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Newborn longterm retention of speech sounds.

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NEWBORN LONGTERM RETENTION OF SPEECH SOUNDS

A Thesis Presented

by

IRINA UTA SWAIN

Submitted to the Graduate School of the
University of Massachusetts in partial fulfillment
of the requirements for the degree of

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September 1987

Psychology

NEWBORN LONGTERM RETENTION OF SPEECH SOUNDS

A Thesis Presented

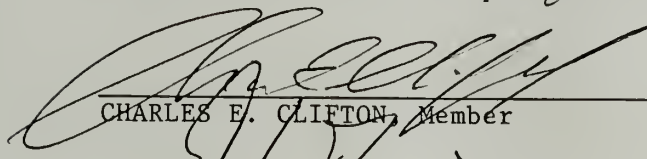
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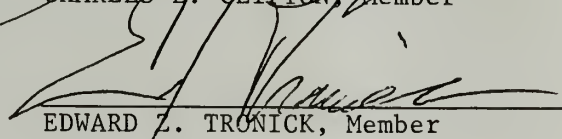
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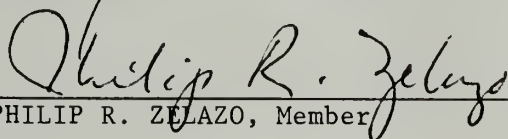
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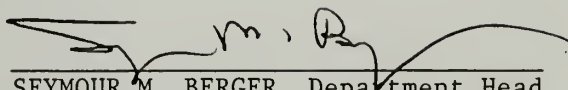
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CHAPTER I

INTRODUCTION

"Throughout recorded history the newborn has been regarded as a helpless, insensitive creature not always accorded the status of someone fully "human". ... If you start off assuming that infants know nothing, can do nothing, then by a kind of self-fulfilling prophecy, the infant's competence escapes detection" (Restak, 1986, p. 197). Recent studies of newborn infants' responsiveness to sensory information have implied that newborns can actively process and organize sensory information. Traditionally, the newborn infant has been regarded as lacking the neural sophistication required for an active "cognitive" mechanism that would accommodate sensory inputs into organized schemas (Dannemiller & Banks, 1983; Olson & Strauss, 1984). However, recent studies of newborn habituation and dishabituation (Brody, Zelazo, & Chalka, 1984; Clarkson & Berg, 1983; Slater, Morison & Rose, 1983; Weiss, Zelazo, & Swain, 1986; Zelazo, Brody, & Chalka, 1984; Zelazo, Weiss, Randolph, Swain, & Moore, 1985) have led to renewed questions concerning the cognitive competence of the newborn, in

particular in terms of learning, memory formation (information processing) and memory capacity.

Habituation

"Few behavioral phenomena rival habituation in usefulness as a measure of the infant's sensitivity and few have as many implications for theories of psychological development" (Kessen, Halth, & Salapatek, 1970, p. 346). Habituation, defined as response decrement to a repeated stimulus, has been described as the "simplest form of learning in which an organism learns to stop responding to insignificant or irrelevant stimuli" (Clifton & Nelson, 1976, p. 159). In their review of infant habituation, Clifton and Nelson (1976) cite Thorpe's early work on habituation in animals as a primary influence on developmental psychologists' investigations of learning in the newborn infant. It was postulated that "if habituation could be demonstrated the infant would be shown to be capable of rudimentary learning soon after birth". As a result "the phenomenon of habituation has received widespread attention among observers of infant behavior, who have regarded it as a means to study cognitive processes" (Clifton & Nelson, 1976, p. 160).

Habituation may be viewed as a mechanism through which information is stored and in which memory functions short term. In habituation, the first presentation of a stimulus is more likely to elicit a stronger response than the subsequent presentation. This suggests that the organism conserves an internal representation of the event, consisting of the stimulus. The response to subsequent presentations will be inversely proportional to the quality of the match between the stored representation and the incoming stimulus. The decrement in observed behavior is inferred to reflect underlying cognitive processes that are sensitive to the infant's increasing knowledge of the stimulus. From an information processing standpoint these cognitive processes involve the infant's active or passive construction of an internal (and perhaps mental) representation or memory of the stimulus and the infant's ongoing comparison of new stimulation with that representation.

The habituation research conducted over the past 25 years indicates that response decrement follows the repetition of a non-reinforcing stimulus and indicates that infants can create memories for visual and auditory events through simple repeated exposure. The early and

subsequent work on visual preferences (Fagan, 1973; 1974; 1978; Fantz, 1958) demonstrated that Infants look reliably at a novel stimulus if paired with a familiar one. The preference for the novel stimulus implies memory for the familiar event.

Theories of habituation of Infant visual fixation (Cohen, 1972; 1973; Lewis, 1971) have been influenced by two empirical observations. First, fixation to visual stimuli tends to decrease between early and late trials of repeated stimulus presentations and second, the rate and magnitude of response decrement to repeatedly presented stimuli is affected by the complexity of the stimulus. Following Sokolov (1963; 1969), it is generally assumed that during habituation trials, the Infant acquires an internal representation, or schema of the stimulus. Specifically, with stimulus repetition a cortical representation (neuronal model) of the stimulus is constructed. The Infant's fixation response is then thought to be determined by the outcome of a process that compares the established schema to the features of the incoming stimulus. Matches with it fail to elicit or actually inhibit orienting, whereas mismatches elicit orienting. Thus, habituation of response reflects a lack of discrepancy between the current stimulus and the

memory based on experience with that stimulus. Fixation time is assumed to be controlled by the discrepancy between the schema and features of the current stimulus: the larger the discrepancy the longer the infant fixates (Cohen, 1972; 1973; Kagan & Lewis, 1965; Lewis & Goldberg, 1969). Fixation time decreases over repeated presentations because the infant acquires a schema. The rate at which fixation time decreases is inversely related to stimulus complexity because it takes more time to develop a schematic representation of a complex than a simple stimulus.

Studies that have used habituation techniques with newborns, however, have not always met with success. One of the best known and earliest of these was reported by Fantz (1964), who was unable to find novel stimulus preferences following habituation in infants under two months of age. Other researchers have also failed to find evidence of visual recognition memory in the newborn infant, in that they have either not been able to habituate the newborn to a repeatedly presented stimulus, or following habituation have not found recovery of attention to, or preference for, a novel stimulus (Haith, 1980; Cohen, 1976).

The above-mentioned failures all employed visual stimuli in their study of habituation. Rose et al. (Rose, Gottfried, Melloy-Carminar, & Bridger, 1982) have argued that failure to find novel stimulus preferences in infants under two months of age most likely was due to the length of the familiarization period allotted to the infant rather than the infant's immaturity (cognitive age). Susan Rose and her associates (1982) stated that regardless of age "infants prefer to look at that which is familiar as they begin to process a stimulus; once processing becomes more advanced, their preference shifts to novel" (p.711). With this in mind it becomes apparent why Fantz (1964) was unable to find novelty stimulus preferences in his sample of newborns. The stimuli employed in Fantz's paired comparison procedure consisted of complex photographs and advertisements cut from magazines. As noted above infants will take longer to develop a schematic representation of a complex than a simple stimulus. The stimuli were presented for 10 one-minute trials. The number and brevity of the stimulus presentations and the complexity of the stimuli themselves most likely account

for Fantz's inability to demonstrate novelty preferences within this paradigm.

Consistent with the notion that the length of familiarization is an important determinant in the demonstration of infant novelty preferences, Werner and Siqueland (1978), employing an infant-controlled procedure, found recognition memory for familiar visual stimuli to be reliable at birth. The minimum length of familiarization time employed by Werner and Siqueland was 5 minutes; however infants varied in amount of time required to familiarize themselves to the stimulus. It was concluded that evidence of recognition memory is most readily found when stimulus exposure time is varied to accommodate individual differences in encoding time.

Further support is given by Friedman's (1972) successful demonstration of infant novelty preferences. Friedman's stimuli consisted either of a 2x2 or 12x12 checkerboard. Friedman allowed the infants as many 60-second trials as necessary for habituation, prior to presentation of the novel checkerboard. Friedman's success can largely be attributed to the simplicity of the stimuli and the infant-controlled procedure.

The above mentioned failures and successes seem to indicate that infants under two months of age are less efficient in encoding the initial stimulus information and memories may be less complete than in older infants after identical familiarization time. Younger infants do take longer to habituate (Slater, Morisson, & Rose, 1984) and are slower to learn an operant footkicking paradigm (Rovee-Collier, 1984; Vander Linde, Morriongello, & Rovee Collier, 1986). Recovery and responsiveness to novel stimuli results from the infant's ability to form a memory or schema for the familiar stimulus in order to discriminate between the two stimuli (Cohen, 1976). However, if the infant is not allowed sufficient familiarization with the original stimulus, it is not surprising that novelty stimulus preferences would not manifest themselves in the infant's response. In particular, the researcher must be sensitive to the "requirements" of the newborn, and must not automatically assume that failed findings are a result of the "failed" newborn. Insensitivity of researchers to take the younger infant's need for

simpler stimuli and increased familiarization time into account most likely accounts for most of the failures.

Early investigations of the infant's auditory competence found that newborns will habituate and recover heartrate accelerations to repeated and novel auditory stimuli (Bartoshuk, 1962; Bridger, 1961). Unfortunately, this early work of neonatal habituation of heartrate changes to auditory stimuli was difficult to interpret as being indicative of information processing and memory formation in the newborn, because the infant's state of arousal was uncontrolled (Clifton & Nelson, 1976). The neonate's heartrate when drowsy is likely to be depressed and in general heartrate vacillates with state changes independent of the stimulus. Moreover, when the infant is drowsy the onset of the auditory stimulus is likely to engage the infant in a startle response. Graham and Clifton (1966) suggested that heartrate accelerations are associated with a defensive reaction in which the organism rejects incoming information. On the other hand, heartrate decelerations were hypothesized to be associated with the orienting response and attention. Bartoshuk (1962) and Bridger's (1961) work on infants' responses to auditory stimulation, although not informative as to the

Infant's ability to process information, was important in the demonstration of the importance of controlling for state when working with the newborn and vastly encouraged others to use the heart rate response with newborns. For example, Pomerleau-Malcuit and Clifton's (1973) successful demonstration of heartrate decelerations to tactual stimuli was largely due to the fact that the infant's state was controlled.

Successful demonstrations of newborn habituation-dishabituation are largely attributable to methodological improvements and researcher's increased sensitivity to the "requirements" of the young infant. Traditional views of the newborn have been yoked to technique, technology, and paradigm, and I would argue that a potential misreading of the newborn was often symptomatic of our lack of an effective paradigm for studying their behavior. Management of the newborn's rapidly fluctuating state of arousal, little awareness of stimulus parameters that optimize neonatal attention, uncontrolled testing environments, procedural issues (i.e. design problems and limitations), improper counterbalancing and high attrition rates are typical problems that have plagued successful studies of habituation. Our limited knowledge of newborn memory

formation, capacity and retention is therefore due largely to the above-mentioned shortcomings (Bertenthal, Halth, & Campos, 1983; Brody et al., 1984; Fantz, 1964; Slater et al., 1983; 1984; Zelazo et al., 1984) which left researchers unable to interpret obtained response decrements. Previous failures to obtain habituation-dishabituation and/or difficulty in interpretation of results in the newborn were largely due to methodological limitations and not due to neonatal limitations, a position echoed by Slater et al. (1984).

Any number of responses can be used to show habituation. Habituation and recovery to novel stimuli occur for heartrate deceleration, visual fixation and high amplitude sucking to visual stimuli (Adkinson & Berg, 1976; Friedman, 1972; Slater et al., 1983; 1984; Werner & Siqueland, 1978). For example, Adkinson and Berg (1976) examined cardiac decelerations to mild intensity colored lights appropriately counterbalanced for order of presentation, and demonstrated habituation followed by response recovery to novelty. Muir and Field (1979) extended the inference of information processing and memory formation among neonates to auditory stimuli using a clearly observable response, headturning to a sound source. Habituation for

localized headturning and heartrate decelerations to auditory stimuli has been demonstrated (Brody et al., 1984; Clarkson & Berg, 1983; Weiss et al., 1986; Zelazo et al., 1984; In press). Zelazo, Brody, and Chalka (1981) demonstrated that 72-hour old Infants displayed turning toward the sound source followed by a decrease in the level of turning, and response recovery to novelty to counterbalanced rattle sounds. Brody, Zelazo, and Chalka (1981) repeated this result using speech stimuli, namely, the English words beagle and tinder. Habituation has also been demonstrated for respiration changes to olfactory stimuli (Engen & Lipsitt, 1965), and heartrate deceleration to tactual stimuli (Pomerleau-Malcuit & Clifton, 1973).

It is essential that researchers are aware of the many factors that influence habituation. To a large extent the answer one obtains from the Infants depends on the habituation question one poses. Infant behavior in habituation paradigms reflects both variation in familiarization and available test alternatives: "Current practice often classifies early learning effects largely on the basis of type of procedure used - a classification format which may in fact prove to bear little relation to the nature of processes involved"

(Bronson, 1982, p.112). The primary factors that influence habituation can be controlled, and if so, the habituation paradigm can serve as an informative test alternative (Bornstein, 1985). These primary factors include: (1) stimulus complexity; (2) degree of interstimulus variation; (3) procedural issues (design); and (4) modality tested. Issues of stimulus complexity were discussed above and are relatively easy to control for. In a heterogeneous stimulus condition, if habituation is desired, the researcher must allow the infant a longer familiarization period (Clarkson, Clifton, & Morrongiello, 1985), than would be required by the infant in a homogeneous stimulus condition. The design the researcher chooses will require careful methodological considerations. In a fixed-trial design the researcher must predetermine the number of trials, the duration of the trials and the intertrial intervals. In an infant-controlled procedure the researcher must be aware that the infants might meet habituation criterion by chance. Serial learning paradigms, like habituation, risk criterion artifact (Bogartz, 1965) or spontaneous recovery (Bertenthal, Haith, & Campos, 1983). Given enough trials, it is possible that the subject will reach almost any criterion (criterion artifact), even

when performance does not significantly depart from chance (Bogartz, 1965). A problem with "chance habituators" is that their responsiveness does not reflect a level of stimulus processing comparable to those infants showing true response decrement. To avoid such a statistical artifact, a partial-lag design should be employed (Bertenthal et al., 1983), in which the habituation sequence is extended with "overlearning trials" to the familiar stimulus after the infant has reached habituation criteria. Typically, this lag control group's performance is compared with that of an immediate-change test group. Finally, it is essential that the researcher is aware that different modalities may yield different results concerning habituation. The age of the infant is an important determinant in evaluating performance across modalities. For example, the newborn infant's auditory system is more mature than its visual system (Banks & Salapatek, 1983), although this quickly reverses after the second month (Aslin, Pisoni, & Jusczyk, 1983). Thus, one might expect that the newborn's responses to auditory stimuli might show habituation and discrimination to a more

sophisticated degree compared to responses to visual stimuli.

The reliable occurrence of habituation in numerous laboratories for different modalities and responses not only indicates a robust phenomenon, but has repeatedly implied that habituation may be used in the investigation and study of cognitive aspects, such as memory in the newborn. Prior to examining recent demonstrations of newborn habituation-dishabituation that appear consistent with a memory interpretation a brief overview of newborn sound localization and the headturning response is appropriate. Muir and Field's (1979) development of the headturning paradigm has facilitated the study, precision, and interpretation of newborn cognitive abilities. This methodology holds the potential for the examination of a variety of characteristics of newborn memory analogous to research with 3- to 5-month old infants. The absence of an effective paradigm and successful demonstrations has led to the conclusion, perhaps prematurely, that newborn information processing capabilities are qualitatively different from those of 3- to 5-month old infants, i.e., that newborns do not process information in the same fashion as older infants and that newborns do not

have "schema-driven" memory. It is my contention that newborn information processing capabilities are not as qualitatively different as assumed, and that the quantitative differences between younger and older infants (i.e., less efficient encoding, etc.) perhaps have misleadingly encouraged this viewpoint. The process which mediates attention, learning and memory is not qualitatively different in the younger infant. The importance of the maturing cortex cannot be overlooked in terms of the richness of cognitive competencies that it facilitates; however, newborn's attentional behavior is not simply a function of neural fatigue or sensory adaptation. It is my belief that the process of creating schema as a function of incoming perceptual information and attending to incoming perceptual information as a function of current schemata, exists from birth.

Headturning Paradigm

The literature on localization of sound has primarily emphasized the behavioral response of headturning. Earliest evidence of infants' abilities to localize sound is found in clinical pediatric literature. Brazelton incorporated this finding as an

Item on the Neonatal Behavior Assessment Scale (Brazelton, 1973). Muir and Field (1979) were the first to adapt this procedure within the context of an experimental paradigm in which the infant is allowed ample time to respond and is held between vertical and supine positions with the infant's head resting free of constraint in the examiner's palm. This paradigm has been employed extensively in three laboratories. To date several studies have examined the conditions under which newborns will orient toward a sound source (Brody, Zelazo, & Chalka, 1984; Clarkson, Morrongiello, & Clifton, 1982; Clifton, Morrongiello, Kullig, & Dowd, 1981; Field, DiFranco, Dodwell, & Muir, 1979; Field, Muir, Pilon, Sinclair, & Dodwell, 1980; Muir & Field, 1979; Weiss, Zelazo, & Swain, 1986; Zelazo, Brody, & Chalka, 1984; Zelazo, Weiss, Randolph, Swain, & Moore, in press).

Headturning is an easily elicited behavior, which is sensitive to a variety of temporal and stimulus parameters. Moreover, the headturning response is readily observable and easy to measure and analyze. Since the headturning paradigm does not require sophisticated equipment and in particular since headturning offers an objective response that may be

manipulated relatively easily, it can serve as an effective paradigm to study several neonatal phenomena, including information processing capabilities.

This thesis will focus on the systematic way that the newborn acts as a perceptual-cognitive information processor and on how, in fact, the processing of information is perhaps qualitatively similar to that seen in older infants. The primary focus of the relevant literature will be on the newborn's auditory competence, because the present study examined newborns' ability to retain auditory information (or auditory experience) in longterm memory within the context of a sound localization experiment employing the habituation-dishabituation paradigm. Consistent with, and borrowing from, Sokolov (1963) the underlying assumption is that infants who show rapid response decrements (habituation) are forming models or internal representations of the stimulus. In the following pages, newborn information processing will be evaluated by reviewing relevant literature on infant habituation-dishabituation and longterm retention. Three themes in particular will be emphasized: (1) the newborn's ability to create "memory" for a repeated stimulus, (2) the newborn's ability to compare and contrast "old" familiar

Information to "new" Information, and (3) the newborn's capacity to retain Information in memory.

Habituation-Dishabituation

Through simple manipulations of the habituation design it has become possible to investigate many aspects of early development of recognition memory and the ontogenesis of memory. Despite recent demonstrations little is known about newborn habituation-dishabituation beyond the demonstration that newborns show reliable response decrement to repeated presentations of a non-reinforcing stimulus and can discriminate novel from familiar "habituated" stimuli. Habituation-dishabituation exhibited by older infants is considered to be indicative of information processing and memory capacity (Cohen, 1973; 1976; Lewis, 1971). However, researchers are less inclined to attribute these same abilities to the newborn (Dannemiller & Banks, 1983).

At least two interpretations can be offered for the findings of recovery of headturning (dishabituation): (1) renewed orientation is a function of auditory information processing (memory formation) on the

newborn's part, or (2) renewed orientation is merely a result of spontaneous recovery as proposed by the sensory adaptation model (Dannemiller & Banks, 1983). The information processing view assumes that infants compare "new" stimuli to the memory of a familiar "old" stimulus, which in turn determines how much attention will be paid to the change in stimuli. Clearly, recovery of localized headturning with this assumption in mind, would imply information processing on the newborn's part.

Supporters of the model of selective-sensory adaptation, rather than inferring information processing, believe habituation-dishabituation of localized headturning reflects sensory adaptation on the part of the neonate (Dannemiller & Banks, 1983). In this view, neither habituation to a repeated event nor dishabituation to a novel stimulus involves information processing. A sensory adaptation model implies that a specific stimulus excites a set of specific receptors and neurons in the CNS, and that with repeated exposure to the stimulus these specific neurons fatigue, resulting in behavioral habituation. Dishabituation results from exciting a completely new neural chain associated with a new stimulus, independent of any

previous experience with the familiar stimulus. In contrast to the proposed information processing model, dishabituation is explained without assuming that the infant compares "new and old" information.

One of the strengths of Dannemiller and Banks' model of sensory adaptation (Dannemiller & Banks, 1983) is that it is testable and they describe five kinds of empirical evidence which could potentially disconfirm their model: "(a) persistence of habituation across time periods in order of hours; (b) generalization of habituation across a group of stimuli whose invariant features are relatively abstract; (c) significant habituation to a stimulus (as indicated by a differential attention to novelty over familiarity) after only a few brief presentations; (d) recovery to a stimulus which has been decreased in intensity (e.g. luminance, contrast, or sound level) from the familiar stimulus; and (e) observing significant behavioral habituation to a repeated stimulus but no decrease in the amplitudes of the early sensory components of the visual evoked potential to the same stimulus" (p.156). In the present study, point (a) will be addressed by presenting newborns with stimuli after a delay of 24 hours in order to rule out neural fatigue.

The habituation-dishabituation procedure has been used to study retention of information in newborns. In particular, the habituation-dishabituation procedure coupled with the headturning paradigm has served as a successful procedure in isolating cognitive capacities of the newborn. Newborns will first turn toward and subsequently habituate to familiar sounds, followed by response recovery to novel auditory stimuli (Brody et al., 1984; Zelazo et al., 1985). Renewed responding or dishabituation to a novel stimulus, but not to the standard (familiar) stimulus, indicates a capacity to discriminate between the two stimuli. Habituation-dishabituation findings thus imply a capacity for recognition memory. Brody and her associates (Brody et al., 1984) showed that 72-hour old infants displayed habituation of headturning to familiar sounds and dishabituation to novel sounds. A mean inter-trial delay of 10-seconds was employed, implying that newborns can remember information for at least this length of time.

Both short term and long term aspects of memory can be assessed using the habituation-dishabituation paradigm. For example a newborn who receives 30 trials of a sound will show response decrement (habituation).

The Infant's loss of Interest, barring artifact, strongly suggests stimulus recognition. If a brief delay is interposed between the 30th and 31st trials, short term memory may be assessed. That is, if the response recovers on the 31st trial, one can assume either that the Infant's short term memory for the repeated sound has decayed (Information processing view), or that fatigued neurons have recovered (sensory adaptation view). Delay periods can be manipulated to establish the exact course of decay or fatigue. By interposing delays of several hours between repetitions of the procedure one can rule out neural fatigue as an explanation for response recovery. More rapid habituation during the second testing would indicate some form of "Information savings" suggesting longterm retention on the newborn's part.

Decrement in responsiveness may reflect genuine habituation of underlying attention, that is, acquisition of information about a repeated stimulus and consequentially a loss of Interest, or (1) sensory adaptation, (2) effector fatigue, or (3) a change in behavioral state. As for the habituation paradigm, it is possible to minimize difficulties in interpretations by including proper methodological controls. By

controlling the infant's state, employing a partial-lag design, and adding a novel stimulus at the end of the procedure it is possible to rule out the possibility of effector fatigue and behavioral change in state as determinants of the infant's responsiveness. Sensory adaptation is more difficult to rule out. Only if the delay between habituation and re-test can be reasonably prolonged without adverse effects on discrimination could the sensory adaptation model be ruled out. Moreover, researchers should consider examining the infant's behavior qualitatively following habituation in order to shed light on the infant's responsiveness. For example, if following habituation the infant systematically responds to the stimulus by avoiding it or by any systematic behavior that differs significantly from chance (depending on the response being measured), stimulus-specific recognition of the redundant stimulus may be inferred, as well as retention of habituation.

Zelazo and his associates (Zelazo et al., in press) measured recovery of headturning to a previously presented sound after a number of different brief delays. The familiar word was treated as novel for delay conditions lasting longer than 100 seconds (100 seconds; 145 seconds). However, a delay of typical

Inter-trial Interval length (10 seconds; control group) and of nearly one minute (55 seconds) was tolerated without significant decay, i.e., there was no response recovery to prehabituated levels.

From the Information processing perspective this finding implies that the previous redundant stimulus was being perceived as novel by the Infant following a delay of ≥ 100 seconds. Recovery of headturning following the longest delays suggests that the Infant's memory must have decayed, because for the shorter delays there was no such recovery indicating that the redundant word was retained and still recognized as redundant. If indeed the proposed memory interpretation is correct, the duration of short term retention may lie between 55 and 100 seconds for the newborn Infant. Thus these results may have indicated the outer limit of the newborn's ability to retain redundant information in short term memory within this paradigm, where a low level of responsiveness on re-test was interpreted as "recognition", whereas recovery of responsiveness was interpreted as "forgetting". The fact that Infants could display renewed interest in an item which they in fact remember tends to detract from the power of this design, for recovery to the habituated stimulus does not

necessarily indicate "forgetting" (Sophian, 1980). From the sensory adaptation perspective, this finding implies that sensory fatigue, built up during repeated presentations of the stimulus, dissipated following the 145-second "rest-period" of no responding. It is difficult to rule out the possibility that delays of 10 and 55 seconds are not sufficiently long for the neurons to recover, whereas delays of 100 and 145 seconds are.

Zelazo and his associates (in press) claim that they have clearly demonstrated that habituation in newborns is not a "cognitive" artifact created by sensory fatigue, by systematically examining the quality of post-habituation behavior of neonates to the habituated stimulus. The analysis of headturns away lends strong support to the information processing view, and can be interpreted as an effort to avoid the sound, and indicates that post-habituation behavior to the familiar stimulus does not simply lead to "no response". If habituation implies that responding to a redundant stimulus will decrease to chance levels, one would expect "no turns" to be as prevalent as turns toward and turns away (Clarkson, Clifton, & Morrongiello, 1985). However, Zelazo et al. (in press) found significant headturns away from the sound when the delay was under

100 seconds. This avoidant behavior was interpreted as an indication that the infant no longer found the stimulus interesting, but in fact aversive. This finding has since been replicated in a study completed by Weiss, Zelazo, and Swain (1986) who investigated newborns' response to discrepancy using a habituation-dishabituation paradigm of headturning in a partial-lag, between-group design. Infants were familiarized to a repeated syllable and then presented either with six additional trials of the standard stimulus (lag-groups) or immediately with a discrepant stimulus that varied in fundamental frequency from the standard. The results obtained imply that recovery of localized headturning is an inverted-U shaped function of stimulus discrepancy from an experimental standard: i.e., the smaller and larger discrepancies elicited least recovery, whereas the moderate discrepancies elicited the greatest recovery. Moreover, the neonates demonstrated a significantly greater percentage of turns away from the sound source compared to turns toward during the lag and control trials. The finding that newborns will continue to avoid redundant information is consistent with the information processing view. Newborns continue to process familiar information, but they respond to it in

a qualitatively different fashion from when it was novel. The sensory-adaptation model would have difficulty in accounting for these results on the basis of fatigue alone (behavioral habituation).

Olson and Strauss (1984) in a review of infant memory state that active memory which is derived from categorical mental representations does not emerge until 6 to 7 months of age. Prior to the development of what the authors refer to as "schema-driven" memory, the infant is endowed with an immature CNS and is only able to integrate perceptual inputs, but cannot create analogous cognitive structures as those seen in older infants. Olson and Strauss regard demonstrations of neonatal preference strictly as a function of stimulus parameters that elicit neural excitation. The view taken by Olson and Strauss that younger infants do not show "schema-driven" memory and that they qualitatively differ from older infants in how they create schema seems entirely reasonable. Yet, even though the competence of the very young infant is far from that of the six-month old, newborn habituation-dishabituation data do suggest that the cognitive processes of the newborn mediate attention, learning, and memory. This thesis will attempt to demonstrate that information

processing on the part of the newborn does direct attention, learning and memory very much like the processes employed by older infants.

Dishabituation findings in the newborn support the information processing view of the newborn as an active, perceptual information processor capable of memory formation. The results imply consistently that the newborn infant appears to be able to create memories for events as well as actively process and respond to novel events. Nevertheless, existing data can be accounted for by a selective receptor adaptation interpretation (Dannemiller & Banks, 1983), at least until such a time that their model is disconfirmed by empirical evidence.

To summarize briefly, newborns have the capacity to retain redundant information over brief intervals (inter-trial intervals in habituation studies are typically 5 to 30 seconds). Second, the outer limit of the neonate's ability to retain redundant information in short-term memory may be somewhere between 55 and 100 seconds (Zelazo et al., in press). The limits of neonatal memory obtained by Zelazo et al. (in press) may be specific to the stimulus conditions and paradigm used, and the generalizability of this finding must

await further research. However, the newborn's ability for such refined memory and discrimination of subtle comparisons suggest that perhaps the newborn is capable of retaining information for longer periods of time in longterm memory. A review of infant longterm retention further serves to solidify my perspective that perhaps information processing in newborns is similar to that seen in older infants.

Longterm retention

Investigators interested in infant memory processes have largely focused on visual habituation as a means of assessing infant retentive capabilities. The underlying assumption being that the decrease in fixation to the familiar stimulus occurs due to the formation of an internal representation for this stimulus. However, the interval between the presentation of the familiar stimulus and its later re-presentation has predominately taken place within an experimental session (Fagan, 1970; 1971; Fantz, 1986) so that visual retention has been of a very short duration in the newborn. Zelazo and his associates (1985) used habituation of headturning to a sound source as a means of assessing newborn's retentive capacities, but again the re-presentation of the same

auditory stimulus occurred within the same experimental session.

Longterm retention has been studied in a series of experiments of 3-month old Infant's footkicking for conjugate reinforcement (Fagen & Rovee-Collier, 1983; Rovee & Fagen, 1976). The basic footkicking paradigm involves presenting infants with a mobile that either moves in a conjugate fashion with the infant's kicking or in a non-contingent fashion. The results demonstrate that 3-month old infants learn the contingency between the stimulus and the response. Retention of this behavior seems to last from 24 hours (Rovee & Fagen, 1976) up to 4 weeks if exposure to the stimulus is offered 24 hours prior to testing (Fagen & Rovee-Collier, 1983).

More recently, this paradigm has been extended to infants as young as 8 weeks to examine the effect of training duration on immediate retention and on longterm retention (Vander Linde, Morrongiello, & Rovee-Collier, 1986). In Experiment 1, the effect of training duration on immediate retention was examined, in which training durations employed were either 6, 12, or 18 minutes. Longer training periods were expected to improve the

Infant's performance in the conjugate footkicking paradigm during immediate retention and after lengthy delays. The results indicate that immediate retention following all training durations was excellent (the longer durations of 12 and 18 minutes significantly improving performance in comparison to the 6-minute session); however, only the longest duration of 18 minutes yielded evidence of one-week retention. No group exhibited retention after a delay of two weeks, which contrasts with the excellent 2-week retention of three-month olds trained for a single 18-minute session (Fagen & Rovee-Collier, 1983).

In Experiment II, the effect of distribution of training on longterm memory was examined. Eight-week old infants were either trained for one single 18-minute session or for three 6-minute sessions separated by 24 hours. Retention was measured immediately following training and after a 2-week delay. The 2-month olds trained for a single 18-minute session showed no evidence of remembering a conditioned response during cued recall tests two weeks after the conclusion of training. However, distributing the training minutes across multiple sessions did improve longterm retention of these infants, suggesting that the infants must have

attended selectively to a sufficient number of originally noticed cues during the longterm retention test. Increasing the number of sessions presumably increased the number of attributes that Infants encoded during training and in turn, the number of potential retrieval cues available to them during the longterm retention test. Since the method of training appears to influence the older Infants' retention a similar manipulation would be expected to facilitate newborn's memory for stimuli.

Martin (1975) found differential responsiveness to familiar visual stimuli following a delay of 24 hours, implying some form of savings on the part of his sample of 2 month olds. Retention was evidenced by test comparisons between means of familiarization trials of the first and second experimental sessions. Martin found a significant decline in attention to the familiar stimulus, as measured by fixation. Martin repeated the same procedure with a sample of 3.5 month and 5 month olds, and found that the effect was related to age, becoming much stronger the older the infant. This finding certainly is consistent with reports that younger infants remember more poorly than older subjects (Rose, 1981; Rovee-Collier, 1984). However, poorer

retention reflects memory content (the number and/or type of cues noticed) and not an inability to process. Increasing the length of familiarization would increase the number of cues and attributes the infant would encode, and in turn would increase the number of potential retrieval cues available to them during a longterm retention test. It is my contention that this is a quantitative difference rather than a qualitative difference between the information processing capacities of the younger and older infant.

Weizmann, Cohen, and Pratt (1971) found delayed recognition memory to visual stimuli in infants as young as 6 weeks, by familiarizing 4-week old infants to a visual stimulus (stable) for 30 minutes a day for a period of two weeks and retesting them at 6 and 8 weeks of age after intervals of 24 hours from last exposure. At both ages recognition memory was evident, with younger infants preferring the familiar stimulus and older infants the novel stimulus.

Bushnell and his associates (Bushnell, McCutcheon, Sinclair, & Tweedle, 1984) in a similar experiment, instructed mothers to familiarize their infants with a visual stimulus for 2 sessions of 15 minutes each day,

over a period of 14 days. There were two groups of Infants recruited at two different ages, 3 weeks and 7 weeks, respectively. The stimulus consisted of any of the possible combinations of shape (circle, triangle, cross) and color (red, yellow, blue). The experimenter retrieved the stimuli from the homes at least 24 hours prior to the test appointment. Half of the subjects were tested at home on the recognition memory test, and the other half was tested in the laboratory. The test consisted of a random sequence of the following stimulus conditions: familiarization stimulus, color change stimulus, shape change stimulus, and both shape and color change stimulus, respectively. Unlike Weizmann et al. (1971), Bushnell and his associates found no significant Age effects. Rather they found both significant Stimulus and Location factors, as well as a significant Location X Stimulus Interaction. Lab tested Infants attended significantly more to the novel stimulus condition than to the familiar stimulus, when both color and shape were changed, while home tested Infants attended more to all 3 categories of novel stimuli than the familiar stimulus. There appears to be a response facilitation in the familiar environment, with local context cues assisting recall. Specifically,

home tested Infants (old context) required only one change in either color or form to elicit response to novelty, whereas, lab tested Infants (new context) required that both form and color be changed, in order for the stimulus to elicit response recovery relative to the familiar stimulus. Bushnell and his associates (1984) claimed that their findings argue against Bronson's (1982) claim that sensory adaptation mediates apparent central encoding in Infants under 2 months of age. Bronson (1982) stated that decrement in infant fixation times is not due to central encoding, but due to peripheral sensory adaptation.

Weizmann et al. (1971) found 8 week-old's preferred novelty, but 6-week old's preferred familiarity. In Bushnell et al.'s study, both 5- and 9- week old's attended more to novel stimuli. Weizmann et al. (1971) used more complex stimuli and passive observation, whereas Bushnell et al. (1984) employed simpler stimuli and an active observation procedure, where the mother attempted to maintain infant's attention throughout each session to facilitate encoding.

Ungerer, Brody, and Zelazo (1978) also demonstrated longterm retention in Infants under three months of age.

Mothers repeated one of two words (either beguile or tinder) and the infant's name 60 times a day, beginning at 14 days of age and maintained for a period of 13 days. Relative to a control group which received no repetition training, the 2- to 4- week olds showed recognition of the experimentally induced familiar word relative to the novel words following 14- to 42- hour delays. This finding of longterm memory for speech following training for 13 days further strengthens the basis for postulating "savings" capacities in newborns.

Carpenter (1975) demonstrated that 2-week old infants are capable of discriminating between their mothers and female strangers. Carpenter employed six different situations in his experiment: (1) mother's face, silent; (2) female stranger's face, silent; (3) mother's face, talking; (4) female stranger's face, talking; (5) mother's face, talking, with female stranger's voice; and (6) female stranger's face, talking, with mother's voice. Results indicate that infants looked longest at the mother's face in the condition where the mother was talking and next longest to the mother's face, silent. Both of these situations were preferred over the two stranger conditions. It is of interest to note that the most disturbing condition

for the infants appeared to be the mismatch conditions in which the wrong face was paired with the wrong voice. Infants showed increased fussiness under these conditions which may have indicated that they found them aversive. The results are interesting in that they clearly demonstrate the infant's ability to discriminate between familiarity and unfamiliarity.

A review of existing research on newborn longterm retention serves to solidify my perspective that perhaps the infant at birth is capable of retaining stimulus information and experience in memory over several hours. Newborn longterm retention has been found for auditory, visual, and olfactory stimuli, respectively. Spence and DeCasper (1986) demonstrated that newborns preferred to listen to a story their mothers had read aloud while pregnant compared to an unfamiliar story. Because the stories employed differed in both their word and melodic content, it was unclear whether the newborns used either or both sources of information to recognize and prefer the story they had heard prenatally. Thus, Panneton and DeCasper (1986) investigated whether newborn infants could use melodic information alone to recognize and prefer a melody they had experienced prenatally. In this experiment pregnant females began singing "Mary Had

a Little Lamb", 2 weeks before their due-dates. The melody was sung with the syllable "la" instead of its words, and it was sung 10 times a day for the remainder of the pregnancy. After birth, infants were tested in a preference procedure to see if they recognized and preferred the melody they had experienced prenatally. The high amplitude sucking paradigm was employed. Results indicate that infants in the prenatal group showed a significant preference for the familiar melody, but infants in the control group showed no systematic preference. Thus prenatal auditory experience with the melodic information is sufficient to affect postnatal auditory recognition and preference, suggesting some sort of "savings" capacity on the newborn's part prior to birth.

Cassel (unpublished manuscript) has demonstrated that given a particular caretaking context, neonates will indicate recognition of mother by the end of the first post-natal week. Cassel does not ascertain that this is a "psychological" recognition of the mother, but instead insists that recognition is manifested through the "reappearance of a specific context gestalt" characterized for the newborn by kinesthetic and motor cues and temporal patterning which have come over the

first week to characterize the particular temporal setting for exchange processes between the infant and caregiver. Cassel found support for his notion of a "context gestalt" by examining the effect of a perturbation of a specific context on the infant. Cassel found significant alteration in pattern of visual contact with the mother (i.e., looking away) as a result of the specific perturbation. There were also several postural adjustments by the infant indicating avoidance. Moreover, MacFarlane (1975) found that 7-day old infants can reliably distinguish their mother's own breast pad from those of strangers. MacFarlane found that the 7-day old infants turned toward the mother's breastpad with an 80% reliability.

Keen, Chase, and Graham (1965) examined newborn heart rate accelerations to auditory stimuli of moderate intensity in the same procedure conducted on two consecutive days, with 24 hours between testings. A 2 second stimulus elicited a brief acceleration which showed no decrement in 30 repetitions over 2 days. However, with a longer 10 second stimulus, an initially prolonged acceleration diminished after a few presentations and remained depressed after the 24 hour interval. The 10 second condition elicited a prolonged

response in age controls hearing the sound for the first time, indicating that there was some form of information "savings" on the experimental group's part.

Evidence exists that infants even younger than 40 weeks gestation show retention of information. Werner and Siqueland (1978) extended the age at which neonates were first found to demonstrate habituation-dishabituation to gestationally younger infants. A high amplitude sucking (HAS) procedure was employed in which visual patterns were contingent upon the increase in rate of high amplitude sucking. Differential recovery in HAS rate to the presentation of the familiar and novel stimulus during the post-test phase provided the measure of visual discrimination and recognition memory. The authors were able to demonstrate that 35-week gestation neonates would habituate HAS in response to repeated colored patterns and recover HAS to novel colored patterns. Approximately half of the sample was re-tested 24 hours after initial training. Six of these 7 infants showed increased levels of differential responsiveness to the familiar and novel stimuli on the replication test. These six infants increased the magnitude of their novelty discrimination scores on the second day. The greater the difference in post-shift

relative to no-shift performance 24 hours after initial training is perhaps indicative of some type of "savings" on the preterm's part.

In conclusion, there is data from which one may conclude that infants under 3 months of age readily adapt their behavior as a result of longterm retention of experienced stimuli (Bushnell et al., 1984; Martin, 1975; Ungerer et al., 1978; Vander Linde et al., 1986; Welzmann et al., 1971). If longterm memory is present in infants as young as two weeks of age (Carpenter, 1975; Ungerer et al., 1978), it seems reasonable to hypothesize that longterm memory may be evidenced in newborns. Moreover, Panneton and DeCasper's (1986) findings of prenatally experienced melody resulting in post-natal preference for that melody, indicate some form of longterm retention on the newborn's part. Certainly, Keen et al.'s (1964) finding of 24-hour retention of habituation of the heartrate response strongly encourages such a viewpoint. Finally, Werner and Siqueland's (1978) demonstration of gestationally immature infants' capacity for discriminating visual stimuli, and the demonstration of greater differences in post-shift performance relative to no-shift performance following 24 hours after original training appears to be

Indicative of some type of "savings" on the preterm's part. This finding certainly justifies the plausibility of hypothesizing that gestationally mature newborns can retain information for at least as long a period of time.

To date, while previous literature suggests longterm retention in newborns, the question remains largely unanswered as to whether infants at birth are capable of creating memories and whether or not they have the capacity for stimulus-specific longterm retention. First and foremost, validation of the proposed information processing view of the infant is vital. While habituation-dishabituation studies generally support the information processing view, response decrement to repeated stimuli followed by recovery to a novel stimulus have not always been convincingly demonstrated in newborn infants (Clifton & Nelson, 1976). Decrements in responding have not always been followed by recovery to the presentation of novelty (Graham, Clifton, & Hatton, 1968). This poses a problem, for without recovery to novelty, habituation to a repeated stimulus cannot be distinguished from fatigue or adaptation. Methodological shortcomings of failed demonstrations of response recovery left researchers

unable to interpret the finding or absence of response recovery in newborns. A primary goal of this study, will be an attempt to solidify and strengthen the existing data implying information processing, by strongly considering these shortcomings and an attempt to overcome them.

Statement of Purpose

To date the question remains largely unanswered as to whether infants at birth are capable of stimulus-specific memory. Investigators interested in infant memory have largely focused on newborn retentive capabilities over relatively short periods. The interval between the presentation of the familiar stimulus and its later re-presentation has generally taken place within an experimental session (Fagan, 1970; 1971; Fantz; 1956; Zelazo et al., in press). Differential responding to the same stimulus and/or event after lengthy delays, has not yet been demonstrated in a convincing manner by the newborn. Moreover, several of the investigations of some form of longterm retention have frequently had methodological shortcomings in that they did not use age controls to determine whether differential responding to the re-presentation was due

to information processing rather than simply age effects. The paradigms employed in the investigation of longterm retention generally were paradigms in which methodological controls were not readily or easily incorporated. Moreover, none of the existing studies tested for stimulus-specific retention, making interpretations of whether merely the previous experience of being in a particular context is retained or whether specific experience with that same stimulus is what is being retained. It is clear from the data discussed above that the neonate will demonstrate habituation and dishabituation to familiar and novel stimuli, respectively. But do neonates systematically adapt their response to a familiar stimulus as a function of previous exposure to that familiar stimulus?

The headturning paradigm employed by Zelazo, Brody, and Chalka (1984) and Zelazo, Weiss, Randolph, Swain, and Moore (in press) offers a vehicle to extend the findings of an initial demonstration of newborn habituation-dishabituation. In the following experiment, "savings" effects will be examined by assessing the infant's headturning response to an off-centered sound source in a habituation-dishabituation paradigm that is repeated over two days, while

Incorporating all proper state and age controls. The behavioral response of headturning will be used as the principal dependent measure, since it appears to be most reliable and an easily observable and analyzable response in newborns.

The hypotheses tested were whether or not newborns exhibit "savings" over a 24-hour period: specifically, did the newborn adapt his/her behavior as a result of longterm retention of a previously experienced stimulus and/or event? Is there stimulus-specificity in that retention? Or, more specifically, is there retention of habituation? These hypotheses were tested by habituating infants' headturning to a repeated word (beagle or tinder). The words beagle and tinder were chosen because previous studies have found them to be of a compelling nature (Zelazo et al., 1984; Zelazo et al., in press). Three groups of infants were tested. The two experimental groups were tested on two consecutive days on the same procedure (with the addition of one methodological control on Day II), with a 24-hour delay between test-sessions. A control group tested only once served as Day II Age Controls. The control group was necessary in order to determine that any changes in performance over days were not based on age-effects due

to recovery processes soon after birth. The experimental paradigm consisted of three phases. During Phase I (habituation) the infant was required to demonstrate initial orientation to the stimulus (3 out of 4 turns toward the sound) and was presented with sufficient trials (N=30) to allow for habituation. Previous studies employing the same paradigm have indicated that on the average infants will take 16 trials to habituate to auditory stimuli (Weiss et al., 1986; Zelazo et al., in press). In Phase II (dishabituation), all infants received five additional trials of the standard sound source following an inter-trial interval (ITI) of 145 seconds. The final phase, Phase III (novelty post-test) followed the five dishabituation trials on Day II. Headturning served as the principal dependent variable.

The habituation-dishabituation paradigm was adapted in two ways for this experiment. Following habituation there was a 145-second ITI followed by five dishabituation trials of the same sound. There were four reasons for the addition of these dishabituation trials: (1) allow for replication and validation of previous post-145-second ITI data (Zelazo et al., in press), and (2) to ensure that decrement in responding

In the habituation trials was not due to fatigue, (3) to avoid the addition of a novel word, and (4) allow for the examination of short term versus longterm memory effects. Typically in other studies employing this paradigm a novel word is introduced, in order to confirm that infants in all groups of the experiment have remained alert and responsive to the auditory stimulus (Weiss et al., 1986; Zelazo et al., in press). Recovery of headturning to a novel word indicates that observed differences are not attributable to differential fatigue or sleepiness. Since experimental group infants were tested on two consecutive days with either the same or different stimulus it was essential that a new word was not introduced; it would have been impractical to confuse possible interpretations of stimulus-specific "savings" due to the addition of a novel word.

Savings effects were examined in terms of differential responding to the re-presentation of the same or different stimulus following a 24 hour delay. Specifically, did newborns treat the familiar sound on Day 11 qualitatively different than on Day 11? Was there retention of habituation? Was there systematic "avoidance" of the familiar sound on Day 11? Replication of previous found results of newborns'

systematic turning away from the sound source would strengthen the implication of the information processing view, that newborns continue to perceive the previously interesting stimulus, but avoid the repeated stimulus. Replication of this finding would serve to rule out the possibility of decrement in responding being due to fatigue (Dannemiller & Banks, 1983). Thus experienced infants (experimental groups) were contrasted to non-experienced (control) infants on Day II. Moreover, the experienced infants were compared to each other in order to verify that there was no differential responding between groups on Day I and to examine whether or not there were any stimulus-specific retention effects on Day II. Appropriate controls were vital in terms of ruling out the probability of age effects, a problem that many "savings" studies frequently overlook, spurious group effects, and in terms of allowing interpretations of stimulus-specific retention to be made.

CHAPTER II

METHOD

Subjects

Thirty-six neonates (18 males and 18 females) were recruited from the well-baby nursery at the Jewish General Hospital in Montreal, Quebec. The sample was predominately caucasian from all socioeconomic levels and was divided into three groups of 12 infants each. The neonates were healthy and fullterm (38- to 42- weeks gestation) with uneventful pre- and perinatal histories. A priori criteria for recruitment into each group included: (I) age of infant, (II) could be tested within one-to-two hours following 9:30 AM feeding, and (III) asleep when located.

Twenty-four neonates in the two experimental groups were first tested at a mean age of 47.1 hours (range = 34-58) and again at 71.1 hours (range = 58-82) hours. Twelve neonates in the control group were tested at a mean age of 71.7 hours (range = 63-79). The choice to test experimental group infants between 34 and 58 hours of age was made because: (I) neonates had ample time to

recover from the delivery (Adkinson & Berg, 1976), (II) the experimental group infants were tested on two consecutive days (the delay between testings being 24 hours), and (III) neonates were typically discharged 72- to 96- hours post-partum. The control group was tested between 63 and 79 hours in order to serve as age controls for the two experimental groups. An age control group helps rule out any possibility that obtained findings could be due to age effects or recovery processes soon after birth. An additional fourteen neonates were tested who were excluded from the sample due to fretting (3), failure to orient (3), and failure to complete second testing (fretting (3), withdrawal of permission (2)).

Previous work with neonates support the a priori criteria (Welss, Zelazo, & Swain, 1986; Zelazo, Welss, Randolph, Swain, & Moore, 1986). Subjects tested one to two hours following feeding are awake and alert. The neonates in this study were tested following their 9:30 AM feeding. This test time was chosen, because this feeding is the least variable feeding time for all the neonates in the nursery. The neonates are kept in the nursery overnight, and are either fed by the nursing staff at 9:30 AM, or taken promptly to their mother's

room for feeding at this time. The subsequent feeding times tend to differ for each infant throughout the remainder of the day, largely influenced by the infant's state and the mother's reluctance to wake the infant for feeding. When a neonate is tested shortly prior to his/her next feeding (generally there are 4 hours between feedings), the infant's state is likely to be poor and as a result the infant will not be able to complete the testing. These a priori criteria thus served to minimize subject-attrition rate.

Apparatus and Materials

Auditory stimuli consisted of one of two words, beagle and tinder. These words were chosen as test stimuli because of their equally low frequency of occurrence (Kucera & Francis, 1967), comparable duration (one second in duration), phonetic content and discriminability (Elmas, 1975), and use in previous studies (Zelazo, Weiss, Randolph, Swain, & Moore, in press), in which they have proven to be compelling. The stimuli were initially recorded by a female experimenter onto a tape-loop, who repeated each word in a consistent volume and intonation at a rate of one word every two

seconds. The loop was then re-recorded on a 30-minute reel-to-reel tape. A silent switch-box was connected to the reel-to-reel tapedeck and receiver, which enabled either pair of the tape tracks (either beagle or tinder) to be played. The auditory stimuli were played on a Pioneer 2-channel tapedeck, amplified through Fischer (model 100) speakers at 75 dB (A-scale). Background noise in the testing room was recorded to be approximately 50 dB.

A third auditory stimulus (papa) recorded at 200 Hz served as the novel stimulus for experimental group and control group infants on Day 11. The computer generated stimulus sound was presented as a discontinuous pulse, with two repetitions of the syllable (i.e. papa). The novel stimulus was played on an Hitachi stereo cassette player. The 2-channel tapedeck and the cassette deck were connected to a Pioneer (model 550) stereo receiver, which allowed the experimenter to alternate between the two stimulus tape players by simply adjusting a silent toggle switch. Sound levels of test stimuli were calibrated from approximate location of the infant's head with a Realistic (Radio Shack) sound level meter at a level of 75 ± 1 dB.

The experimenters wore Realistic Nova-40 headphones and Sony walk-man inner-ear headphones. These headphones simultaneously presented all three stimulus words in order to obscure the location of the stimulus and the experimental condition, in order to minimize influencing the infant's response. The infant's behavior was recorded with a Radio Shack Co-Co computer which had been modified as an event recorder.

Design

The design of the study is presented in Table 1, along with the age of each subject group and the stimulus they received at each testing. One experimental group (No Change) received the same stimulus on each of two consecutive days. Either the word beagle or tinder was presented laterally for 30 trials and again for an additional 5 trials following an ITI of 145 seconds. The same procedure was repeated 24 hours later with the addition of a 5 trial novelty post-test. A second experimental group (Change) received the same treatment except that a different word (either beagle or tinder) was used on Day II. A third group served as Day II age controls, half of which had beagle

and half had tinder. All infants were randomly assigned to the No Change (e.g. beagle-beagle), Change (e.g. beagle-tinder) and Day 11 controls.

Procedure

A sleeping infant was taken from the nursery or the mother's room to a dimly-lit, sound attenuated room adjacent to the nursery. To encourage an alert state of testing, a subset of reflexes (including Moro, rooting, sucking and the palmer grasp) were elicited and an attempt to engage the infant in visual fixation was made. The wake-up procedure lasted approximately 10 minutes and if needed a small amount of glucose water was given to the infant to aid in establishing an alert, inactive state. Less than half an ounce (5% concentration of glucose water) was given to the infant. The infant was burped and the diaper changed if necessary. Engaging the infant in such behaviors aided in establishing an alert, inactive state with infants participating in earlier studies (Weiss, Zelazo, & Swain, 1986; Zelazo, Weiss, Randolph, Swain, & Moore, in press) and proved beneficial during pilot work.

Once awakened, the Infant was held by one experimenter (the "holder") at a 45-degree angle between the vertical and supine positions, with the Infant's head and shoulders supported in the right hand, and its lower back and buttocks in the left hand. The "holder" leaned against a warming table for support, with the two stereo speakers placed on each side of the table, approximately 30 centimeters from the Infant's ear. A second experimenter coded duration and direction of headturning, fretting, and eyes open and closed by depressing the corresponding buttons on the silent button-box connected to the event recorder computer. A 45-degree turn that was sustained for at least 3 seconds was coded as a headturn. The 45-degree turn was measured by the second experimenter who observed a protractor that was above the Infant's head. The duration of headturn was recorded by the same experimenter who depressed the appropriate button on the button-box connected to the event recorder computer, which was programmed to indicate the passage of three seconds and thus the end of that experimental trial. Eyes closed and fretting were coded to monitor the Infant's state changes during the test session. A third experimenter determined the experimental group to which

the Infant was assigned and presented the stimulus for each trial.

Trials lasted 30 seconds or until the Infant demonstrated a sustained 3-second headturn to the stimulus with either a headturn toward or away from the sound source (Mean Intertrial Interval (ITI) = 7 seconds). Any headturn within the middle 90 degrees of the 180-degree arc of possible turns was be coded as "no turn". The 45-degree criterion is conservative relative to the criteria of 6- and 15- degrees used by Muir and Field (1979) and Clarkson, Clifton, and Morrongioello (1985), respectively. A conservative criterion was chosen to reduce the probability of spurious turns (Weiss, Zelazo, & Swain, 1986; Zelazo, Weiss, Randolph, Swain, & Moore, In press). Following each trial, the Infant's head was recentered by the "holder". Auditory stimuli were presented in a LRRL order with initial side of presentation counterbalanced within experimental and control groups and for each of the two standard stimulus words and the novel stimulus word. The number of trials

presented to the infant in each phase of the experiment was fixed.

On Day 1, to establish that the standard stimulus had been localized infants were required to turn toward the sound for three of four consecutive trials within the first nine to eleven trials. Failure to demonstrate this criterion of orientation resulted in termination of testing. This orientation was used to ensure that all infants in all groups localized the sound at a common level. The decision to exclude infants who did not orient within the first 9 to 11 trials was made due to previous research employing this headturning paradigm (Weiss et al., 1986; Zelazo et al., in press) which implied that infants not orienting within the initial 9 to 11 trials are not sufficiently attentive to the stimulus. Moreover as the total number of trials approaches 21, there is a significant likelihood that the infant's demonstration of orientation may be a chance event. The decision to set a flexible range of number of trials to reach orientation is primarily due to the criterion of orientation (3 out of 4 turns toward the sound source). Thus if the infant shows two headturns toward the sound source during the last two trials permitted for orientation, the infant was given

one or two additional trials in order to allow for the criterion of orientation to be met. During the remaining trials of the experiment the infant's responses were simply coded in terms of the restrictions placed on the trial by the headturning criteria and/or length of the trial. Infants were only excluded from the sample if the infant could not be kept in a reasonably alert, quiet state. This study and earlier studies (Clifton et al., 1981; Zelazo et al., 1984) emphasized headturning toward the sound source as the principal measure. Headturning is a trichotomous variable: Infants can either turn toward the sound, away from the sound, or not turn at all (Clarkson, Clifton, & Morrongiello, 1985).

The general protocol of stimulus presentation was thus divided into two phases on Day I and three phases on Day II. On Day I these phases were habituation and dishabituation, respectively. Likewise the phases were identical on Day II with the addition of a novel stimulus (novelty post-test). The choice of the 145 second ITI as a dishabituation phase was made to avoid introduction of a novel word on Day I. Zelazo, Weiss, Randolph, Swain, and Moore (in press) demonstrated that neonatal headturning to familiar words recovers following

Intertrial Intervals of 100 and 145 seconds, but not 55 or 10 seconds. Thus the ITI of 145 seconds was assumed sufficient to allow response recovery (dishabituation). On Day II five presentations of a novel word following the dishabituation phase were given to insure that response decrement to the standard stimulus was not produced by fatigue or a change in arousal state.

Measures

Three independent variables were assessed: (1) group assignment, (2) sex, and (3) repeated measures trial blocks. The first two independent variables were between group comparisons, while trial blocks served as the repeated measure. Trial blocks in the initial habituation phase of the experiment were formed by dividing each infant's total number of standard trials into equal fifths. Trials were blocked as groups of five trials with (I) 6 trial blocks in habituation phase (II) one trial block in dishabituation phase on Day I and (III) one trial block for each the dishabituation and novelty phase on Day II.

Three types of dependent variables were observed: (1) percentage of trials in which turning toward the

sound occurred during each trial block, (2) percentage of quiet, alert state across each trial block, and (3) percentage of trials in which turns away from the sound occurred in each trial block. Headturning was expressed as a percentage of each trial block in which the infant turned toward the sound, away from the sound, or not at all.

Reliabilities

Interobserver reliability was calculated from two observers who coded headturns and state changes independently with non-experimental pilot infants during ten "mock" experimental sessions. Reliability coefficients for headturning were determined as a percentage of agreement in which both coders recorded a 3-second headturn in the same direction on the same trials. Interobserver agreement was demonstrated in 87.32% of the 300 trials for which reliability was computed. To determine the reliability of the state measures each observer's coding was reduced to a percentage of trial blocks in which they recorded eyes closed and fretting. Interobserver agreement was demonstrated in 84.32% of the state reliability trials.

CHAPTER III

RESULTS

The principal dependent variable was the percentage of trials in which headturning toward the sound occurred during each trial block. Two separate analyses were performed to assess the two phases of the experiment on Day 1. In the habituation phase, six trial blocks of the standard stimuli were compared for the two experimental groups (No Change and Change groups, respectively). It was expected that there would be no Group main effect or interaction, indicating that groups were similar. A Trial Block main effect was expected to confirm habituation of headturning. In the dishabituation phase, one trial block of the standard stimulus was compared for the two groups following the 145-second intertrial delay. No main effect or interaction was expected for groups, indicating that groups were similar. It was expected that a comparison of the last habituation block to the dishabituation block would reveal a Trial Block main effect, indicating that infants recovered their responding following the delay.

Three separate analyses were performed to assess the three phases of the experiment on Day II. In the habituation phase, trial blocks were compared for all three groups (No Change, Change and Control groups, respectively). It was expected that there would be a Group effect, with Infants in the No Change group differing from the Controls. A Trial Block main effect was expected to once again confirm habituation. A Group X Trial Block Interaction was expected to confirm the Group main effect. In the dishabituation phase a Group main effect was predicted, as was a Group X Trial Block Interaction. In the novelty post-test phase, trial blocks of the novel stimulus were compared for all three groups. It was expected that there would be no Group main effect, indicating that Infants in each group were awake and responsive, and that fatigue was not a primary determinant of the results.

Following preliminary analyses, the results will be presented in the following order: Responses on Day I and Responses on Day II, respectively, with appropriate analyses for each of two phases on Day I and three phases on Day II. Following these analyses there will be a discussion of the responses on Day I in comparison to those same responses on Day II. Finally, analyses of

"turns away" and "testable state", respectively, will be considered. This section of the thesis will conclude with a summary of the principal findings.

Preliminary Analyses

Two variables were analyzed before the major analyses were performed: sex and the stimulus (beagle vs. tinder), respectively. These variables were counterbalanced across groups and were not expected to yield main effects or interactions with other variables. On Day I, for all experimental phases (habituation and dishabituation, respectively), a 2(group) X 2(sex) X 7(trial blocks) analysis of variance indicated a significant Sex main effect ($F=5.35$ (1,20), $p<.05$), however there was no significant Group X Sex interaction ($F=1.41$ (1,20), n.s.). Females were generally less responsive than males on Day I, eliciting an average of 40% and 43% turning toward the sound for the No Change and Change groups, respectively, in comparison to males who elicited an average of 54% and 47% turning toward the sound for the No Change and Change groups, respectively. On Day II, for all experimental phases (habituation, dishabituation, and novelty post-test,

respectively) a 3(group) X 2(sex) X 8(trial block) analysis of variance indicated a significant main effect for sex ($F=7.07$ (1,30), $p<.01$). Again males were more responsive on Day 11, turning toward the sound an average of 35%, 47%, and 54% for the No Change, Change, and Control groups, respectively, in comparison to the females who turned toward the sound only an average of 33%, 40%, and 43% for the same groups. As on Day 1, the Group X Sex Interaction was non-significant ($F<1$ (2,30), n.s.). Therefore, in all of the phases of the experiment, although there were significant differences between females and males, there were no significant Group X Sex Interactions, hence, all subsequent analyses were performed pooling across sex; group assignment served as the independent variable with repeated measures across trial blocks. A 2(group) X 2(stimulus) X 7(trial block) ANOVA yielded that during initial habituation and dishabituation there was no Stimulus

main effect ($F=1.68$ (1,20), n.s.) nor any Stimulus X Group Interactions ($F<1$ (1,20), n.s.).

Responses on Day 1

A. Response to the standard stimulus. The two experimental groups were compared for their percentage of headturning toward the standard stimulus on Day 1 across the first 30 habituation trials, blocked into six 5-trial blocks. A 2(group) X 6(trial block) ANOVA revealed that both the Change and No Change groups decreased their response to the sound across trials, indicating habituation (Trial Block $F=18.37$ (5,110), $p<.0001$), see Figure 1a. Infants initially turned toward the sound 63% in trial block 1, began to decrease their responding across trial blocks 2,3, and 4, and dropped to 27% and 21% by trial blocks 5 and 6 (linear trend on trial blocks, $F=77.22$ (1,22), $p<.0001$). There was no interaction between experimental group condition and trial blocks during the standard habituation phase ($F<1$ (5,110), n.s.). As expected, the groups behaved similarly on Day 1, as their experimental treatment did

not vary during the first testing session (see Figure 1a).

B. Reponse following 145-second ITI. The purpose of the 145-second ITI was to demonstrate that each infant was still responsive to auditory stimuli following habituation. Presentation of a novel word was avoided in order not to confuse possible "savings" effects of the specific stimulus on Day 11. Infants' response to the standard stimulus following a 145-second ITI was assessed in a 2(group) X 2(trial block) ANOVA in which the last block of the standard habituation phase prior to the 145-second ITI was compared to the dishabituation trial block. Both groups responded more on dishabituation trials compared to their response on the preceding trial block (Trial Block $F=50.47$ (1,22), $p<.0001$), indicating response recovery to the previously habituated standard stimulus. As expected there was no interaction between experimental group condition and trial blocks ($F<1.0$ (1,22), n.s.). When collapsed over group assignment infants showed a mean percentage of 72% of headturns toward the sound following the ITI,

compared to the 21% displayed in the last trial block prior to the delay (see Figure 1a).

Responses on Day II

A. Response to the standard stimulus. The principal question asked in this study is whether habituation of headturning following a 24-hour delay can discriminate among infants who receive either the same or different stimulus and whether both of these groups might differ from age controls who heard the stimulus for the first time. The focus of this study was an analysis comparing headturns toward the sound across trial blocks of an exact replication of the procedure following a delay of 24 hours. The groups might differ in several ways. The most likely difference would be the initial response on Trial Block 1, the first stimulus presentation following the 24-hour delay. Secondly, the groups might differ in habituation rate, with the infants hearing the same sound habituating more quickly over the trial blocks. Finally the groups might differ during recovery, with the No Change group expected to recover the least. The three groups were compared for initial responding on Trial Block 1 in a

3(group) X 1(trial block) analysis of variance. A significant Group main effect was found ($F=5.36$ (2,33), $p<.001$), and subsequent post-hoc analyses revealed that the No Change group differed significantly from the Age Controls ($p<.01$) in terms of their responsivity on Trial Block 1, whereas the Change group did not. All three groups were compared for their headturns toward the sound on Day 11 in a 3(group) X 6(trial block) analysis of variance. As on Day 1, there was a significant main effect for trial blocks ($F=27.92$ (5,165), $p<.0001$), with a linear trend accounting for most of the variance ($F=45.65$ (1,22), $p<.0001$). There was no Group X Block Interaction ($F=1.1$ (10,165), n.s.).

Figure 1b displays the groups' responses over trial blocks showing a drop from 69% on trial block 1 to 15% on trial block 6, suggesting habituation. A group main effect ($F=4.910$ (2,33), $p<.01$) and subsequent post-hoc analyses (Scheffe) revealed that the No Change group made fewer headturns toward the sound than Age Controls ($p<.05$).

B. Response following 145-second ITI. The three groups were compared for their percentage of headturning during the last habituation trial block and the

dishabituation block following the delay of 145 seconds. The question asked was whether recovery of headturning following an intertrial delay can serve to discriminate between infants of differential stimulus experience? A 3(group) X 2(trial block) ANOVA comparing the last habituation block to the dishabituation block revealed a Group X Trial Block Interaction ($F=20.2$ (2,33), $p<.0001$). Follow-up analyses (Scheffe) indicated that the No Change group differed significantly from both the Age Control and Change groups ($p<.05$), indicating the Change and Age control groups displayed recovery following the 145-second ITI, whereas those in the No Change group did not. Figure 1b shows that these infants responded to the sound on only 12% of these trials following the delay in comparison with the mean percentage of 53% and 65% displayed by the Change and Control groups, respectively.

C. Response to novel stimulus. Presentation of the novel stimulus provided an opportunity for all infants to show their responsivity to a new auditory stimulus following a long habituation series. Moreover, analysis of the experimental groups' responses to a uniformly presented novel sound retrospectively

emphasizes that the previous group differences in responding following the 145-second delay on Day II were not spurious group effects. A 3(group) X 2(trial block) ANOVA compared infants on the last habituation block to the novel stimulus block, and found recovery to the new word in all groups (Trial Block $F=64.01$ (1,33), $p<.0001$). Moreover, an ANOVA comparing the trial block following the 145-second ITI to the novelty trial block, revealed a Group X Trial Block Interaction ($F=7.76$ (2,33), $p<.0017$). Subsequent post-hoc analyses (Scheffe) revealed that the No Change group differed from both the Change and Age Control groups, indicating the No Change group recovered to novelty relative to its post-ITI behavior, whereas the Change and Age Control groups retained their responding ($p<.01$), see Figure 1b.

Responses on Day I versus Day II

Figures 2 and 3 compare the percentage of headturning toward the sound on Day I vs. Day II for the No Change and Change groups, respectively. A 2(group) X 2(day) X 6(trial block) ANOVA comparing the groups' percentage of headturning toward the sound during habituation blocks on Day I and II, yielded no

significant day effects of any sort. This indicates that neither the No Change or Change groups were less responsive during the habituation trials on Day II in comparison to Day I. A 2(group) X 2(day) X 1(trial block) ANOVA, comparing the percentage of headturning toward the sound on the dishabituation block on Day I and II, revealed a Day effect ($F=38.03$ (1,44), $p<.0001$), and a Group X Day Interaction ($F=9.11$ (1,44), $p<.004$). The No Change group's post-ITI behavior on Day II sharply contrasts to that on Day I (see Figure 2). The Change group's responsiveness following the 145-second intertrial delay is similar on both days (see Figure 3).

Turns away

The preceding analyses emphasized headturning toward the sound. An examination of turns away from the sound adds a new dimension to our understanding of sound localization. Turning away can be interpreted as an effort to avoid the sound. If one assumes that repetition of the same sound would eventually lead to avoidance rather than simply no response, one would predict that the No Change group would show increasing turns away on Day II over trials.

A 2(group) X 6(trial block) ANOVA comparing the two experimental groups' percentage of turning away from the sound on Day I, revealed no group differences ($F=2.17$ (1,22), n.s.). A 3(group) X 6(trial block) ANOVA comparing the groups' percentage of turning away from the sound over the first six trial blocks on Day II, revealed a Group main effect ($F=4.79$ (2,33), $p<.01$). Post-hoc analyses indicated that the No Change group differed significantly from the Age Control group in their percentage of turning away from the sound ($p<.01$). Collapsed over trial blocks, the No Change Infants displayed a mean percentage of 39% of turns away from the sound compared to 26% for controls.

Comparing turns toward to turns away from the sound offers an additional vehicle to assess whether an oft-repeated stimulus eventually becomes noxious. Trends for attention to the standard sound were assessed with difference scores calculated for each Infant by subtracting the number of turns away from the number of turns toward in each trial block. Scores not significantly different from 0, indicate random turning. A 2(group) X 6(trial block) ANOVA comparing the two experimental groups' difference scores for the habituation trials on Day I, revealed a significant

Trial Block effect ($F=4.84$ (5,110), $p<.0005$), with no group differences ($F=2$ (1,22), n.s.). Turns toward the sound predominated in early trial blocks, whereas turns away predominated in the last two trial blocks of the habituation phase (see Figure 4a). Turning toward predominated in the dishabituation trial block (trial block 7), with no group differences ($F<1.0$ (1,22), n.s.), see Figure 4a.

A 3(group) X 6(trial block) ANOVA comparing the three groups difference scores for habituation behavior on Day 11 revealed a Trial Block main effect ($F=9.02$ (5,165), $p<.0001$) and a Group main effect ($F=8.56$ (2,33), $p<.0001$). Again, turning toward the sound predominated in the early trials, whereas turns away predominated in later trials. Subsequent post-hoc analyses (Scheffe) on the Group main effect indicated that the No Change group differed significantly from both the Change and Age Control groups ($p<.01$), in that they displayed a larger percentage of turning away during the habituation trials on Day 11 than the Change and Control groups' Infants (see Figure 4b).

At the point of the dishabituation block of Day 11, the No Change group had heard the same word 65 times.

If the baby's post-ITI behavior approached chance levels the difference between headturns toward and away should have approached zero. An ANOVA comparing Infants on this block revealed a Group main effect ($F=11.73$ (2,33, $p<.0001$)). Figure 4b indicates that the No Change group responded with headturns away from the sound, whereas the Change and Age Control groups turned toward the sound following the 145-second ITI. Follow up analyses found that the No Change group differed significantly from the other two groups ($p<.01$), suggesting that headturning had become aversive for the No Change Infants.

A 2(group) X 2(day) X 6(trial block) ANOVA, revealed that there was a Day X Group interaction ($F=7.01$ (1,44), $p<.01$) for habituation trials. Moreover, a 2(group) X 2(day) X 1(trial block) revealed a Day effect ($F=20.04$ (1,44), $p<.0001$) and a Group X Day interaction ($F=7.08$ (1,44), $p<.01$). Both of these analyses support the increased responding with turns away for the No Change group on Day II (see Figures 4a and 4b).

State

Measurement of state was determined from coding the amount of fretting and eyes closed for each trial throughout each phase of the experiment. The following analyses employed the dependent measure of "testable" state, which is operationally defined as the percentage of each trial block in which the infant was neither fretting nor had eyes closed. Thus, testable state represents the percentage of each trial block that the baby was awake, alert, and quiet.

A 2(group) X 7(trial block) analysis of variance revealed no significant group differences in percentage of quiet, alert state on Day 1 ($F < 1.0$ (1,22), n.s.). A Trial Block effect ($F = 7.66$ (6,132), $p < .0001$) indicated that in general the neonates were in a more awake and alert state in early trials of habituation and became more drowsy and fretful by the end (see Figure 5a). Figure 5a reveals that there was a descending trend of quiet, alert state on Day 1 during the habituation trials, with a slight improvement of state following the 145-second intertrial delay.

A 3(group) X 8(trial block) analysis of variance revealed no significant group differences in state on Day 11 ($F < 1.0$ (2,33), n.s.). As on Day 1, there was a significant Trial Block effect ($F = 3.77$ (7,231), $p < .01$), again indicating a slight deterioration of quiet, alert state during habituation trials. Figure 5b demonstrates this decreasing trend, with infants displaying slightly more positive state in early trial blocks and deterioration over trial blocks, with a slight improvement in trial block 7 and to the novel stimulus, but again this difference was non-significant ($F < 1.0$). A 2(group) X 2(day) X (trial block) ANOVA was performed to ensure that there were no significant Day main effects ($F < 1$ (1,44), n.s.) in terms of the infants' "testable" state, nor any interactions ($F < 1.0$ (1,44), n.s.). Figure 6a and 6b reveal that there are no significant day differences in the percentage of quiet, alert state displayed by the two experimental groups ($F < 1.0$).

Summary of Results

On Day 1, all infants responded to the sound initially by orienting toward the sound source, and

decreased their response over trials. Following the 145-second silent delay they, again turned toward the sound, suggesting that their decreased responding was due to habituation rather than a state change or fatigue. Infants who continued to hear the same sound during habituation trials on Day II were less responsive than infants tested for the first time in this situation, indicating "savings". Moreover, the former infants shifted their response to turning away from the sound during Day II. Finally, this group did not recover following the 145-second ITI on Day II, whereas infants who heard a different sound on Day II or experienced the procedure for the first time, did. These effects imply retention of habituation for a specific sound in this group who had the same sound over 60 times. All groups displayed comparable levels of recovery to the novel post-test stimulus, emphasizing that the group differences found following the 145-second ITI were not due to state changes or other extraneous factors that might have prevented one group's recovery.

CHAPTER IV

DISCUSSION

The results of this study replicate the finding that neonates will turn toward laterally presented auditory stimuli (Muir & Field, 1979), habituate to repetition of familiar stimuli, and recover (dishabituate) to phonetically novel stimuli (Brody, Zelazo, & Chalka, 1984; Zelazo, Brody, & Chalka, 1984; Zelazo, Weiss, Randolph, Swain, & Moore, In press). Moreover, these data extend the initial demonstration of newborn habituation-dishabituation by including the influence of (1) an intertrial delay of 145 seconds on previously habituated stimuli and (2) a 24 hour delay before the repetition of the same procedure.

On Day 1, neonates in this study displayed dishabituation to the previously experienced (familiar) stimulus, as they would to a novel word, after a 145-second delay, replicating Zelazo et al., (In press), who found that 72-hour old neonates displayed recovery of localized headturning following delays of 100 and 145 seconds, but not delays of 10 and 55 seconds. An intertrial interval of 145 seconds allows sufficient

time for response recovery to the previously habituated sound.

The central findings of this study imply that newborns respond to the repetition of the same procedure following 24 hours, as a function of whether or not they received the same stimulus 24 hours previously (No Change) or a different stimulus (Change). Newborns experiencing the same stimulus were less responsive than control infants who were hearing the stimulus for the first time. Moreover, newborns in the No Change group displayed a greater percentage of headturns away from the sound than controls. Furthermore, the 145-second intertrial delay was insufficient to elicit recovery of headturning in the No Change group, indicating some form of "information savings" from the day before on the newborn's part. Interestingly enough, the intertrial delay was sufficient to elicit renewed responding in the Change group, indicating stimulus specific retention on behalf of the No Change group. Furthermore, the Change group responded following the 145-second ITI exactly as the Control group. This demonstration of differential responding following an intertrial delay on Day II is consistent with a memory interpretation. Response recovery implies that the previously familiar sound is

treated as novel, whereas continued responding at the habituated level implies that the familiar sound has remained redundant and uninteresting.

The analysis of headturns away strengthens the information processing view. If habituation implies that responding to redundant stimuli will decrease to chance levels, one would expect "no turns" to be as prevalent as turns toward or turns away following habituation. However, a close examination of post-habituation behavior to the familiar stimulus revealed that the continued presentation of the habituated stimulus did not simply lead to "no response". Following the 145-second delay neonates in the No Change group systematically turned away from continued presentations of the standard stimulus presumably in an effort to avoid the sound. This "systematic" avoidance implied that the neonate was still able to perceive the stimulus, but the stimulus had become aversive and elicited avoidant headturning. These data, taken together, lend themselves to interpretations of newborn information processing, and are consistent with Sokolov's (1963) model of orienting and defensive responses as a reaction to stimuli. According to Sokolov (1963), orienting responses involve stimulus

Integration, whereas defensive responses involve stimulus rejection, and the "orientation reactions appearing in response to almost any kind of stimulus are, in time, either displaced by defense reactions, or become extinguished" (Sokolov, 1963, p. 52). This theoretical framework may be applied to newborn auditory sound localization: auditory stimuli which prove sufficiently strong on repetition will give rise to defense reactions, and at the same time will give rise to stable orientation reactions in the immediately preceding period. The 145-second ITI on Day I appears sufficient to encourage the return of previously habituated orientation reactions; however, on Day II the delay no longer is able to reinstate the orientation reactions in the No Change group. The infants in this group continue to reject the familiar stimulus, shown by their defensive response of "turning away" from the stimulus.

In support of the above interpretation, Engen, Lipsitt, and Kaye (1963) found that with successive presentations of unpleasant odor stimuli, newborns progressively changed their response from a diffuse, disorganized response (i.e., whole body movements, fussiness) to a smooth, efficient response (i.e., a

quick headturn away from the direction of the odor) in escaping the odor stimuli. Moreover, Pomerleau-Malcuit and Clifton (1973) demonstrated that a noxious tactual stimulation elicited turning away from the stimulus. The failure of an oft-repeated stimulus to re-elicit orienting responses also appears in newborn visual behavior. In the paired comparison procedure (Fantz, 1959; 1964) the repeated familiar visual stimulus was avoided (i.e., there was no prolonged fixation), whereas the novel stimulus captured the infants' attention (visual orienting).

Earlier, I defined habituation as a waning of a response resulting from repeated stimulation not followed by reinforcement. Under what conditions may response decrement be taken as evidence for a learning process? The present data address this question. On Day 11, the No Change's group non-responsivity following the 145-second intertrial interval provides evidence that the infants have learned not to respond to the familiar stimulus. All the proper controls (i.e., the inclusion of a Change group and Age Controls) allow this conclusion to be made. Moreover, since adaptation and fatigue can be ruled out as a basis for response decrement (i.e., all infants in all groups responded

Identically to the novel word "papa"), one may conclude a process of learning, that is, learning not to respond to redundant stimuli.

Dannemiller and Banks(1983) correctly suggested that the most parsimonious interpretation of previous demonstrations of newborn habituation-dishabituation was a model of selective sensory adaptation. However, this model cannot account for the present data. Dannemiller and Banks (1983) characterized habituation as a function of selective neural fatigue, while recovery to a novel stimulus was due to the activation of a new set of neurons. However, the two principal findings reported above, beg their description of dishabituation.

A sensory adaptation model can account for recovery following a Intertrial silent delay, in that, sensory fatigue would build up during repeated presentations of the stimulus, and would dissipate following a "rest period" of no responding. However, the model cannot account for the non-recovery of the No Change group following the 145-second Intertrial delay on Day II. The sensory adaptation model falls short of explaining the experimental groups' differential responding on Day II following the Intertrial delay, largely influenced by

whether or not the the group received the same (No Change) or different (Change) stimulus on Day II. For the No Change group continued experience with the same stimulus facilitated retention of habituation, and hindered recovery following the delay. Second, the systematic avoidance of the standard stimulus implied that the neurons associated with that stimulus were not fatigued. The infants had to hear the counterbalanced location of the sound in order to consistently turn away from it. Again, this finding is at odds with a sensory adaptation model which would predict that post-habituation responding if retained over a 145-second intertrial delay should be reduced to chance. These data seem best explained by a information processing model. Implicit in this model is that neonates retain information about a repeated stimulus, and dishabituate following a 145-second intertrial delay as a function of previous experience with that stimulus.

A paradox exists, however, in the results reported above: If there is retention of habituation across several hours, why do neonates respond at all to the familiar sound during the habituation trials of the same sound following 24 hours? How would an information processing approach account for this seeming

contradiction of memory at one point in the procedure but not in another?

A good framework for interpreting these data lies in operationalizing 3 possible hypotheses of newborn longterm retention within the present study's experimental context (paradigm). There are three possibilities of how "savings" effects might manifest themselves in the infant's response during an exact replication of the procedure following 24 hours. These possibilities vary in their extent of retention. Specifically, there are two extreme possibilities ("all-or-none" longterm retention, respectively) and a third possibility which represents a "middle ground" of the two extremes.

First, one can hypothesize, that 24-hour retention of the specific stimulus would manifest itself both during habituation and dishabituation trials on Day II. This hypothesis suggests that following the 24-hour delay, the infants in the No Change group would remain habituated to the familiar stimulus or at least would be significantly less responsive relative to their responsivity on Day I. Second, one can hypothesize that there is no trace of stimulus-specific retention

following 24 hours in either the habituation trials or the dishabituation trials. This hypothesis suggests past experience in general would produce habituation, regardless of whether the same or different word was presented. Finally, one could hypothesize that 24-hour retention of the specific stimulus would manifest itself in either the infant's response during the habituation trials or in the infant's response during the dishabituation trials. This hypothesis suggests dissociating habituation from dishabituation (recovery) and vice versa. This hypothesis is consistent with the present data. A comparison of the No Change group's responsivity to the sound on Day II to Day I indicated no significant differences for the habituation trials. However, a day comparison of the dishabituation trials did reveal significant differences. Comparison between the two experimental groups' habituation behavior on Day II did indicate significant group differences during these trials (i.e., the No Change group was less responsive than the Change group and turned significantly more away from the sound). However, comparison between all three groups' responsivity on the first trial block following the 24-hour delay did reveal that the No Change group was significantly less

responsive than the Age Controls. Moreover, the Change group did not differ significantly from the Age Controls, indicating that the No Change group's performance on this trial block was influenced by their previous experience with the same word. This suggests that perhaps all habituation trial blocks should not be collapsed together when searching for Day effects, and that the first presentations following the 24-hour delay are the most sensitive to traces of memory.

An information processing view would account for this seeming contradiction of memory at one point in the procedure (dishabituation trials) and not at another (habituation trials) when comparing days, by regarding the habituation trials as "reminder trials". Rovee and Fagen (1976) found retention of conjugate footkicking to last up to 4 weeks if exposure to the stimulus was offered 24 hours prior to testing. In line with Rovee and Fagen (1976), it is possible to hypothesize that the habituation trials in the present study served as a "reminder" prior to the retention test (dishabituation trials). Re-exposure to the same stimulus presumably increased the number of attributes that infants encoded during habituation trials and in turn, the number of

potential retrieval cues available to them during the longterm retention test.

A direct test of this explanation would be to familiarize neoantes on Day 1 as in the present study, but, on Day 11 have one No Change group that receives 3 to 5 minutes of passive experience with the familiar stimulus prior to the repetition of the same procedure and another No Change group that simply re-experiences the familiar stimulus again during the second repetition of the procedure (i.e., habituation trials). The 3 to 5 minutes of passive exposure to the familiar stimulus could be delivered at midline, so the infant would not turn toward the sound. This procedure would serve as passive exposure to the stimulus (reminder) prior to the habituation trials for the former group. A third group would receive both passive experience and the procedure for the first time on Day 11 (controls). Perhaps, the infants in the No Change group who receive passive exposure to the familiar stimulus, would now show retention effects in the habituation trials on Day 11 relative to these same trials on Day 1, suggesting that

the "reminder of the stimulus" served to recall their previous experience with that stimulus.

In contrasting information processing by younger and older infants, Olson and Strauss (1984) suggested that "schema driven" memory emerges as a result of cortical maturation at only 6 months of age. Specifically, the authors characterized younger infant's ability to learn and remember as "constrained by neurological immaturity" (p.24), and therefore classified the cognitive processes employed by younger infants as qualitatively different. In the introduction I questioned whether the process that mediates attention, learning, and memory is qualitatively different at 6 months than the process employed by newborns. As stated earlier, the importance of the maturing cortex cannot be overemphasized in terms of the cognitive competencies that it facilitates; however, there are at least two sets of findings which imply that young infants process information in a similar fashion similar to older infants: (1) The data of newborns' response to stimuli following a intertrial delay reported above, implied that newborn attention is mediated by their existing schemata of relevant stimuli. It is remarkable that their retention of a stimulus is

much like that of older infants. What does distinguish newborns from older infants is the amount of familiarization required and the length of possible retention (Rovee-Collier, 1984). (2) A second body of data that implies similar information processing processes in younger and older infants is found in demonstration of longterm retention in infants under 3 months of age (Bushnell et al., 1984; Keen et al., 1965; Ungerer et al., 1979; Welzmann et al., 1971; Werner & Siqueland, 1978). Moreover the data reported above, implied that infants were able to recognize delayed presentations of a stimulus in the absence of a mature neocortex.

Olson and Strauss (1984) stated that examples of newborn habituation are best interpreted as a "manifestation of the infants' developing sensory abilities and the degree of cortical excitation that is generated by an individual stimulus....."lower order" explanations must also be considered when interpreting the newborn's learning and memory abilities" (p.8). It is argued here that newborns demonstrate sensitivity to intertrial delays and can retain previous experience for a period of 24 hours, and that these data (reported above) lend themselves to conclude that both younger and

older infants rely on similar processes to organize perceptual input into cognitive structures. Clearly, maturation greatly influences the development of perceptual and cognitive abilities; however, newborns do create cognitive representation (schema, memories) of repeated sensory information. Their attentional behavior is not simply a function of neural fatigue or sensory adaptation. Furthermore, newborn attention is mediated by the degree of previous experience with sensory information. In conclusion, the argument presented here is that the process of creating schema as a function of incoming sensory information, and attending to sensory information as a function of previous experience and of the current schemata, exists from birth.

In closing, there are several methodological points that merit discussion. The usefulness of the habituation-dishabituation paradigm coupled with the headturning procedure has been clearly demonstrated by this investigation. The re-presentation of the same sound after a silent intertrial delay may offer a more sensitive measure of retention of habituation in that it allows for response recovery to occur if habituation is not retained and allows for comparisons between short

and long term aspects of memory to be made (i.e., in this study longterm retention of experience on Day I appears to affect short term retention on Day II). The delay paradigm coupled with a novelty post-test offers a methodology for investigating long term retention in neonates and in particular stimulus specificity of that memory, and therefore, a direct test of the sensory adaptation model.

"Simply watch, observe carefully, don't underestimate, don't interrupt, don't overstimulate -- these are simple rules but nonetheless ones that many observers of infants over the years have found hard to apply" (Restak, R., 1986, p.181.).

APPENDIX A
FIGURES

Figure 1a.

Mean Percentage of Trials with Turns
Toward the Stimulus on Day I.

Figure 1b.

Mean Percentage of Trials with Turns
Toward the Stimulus on Day II.

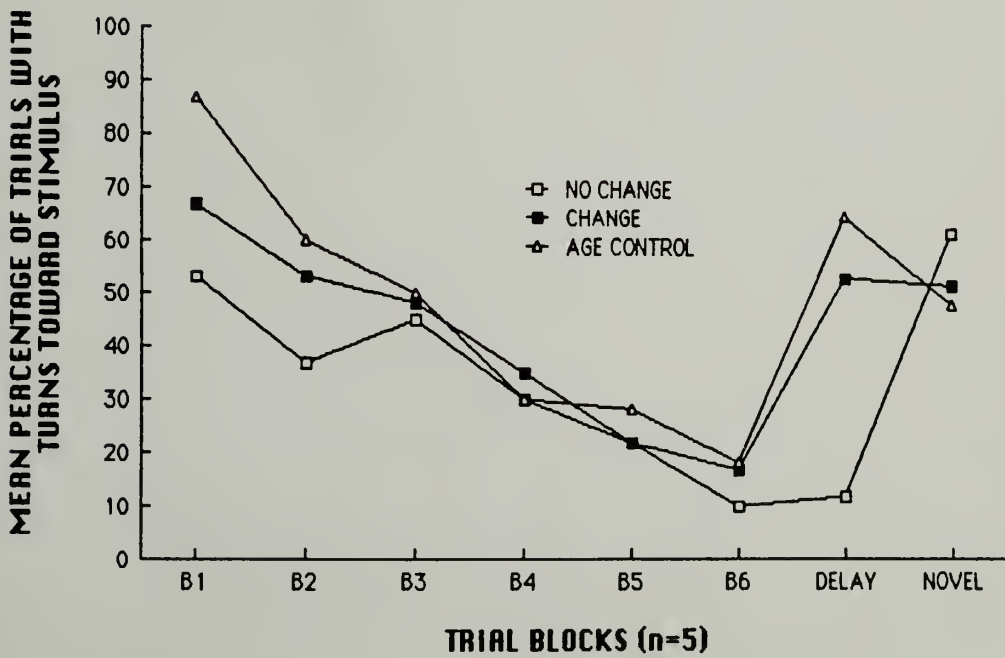
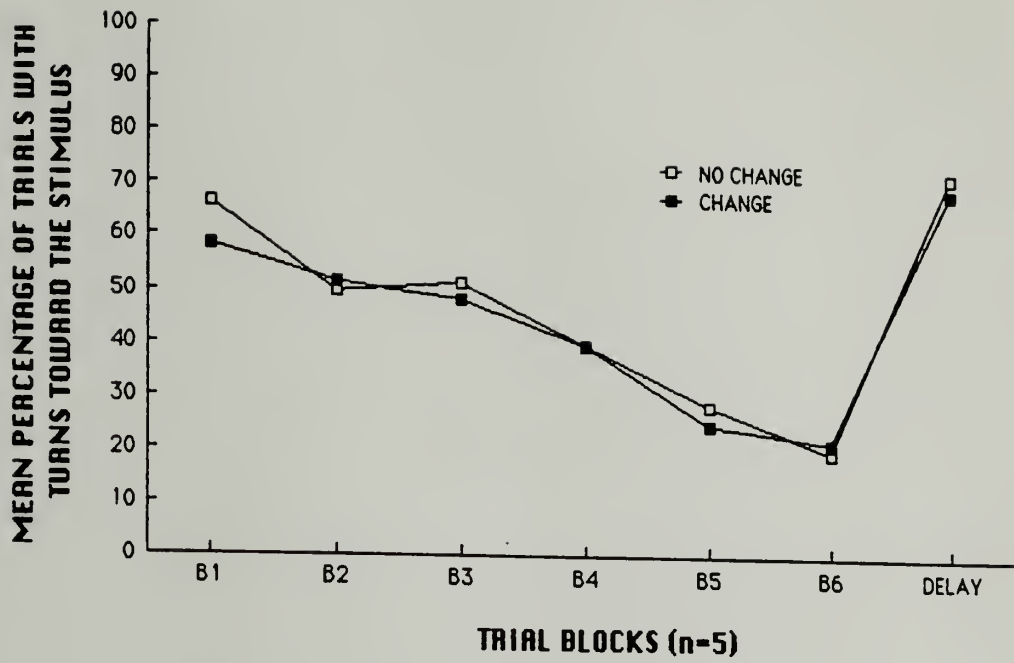


Figure 2.

Mean Percentage of Trials with Turns Toward
the Stimulus for the No Change Group
on Day I and Day II.

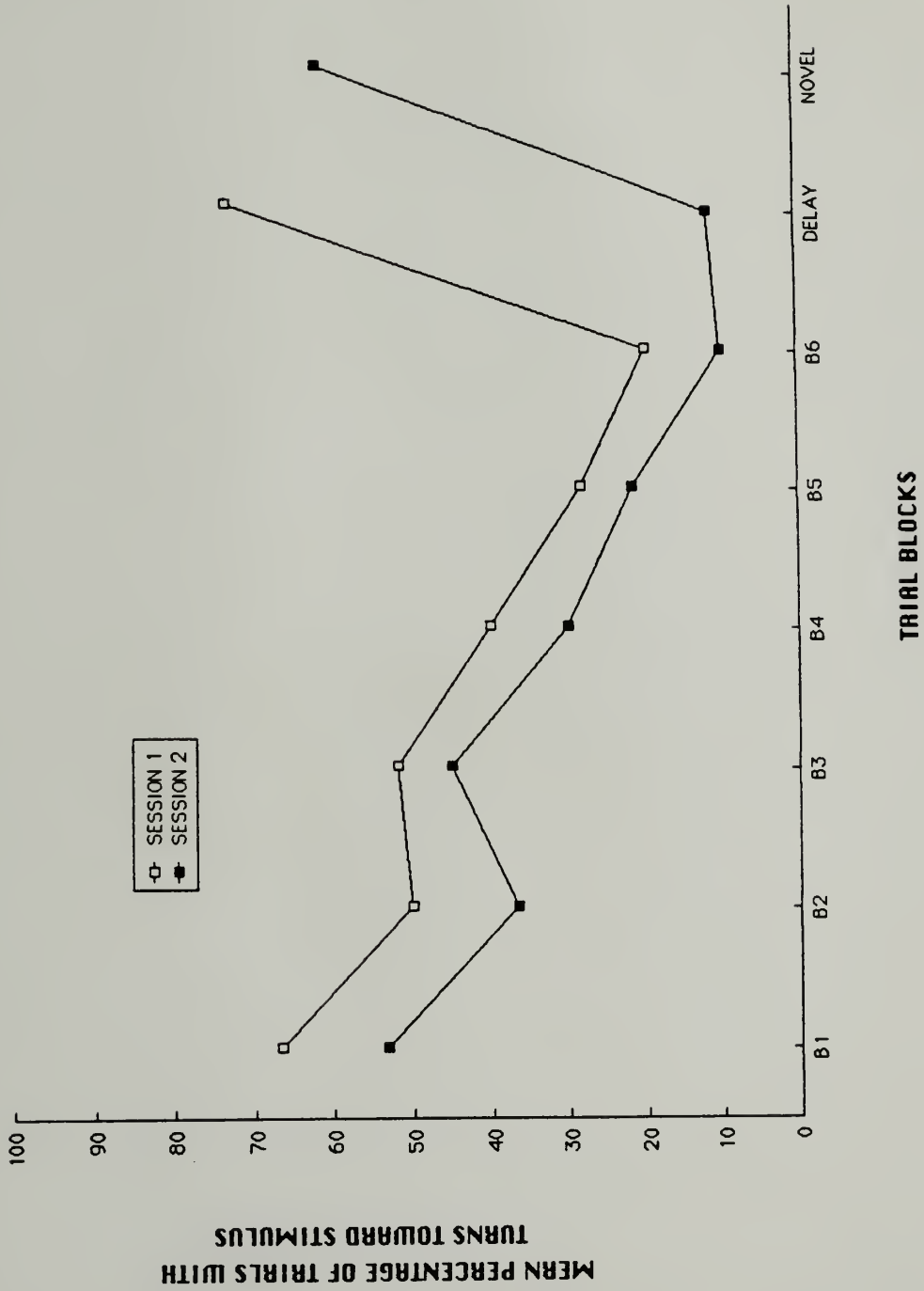


Figure 3.

Mean Percentage of Trials with Turns Toward
the Stimulus for the Change Group
on Day I and Day II.

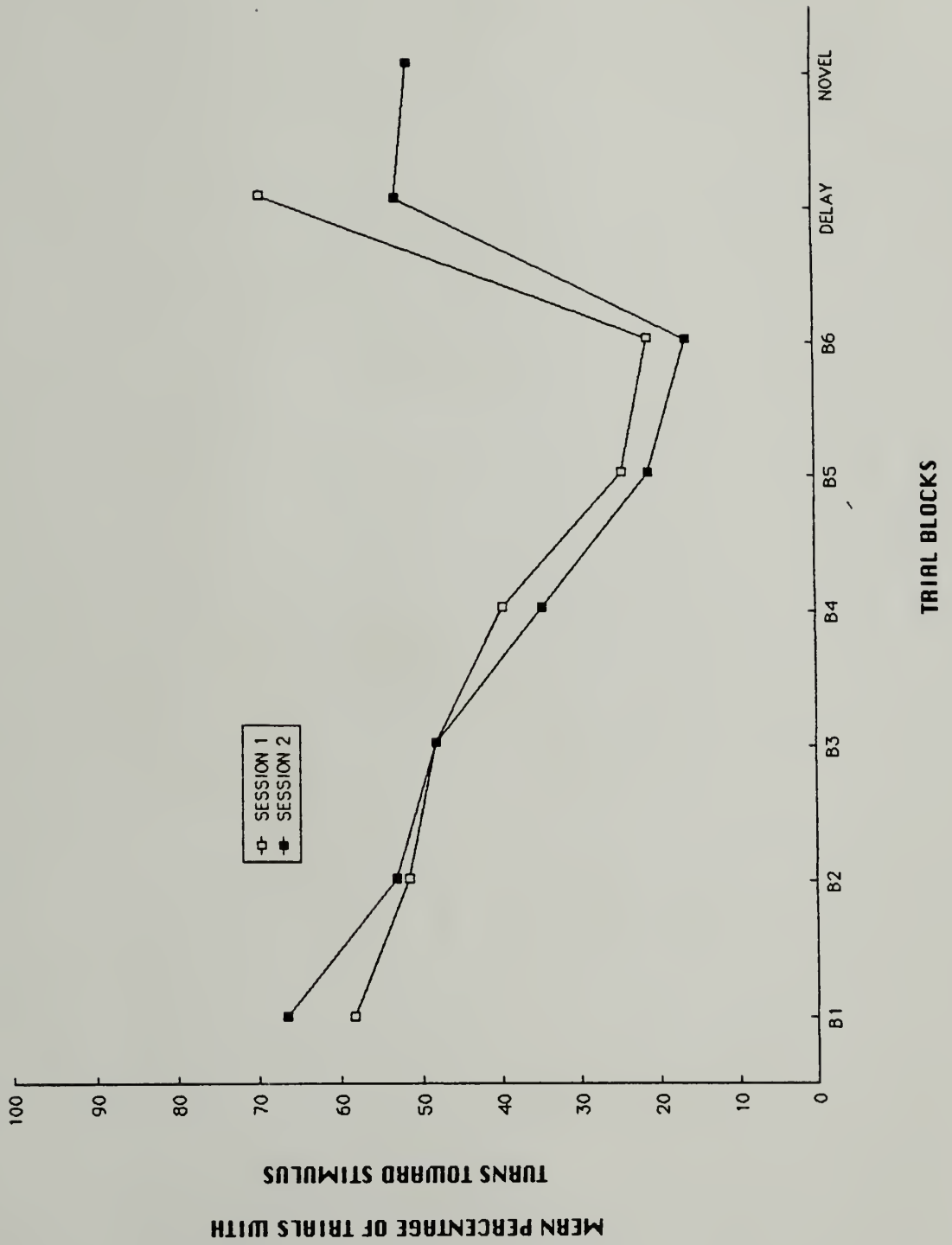


Figure 4a.

Difference Scores between Turns Toward
and Turns Away on Day I.

Figure 4b.

Difference Scores between Turns Toward
and Turns Away on Day II.

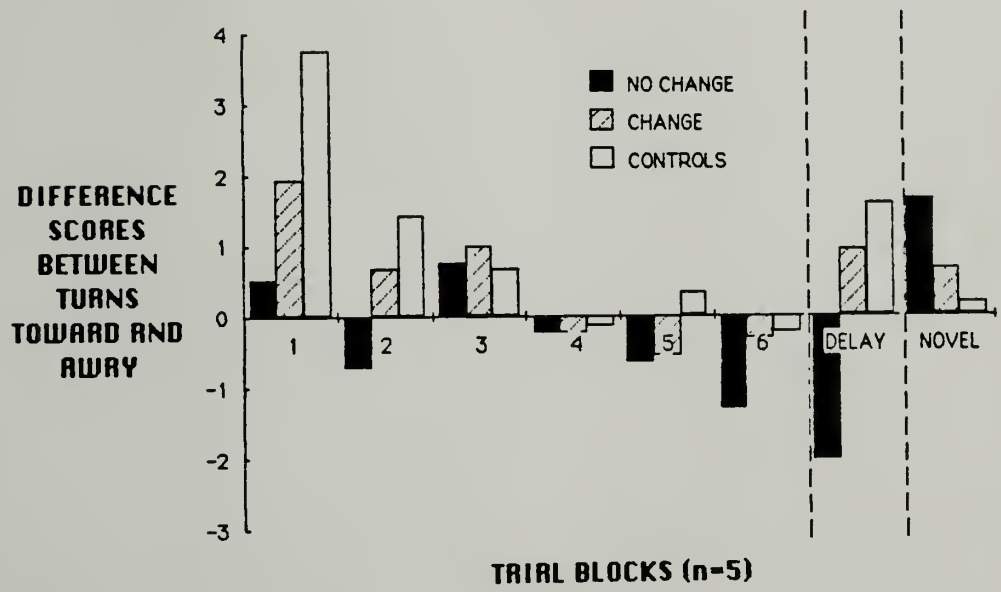
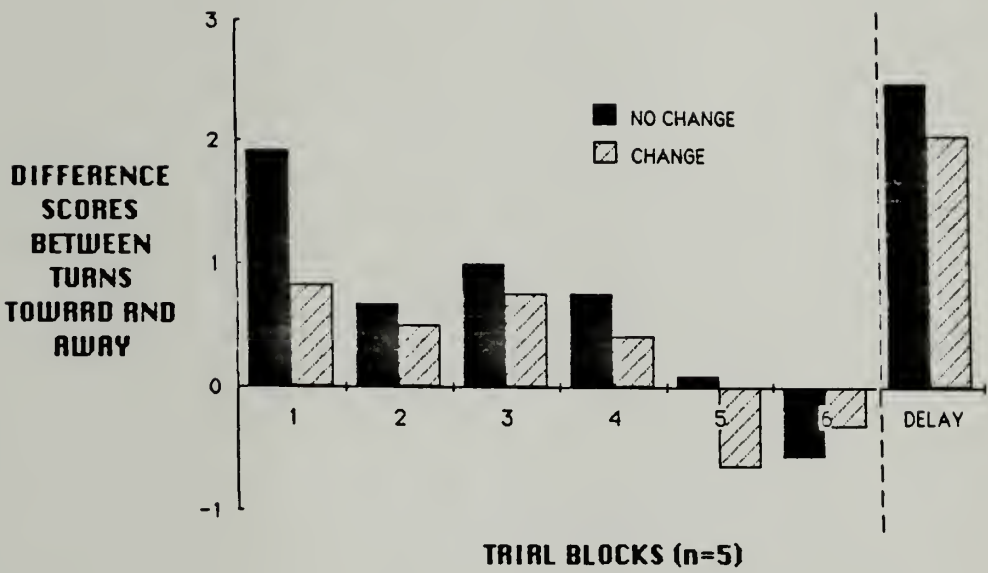


Figure 5a.

Mean Percentage of Positive State
on Day I.

Figure 5b.

Mean Percentage of Positive State
on Day II.

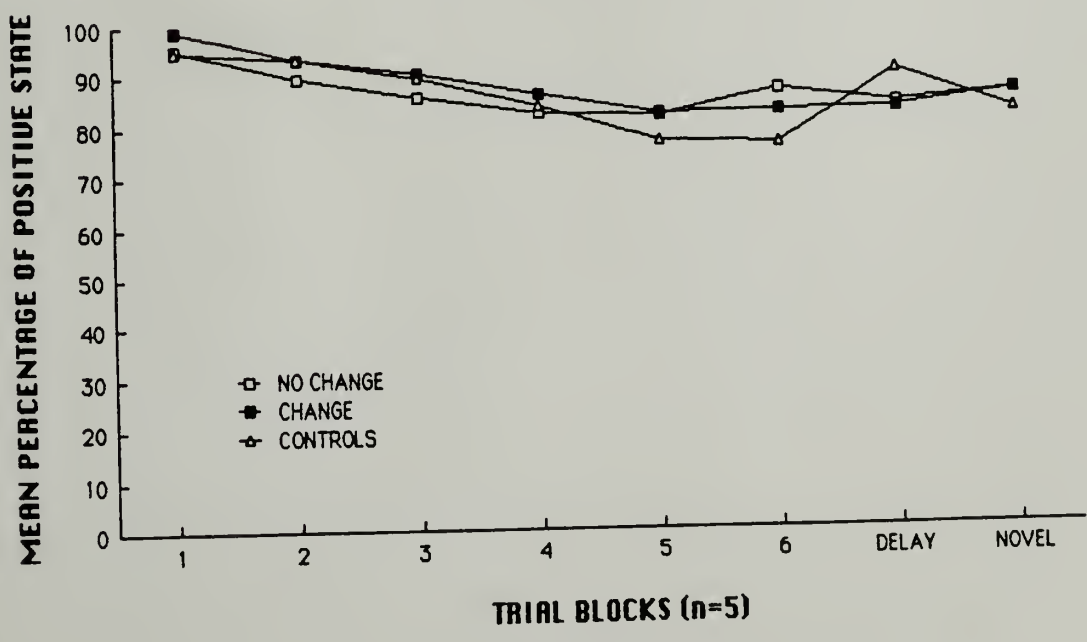
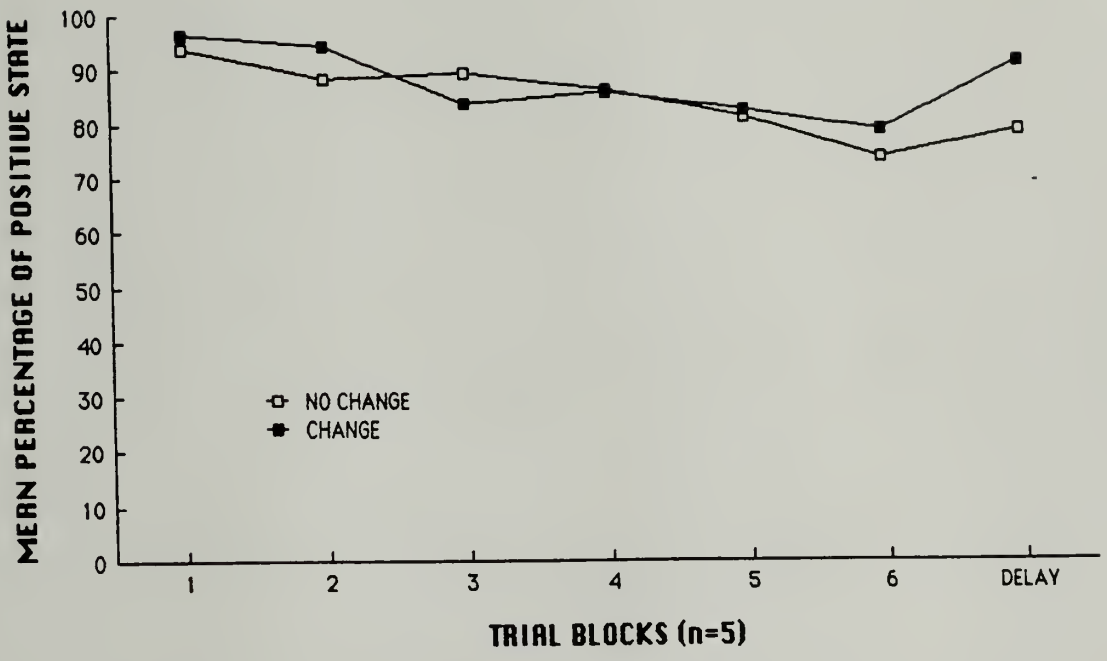
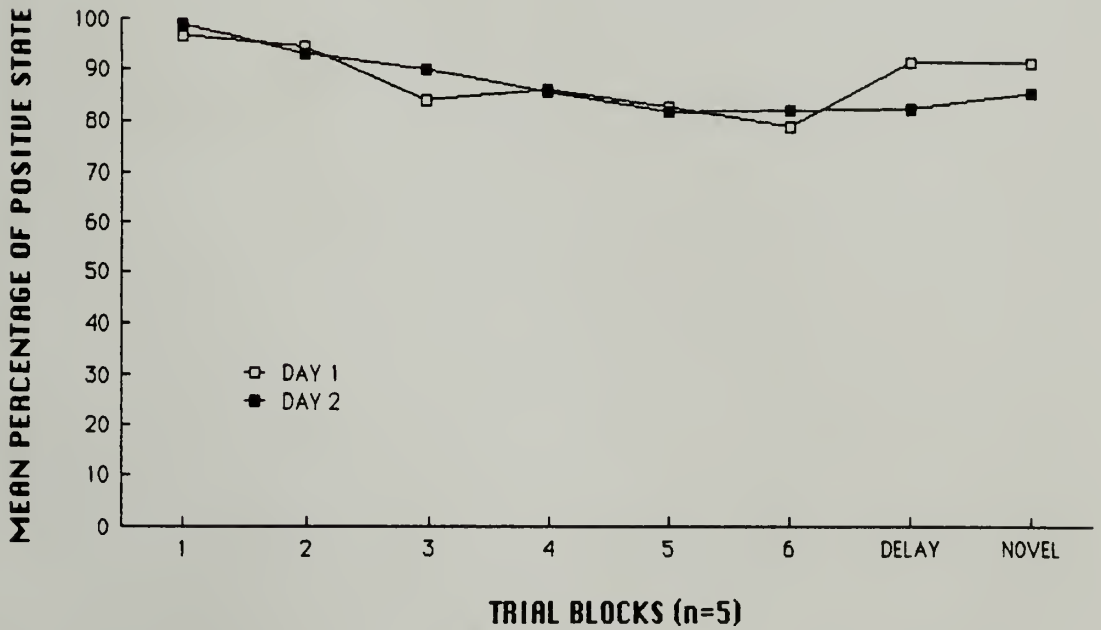
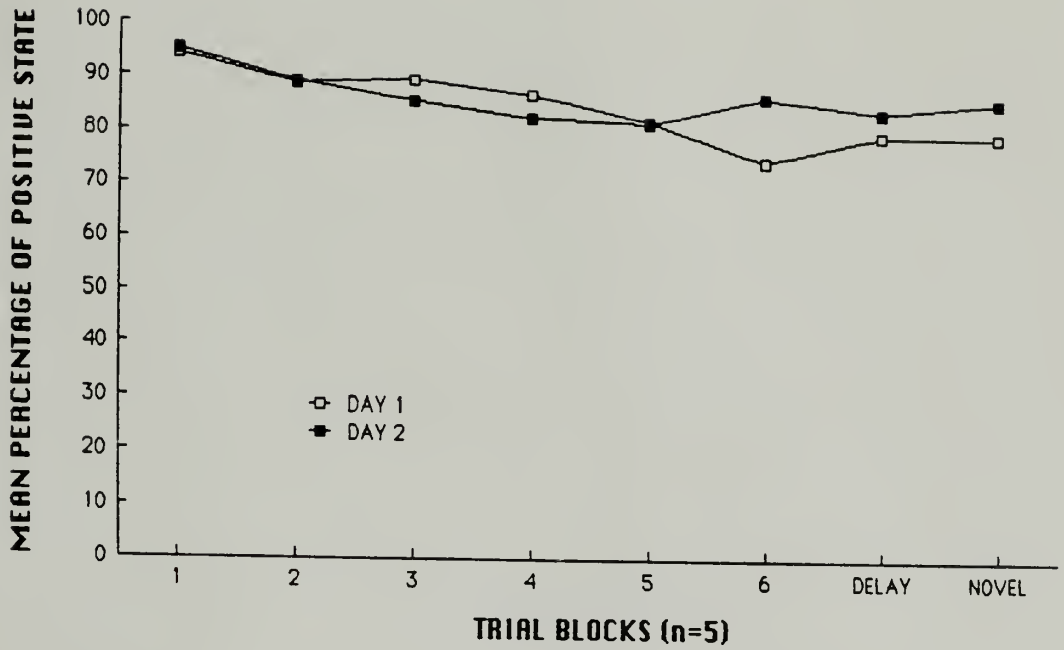


Figure 6a.

Mean Percentage of Positive State for the
No Change Group on Day I and Day II.

Figure 6b.

Mean Percentage of Positive State for the
Change Group on Day I and Day II.



APPENDIX B

TABLES

DAY I

DAY II

GROUP	N	MEAN AGE HRS.	STANDARD STIMULUS	# OF TRIALS (STAND)	DELAY (SEC)	# OF TRIALS (STAND)	MEAN AGE HRS.	STANDARD STIMULUS	# OF TRIALS (STAND)	DELAY (SEC)	# OF TRIALS (STAND)	# OF TRIALS (NOVEL)
NO CHANGE	6	46.83	BEAGLE	30	145	5	70.92	BEAGLE	30	145	5	5
	6		TINDER	30	145	5		TINDER	30	145	5	5
CHANGE	6	47.33	BEAGLE	30	145	5	71.25	TINDER	30	145	5	5
	6		TINDER	30	145	5		BEAGLE	30	145	5	5
CONTROL	6						71.75	BEAGLE	30	145	5	5
	6							TINDER	30	145	5	5
PHASE			HABITUATION		DIS-HABITUATION			HABITUATION		DIS-HABITUATION		NOVEL POST-TEST

Table 1. Design.

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