DOCUMENT RESUME

ED 248 024 PS 014 509

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TITLE The Effect of Crying on Long-Term Memory in Young Infants.
PUB DATE Apr 84
NOTE 17p.; Paper presented at the Annual Meeting of the Eastern Psychological Association (55th, Baltimore, MD, April 12-15, 1984).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Affective Behavior; Cues; Emotional Response; *Infant Behavior; Infants; *Long Term Memory; Operant Conditioning; *Reinforcement; Retention (Psychology)
IDENTIFIERS *Crying; *Retrieval (Memory)

ABSTRACT

The influence of negative affect on the retrieval of information from memory during infancy was investigated in two studies through the use of an operant conditioning paradigm. The procedure used, known as "mobile conjugate reinforcement," involves a free operant task in which an infant is reinforced for footkicking by the movement of an overhead crib mobile. This procedure produces rapid learning in 2- to 4-month-old infants: the infant learns the footkick response in a distinctive setting in which details of the crib, stands, mobile, and even ribbon serve as possible contextual cues for the production of the conditioned response when the infant is returned to that specific context at a later time. Results of the first experiment indicated that infants' crying in reaction to a change in the number of mobile objects displayed (i.e., reward shift) had a deleterious effect on their memory for a learning task, thus providing some of the first direct evidence that negative affect influences infants' memorial capabilities. The second experiment was conducted to investigate two possible explanations for the findings: state-dependent retention and memory loss. Results refuted the state-dependent hypothesis. Generally, results provided evidence that negative affect associated with an event produces rapid forgetting of that event, but that this forgetting is not a permanent loss of information. Such forgetting may best be viewed as the result of retrieval failure. (RH)

The Effect of Crying on Long-Term Memory in Young Infants

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Paper presented at the 55th annual meeting of the Eastern Psychological Association, Baltimore, Maryland, April 15, 1984.

In the 19th century Bain (1859) and Spencer (1890) proposed that pleasant experiences tend to be remembered and unpleasant ones forgotten. Freud (1927) theorized that unpleasant perceptions are denied and undesired memories repressed. A psychoanalytic orientation provided the framework for Rappaport (1961) who concluded that affective intensity had its major effect on memory.

The interplay of affective and cognitive processes has a long history, but one in which confirmation through experimentation has been characterized by a lack of methodological sophistication. In the present two studies we revived this line of research but through the use of an operant conditioning paradigm in which we investigated the influence of negative affect on the retrieval of information from memory during infancy.

Our procedure, known as mobile conjugate reinforcement, is a free operant task in which an infant is reinforced for footkicking by the movement of an overhead crib mobile. This produces rapid learning in 2-4 month old infants. The infant is placed supine in his or her crib to which 2 mobile stands have been attached. A white ribbon is wrapped around the infants ankle and connected to a suspension hook from which the mobile hangs. The ribbon permits the infant to pull and release the stand, thereby moving the mobile. The resulting movement varies directly with the rate and vigor of the infants footkicks.

To study infant memory we have followed the general paradigm of animal memory researchers. The infant learns the footkick

response in a distinctive setting in which details of the crib, stands, mobile, and even ribbon serve as possible contextual cues for the production of the conditioned response when the infant is returned to that specific context at a later time.

An illustration of our procedure appears in Table 1. The four sessions are represented as S1; S2, S3, and S4. The numbers inside the rectangles represent the number of objects suspended on the mobile. The numbers outside and above the rectangles represent the amount of time spent in that phase of the session. The broken line indicates the absence of a reinforcer. In other words, here the mobile was in view but nonresponsive. The solid line indicates the presence of the reinforcing stimulation (mobile movement).

Each session began with a 2-minute period in which a mobile containing 10 identical objects was placed on a stand to which no ribbon was attached. In the first session this period served to define the infants operant level of footkicking. In all subsequent sessions it represented a long-term retention test. Here, with the mobile in view but non-responsive, reinforcement (mobile movement) was absent. However, the specific details of the mobile could serve as contextual retrieval cues for conditioned responding, and performance here could then be assessed in relation to operant level. Also, because reinforcement was not present during the long-term retention test, retention of the contingency could be assessed separately from any relearning. Following the operant level or long-term retention test period in

S1 and S2, the 10-object mobile was placed on the stand to which the ribbon was attached for 10 minutes of reinforced practice.

Session 3 began with the 10-object mobile again on the inactive stand for 2 minutes but followed by only 4 minutes of reinforced practice, referred to in the table as preshift. Infants were then shifted to the 2-object mobile for 10 minutes of reinforcement, which is labelled postshift. This was followed by a final 2 minutes with the 2-object mobile on the inactive stand. The session was, however, terminated early if the infant cried for 120 continuous seconds. The shift in mobiles led to crying in 53% of the babies experiencing the shift.

The retention test session occurred at some point later in time and is labelled S4 in the table. As with Sessions 1 and 2, Session 4 consisted of an initial 2 minutes of non-reinfoced mobile exposure to either the 10- or 2-object mobile followed by 10 minutes with the same mobile once again on the active stand. A final 2 minutes with the mobile on the inactive stand completed each infants task experience.

During each session, a trained observer positioned out of the infants view recorded the number of footkicks and the durations of visual attention and crying. A footkick was defined as a vertical or horizontal excursion of the attached foot that at least partially retraced its original path in a smooth, continuous motion. Visual attention was timed when the infants head and eyes were oriented upward in the direction of the mobile and, of course, the eyes were open. Measures of interobserver

reliability obtained for all measures for twelve infants exceeded .90.

To measure retention at a later interval, each infants' number of footkicks during the Session 4 long-term retention test was divided by his or her number of footkicks during Session 1 operant level. This is shown in Table 1 by the solid line connecting the first 2 minutes of Sessions 1 and 4 and is called the "baseline ratio". Baseline ratios reflect the extent to which each infants response rate during the final long-term retention test continues to exceed that infants pretraining response rate. A baseline ratio of 1.00 reflects a return in performance to operant level (i.e., the infant had the same number of footkicks during the 2 minutes immediately following the retention interval as he or she had prior to learning the task).

Using a procedure similar to this, Fagen and Rovee (1976) and Mast, Fagen, Rovee-Collier, and Sullivan (1980) found that many infants would cry when shifted from a mobile containing 10 identical objects to one containing only 2. To study the role of affect on infant memory, Ohr, Fagen, and Ribner (1983) capitalized on their findings.

Thirty-six infants with an average age of 105 days were randomly assigned to different groups with the stipulation that each group contain approximately equal numbers of male and female infants. All infants were full-term, healthy, and apparently normal. Each was seen in his or her own home at the same time

each day.

In brief, these infants were trained for 2 consecutive days with the 10-object mobile. On the third consecutive day, after viewing the 10-object mobile, infants were switched to a mobile containing only 2 of the suspended objects. One week later retention of the contingency was assessed by re-exposing half of the infants to the 10-object mobile and half to the 2-object mobile. One week was chosen as the retention interval because we knew from previous work that retention of the contingency is good at one week following only 2 days of reinforced practice and therefore, any effect that crying had on retention could not be due to the fact that the third session was attenuated for infants who cried in response to the shift in mobiles.

Figure 1 presents the 1 week baseline ratios for infants in the shifted groups who either had or had not cried 1 week earlier. The numbers on the bottom of the figure refer to the number of objects in the preshift, postshift, and retention test mobiles, respectively. As can be seen, regardless of the mobile present during the 1-week retention test, only infants who hadn't cried had baseline ratios significantly above one. Infants who had cried 7 days prior gave no evidence of retention. Not shown in this figure is the fact that the baseline ratios of the non-crying infants were not different from the ratios of infants in 2 control groups who received either the 10- or 2-object mobile throughout.

The results of the above study indicated that crying had a

deleterious effect on young infants memory for a learning task, thus providing some of the first direct evidence that negative affect influences infants' memorial capabilities.

One possible explanation for these findings revolves around the phenomenon of state-dependent retention. Briefly, this refers to the well documented fact that material learned in one particular internal state is best remembered when the organism is again in that state. A state dependent explanation would indicate that infants who cried in response to the shift showed poor retention one week later because of the mismatch in emotional state.

A second explanation of the effects of the infants negative emotional reaction to the shift in mobiles indicates that crying may alter the structural integrity of memory attributes making them irretrievable. In other words, the memories are no longer available at time of attempted recall; they are lost.

Ohr et al (1983) argued however, that crying and its underlying negative emotional state acted as an amnestic agent to produce rapid forgetting in a manner similar to other amnestic agents such as electroconvulsive shock, hypothermia, and certain drugs. Following Spear (1973) and others, they assumed that the information acquired was available to influence behavior at any time, although it may not have been accessible for retrieval. This is also consistent with the psychoanalytic literature where negative affect is viewed as a threat to the integrity of the ego, resulting in repression of the experience into the uncon-

scious and, therefore, forgetting.

Which of these explanations was correct served as the basis for our second study. If the infants' memory for the contingency was not altered by the crying, nor state-dependent, then we sought to determine the conditions under which the infants' prior learning could be expressed.

Animal memory researchers have reported that by providing animals with a portion of the original learning context, they could alleviate forgetting. Spear and Parsons (1976), for example, trained rats in a Pavlovian conditioning paradigm. The rats rapidly learned the task and retained it for 24 hours. It was, however, forgotten after 28 days. Forgetting was alleviated, however, and performance returned to the 24 hour post-training level, by returning the rats to the original learning context and giving a single re-presentation of the reinforcer.

Our reactivation treatment was similar to that of Spear and Parsons (1976), but modified to accomodate our conditioning and retention paradigm. It consisted of placing the infant in an infant seat to be placed in the crib and under the moving mobile for 3 minutes. The ribbon was not attached to the infants ankle, but draped over the side of the crib to be drawn and released by the experimenter. Half of the infants received the 10-object mobile as the reactivation stimulus and the rest received the 2. The experimenter moved the mobile in a manner similar to each infant's rate of footkicking during the final 4 minutes of pre-

or post-shift.

Seventy-eight infants with an average age of 113 days were randomly assigned to either reactivation or no reactivation groups with the stipulation that each group contain approximately equal numbers of male and female infants. All infants were full-term, healthy, and apparently normal. Each infant was seen in his or her own home at the same time each day. Once again, we trained infants for two days with the 10-object mobile and shifted them to the 2-object model on the third day. Now, however, we tested infants for retention of the contingency after 3 weeks instead of just one as in the first study. In other words, here the interval between Session 3 and Session 4 was 21 days. Some of the infants, however, received the reactivation treatment 24 hours prior to this 3-week retention test.

Results from the non-reactivated group enabled us to determine the interval at which forgetting was complete regardless of whether the infant cried in response to the shift. A 3-week retention interval was chosen because unpublished data from our laboratory indicated that after 3 days of training, retention was excellent after 2 weeks but reliable forgetting occurred after 3 weeks. Results from the reactivated group enabled us to determine if following forgetting, the conditioned footkick response could be reinstated by the reactivation treatment which reintroduced a portion of the original learning context.

Three-week baseline ratios for infants in the reactivation and no-reactivation groups who either did or did not cry 3 weeks

prior are presented in Figure 2. As can be seen, the ratios were different depending upon whether infants were in the reactivation or no-reactivation condition but not upon whether or not they had cried. Specifically, only infants who had received the reactivation treatment 24 hours prior to retention testing had baseline ratios significantly above one. There was no significant difference in the reactivated infants between the crying and no crying groups. Infants who had not received the reactivation procedure did not have baseline ratios significantly above 1.00 nor were there significant differences between the crying and non-crying infants.

Consistent with the view that memories are permanent and that forgetting reflects a retrieval failure rather than a loss of information, we had hypothesized that regardless of the affective state present at the conclusion of training, memory retrieval would be possible if infants were provided with a reminder or reactivation treatment prior to the retention test. The results of the second study supported this hypothesis and indicate that the crying in the Ohr et al (1983) study probably produced accelerated forgetting and not some permanent amnesia or state dependent deficit.

The results of this study refute the state dependent hypothesis because expression of memory was possible regardless of the match between the affective state at the conclusion of training and the affective state at the time of retention testing. In addition, our results controvert the argument that

an infants' negative emotional reaction to the reward shift somehow alters the structural integrity of the stored memory attributes making them irretrievable.

In conclusion, our results provide evidence that negative affect associated with an event produces rapid forgetting of that event but this forgetting is not a permanent loss of information, but rather may best be viewed as the result of a retrieval failure. Surprisingly, this leads us back to Freud (1927) because our results also lend credence to his theory. He proposed that memories are permanent although some are not immediately accessible to conscious awareness. By providing an opportunity to arouse memories which in turn, arouse others, as in free association, Freud believed the repressed memories could be made available to awareness. Although our study only provides indirect confirmation of Freud's hupothesis, the use of a paradigm such as ours to get at a theory empirically difficult to confirm is definitely worth investigating.

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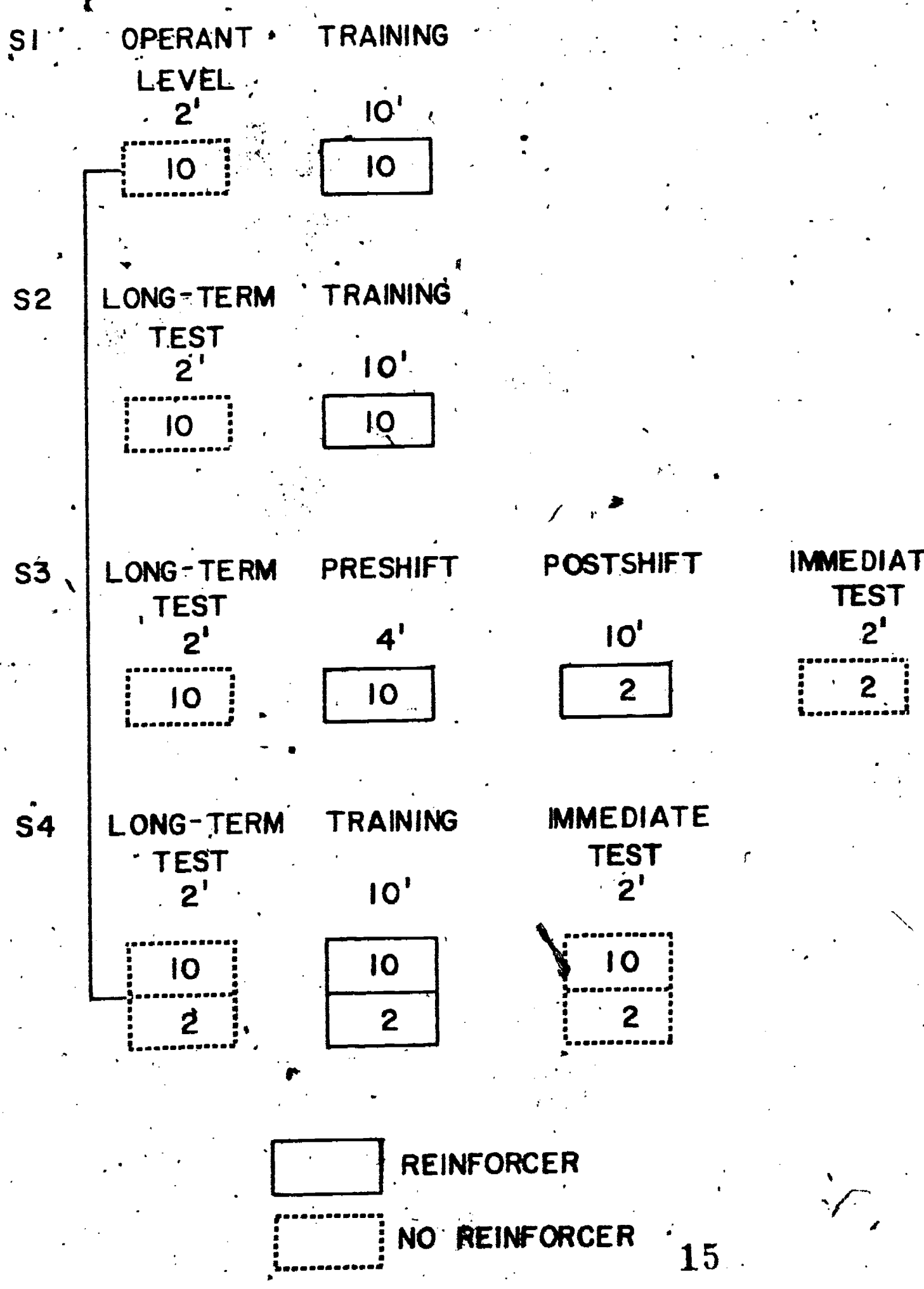
TABLE 1

RETENTION PARADIGM



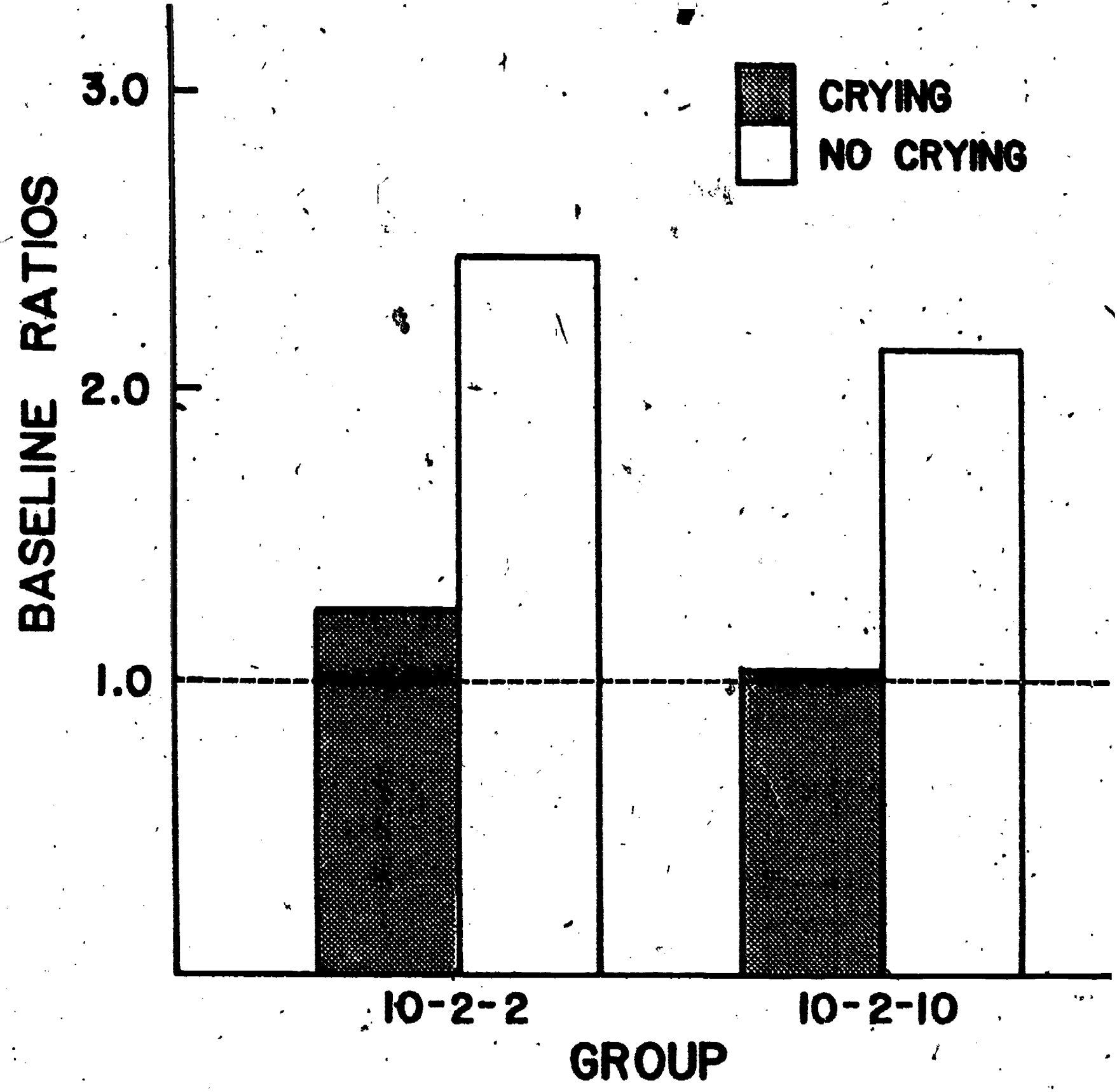
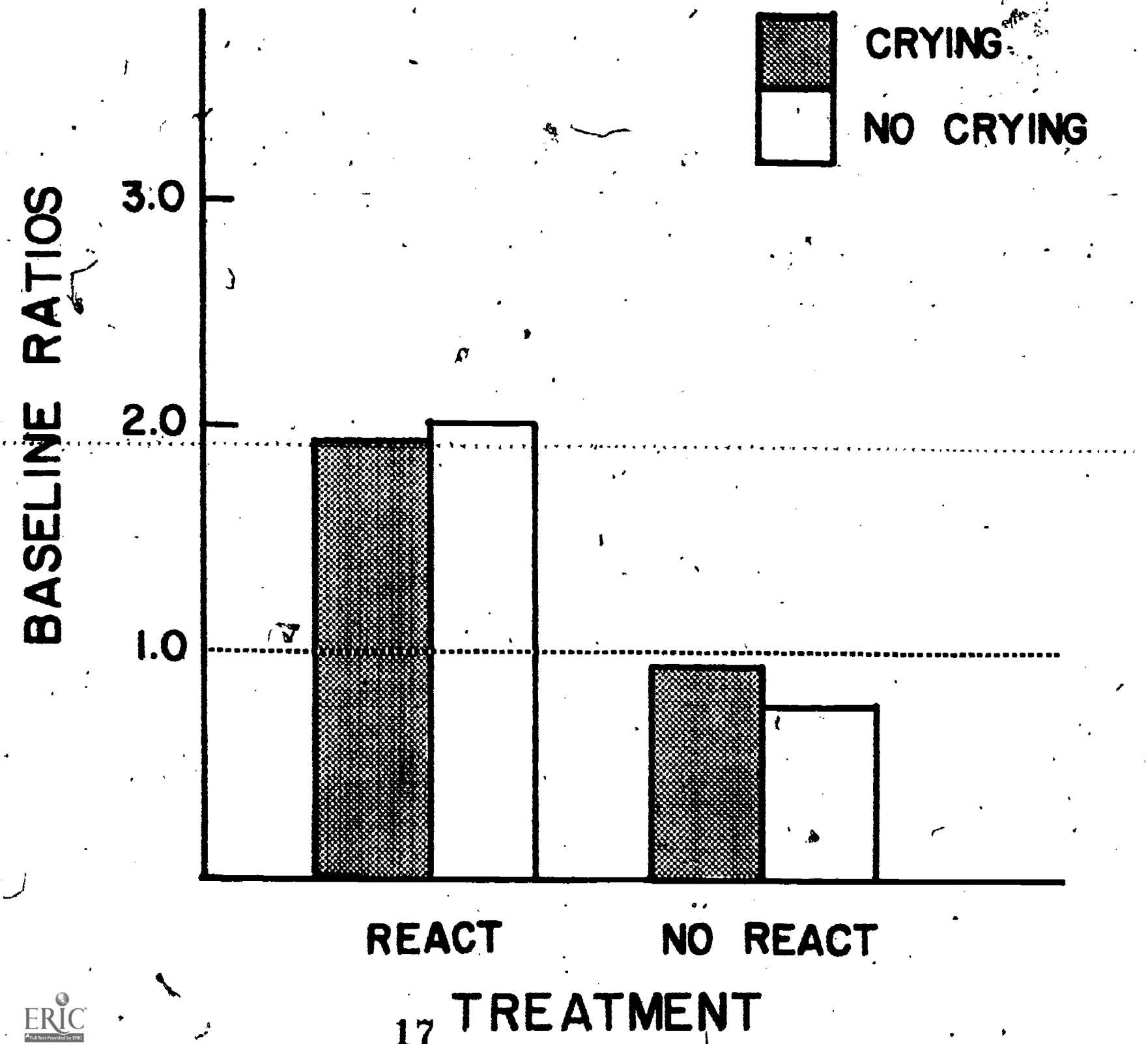


FIGURE 1

FIGURE 2


CRYING
NO CRYING
BASELINE RATIOS
3.0
2.0
1.0
REACT
NO REACT
TREATMENT