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Habituation–Dishabituation to Speech in the Neonate

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A counterbalanced between-groups design with repeated measures was used to demonstrate that both male and female neonates would habituate and dishabituate to repeated and novel speech sounds. Twenty-four full-term newborns with a birth weight greater than 2,400 grams and a mean age of 72.2 hours served as subjects in a head-turning sound-localization task. The results clearly indicated the reliable occurrence of two basic processes in the neonate: spatial orientation to sounds and response decrement to repeated speech sounds followed by response increment to novel speech sounds.

Recently, it has been reliably demonstrated that neonates will turn their heads to spatially orient to sounds (cf. Clifton, Morrongiello, Kulig, & Dowd, 1981; Muir & Field, 1979). Zelazo, Brody, and Chaika (1981, 1982) subsequently showed that this reflexive-like response, head turning to sounds, would habituate and dishabituate to repeated rattle sounds in female newborns. In contrast to previous neonatal auditory habituation experiments (cf. Bartoshuk, 1962; Bridger, 1961; Graham, Clifton, & Hatton, 1968; Kittner & Lipsitt, 1976), Zelazo et al. (1981, 1982) used a combination of strict methodological controls: The order of stimulus presentations was counterbalanced, response decrement to the repeated standard stimulus was demonstrated, and subsequent response recovery to a novel stimulus was established, using a procedure adapted from older infants (Zelazo, 1979, 1981).

The present experiment extended this research to establish that neonatal head turning would habituate and dishabituate to repeated and novel speech stimuli, respectively, in both male and female infants. A number of researchers have demonstrated that newborns are highly responsive to speech and to the sound of the human voice (cf. Cohen & Salapatek, 1975; Wolff, 1959). Halton (1982) has demonstrated that newborns will exhibit reflexive head turning to the source of speech sounds. Two-through 4-week-old infants have been found to display differential responding to familiar versus novel English words after a 41-hour delay (Ungerer, Brody, & Zelazo, 1978). Furthermore, the sucking response in 1-month-olds has been shown to habituate and recover to repeated and novel English phonemes (Eimas, 1975).

The present study differs from previous speech-discrimination studies in that most speech-discrimination studies have involved 1- to 5-month-old infants, not neonates (cf. Cohen & Salapatek, 1975). One study reported by Butterfield and Cairns (1974) used a habituation-dishabituation procedure with the neonatal sucking response, but the description of the study is incomplete; synthetic, rather than natural speech stimuli were used; and the results of the study have not been replicated. One of the most important omissions in the study is that the authors do not report the percentage of newborns who completed the study. Doubts about the generalizability of neonatal habituation studies have arisen because these studies have been plagued by high

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subject dropout rates, commonly as high as 90% (Butterfield & Cairns, 1974).

The present experiment sought to reproduce Butterfield and Cairns's (1974) lone finding of neonatal habituation-dishabituation to speech and Zelazo et al.'s (1981, 1982) lone finding of neonatal habituation using head turning as the dependent measure. The present experiment also sought to rectify some of the limitations of these two studies and to extend their findings. Thus, in the present experiment, natural, rather than synthetic, speech stimuli were used, extending Butterfield and Cairns's (1974) study; and both male and female neonates were tested, extending Zelazo et al.'s study (1981, 1982), which tested only females. Like the Zelazo et al. study (1981, 1982), strict methodological controls were used, including counterbalanced stimulus orders and stringent criteria for initial responding, habituation, and dishabituation. However, the procedure used in Zelazo et al.'s study (1981, 1982) was modified in the present study to reduce subject losses, which have been characteristically high in most neonatal habituation studies. It is important to lower this high subject loss rate if the habituation procedure is to be useful as a clinical assessment tool. To summarize, the present experiment systematically examined whether male and female newborns were capable of habituating to repeated natural speech and dishabituating to novel natural speech, as measured by a head-turning localization task using counterbalanced stimuli.

Method

Subjects

Twelve male and twelve female infants, mean ages 70.0 hours (range 49–98 hours) and 74 4 hours (range 51–102 hours) respectively, completed the study. In contrast to the experiment done by Zelazo et al. (1981, 1982), in which 20 of 58 infants were eliminated due to irritability, only one additional infant in the present study could not be tested. The low dropout rate is thought to be due both to a pretesting procedure in which infants were awakened gently and to a reduction in the length of the testing trials used by Zelazo et al. All newborns were selected randomly from the well-baby nursery at St. Margaret's Hospital for Women in Dorchester, Massachusetts. The sample was predominantly Caucasian from a lower middle to middle-class socioeconomic group. All newborns were healthy and full term, weighed more than 2,400 g at birth, and were free from major complications during pregnancy and delivery. Half of the males and half of the females were randomly assigned to a control group.

Procedure and Stimuli

All newborns were taken to a quiet, dimly lit laboratory between feedings. Before testing, infants were placed on a large table and their hospital undershirts were removed in order to put them in an alert, inactive state. They were allowed to lie free for 2 to 3 min, then held in a face-to-face upright position in the examiner's arms for another few minutes. After infants were in an alert, inactive state, a seated examiner held the infants in a supine position between two stereo speakers, located approximately .3 meters from each of the infant's ears The infant's head and shoulders were cupped in the examiner's right hand and the infant's lower back and buttocks were cupped in the examiner's left hand, using a procedure adapted from Muir and Field (1979). Examiners holding babies were unaware of the infants' group assignments and wore headphones with music playing to obscure the location of the sound source. Another observer, blind to the infants' group assignment, recorded head turns by pressing buttons on a silent button box The head turns were recorded as deflections on a Beckman R-511 Dynograph recorder. A third examiner kept track of trial lengths, stimulus presentation, infant group assignment, and habituation criteria.

Infants heard repeated trials of an assigned "standard" stimulus word (either "tinder" or "beagle") in a prehabituation phase of the experiment These two words were chosen as test stimuli because of their low frequency of occurrence (Kucera & Francis, 1967), their comparability in length, and their phonetic content, which has been found to be discriminable by infants in previous research (Eimas, 1975). The two words were each recorded and played on a separate channel of a Pioneer two-channel tape deck, Model #RT 1050 Initially, two tape loops (one for each stimulus word) were recorded by a female experimenter, who repeated each word in a consistent volume and neutral intonation at the rate of one word every 2 s. The actual duration of each word was approximately 1 second. Each tape loop was then transferred onto a larger tape for 30 minutes of continuous recording. A silent switch box was used to prevent clicking sounds from occurring when stimuli were changed Words were played to the infants at a 78 dB volume, A weighting, measured by a Realistic sound-level meter Half of the infants in both the experimental and control conditions heard "tinder" and half heard "beagle" as their standard stimulus These assignments were randomly determined.

Sounds were presented in a left-right-right-left order with initial side of presentation counterbalanced within experimental and control groups Presentation of the stimulus continued until the infant made a 60° turn toward or away from the sound source and held that position for 3 s If head turning did not occur, the trial was terminated after 30 s of stimulus presentation Intertrial intervals (ITI) averaged 10.69 s with a range of 2.0 s to 75.0 s. The ITI varied in length because the examiner established an alert, inactive state before the onset of each trial, stimulating infants if they were drowsy or quieting them if they were fussy The infants' heads were also returned to the midline before each trial began

During a prehabituation period, infants were required to turn toward the sound for 3 of 4 consecutive trials. Once the infants reached this localization criterion (after an average of 4.08 trials for experimental babies; 3.75

trials for control babies), trials were repeated until the infant habituated, that is, did not turn toward the sound and/or turned away from the sound for 3 consecutive trials. Experimental babies required an average of 6.75 trials postlocalization criterion to habituate; control babies required an average of 6.41 trials to habituate. The prehabituation procedure was used to ensure that babies in both experimental and control conditions were localizing sounds at a common level before habituation occurred. Muir and Field (1979) had reported that newborns turned their heads toward the source of a sound immediately and clearly. Because of the discrete nature of the head-turning response (as opposed to duration of visual fixation, for example), as well as its potential as a measure of individual differences, it was desirable to establish the reliable occurrence of sound localization by requiring a baseline level of responses as a condition for entry into the experiment. The prehabituation procedure thus prevented infants who did not orient initially from being treated as habituators.

Immediately following habituation to their assigned standard stimulus, a dishabituation (transformation) phase 1 was begun in which infants in the experimental groups were presented with the alternative stimulus. Thus, for infants receiving "tinder" as the standard, "beagle" was presented as the alternative; for infants receiving "beagle," "tinder" was the alternative. For experimental infants, the new stimulus was repeated for a minimum of six trials or until the infant did not turn and/or turned away for at least three consecutive trials. Control infants were presented with six additional trials of the standard stimulus during Dishabituation (Transformation) Phase 1. Following Dishabituation (Transformation) Phase 1, a second dishabituation (return) phase was begun in which infants in the experimental group were again presented with 6 trials of the original standard stimulus. Infants in the control group continued to be presented with the unchanged standard stimulus for 6 more trials.

To summarize, there were three phases to the experiment: a prehabituation-habituation (standard) phase, a dishabituation (transformation) phase 1, and a dishabituation (return) phase 2. During the prehabituation-habituation (standard) period, both experimental and control groups were required to meet an orienting criterion to a standard sound source followed by a variable number of trials until each infant met the criterion for habituation. On establishing habituation, Dishabituation (Transformation) Phase 1 was introduced in which a novel stimulus was presented to experimental infants followed by habituation. During Dishabituation (Transformation) Phase 1, control infants continued to hear 6 additional trials of the original stimulus. During Dishabituation (Return) Phase 2, experimental infants were again exposed to the original stimulus for 6 trials, as were control infants. The average length for the entire test procedure was 13.0 minutes with a range from 7.66 min to 22.50 min.

Interobserver Reliability

Interobserver reliability for the principal dependent measure, head turning toward the sound source, was determined for two different observers using four infants. One of the observers was always "blind" to the source and content of the speech stimuli by wearing stereo earphones. All trials for the four infants (totaling 80 observations) represented the data points for comparison. There was perfect agreement in 95% of the trials between the two observers.

Results

An initial analysis of variance (ANOVA) was performed to determine whether order of stimulus presentation within experimental and control groups yielded differences in the mean percentage of trials in which localized head turning occurred during each of the three phases of the experiment. The order of stimulus presentation (i.e., whether tinder or beagle was presented first) did not yield any differences, permitting the two orders for experimental and control groups to be pooled. Thus, all analyses reported below were calculated for group (experimental vs. control) and sex as the independent variables, with trial blocks as a repeated measure. Trial blocks consisted of groups of approximately three trials each, as discussed below. The dependent measure was the percentage of trials in each block in which localized head turning occurred. Three separate analyses were performed: an examination of responding during the prehabituation-habituation (standard) phase; a comparison of responding at the beginning of Dishabituation (Transformation) Phase 1 with responding at the end of the prehabituation-habituation (standard) phase; and a comparison of responding at the beginning of Dishabituation (Return) Phase 2 with responding at the end of Dishabituation (Transformation) Phase 1.

Prehabituation/Habituation Phase

Trials during the prehabituation-habituation (standard) phase were divided into four equal blocks for each infant. This was done because the number of trials needed to reach the habituation criteria varied across infants, and it was desirable to use all of the data. Each of the four trial blocks consisted of approximately three trials. It was decided not to use backward habituation curves because their use would have entailed disregarding some of the data. Moreover, clear evidence of initial responding as indicated by a complete display of all data is important to this procedure because the dependent variable, head turning, is both a discrete and low-frequency response, unlike sucking or visual fixation, which occur with greater frequency. The ANOVA revealed only one significant effect: Head turning varied over trial blocks, $F(3, 60) = 32.18, p < .001$. The mean percentage of head turns by the experimental and control groups over the four trial blocks for the nonsignificant Group × Blocks interaction, $F(3, 60) = .63$, *ns*, is illustrated in Figure 1. The means for the experimental babies over the four trial blocks were .77, ($SD = .29$), .67 ($SD = .33$), .52 ($SD = .39$), and .10 ($SD = .15$). The means for the control babies were .88 ($SD = .23$), .95 ($SD = .14$), .53 ($SD = .33$), and .05 ($SD = .11$).

Both experimental and control groups behaved similarly, $F(1, 20) = .30$, *ns*, as did both males and females, $F(1, 20) = 1.94$, *ns*, during this initial phase. A Neuman-Keuls post hoc analysis revealed that differences between the mean percentage of head turning for each pair of the four trial blocks was significant, with the exception of the difference between the first two trial blocks (all *p*s < .01).

Dishabituation Phase 1

The mean percentages of localized head turns during the final three trials of the prehabituation-habituation (standard) phase were compared with the mean percentage of localized head turns during both the first three trials and the second three trials of Dishabituation (Transformation) Phase 1. The ANOVA

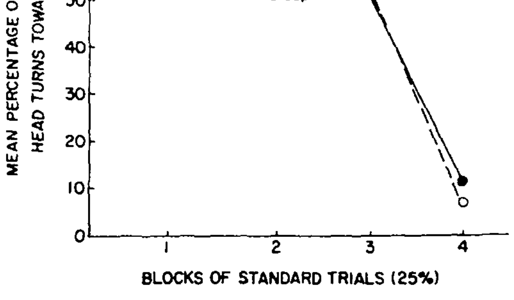

Figure 1 Percentage of head turns toward sound source for prehabituation and habituation (Standard) trial blocks

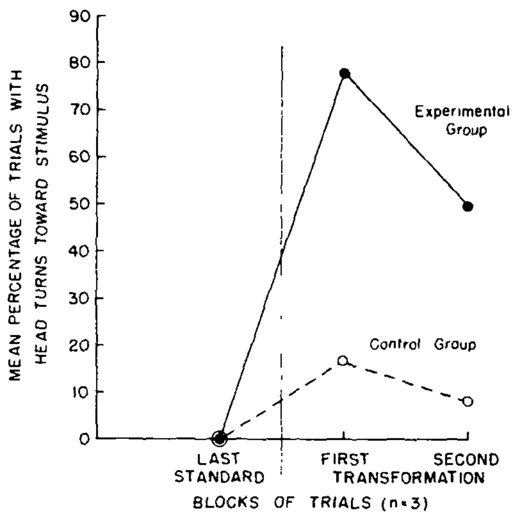

Figure 2 Percentage of head turns toward sound source for last habituation (Standard) and first two dishabituation (Transformation) Phase 1 trial blocks

revealed significant effects for groups, $F(1, 20) = 73.50, p < .001$; trial blocks, $F(2, 40) = 26.17, p < .001$; and a Groups × Trial Blocks interaction, $F(2, 40) = 11.29, p < .001$, illustrated in Figure 2. It can be seen in Figure 2 that although both experimental and control groups began and finished their rate of head turning at near identical points, there was greater recovery of head turning for experimental infants who heard the novel speech stimulus than for control infants. A Newman-Keuls post hoc analysis revealed that experimental infants had a significantly greater percentage of mean head turns than control infants during the first and second Dishabituation 1 (Transformation) trial blocks (*p*s < .01) but not during the last habituation (standard) trial block. During the last habitation block, the means and standard deviations for the percentage of head turns by both experimental and control babies were 0. During the first and second blocks of Dishabituation Phase 1, the mean percentages of head turns by experimental babies were .80 ($SD = .22$) and .50 ($SD = .35$). For control babies, the means were .17 ($SD = .21$) and .08 ($SD = .14$). These results confirm the primary prediction of interest, namely, that infants hearing the novel word would display dishabituation of head turning relative to control infants hearing a redundant signal. Again, both males and females behaved similarly, $F(1, 20) = 2.69$, $p = .12$.

Dishabituation Phase 2

The mean percentages of localized head turns during the final three trials of Dishabituation (Transformation) Phase 1 were compared to the mean percentages of localized head turns during both the first three and second three trials of Dishabituation (Return) Phase 2. The ANOVA revealed significant effects for groups, $F(1, 20) = 4.47$, $p < .05$, for trial blocks, $F(2, 40) = 7.74$, $p < .005$, and for the Groups × Trial Blocks interaction, $F(2, 40) = 4.96$, $p < .025$, illustrated in Figure 3. A Newman-Keuls post hoc analysis revealed that experimental infants had a significantly greater percentage of localized head turns than control infants during the first and second Dishabituation (Return) Phase 2 trial blocks but not during the last trial block in Dishabituation (Transformation) Phase 1. During the last trial block of Dishabituation Phase 1, the mean percentage of head turns by experimental babies was .02 (SD = .08) and by control babies it was .08 (SD = .10). During the first and second blocks of Dishabituation Phase 2, the mean percentages of head turns by experimental babies were .47 (SD = .37) and .28 (SD = .30) and by control babies they were .14 (SD = .25) and .06 (SD = .18). These results provide a within-subjects replication of the dishabituation that was displayed clearly by experimental infants in Dishabituation (Transformation) Phase 1. As in Dishabituation (Transformation) Phase 1, male and female infants did not differ in their responses during Dishabituation (Return) Phase 2, $F(1, 20) = .50$, *ns.*

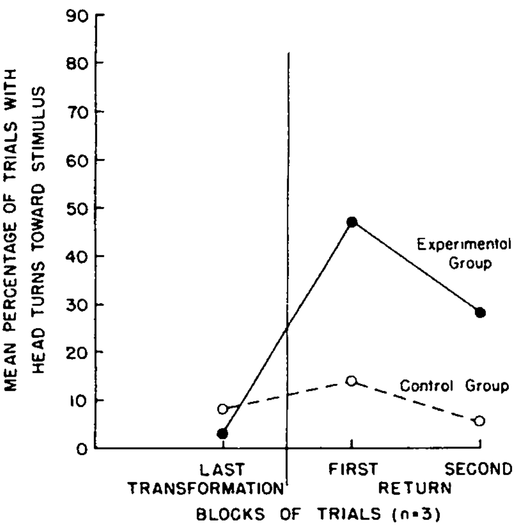

Figure 3. Percentage of head turns toward sound source for last dishabituation (Transformation) Phase 1 and first two dishabituation (Return) Phase 2 trial blocks.

Discussion

The present study's results systematically confirm two basic neonatal capabilities in response to speech sounds: spatial orientation and habituation-dishabituation. The results extend previous research demonstrating that neonates will orient to rattle sounds (Clifton et al., 1981; Muir & Field, 1979; Zelazo et al., 1981, 1982). The strict methodological criteria used in the present study indicate that head turning is a clearly reliable and observable neonatal measure that carries potential for both clinical and research application with neonates.

Historically, neonatal habituation-dishabituation has been difficult to establish (cf. Butterfield & Cairns, 1974) and has been characterized by high subject losses. The present study not only brought subject losses to a desirable level (1/25) but also increased the duration of infants' task attentiveness to as long as 23 minutes. Moreover, in the present study, the use of counterbalanced stimuli, the absence of order effects, the attainment of response decrement by 100% of the sample, and the highly reliable response increment shown by the experimental group (including a within-subjects replication of the dishabituation) extend the clarity of findings from the initial neonatal habituation-dishabituation study using head turning (Zelazo et al., 1981, 1982). Thus, methodological improvements made in the present study increase confidence in the demonstration of the newborn's auditory habituation-dishabituation capability.

The findings from this study also extend the head turning habituation-dishabituation research (Zelazo et al., 1981, 1982) to male as well as female neonates. Unlike the present study, this previous research had not clearly demonstrated recovery of localized head turning by the experimental group during the second dishabituation phase (Zelazo et al., 1981, 1982). The difference in infants' performance during Dishabituation Phase 2 may be due to the shorter task duration in the present study (M = 13 min), as compared with the previous study (M = 17.45 min). The use of 30-s rather than 45-s trials in the present experiment may have produced less fatigue during Dishabituation Phase 2, leaving infants better able to process incoming information. Finally, the present study also corroborates Butterfield and Cairns' study (1974), indicating that neonates will habituate to some aspects of language and extends these findings to natural, as opposed to synthetic, speech stimuli.

The demonstration of habituation of localized head turning in both experimental and control groups, and dishabituation in the experimental, but not the control group, implies that 72-hour-old neonates are able to retain some aspect of English words. The present study cannot specify exactly which aspect of speech neonates remember: for example, phonetic contrast, voice timbre, and/or intonation. Moreover, it is possible that infants did not form memories for repeated and novel words but instead discriminated familiar versus novel words on the basis of differential stimulation of categorical phoneme receptors, as suggested by the research on infant speech perception (Eimas, 1975). The present study cannot directly address this issue. However, since the habituation-dishabituation paradigm has been used as a measure of information processing in older infants (cf. Cohen & Salapatek, 1975; Zelazo, 1979, 1981), and in neonates using visual stimuli (Adkinson & Berg, 1976), the results strongly imply that neonates can remember some aspect of speech, not merely that they are capable of sensory adaptation or discrimination (cf. Zelazo et al., 1982).

References

Adkinson, C., & Berg, W. (1976) Cardiac deceleration in newborns. Habituation-dishabituation, and offset responses. *Journal of Experimental Child Psychology, 21*, 46–60

Bartoshuk, A. K. (1962). Human neonatal cardiac acceleration to sound: Habituation and dishabituation. *Perceptual-Motor Skills, 15*, 15–27.

Bridger, W H (1961) Sensory habituation and discrimination in the human neonate *American Journal of Psychiatry, 117*, 991–996

Butterfield, E C, & Cairns, G F. (1974). Discussion summary—Infant reception research. In R L Schiefelbusch & L L Lloyd (Eds) *Language perspectives, Acquisition, retardation and interaction* (pp 75–102) Baltimore University Park Press

Clifton, R., Morrongiello, B, Kulig, J, & Dowd, J (1981). Newborns' orientation toward sound Possible implications for cortical development. *Child Development, 52*, 833–838

Cohen, L, & Salapatek, P (Eds). (1975). *Infant perception From sensation to cognition* (Vol 2) New York. Academic Press.

Eimas, P. (1975) Speech perception in early infancy In L Cohen & P Salapatek (Eds.), *Infant Perception From sensation to cognition* (Vol 2, pp. 193–231). New York Academic Press

Graham, F K, Clifton, R. K, & Hatton, H. M (1968). Habituation of heart rate response to repeated auditory stimulation during the first five days of life *Child Development, 39*, 35–52.

Halton, T (1982) *The newborn infant's directional response to speech and music* Unpublished doctoral dissertation, Boston University

Kittner, S, & Lipsitt, L P (1976) Obstetric history and the heart rate response of newborns to sounds *Developmental Medicine and Child Neurology, 18*, 460–470.

Kucera, J., & Francis, W (1967) *Computational analysis of present-day American English* Providence, RI: Brown University Press

Muir, D, & Field, J (1979) Newborn infants orient to sounds. *Child Development, 50*, 431–436

Ungerer, J., Brody, L, & Zelazo, P (1978) Long-term memory for speech in 2 to 4-week-old infants. *Infant Behavior and Development, 1*, 177–186

Wolff, P (1959) Observation of newborn infants *Psychosomatic Medicine, 21*, 110–118

Zelazo, P. R (1979) Reactivity to perceptual-cognitive events Application for infant assessment. In R. Kearsley & I Sigel (Eds.), *Infants at risk Assessment of cognitive functioning* Hillsdale, N J. Erlbaum

Zelazo, P R (1981) An information processing approach to infant cognitive assessment In M Lewis & L Taft (Eds.), *Developmental disabilities Theory, assessment and intervention* (pp 229–255) Jamaica, New York: S P Medical and Scientific Books.

Zelazo, P, Brody, L, Chaika, H (1981, April). *Auditory habituation and dishabituation in the newborn* Paper presented at the Annual Meeting of the Eastern Psychological Association, New York

Zelazo, P, Brody, L, & Chaika, H (1982) *Neonatal habituation and dishabituation of head turning to auditory signals* Paper submitted for publication.

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