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Habituation of Infants' Cardiac Response to Speech Stimuli

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TREHUB, SANDRA E., and CURRAN, SUSANNE. Habituation of Infants' Cardiac Response to Speech Stimuli, CHILD DEVELOPMENT, 1979, 50, 1247–1250. In an attempt to explore the relation between the amount of variability in a stimulus and rate of habituation to that stimulus, 4 groups of infants 4–5 months of age were presented with repeated speech stimuli which were synthesized exemplars of [baba], natural exemplars of [baba] or [kaba], or novel syllables on each trial. Infants' cardiac responses to the auditory stimuli were recorded, and the number of trials to a proportional criterion of habituation of the heart-rate decelerative response was determined. Infants were found to habituate most rapidly to the synthesized [baba] stimulus which remained constant across trials and least rapidly to the speech syllables which changed from trial to trial.

Although habituation techniques have been widely used as means of exploring infant perception and memory, the phenomenon of habituation in infancy is still poorly understood (Jeffrey & Cohen 1971). Sokolov's (1963) work on the orienting reflex has fostered the view that habituation reflects ongoing cognitive processes (Cohen 1973; Lewis 1971) and is, therefore, of conceptual as well as methodological significance. Upon successive presentations of a stimulus, a hypothesized neuronal model is constructed and elaborated so as to incorporate information concerning the properties of the repeated stimulus. As the model gets increasingly elaborated (stimulus features encoded), the orienting reflex decreases in magnitude or habituates.

Some researchers have hypothesized that the more complex the stimulus or the more information involved, the longer the infant will take to form a memory engram or model of that particular stimulus. In support of this view, several studies have found the rate of habituation of visual fixation to be a monotonic function of stimulus complexity (Caron & Caron 1969; Cohen 1973; Fantz 1964). Brown (1974), however, found lesser presentations to checkerboard stimuli of intermediate complexity, a finding which supports theories which relate attention to optimal levels of complexity (McCall & McGhee 1977) rather than to complexity per se.

The relation between complexity of stimulation and rate of habituation has not been explored in the realm of infant auditory perception; this was the principal focus of the present investigation. Specifically, habituation of infants' cardiac response (heart rate) was compared for groups of infants receiving various recorded stimuli which differed in complexity, operationally defined for the present purposes in terms of extent of stimulus variability. Heart-rate deceleration was selected as the response measure in the present study because it is a prominent physiological component of the orienting response, one which is thought to index attentional processes reliably (Graham & Clifton 1966). Speech stimuli were selected over other auditory stimuli on the basis of earlier work which pointed to the important stimulus properties of human speech (Haugan & McIntire 1972).

On the basis of Sokolov's (1963) ideas, it was expected that infants' heart-rate decelerative response to auditory stimulation would habituate more slowly as the amount of stimulus variability increased. In the present study, four stimulus sets which differed in the extent of such variability were employed: repetitions of a synthesized version of [babá], repetitions...
of a natural speech version of [baba], repetitions of a natural speech version of [kaba], and natural speech versions of a reduplicated monosyllable that changed from trial to trial (e.g., [baba], [gigi], [pupu], etc.). The first set (synthetic [baba]) provided the greatest amount of invariance over time because the vowel portion of stimulation was steady state or unchanging; the second set (natural [baba]) reflected the moment-to-moment variations found in natural speech in contrast to the steady-state portions of the synthetic stimuli; the third set (natural [kaba]) had an added variation in the second contrasting syllable. Whereas these three stimulus sets involved some within-stimulus variation coupled with invariance across trials, the fourth stimulus set (syllable-change group) had the added variation of changes in consonants and vowels across trials.

The synthetic [baba] tape comprised 30 trials of three-formant tokens of [baba], concatenations which had been synthesized by rule as single syllables. The natural [baba] tape comprised 30 identical trials of [baba] spoken by a female adult. The natural [kaba] tape consisted of the same voice saying [kaba]. In anticipation of the possibility of slower habituation for the syllable-change group, the fourth tape consisted of 50 trials of the female voice saying different consonant-vowel syllables. All stimuli were 1 sec in duration, and each of the stimuli and component syllables were of approximately equal intensity (flat inflection). All stimuli were presented at 68-70 db (A scale). Each trial consisted of three presentations of the two-syllable stimulus separated by 1-sec interstimulus intervals. Intertrial intervals (stimulus offset to onset) varied randomly from 25 to 35 sec. Infants were said to have habituated at the first two consecutive trials in which they showed a response decrement of 50% or more compared with the level of responding on the two initial trials. When a 50% or greater response decrement was obtained on each of two consecutive trials, the second of those trials was designated as the trial at which the infant habituated.

The subjects were 66 infants, 4½-5½ months of age. Infants were excluded from the data pool if they failed to react to sound presentation during the first two trials with an average heart-rate deceleration of at least 7.5 beats per min (bpm) in the first 6 poststimulus sec (N = 12), if they fussed excessively or cried during testing (N = 10), or if their heart-rate record was unreadable due to large movements (N = 4). The final sample consisted of 40 infants, 20 females and 20 males, with a mean age of 19.98 weeks. Infants were assigned to one of the four stimulus conditions so as to equalize as far as possible the age and sex composition of these groups.

Two testing rooms separated by one-way glass were used. One room was used for mother and infant, and a comfortable chair which faced the glass was provided for them. A 12-watt/8-ohm speaker (Radio Speaker of Canada) was placed approximately 1.4 m in front of the chair. A multicolored lantern that revolved during testing was used to direct the infant's attention toward the loudspeaker. The lantern was concealed by a small wooden screen and was placed directly in front of the speaker. A set of headphones (Sony Stereo DR-5A) connected to a cassette tape recorder (Toshiba KT-20P) served to distract the mother from the sound presentation directed to the infant. Ambient noise level at the infant's head was 43 db (A scale), as measured by a General Radio Company sound level meter (type 1551C). The second room contained the equipment and experimenter. A Beckman R511 Dynograph was used to record infants' heart rate, and a Beckman Type 9857 cardiotachometer converted heart beats to rate in bpm. The output from one channel of a Uher tape recorder (Royal Deluxe) was fed into the speaker in the subject room. This output was also fed into the Dynograph, which triggered an event recorder.

After a brief familiarization period, three sites on the infant's body were cleaned for electrode application. These included areas slightly above each nipple and approximately 2.5 cm above the navel. Beckman miniature electrodes (650437) were then applied. The mother was instructed to sit quietly in the chair and to hold the infant seated on her lap facing away from her. The mother was also asked not to interact with her infant during the test session. She was further instructed to listen to the music on the cassette tape (via the headphones) when this was made available. (Mothers later reported that they had attended to the music.) The lantern was then uncovered, the headphones were placed over the mother's ears, and the experimenter left the room. This designated the beginning of the test session. In the equipment room, the experimenter adjusted the heart-rate reading so that it fell within the calibration range (usually 120-180 bpm). Approximately 30 sec after
leaving the room, the experimenter turned on the tape recorder, and the test session continued without interruption until the infant fussed or cried, until movement artifact precluded further heart-rate readings, or until the maximum number of stimulus presentations had taken place.

Heart rate was reduced from the polygraph record (1.5 bpm = 1 mm vertical pen displacement; 1 sec = 1 cm horizontal pen displacement) by calculating the average heart rate for 1 sec immediately prior to stimulus onset (prestimulus) and the average heart rate for each of the 12 sec after stimulus onset (poststimulus). When there was a change in heart rate within a second, heart rate for that second was the weighted average of the different heart rates observed within that second. A second rater calculated heart rate independently, and differences never exceeded 0.5 bpm in any second. Twelve difference scores were obtained by calculating the difference in heart rate between each of the 12 poststimulus sec and the prestimulus second. A single numerical index of the level of responding on each trial (deceleration index) was computed by averaging three adjacent difference scores of peak magnitude from the 12 poststimulus difference scores. The three selected difference scores followed the peak, ended with it, or surrounded it, depending upon which three yielded the highest average. The initial level of responding was calculated by averaging the deceleration indices of the first two trials of stimulus presentation. There were no group differences in initial response, as revealed by an analysis of variance.

The median number of trials to habituation for synthetic [baba], natural [baba], natural [kaba], and syllable-change groups was 5, 7, 6.5, and 11, respectively (M = 6.1, 7.4, 7.4, and 10.3). These data were analyzed with a Kruskal-Wallis analysis of variance by ranks, and an overall significant difference between groups was found, \( H^* (3) = 8.03, p < .05 \). Mann-Whitney \( U \) tests indicated significant differences between synthetic [baba] and syllable-change groups, \( Z = 2.48, p < .01 \); between natural [kaba] and syllable-change groups, \( Z = 1.67, p < .05 \); and between synthetic [baba] and natural [kaba] groups, \( Z = 1.73, p < .05 \). Similar comparisons between natural [baba] and syllable-change groups and between synthetic [baba] and natural [kaba] groups closely approached acceptable significance levels, \( Z = 1.56, p < .06 \), and \( Z = 1.44, p < .07 \), respectively. No other comparisons including sex differences were significant.

As predicted, rate of habituation was related to the complexity of the stimulus, defined here in terms of the extent of stimulus variability. Infants habituated most rapidly to synthetic [baba] and least rapidly to the syllable-change stimulus. This finding provides qualified support for the view that habituation is a function of stimulus complexity (Caron & Caron 1969; Fantz 1964), such that the more variability or information in a stimulus the longer the infant will attend, or the longer it will take to form an engram of that stimulus. If stimulus variability is accepted as an index of complexity, then the present study can be said to extend the relation between stimulus complexity and rate of habituation to the auditory realm, at least so far as the cardiac decelerative response is concerned. Support for the complexity-habituation relation is qualified in the sense that a perfect ordering in rate of habituation was not obtained for the four groups. That is, although the synthetic [baba] group habituated most rapidly and the syllable-change group least rapidly, the two intermediate groups, natural [baba] and natural [kaba], did not differ significantly from each other. It should be noted, however, that the synthetic stimulus was modeled after a male speaker while the remaining stimuli were generated by a female speaker. Thus, it is possible that differences associated with perceived sex of speaker could have contributed to more rapid habituation to synthesized compared with natural syllables.

There are a number of alternative explanations for the absence of differences between natural [baba] and [kaba] groups. Infants might not be capable of discriminating [ka] from [ba], in which case they would be expected to respond in similar fashion to the natural [baba] and [kaba] stimuli. However, these syllables differ in both voicing and place of articulation, and there is ample evidence that young infants can discriminate both of these features, even when they occur independently (Morse 1972; Trehub & Rubinstein 1972). Alternatively, the similarity in rate of habituation between natural [baba] and [kaba] groups may indicate that the habituation process does not reflect fine gradations in infants' information-processing activities. Even if the rate of habituation can reflect such gradations, the present measure of number of trials to a 50% decrement criterion may not
be sufficiently sensitive for that purpose. Finally, the increased variability of natural [kaba] compared with [baba] may not be reflected in greater psychological complexity for infants. In this regard, it should be noted that several adults who rated these stimuli on the complexity dimension considered [kaba] to be more complex than [baba]. For these adults, however, the synthetic stimulus was rated as more complex than [kaba] or natural [baba].

In summary, an infant's rate of habituation appears to be related, at least in part, to the variability present in auditory stimulation. These results, while offering partial support for theories linking complexity and rate of response decrement, cannot be used to discredit theories of habituation that relate attention to optimal levels of complexity (McCall & McGhee 1977). These theories predict an inverted-U function between complexity and responding such that a stimulus which is either too simple or too complex will elicit minimal attention. Exponents of such a viewpoint would argue that the stimuli of the present study were drawn from the initial or ascending portion of the inverted-U curve and that the inclusion of stimuli of greater complexity would reveal the expected function.

References


Haugan, G. M., & McIntire, R. W. Comparisons of vocal imitation, tactile stimulation and food as reinforcers for infant vocalizations. Developmental Psychology, 1972, 6, 201-209.


Trehub, S. E., & Rabinovitch, M. S. Auditory-linguistic sensitivity in early infancy. Developmental Psychology, 1972, 6, 74-77.