant and in stressing continuity of smiles following mastery, and smiles following excitation. In unraveling the changing meaning of the smile, a number of developmental principles are revealed, including the following: (1) developmental sequences may be repeated, though in a transformed and elaborated manner; (2) the infant becomes increasingly active in producing and mastering his own experience; (3) social and individual functions of the smile converge in promoting accommodation to and assimilation of novel events; (4) fear and joy, and wariness and smiling have a close functional relationship with respect to novelty; and (5) cognitive and socioemotional aspects of development are inseparable. (Author/GO)

The Ontogenesis of Smiling and Laughter:

A Perspective on the Organization of Development in Infancy

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Abstract

From a consideration of developmental data an integrative perspective on infant development is evolved emphasizing the function of the smile. From the earliest spontaneous smiles of the newborn period to mature smiling and laughter, a central role was revealed for an excitation (tension)-relaxation process in producing smiles. This notion is complementary to social and cognitive theories of smiling but is more basic in pointing to the function of the smile for the infant and in stressing continuity of smiles following mastery and smiles following excitation. In unraveling the changing meaning of the smile a number of developmental principles were revealed, including the following: (a) developmental sequences may be repeated, though in a transformed and elaborated manner, (b) the infant becomes increasingly active in producing and mastering its own experience, (c) social and individual functions of the smile converge in promoting accomodation to and assimilation of novel events, (d) fear and joy, wariness and smiling, have a close functional relationship with respect to novelty, and (e) cognitive and socioemotional aspects of development are inseparable.

The Ontogenesis of Smiling and Laughter: A Perspective on the Organization of Development in Infancy

In recent years infant smiling has been discussed from a variety of perspectives (e.g., Gewirtz, 1965; Bowlby, 1969; Spitz, Emde, & Metcalf, 1970; Vine, 1973; Zelazo, 1972). The view that the smile reflects both underlying cognitive processes and cognitive growth, for example, is currently attracting considerable attention and is well supported in the literature (Kagan, 1971; McCall, 1972; Shultz & Zigler, 1970; Sroufe & Wunsch, 1972; Zelazo & Komer, 1971). Nonetheless, a complete account of smiling, broadly conceived of as a developmental phenomenon, has not yet appeared. The major tasks of tracing changes in the meanings of the smile during the course of development, revealing the relationship between early (endogenous) smiles and later smiles, specification of the function of the smile <u>for the infant</u>, and relating developmental changes in smiling to general principles of development have yet to be accomplished. Thus, an attempt to integrate the various perspectives vis-a-vis the functions proposed for the smile, and the physiological, social, and cognitive components of smiling seems timely.

As Kagan (1971) has aptly stated, the smile "serves many masters," and even when morphologically stable, the meaning of this ubiquitous behavior changes with development. A common thread in this development can be discerned, however, in the relation of the smile to a tension release process. An examination of developmental changes in morphological and dynamic features of smiling, from its earliest beginnings to the evolution of laughter by age 4 months, reveals a striking relationship

between smiling and such a process. Likewise, even following the emergence of mature smiling and laughter, the role of tension is apparent in progressive changes in the nature of stimulus situations potent for eliciting positive affect.[1]

The Ontogenesis of Smiling and Laughter

Early Smiles

The very earliest smiles have been called "endogenous" (e.g., Spitz, Emde, & Metcalf, 1970) or "spontaneous" (Wolff, 1963) because they occur in the absence of known stimulation, most commonly during sleep. In well-conceived studies, Emde and his colleagues have shown that these low-intensity smiles, which involve only turning up the corners of the mouth, are not related to gastric activity or to vegetative drive state (e.g., time since feeding; Emde & Koenig, 1969). Rather, they are correlated with spontaneous CNS discharge of subcortical origin. This conclusion is supported by a wide variety of evidence. These smiles occur in bursts almost exclusively during REM sleep, especially when the eyes are first closed and in the middle portion of REM episodes, periods which are characterized by a pattern of low arousal (Emde & Koenig, 1969; Wolff, 1963). They are inversely related to other spontaneous behaviors (for example, they do not occur when the infant is stirring or for about 5 minutes following startle; Takahashi, 1973; Wolff, 1963), and they decrease in frequency with age over the first 3 months of life (Spitz et al., 1970). Finally, they are more frequent in premature babies and have been found to occur in a microcephalic infant (Emde, McCartney, & Harmon, 1971; Harmon & Emde, 1972). The conclusion that emerges from these data is that endogenous smiles are associated with low, oscillating states of

excitation, of brain stem or limbic system origin, with the smile occurring as the excitation rises above, then falls below, some threshold. (See schematic of the excitation-relaxation cycle in Figure 1a.)

Insert Figure 1 about here

Interestingly, the first elicited (exogenous) smiles also are obtained when the infant is asleep; that is, stimuli that do not effectively elicit smiling during the waking state in the first week of life are effective when the infant sleeps (Wolff, 1963). This is perhaps because of the relatively low level of arousal before and following stimulation. The stimulation apparently increases the level of excitation above the threshold, with the smile occurring as relaxation follows, between 6 and 8 seconds after stimulation (Wolff, 1963). (See Figure 1b.) The very earliest waking smiles may be elicited by low level tactile and kinesthetic stimulation (light touches on sensitive areas, blowing on the skin, gentle jogging; Emde & Koenig, 1969; Watson, 1924). It is important to note that these first elicited smiles, like the spontaneous smiles, are low intensity responses to mild stimulation, typically involving only the corners of the mouth (see Table 1).

According to Wolff (1963), the first smiles readily elicited when the infant is awake occur when the infant is satiated following feeding. The infant is drowsy and glassy-eyed ("intoxicated"; Wolff, 1963). The response is of larger magnitude, moving in the direction of the broad smile. (Primarily, the mouth corners are drawn farther; it is neither the grimace of the first week nor the alert smile of 4 weeks.)[2] Wolff

reports that auditory stimulation, especially any high-pitched voice, is the most effective elicitor (although he apparently did not employ rhythmic, gentle tactile stimulation). Thus, by the second week of life the expression of positive affect is less dependent on low levels of modulated stimulation; still, the effectiveness of external stimulation depends upon a generally low level of background excitation.

Insert Table 1 about here

By the third week of life, the first alert smiles occur.[3] While awake and with focused attention, the infant smiles, especially at voices, according to Wolff's data. This alert smile involves a brightening and crinkling of the eyes with the mouth pulled ~~into~~ a "grin," and its latency is now only 4-5 seconds post stimulation, suggesting a steeper gradient of excitation and faster recovery. At this point a nodding head accompanying vocal stimulation is more effective than voice alone, again implying greater stimulation-produced tension. The term "tension" seems appropriate at this point since for the first time the infant's attentional processes play a partial role in engendering the excitation.

This progression continues in the fourth week, wherein Wolff found the mother's voice especially effective, even causing an interruption of feeding for the smile. In this and in other ways the smile has become more independent of organismic state. The first smiles to a silent moving face occur, and during visual tracking of a slowly moving object (producing a "hypnotic-like" state), a sudden movement of the hand across the field of vision elicits "surprise" smiling. These steps represent

the roots of the infant's own involvement in tension production, though the smiles are still primarily in response to stimulation as opposed to stimulus content. Also during the fourth week, pat-a-cake (three vigorous bounces of the hands), which had not elicited any smiling at 3 weeks, became the most effective stimulus employed for 7 of Wolff's 8 subjects, and remained so across the first 3 months, even producing smiling in fussy infants. The smile elicited by such vigorous stimulation is a maximal smiling response, close to a chortle.[4]

There is something special about the ability to cope with this degree of stimulation. Perhaps the active smiling which it engenders means that even at this early age some cortical modulation of the stimulation-produced (global) arousal is possible, by virtue of the infant's increased ability to assimilate at least portions of the impinging stimulus situation (see "model" below) and to follow changes in the stimulation. As the degree of excitation increasingly becomes a function of the extent to which the infant is "engaged" by the stimulus, we speak of the infant's efforts to stay with the stimulus as engendering tension. It is not yet a matter of processing stimulus content, however.

Wolff concluded his detailed observations with the fifth week. At this time the voice waned in its effectiveness, and the nodding head became the first visual stimulus to consistently elicit smiling. Smiles could be elicited up to 23 trials in a row, and could be reinstated and maintained for many more trials if the experimenter put on a mask, then sunglasses over the mask, then removed the mask, etc. The masked face with wagging tongue was more effective than mask alone. All of these observations imply the need for a dynamic stimulus to maintain sufficient tension for smiling during this time.

Schema Formation and Recognition

Presentation of a stationary face does not consistently elicit smiling until about the 8th or 10th week (Ambrose, 1961; Gewirtz, 1965; Spitz, Emde, & Metcalf, 1970; Wolff, 1963), although by 5 weeks it was potent when in motion. This is indeed an important developmental landmark, probably reflecting the first formation of a true visual schema. Spitz et al. (1970) have shown that this development is paralleled by the decline of endogenous smiling and infantile fussiness and by important developmental changes in the EEG and sleep patterns with maturation of the cortex. All of this points to a qualitative turn in development with the infant becoming dramatically more responsive to the surround. Stated differently, the fluctuating tension state required for smiling can now clearly be a function of the infant's cognitive engagement. The involvement of cognitive developmental processes is suggested by several lines of evidence, including the observation that institutionalized infants are delayed by several weeks in reaching peak responsiveness to the immobile face (Gewirtz, 1965).

During the period from about 5 to 8 weeks, the infant seems to be most responsive to dynamic visual stimulation (the nodding head and Wolff's masked face with wagging tongue); thus, Salzen (1963) found with an 8-week-old subject that rotation increased the effectiveness of cardboard stimuli and that blinking lights were more effective than a static display. The infant's increased capacity to attend to and follow contrast and change mediate the smile, but still the tension seems to derive primarily from stimulation, rather than the processing of a stimulus configuration (content). At this time there is little specificity of the

stimulus content. Increasingly, however, mere changing visual stimulation will not suffice (though certain dynamic situations are, of course, quite effective). Rather, as with the face, stationary but "meaningful" visual stimuli become more effective (Shultz & Zigler, 1970; Zelazo & Komer, 1971). Thus, Shultz and Zigler (1970) found with 3-month-olds that a stationary clown was more effective in eliciting smiles than a moving clown. Employing Piaget's (1952) concept of recognitory assimilation, Shultz and Zigler argue that the infant can more readily "master" the stationary clown. The tension-relaxation cycle produced by "effortful assimilation" (Piaget, 1952; Kagan, 1971) reflects a fundamentally different process than excitation produced by stimulation; it is more cognitive than perceptual and represents a more active role for the infant.

The following observations attest to the fact that effortful assimilation (tension production and release) is central in these smiles. First, stimuli once effective in eliciting smiles lose their potency over time. In normal home-reared infants, for example, the immobile face declines in effectiveness after 3 or 4 months of age (Ambrose, 1961; Gewirtz, 1965; Kagan, 1967; Spitz et al., 1970; Takahashi, 1973). Also it is well demonstrated that within single experiments, repeated stimuli decline in potency. The infant scrutinizes the stimuli with neutral affect during the initial trials, then smiles for several trials before returning again to affectively neutral looking. (Piaget, 1962, argues that there is initially a process involving accomodation followed by smiling during pure assimilation.) When a novel aspect is introduced, there is renewed orienting to the transformed stimulus, with a decline in positive affect if the infant still had been smiling to the original, followed by smiling to

the altered stimulus on subsequent trials and again a decline (Kagan, 1971; Shultz & Zigler, 1970; Sroufe & Wunsch, 1972; Zelazo, 1972; Zelazo & Komer, 1971). Finally, older infants smile sooner than younger infants to the same novel stimulus situations (Zelazo, 1972).

Kagan (1971) summarized the situation with respect to the face in the following way:

> The smile declines because his schema for a face becomes so well articulated that all faces or representations of faces are immediately recognized as such. There is no tension; no effort is required for assimilation, and hence, no smile. (p. 153, italics added)

Similarly, Zelazo (1972; Zelazo & Komer, 1971) has attributed curvilinear trends within experiments with auditory and visual stimuli to an initial inability to assimilate the stimulus, then effortful assimilation (and smiling), and finally complete assimilation with little effort on the final trials when affect is again neutral. Thus, these investigators see a role for tension (effort) in the "recognitory" smiles.

Summary and model. Early elicited smiles, though manifesting progressive changes, are in an essential way more closely related to endogenous REM sleep smiles than to smiles reflective of effortful schema formation. First, gentle, modulated tactile and auditory stimulation, which makes no requirements for directional attention or analysis of content, is most effective (see Table 1). Such stimulation, because of its rhythm, intensity, and modulated quality "artificially" produces the fluctuating CNS states which were associated with REM smiles, especially when the infant is drowsy or entranced. Later, as the infant matures,

the system is capable of faster tension swings. The infant can be captured by complex or changing stimuli, even when the level of background excitation (arousal, alertness) is moderately high. Smiling occurs in the alert state, to more vigorous stimulation, and to dynamic visual or visual-auditory stimulation which requires directed and sustained attention. These smiles are of shorter latency and larger magnitude, reflecting both the greater background and cognitively engendered tension. With the increasing importance of schema-formation in occasioning smiles, it is no longer stimulation per se that produces the tension→relaxation-smile, but the infant's effort in processing of stimulus content. As we shall see, this progression continues throughout the first year of life.

In the model we are developing, it is assumed that there is rapid increase and recovery of cortically mediated (content based) tension, producing the "arousal jag" (Berlyne, 1969) required for smiling and laughter, and that this occurs against the backdrop of slowly recovering global arousal produced by stimulation. Relevant, then, are both the development of tension tolerance and the ability to assimilate aspects of the stimulation. The occurrence of smiling (or laughter) would also depend on salience of the stimulus situation and context (see Sroufe et al., 1974), as well as the extent to which the stimulation was assimilable. As the infant becomes more actively involved in transacting with the stimulus, there is no longer a one-to-one correspondence between stimulation and arousal.

The Development of Laughter

In comparison with smiling, laughter, which is the maximal positive affective response (Washburn, 1929), requires a greater and typically

more rapid build-up of tension. Most often the laugh occurs immediately or within 2 seconds after stimulation. In studies of laughter which appears at about 4 months, clear developmental trends were found in the nature of items potent for its elicitation (Sroufe & Wunsch, 1972). Closely paralleling the case for smiling in the first quarter year of life, the elicitors of laughter proceed during the first year from intrusive stimulation (tactile and auditory) to interesting social-visual events.[5]

At first, physically vigorous stimulation is most potent. Of 28 items in our battery, laughter was produced in one-third of the 4-month-olds only by a vigorous kissing of the stomach and "I'm gonna get you" (looming approach with talking, building somewhat slowly but abruptly terminating with tickling the ribs). Five-month-olds laughed in addition at the mother vocalizing a resounding BOOM BOOM BOOM. One-third of the 6-month-olds laughed at a swelling, loud "aah" with abrupt cut-off, at being rather gently jiggled, and tickled under the chin, and at the two items successful at 4 months. This was the first age where one-third laughed at a visual item (mother approaching with cloth-covered face; a dynamic visual stimulus).

The trend during the second quarter is from laughter at vigorous, to laughter at less vigorous but more "provocative" tactile and auditory stimulation. This is followed by a trend in the second half year towards laughter to social and more subtle visual stimulus situations, with the intrusive, vigorous items declining in potency. Thus, for example, one-third of the 8-month-olds laughed at peek-a-boo (performed without sound) and at their own faces being covered, as well as to mother's approach

with covered face, mother shaking her hair, mother crawling on the floor, and at pulling a dangling cloth from mother's mouth. The only clearly potent auditory or tactile item was "kissing stomach." This trend continued month by month, with 12-month-olds laughing at the greatest proportion of the visual and social items. They laughed most to the items which provide an obvious element of cognitive incongruity: mother "walking like a penguin," approaching with mask, sucking on the baby's bottle, and sticking out her tongue (pulled in as baby reaches), as well as to each of the social and visual items successful at 8 months. (In all, one-third or more laughed to 9 of the 14 social and visual items.) They also laughed at four tactile and auditory items, but when infants in the last quarter laughed at such items it was clear that the item had been transformed; for example, they laughed in anticipation of the mother actually kissing the stomach. Similarly, the oldest babies often laughed hardest when stuffing the cloth back into mother's mouth. Clearly, then, with laughter as with smiling, there is a progression toward a more active role for the cognitively maturing infant in producing the requisite tension (see Sroufe & Wunsch, 1972, for further detail).

A steep, sharp tension fluctuation ("arousal jag," to use Berlyne's 1969 term) is required to produce laughter; the response, of course, is maximal. Observations with the "swelling aah" item illustrate this. First, this item (and the loud BOOM BOOM BOOM) sometimes produced crying in infants before the age of onset of laughter. When this occurred, the same item was especially likely to produce laughter the following month (the infant now having an alternative response to such a marked tension fluctuation, a greater ability to tolerate tension, and/or the capacity

to transform a portion of the tension). Second, if instead of swelling the sound in a positively accelerated function, with an abrupt cutoff, it was swelled, tapered, and reduced in loudness (vs.), the item did not produce laughter. Similarly, other items which build to a climax are maximally potent for laughter (e.g., the best item, "I'm gonna get you," with looming and a poke in the ribs). Granting the importance of a steep gradient of tension and rapid recovery, the laughter of older infants to the mother sucking on their bottle or walking "like a penguin" reflects a rapid processing of incongruity, a cognitive production of a rapid tension fluctuation, build-up, and resolution. This is a remarkable development, with profound implications, fully comparable to the qualitative developmental change reflected by the smile of recognition at 3 months (see later section on "function").

From Recognition to Mastery: From Passive Recipient to Agent

We believe that the infant progresses from smiling and laughing in response to intrusive stimulation, and to stimulation mediated by active attention, then to smiling and laughing in response to stimulus content, towards an ever more active involvement in producing the stimulus itself. Kagan (1971), for example, finds that 2-year-olds smile following the solution of a problem (e.g., finding an embedded figure), with smiling more likely the more difficult the problem solved. Here the stimulus for smiling is clearly a product of the child's cognitive processes, not the picture on the page. At the same time, we find it increasingly difficult to elicit smiling to simple repetitive stimuli or static stimuli with development. "Effortful assimilation" increasingly involves more than recognition.

With the laughter items, it was noted that in the second half year those in which the infant participated became more potent (pulling the cloth from mother's mouth, reaching for the protruding tongue), and later infants laughed more at their own productions (attempting to stuff the cloth back into mother's mouth). Informal observations suggest that the tendency to laugh in situations in which the infant is agent, rather than recipient, increases into the second year of life with, for example, infants laughing more vigorously to covering the observer's face with a cloth than having their own face covered.

Piaget (1952; 1962) introduced both the concepts of recognition and mastery with regard to smiling, and investigators of early schema-related smiling have generally used one term or the other (Shultz & Zigler, 1970; Zelazo & Komer, 1971). In light of the discussion above, "mastery" would seem to be the broader concept (with recognition considered a form mastery), since it can encompass early smiling with recognition as well as the smile following problem solution. It also implies an active role for the infant in engaging the surround. The infant's active role, even in early smiling, is underscored by Watson's (1972) work on "contingency" smiling, in which vigorous smiling and cooing were found with some 8-week-olds in response to contingent mobiles (responding to head turns or leg kicks) but not to non-contingent mobiles. Piaget (1962) himself spoke of "pleasure at being a cause" being added to "functional pleasure" after about age 4½ months (the third stage, p. 91). Clearly, however, mastery continues to evolve over the first year and beyond.

The Tension Release Hypothesis:

Explicit Studies and Conceptual Development

Our work on the development of laughter was conceived with the tension release hypothesis in mind. Thus, a range of items was selected that varied in sensory modality, physical intensity, and apparent incongruity of content. Also, items were included that were similar to those previously reported to produce fear (loud sounds, loss of balance, looming approach, and masked approach), since these would be expected to produce the requisite tension (and therefore laughter in a secure context; see Sroufe et al., 1974, and the section on "function" below). Finally, items were presented repeatedly so that trial-by-trial effects could be examined. The data were clear and compelling. Laughter reliably built from smiling on earlier trials (often with an initial trial or two of neutral expression) and faded again to smiling on later trials (Sroufe & Wunsch, 1972). As effortful assimilation was implicated in recognitory smiles, faster effortful assimilation or effortful assimilation of more elements of the situation, and therefore a steeper tension fluctuation, was implicated in laughter.[6]

Since the laughter study we have gone on to show that by varying context the "same" stimulus situations can lead to intense positive or negative affect (Sroufe et al., 1974; see "function" section below) and have sought to examine the tension notion in three other ways. First, we have examined heart rate and other physiological responses anticipatory to laughter. Second, we have studied the development of smiling and laughter in infants with Down's Syndrome, with special attention to the most extremely hypotonic babies. Finally, we have examined the place and

function of affective expression in the stream of behavior, showing that the smile, as a reflection of tension release, logically precedes an overt motor act (see the section on "function").

Physiological antecedents of smiling and laughter. One model we have been working with is depicted in Figure 2, which is a schematic of observed heart rate changes during both aversive and positive reactions to masked approach. In this situation either mother or stranger calls the infant's name, presents the mask, covers her face, then slowly leans to within reach. In each case there is an initial heart rate deceleration of large magnitude, and at this point we cannot predict the infant's reaction from either physiological records or videotaped overt behavior (Sroufe et al., 1974). In an aversive situation, as when a stranger approaches in the mother's absence, a tachycardia (acceleration) follows the deceleration (OR), becoming more pronounced with crying. With the mother presenting the item, unless the infant has been previously frightened, the deceleration to her approach continues right to the point of smiling, laughing, and reaching; it is followed, of course, by tachycardia associated with the vigorous muscular discharge. These heart rate patterns are very reliable, and they suggest that dramatic orienting and appraisal (we refer to "being captured by" and "evaluating" the stimulus situation) are an intricate part of both fear and strong positive affect.[7]

There are also predictions from our model concerning muscle tension (EMG). Muscle tension should first decline sharply to a very low point, then perhaps increase just prior to laughter.[8] Since heart rate continues to decelerate, a temporary dissociation of the usual EMG-HR

Insert Figure 2 about here

coupling may occur. Another pattern that would be expected, especially with older infants, is complete muscular quieting, without apparent change until the burst of tension that occurs with laughter. With rapid processing of the incongruity, the "tension jag" prior to laughter may not be apparent on the EMG record. This research is proving difficult to carry out, because laughter is difficult to elicit in the laboratory after we have disturbed the infant by attaching the leads necessary to record HR, two channels of EMG, and respiration. Nonetheless, the muscular quieting phase is well established, and this should be a fruitful area for further work.

Laughter and smiling in infants with Down's Syndrome. Observations on more than 20 infants with Down's Syndrome (Cicchetti & Sroufe, 1975) offer further support for the role of active processing and tension in producing laughter. Down's infants lag considerably behind normal infants in the onset of laughter (4 months or more), and laughter remains rare. In time, however, they do laugh at items in the same order reported by Sroufe and Wunsch (1972) for normal infants. Also, they will frequently smile at situations eliciting laughter in nonretarded infants and, again, in the same order. Especially with the nonreflexive, more cognitively sophisticated items, Down's infants seem unable to process the incongruity with sufficient speed to produce the "tension jag" required for laughter (although the differential smiling suggests developmental changes in comprehension). This notion is supported by the long latencies to smile and laugh in these infants. It is also interesting

to note that extreme abnormalities in muscular tension seen in some of these infants can be related to laughter. The three most markedly hypotonic (flaccid) infants in the sample did not laugh at all before age 13 months and then very rarely, though performance on Uzgiris-Hunt scales placed them not nearly so far behind the other infants in terms of cognitive development (e.g., having attained stage 4 object concept). (See Cicchetti & Sroufe, 1975, for a further discussion.)

The concept of tension release. It should be clear from the preceding discussion that we are not promoting a drive reduction model or the closed hydraulic energics of classic psychoanalysis. The tension we are speaking of is not always present, seeking discharge, and is not necessarily aversive. Ultimately, it can be of either positive or negative hedonic tone. In a secure context, infants actively seek to reproduce incongruous, tension-producing situations. Therefore, we deliberately avoid speaking of tension "relief" or "reduction." Thus, our position is distinct from Ambrose's (1963) ambivalence position and even from other cognitive positions, such as Kagan's (1971), which imply that processing incongruity necessarily involves a negative component:

> The smile that accompanies recognition of a face requires, first, a build up of tension during the brief period of uncertainty that the infant must experience . . . . The smile can reflect the assimilation and the accompanying drop in the tension. . . . (T)he infant who smiles may have a capacity to build up a tension . . . and to be relieved of it. (p. 155)

Our position, which is nonetheless similar to Kagan's, is unique primarily in assuming that the initial orienting, appraisal, and tension production

is not affectively charged and that affect is determined by context as well as by stimulus discrepancy. The same stimulus situation can lead to either strong negative or positive affect depending on the infant's context-based "evaluation" of the incongruity. (See Sroufe et al., 1974, for an expanded discussion.)

The tension in question does have a physiological component. Spitz' idea of a physiological prototype (e.g., Spitz et al., 1970) is germane here. While the excitation-relaxation cycle underlying the early endogenous smile represents spontaneous CNS discharge of subcortical origin, and the later smiles are primarily under the influence of cortical processes, there are still autonomic and muscular components. The process has been transformed and elaborated with development, but still embodies the earlier physiological component.

The tension fluctuation process which is so apparent in every phase of the development of smiling and laughter and which has such striking overt behavioral and physiological manifestations, must be of functional consequence. In particular, the functional significance of this mechanism for the infant, as it transacts with the environment, remains to be specified.

The Function of the Tension Release Mechanism

For survival and adaptation it is of fundamental importance that the human organism have special capacities for dealing with situations of uncertain consequence. Ethologists (Hess, 1970; Bowlby, 1973) have stressed the survival value of wariness concerning the unknown (given the reality of predation in the "environment of evolutionary adaptiveness"). We would emphasize more the developmental value of transactions with novel and

unknown aspects of the environment. Through failures of assimilation, schemata become both broadened and differentiated by accomodation (Piaget, 1953).

Careful study reveals that the infant's motivation concerning the unfamiliar, perhaps especially strange persons, is quite complex (Bronson, 1972; Sroufe et al., 1974). For example, infants, even in the second half year of life, clearly have strong affiliative tendencies toward unfamiliar persons (attending to them, smiling at them at a distance, exchanging objects; Bretherton & Ainsworth, 1974; Rheingold & Eckerman, 1973; Sroufe et al., 1974). However, they also show avoidance or subtle signs of wariness (e.g., gaze aversion, "worried facial expression") and do not smile when the stranger actually makes physical contact, expecially if familiarization time is kept to a minimum. The tendency to express wariness is as well documented as the affiliative tendency. Subtle aversive responses can be reliably coded and have been validated against the criterion of heart rate (HR) acceleration, and the pattern of reactions (declining smiles, HR acceleration) shown to be distinctly different from results with mother approach (Waters, Matas, & Sroufe, 1975).

Not surprisingly, the human organism is equipped with capacities appropriate to this complex motivation and to the saliency of unfamiliar stimulus situations. The most widely discussed capacity has been the orienting response (OR). When the organism is confronted with a novel stimulus situation of moderate intensity (or change or termination of stimulation), a complex of motoric, sensory, and autonomic reactions occur (for example, orientation of the sensory receptors, muscular quieting, HR deceleration, increased blood flow to the brain), all of which heighten

the capacities of the animal to process and respond to environmental information (Graham & Clifton, 1966; Sokolov, 1963).[9] While this highly adaptive process is now well known, it is nonetheless remarkable. For an opportunistic organism whose adaptation is based on a flexible use of the environment, it is critical that distracting motor activity cease in orienting to a salient, novel stimulus situation. But when orienting is so dramatic and total, it is likewise important that there be mechanisms to terminate it and allow rapid response to the situation. As we shall discuss below, it is also advantageous to a social-verbal animal that these mechanisms involve overt facial and vocal expression.

Our thesis that smiling and laughter are closely associated with tension release originally was derived from observation of the close relationship between fear and laughter--for example, the same stimulus situations (in different contexts) being equally potent for producing crying or laughter (Sroufe & Wunsch, 1972). Following orienting, stilling, and tension build-up in an insecure context (or too much stimulation for the developmental level), crying is the infant's mechanism for tension release. In a secure context (e.g., playing with mother in the home), the tension produced by the same novel, incongruous stimulation can result in smiling or laughter. Unlike crying, however, smiling and laughter are not associated with avoidance; whereas the crying infant avoids the situation even sooner on subsequent presentations, the smiling infant maintains a positive orientation, actively seeking to continue commerce with the novel situation. This ultimately promotes assimilation. For the infant, then, a major function of tension release with positive hedonic tone is to promote engagement of novel stimulus situations and thereby cognitive and emotional growth.[10]

An important corollary function concerns the release of overt behavior. Metaphorically, during the orienting and appraisal period the infant is "captured" and "frozen" by the incongruous stimulation. When the mother or the stranger engages in masked approach with the infant (see above), in every case infants cease ongoing activity, still completely, and stare intently at the masked face. With the mother (or sometimes stranger following mother) the face then brightens, the infant smiles or laughs, then reaches. The reach and smile may occur simultaneously, but the reach never precedes the smile. This suggests both that the smile is the final point of the appraisal process (Bowlby, 1973; Sroufe et al., 1974) and that the tension release→smile terminates inhibition of the overt motor behavior.

Other Theories of Infant Smiling

Our emphasis on the close association between smiling and tension release is not to deny the important social roles of the smile; for example, in eliciting approach from others (Vine, 1973). In fact, in the context of promoting survival, this is the most likely biological function maintaining the smile in the species repertoire, and, as will be discussed below, is complementary to the tension release function. However, while social interpretations make sense of overt expressive components of tension release (as opposed to a non-facial response), they say nothing about the function of tension release for the infant (see also Vine, 1973).

Moreover, our interpretation does not deny the insightfulness of previous investigators vis-à-vis the relationship of smiling to recognition, mastery, and other cognitive constructs (Kagan, 1971; McCall, 1972; Shultz & Zigler, 1972; Zelazo, 1972; Zelazo & Komer, 1971). Our view is

consistent with these cognitive positions but, in answering the question of why the smile occurs with mastery or recognition, stresses a different level of analysis, one which underscores the continuity between early endogenous and later exogenous smiling. Also, as Piaget has argued (e.g., Piaget & Inhelder, 1969), it is important to recognize that affect and cognition are two aspects of the same process; it is a distortion to discuss the cognitive underpinnings of affect without also noting the interdependence of cognitive activity with affect.

Finally, we are well aware that with development the smile may become purposeful or stylistic and may no longer be so clearly tied to tension release in every case, and that the nature of the tension can become complexly elaborated and differentiated (as with "nervous" smiles in viewing "threatening" cinema content). Moreover, we have data indicating that smiling and laughter are not simply a continuum. Not all smiles are small laughs; and plots of developmental changes in potency of items for eliciting smiling as opposed to laughter yield quite different results for normal infants. (See Sroufe et al., 1974, footnote #8, p. 61.)

Still, we have been impressed with the power of the tension release notion in encompassing all of the data on smiling and laughing in the first year of life, and in pointing to an important adaptive system for the infant. Neither the social positions, nor the Innate Releasing Mechanism position, nor the learning positions to be discussed below can encompass the findings on smiling (following sufficient exposure) to previously not experienced, nonsocial stimuli (see also Zelazo, 1972). And the recognition-mastery hypothesis stops

short of specifying the facilitating role of smiling-tension release in the mastery process.

Social interpretations. Increasingly during the first year the smile becomes primarily a social behavior, being a major component of the infant's greeting behavior, becoming differential with respect to attachment figures, and being more frequent when in the presence of people than when alone (Ainsworth, 1973; Vine, 1973; Wahler, 1967; others). Indeed, because of the ease of elicitation by social stimulation, elicited smiles have in the past been referred to as "social" smiles to distinguish them from spontaneous smiles. The smile clearly plays important roles in eliciting approach from others, in communicating well-being, and in promoting mother-to-infant attachment (Ainsworth, 1967; Bowlby, 1969; Vine, 1973; others). It seems reasonable that when the first smiles to the face tell the caregiver "he recognizes me" (which he, of course, does not in a personal way), the caregiver is motivated to be affectively positive, more social, and more effectively stimulating, actually supporting the cognitive development that will lead the infant to true recognition.

Moreover, the smile has an important place in the development of reciprocity. First, the smile reinforces caregiver behaviors, encouraging repetition of actions and promoting interactive chains. Thus, this social function of the smile supports the function of positively toned tension release in providing for the infant's own tendency to perpetuate novel stimulus situations. Also, as a behavior each partner can exhibit, as well as elicit from the other, it has an important place in the learning of mutual effectance. Finally, smiling-tension release, as well as

gaze aversion, may have a special role in modulating arousal within face-to-face interactions, which are crucial for the development of reciprocity (Blehar & Lieberman, 1975; Brazelton, Koslowski, & Main, 1973; Robson, 1967; Waters et al., 1975; Zaslow & Breger, 1968). Affective development clearly contributes to social and cognitive development, while at the same time changes in the meaning of the smile reflect cognitive growth.

Appeasement. One social function proposed for the smile by animal ethologists is appeasement (e.g., Van Hoof, 1973). Vine (1973) has pointed out that this attributes too much awareness to the young infant, that it cannot account for nonsocial smiles, and that it does not square with the active smiles in the greeting of attachment figures. In our own research we have found a decreasing probability of smiling as a stranger approaches (becoming 0 at "pick up"), along with continued smiles to mother during approach (Waters et al., 1975). While smiling to a stranger at a distance could be reconciled with the appeasement position, continued smiling to the mother cannot.

Innate releasers of smiling. It has been argued that the eyes and later the full face are pre-potent stimuli, which function as an innate releasing mechanism (IRM) for smiling (Ahrens, 1954; Spitz & Wolf, 1946). Such a concept captures the incredible reliability of the face as a stimulus for smiling at age 3 months, and also follows from Wolff's (1963) finding that smiling occurs shortly after the infant fixates on the eyes in searching the face. However, the recognition or mastery hypothesis seems to have broader explanatory power. Eyes and full faces elicit smiles in 6- to 12-week-olds because very early they attract the infants' attention (Robson, 1967) and can be rather quickly recognized, though

with some effort. Profiles and nonsocial stimuli, such as those used by Spitz and Wolf (1946) fail to elicit smiling because they are too discrepant from available schemata (Vine, 1973; Zelazo & Komer, 1971). With repeated trials, smiling can be elicited by nonsocial stimuli. Still, adult experience confirms that there is something special about eye-to-eye contact as a source of tension and smiling, much of which is related to the context in which it occurs (Brazelton et al., 1973).

The smile as learned. Much of the discussion of social functions suggests important roles for learning, broadly conceived, in the metamorphosis and differentiation of the smile during infancy. Differential greeting, reciprocity, and elicitation of maternal approach and repetition of acts all imply important learning on the part of the infant and caregiver. Likewise, the waxing and waning of smiling with repetition of a stimulus, which Piaget would conceptualize in terms of accomodation and assimilation, clearly involves learning and memory.

It is also clear, however, that traditional models of learning, classical and instrumental conditioning, are not at all adequate in accounting for the acquisition, development, and functioning of the smile in the first year of life. Difficulties with the classical conditioning position have been outlined by Gewirtz (1965): (a) Atypically, the smile response is elicited by a wide range of "USs" (visual, auditory, and tactile-kinesthetic). (b) Gross stimuli (e.g., the face) presented unchanging for long periods elicit repeated smiles (vs. a reflex). (c) The supposed CS (e.g., aspects of the caretaker) elicits smiles initially and does not permit discrete presentation. Indeed, Watson (1967) found that infants smiled more to a full face at 0° rotation than at 90°

rotation, the view that would be associated with nursing. These results seem to discredit the notion that infants smile at visual stimuli because of their association with drive reduction.

At one time it was thought that smiling might be accounted for primarily by operant conditioning. Since Brackbill (1958) had demonstrated scheduling effects, it was apparent that smiling rate was at least responsive to contingencies. Now it is clear, however, that despite the influence of contingent reinforcement (Brackbill, 1958; Etzel & Gewirtz, 1967; Wahler, 1967; Zelazo, 1971), it is of secondary importance to recognition-assimilation and subsequent habituation (Zelazo, 1972). Thus, in Zelazo's (1971) important study, smiling rate was initially high for the contingent social reinforcement group (talking, smiling, touching), the non-contingent social reinforcement group, and the unresponsive experimenter group, but smiling decreased in all groups over trials, though with greater scalloping across trials (days) for the contingent group. This study also casts doubt on the notion of the face as a discriminative stimulus for smiling (Gewirtz, 1965). In another study, Wahler (1969; see Zelazo, 1972) found that mothers could control babbling and cooing but were completely unable to control laughter operantly. In concert with the well-demonstrated waxing and waning of smiling with repeated presentation of non-social stimuli, without external reinforcement, these studies cast doubt on the significance of external reinforcement as an explanation of infant smiling.

Summary and Conclusions

In tracing the ontogenesis of smiling and laughter, not only was a continuing role for tension apparent, but also basic descriptive

principles of development were revealed. The evolution from stimulation-produced excitation to cognitively-produced tension (the imposition of meaning by the infant on the stimulation) seen in the first 3 months was elaborated and transformed but in a basic way repeated in the final quarters of the first year in the development of laughter. Development proceeds in the manner of a spiral. Parallel to this first principle is a second, the tendency of the infant to move toward incongruity, to be increasingly active in producing and mastering novel experiences.

At the same time, emphasis on the function of tension release for the infant places the smile within a constellation of important mechanisms for dealing with novel aspects of the surround. In doing so, a close relationship was revealed between the constructs of joy and fear and between smiling and wary behaviors, both of which can serve the function of modulating arousal level (Waters et al., 1975).

Rather than being competitive hypotheses, the proposed tension release notion, with its close ties to cognitive processes, and the social theory of the smile are complementary. Their relationship underscores other fundamental aspects of development. First, the infant's active participation in its own development is supported by the social world. As positively toned release of tension supports the infant's strong tendency to maintain contact with novel stimulation at the edge of its cognitive capacities, so also does the range and continuity of challenging variations returned by the caregiver in response to the infant's signal of well-being and pleasure. In this and in other ways, cognitive and social-emotional aspects of development are inseparable. The cognitive underpinnings of developmental changes in the processes

signified by the smile are clear; strongly implied also is the role of the attachment relationship and interaction with a sensitive, responsive caregiver in expanding the infant's tolerance of tension and in promoting expansion of schemata (Brazelton et al., 1973). In a reciprocal manner, cognitive changes promote exploration, social development, and the differentiation of affect; and affective-social growth leads cognitive development, as in the caregiver's renewed closeness with the infant upon the beginnings of "recognition" smiles. Neither the cognitive nor the affective system can be considered more dominant or more basic than the other; they are inseparable manifestations of the same integrated process (Piaget & Inhelder, 1969). It is as valid to say that cognition is in the service of affect as to say that affect reflects cognitive processes.

In a manner yet to be specified, these cognitive and social factors promote the evolution from the pleasant physiological state reflected in the neonatal smile, and the pleasure of early recognitory smiles, to the joy of mastery and engagement. As we comprehend this process, we move closer to an integrated conceptualization of the social-emotional and cognitive growth of the infant.

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Footnotes

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[1]Our preference for the term "tension" as opposed to the related concept of "arousal" and the distinction of our usage from the psychoanalytic concept of "tension" will become clear in discussion.

[2]It is also interesting to note that the endogenous smiles occurring during drowsy REM are of larger magnitude than those occurring during sleep REM (Emde & Koenig, 1969).

[3]There are wide individual differences in the age of appearance of these and other smiles, probably due in part to gestational age. Still, the sequence and the relationships between state, latency, and magnitude of the response should be as described.

[4]Wolff does not report the smile latency here but does say: ". . . smiling intensity increases with repetition, the response latency becomes shorter, and the baby's excitement increases with repetition of the game" (p. 126).

[5]The data presented here are from a detailed longitudinal study of 10 infants; they are consistent with two cross-sectional studies, based on a total of 96 infants (Sroufe & Wunsch, 1972). Up to six presentations were done in testing for laughter, and the mother was the stimulus agent in each case.

[6]Whether laughter or smiling occurs is also strongly influenced by context, salience, and background level of global tension (Sroufe & Wunsch, 1972; Sroufe et al., 1974).

[7]Herbert Spencer (1863) has written of "nervous energy" being "checked in its flow" to describe this situation, with the excess "discharging," resulting in an "efflux through the motor nerves . . . producing the half convulsive acts we term laughter" (p. 114).

[8]Recall that items which "build" and have a sharp focal point ("I'm gonna get you," with "I'm" protracted; swelling "ach"; "kissing stomach") are the most potent items for laughter.

[9]Only if the stimulation is painful or of such physical intensity and rapid onset to produce startle is there a deviation from this pattern in the face of novel stimulation.

[10]The major change in our position since 1972 is that we now tend to view smiling and laughter as components of the tension release process, rather than as functional in that release. (See Rothbart, 1973, for a similar tension release interpretation of laughter.)

Table 1

The Development of Smiling and Laughter

Age	Response	Stimulation	Latency	Remarks
Smiling				
Neonate	Corners of the mouth	No external stimulation		CNS fluctuations
Week 1	Corners of the mouth	Low level, modulated	6-8 sec.	During sleep, boosting of tension
Week 2	Mouth pulled back	Low level, modulated; voices		When drowsy, satiated
Week 3	Grin, including eyes	Moderate level, voices	4-5 sec.	Alert, attentive (nodding head with voice)
Week 4	Grin, active smile	Moderate, or moderately intense	"Reduced"	Vigorous tactile stimulation effective
Weeks 5-8	Grin, active smile, cooing	Dynamic stimulation, first visual stimulation	3 sec. or less	Nodding head, flicking lights, stimulation which must be followed
Weeks 8-12	Grin, active smile, cooing	Static, visual stimulation, moderately intense	Short	Trial by trial effects, effortful assimilation, recognition; static at times more effective than dynamic

(continued)

(Table 1 continued)

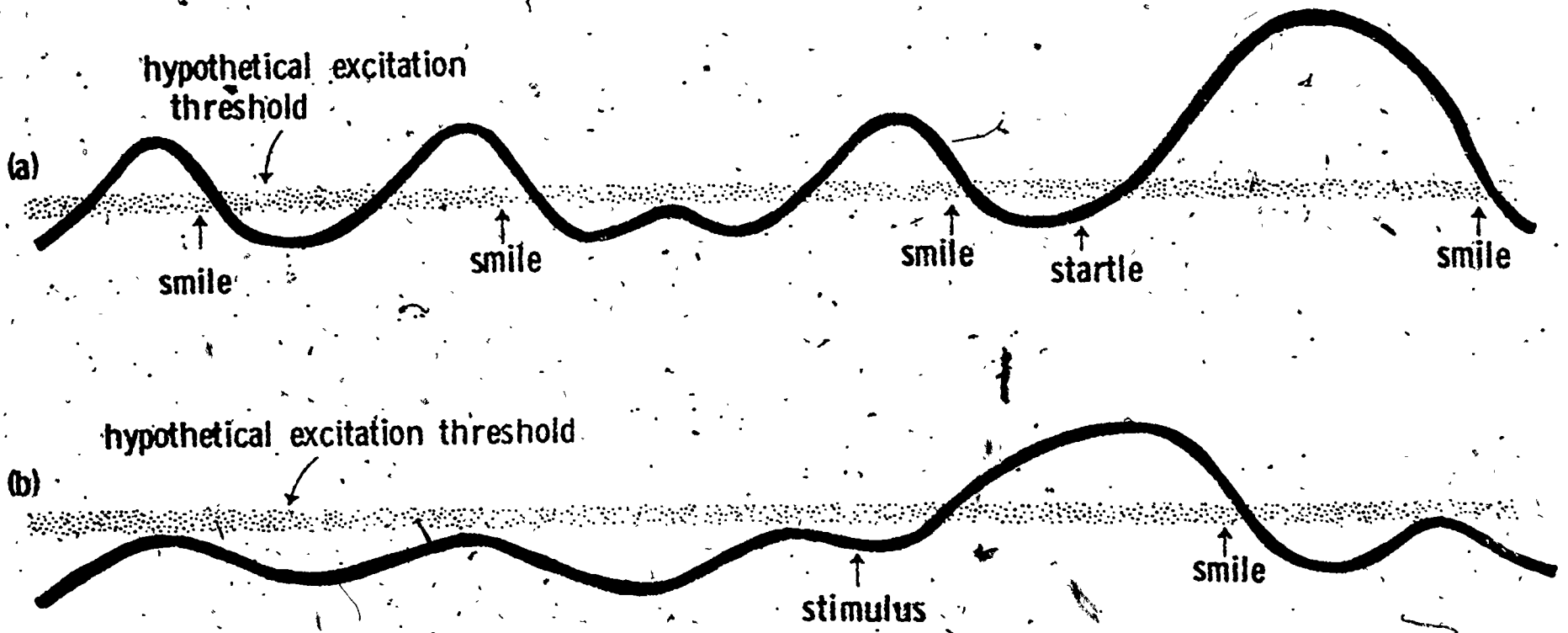
Laughter				
Month 4	Laughter	Multimodal, vigorous stimulation	1-2 sec.	Tactile, auditory
Months 5-6	Laughter	Intense auditory stimulation, as well as tactile	Immediate	Items which may have previously caused crying
Months 7-9	Laughter	Social, visual stimulation, primarily dynamic	Immediate	Tactile, auditory decline
Mos. 10-12	Laughter	Visual, social	Immediate or in anticipation	Visual incongruities toward participation

Figure Captions

Figure 1. Schematic illustration of the excitation-relaxation cycle, showing hypothetical threshold and relationship to overt behaviors.

Figure 2. Schematic illustration of heart rate change associated with positive and negative responses to approach by a masked adult.

FIGURE 1



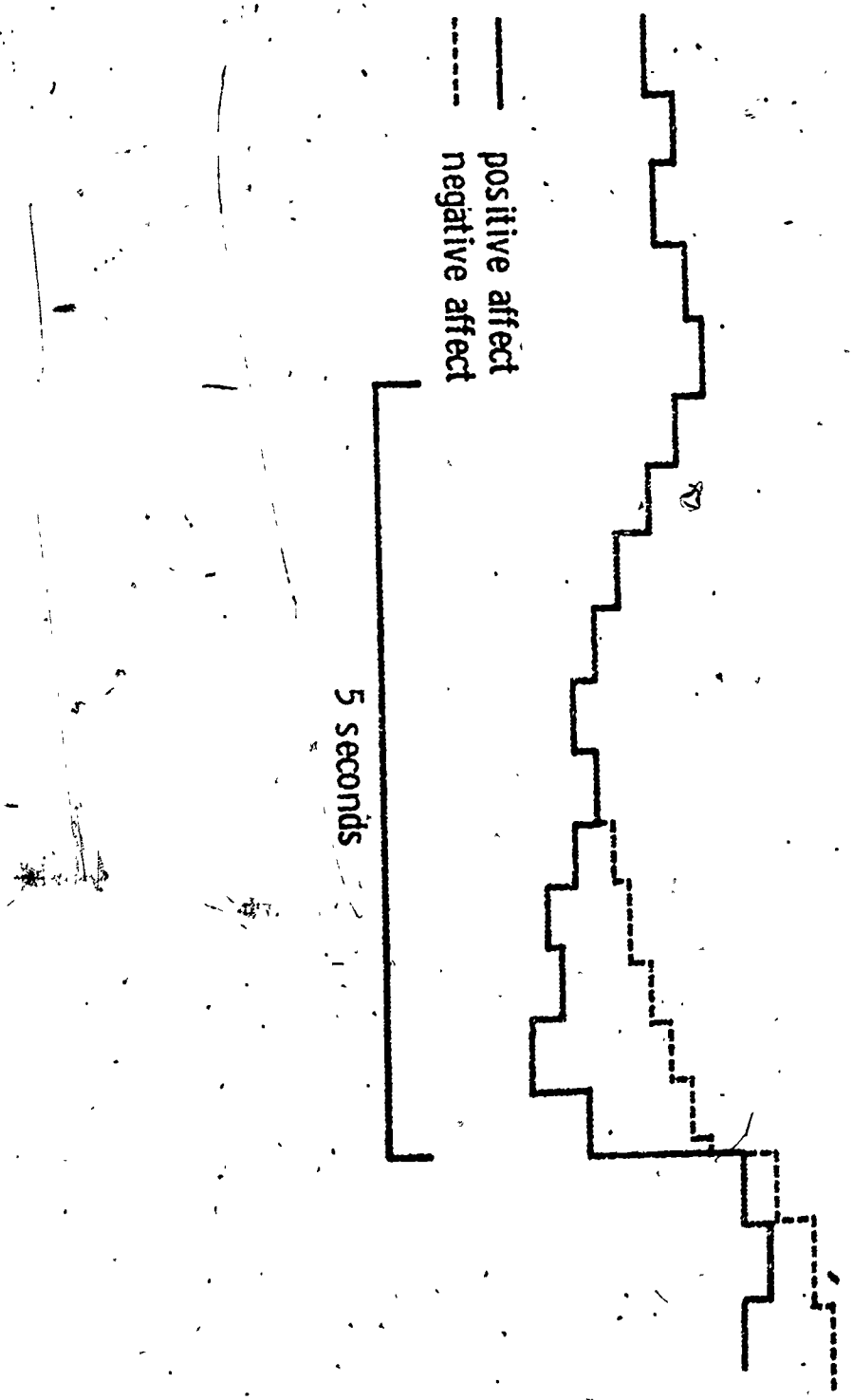


FIGURE 2