SHORT-TERM HABITUATION OF THE INFANT AUDITORY EVOKED RESPONSE

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Short-term habituation of the vertex auditory evoked response was studied in six infants (age 10 to 14 weeks). The infants were presented trains of four synthetic speech stimuli. The average amplitude of the evoked responses was largest to the first member of the stimulus train and then decreased rapidly. The average amplitudes to the second, third, and fourth stimuli in the train were 36, 41, and 22% of the first stimulus amplitude, respectively. The results suggest that the auditory evoked response of awake infants satisfies several of the criteria for short-term habituation.

When adults are presented acoustic stimuli grouped into discrete trains (for example, clicks at one-second interstimulus intervals with 100-second inter-train intervals), the amplitude of the auditory evoked response (AER) at the vertex decreases as a negative exponential function of the number of stimulus presentations; it decreases faster the faster the stimulus presentation rate and recovers spontaneously when stimuli are withheld (Fruhstorfer, Soveri, and Jarvilehto, 1970). The decrease in AER amplitude reaches asymptote by the third to fifth presentation of a stimulus in a train (Ritter, Vaughan, and Costa, 1968; Fruhstorfer et al., 1970). Fruhstorfer (1971) has argued that the observed short-term reduction in AER amplitude over the first three to five presentations of a stimulus in a train is an instance of habituation (Thompson and Spencer, 1966).

Although short-term habituation of the AER has been well documented for adults, it has not been reported for infants. Weber (1972) presented 14- to 18-week-old infants with a single train of stimuli grouped into alternating blocks of 2000-Hz pure-tone stimuli and 125-Hz square-wave stimuli. The interstimulus interval was constant (1.5 seconds) throughout the train. No systematic decrement in AER amplitude within the blocks of stimuli was observed. Weber concluded that the neural structures underlying short-term AER habituation may not be fully developed until some time after birth. However, this conclusion may have been premature since Weber did not present discrete stimulus trains, but rather a single stimulus train. To facilitate the comparison of infant and adult data on AER habituation, the present study used a paradigm similar to that of Fruhstorfer et al. (1970) to investigate the effects of repeated stimulus presentation on the amplitude of the infant vertex AER. At the same

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time, the study served to establish an efficient methodology for collecting reliable AERs from awake infants.

METHOD

Subjects

A total of six infants (five males and one female) completed all of the conditions of the study. All of these infants were between 10 and 14 weeks old. For two additional infants, the experimental sessions were terminated before completion due to excessive crying.

Apparatus

Recording of the electroencephalogram (EEG) was made from the scalp using a single silver-disk electrode located 1 cm lateral to the fontanel which was referenced to the right earlobe. Electrodes were attached to the scalp by styrofoam adhesive pads and an elastic headband. Electrode impedance was less than 6 K Ohms.

The EEG signals were transmitted by telemetry (Narco FM-1100-E3) to an AC preamplifier (W-P Instruments DAM 6) and an oscilloscope amplifier (Tektronix RM 502A) which also served as a monitor. The frequency response curve after amplification was flat between 2.0 and 30 Hz. The amplified EEG was stored on tape for later analysis using a Vetter FM-3 Recording Adapter and Sony 355 tape deck.

The extraction of the evoked response from the EEG was carried out on- and off-line by a computer of average transients (Fabri-Tek 1072). The sweep duration was one second. The averaging cycle of the computer was triggered by a pulse from the second channel of the stimulus presentation tape. The onsets of the cuing pulses and the synthetic speech stimuli were simultaneous. The AER records were written out on an *X-Y* plotter (Hewlett-Packard 7035b).

Stimuli

The stimuli used in this study were trains of the stop consonant–vowel syllable [ba]. The duration of the syllable was 250 msec, the rise time measured from stimulus onset to maximum stimulus amplitude was 25 msec, and the intensity was 65 db SPL. The stimuli were generated on the Haskins Laboratories' computer-controlled speech synthesizer (Mattingly, 1968).

Design and Procedure

During a session, 15 trains of four stimuli were presented at a rate of one train every 30 seconds from an AR 4-X loudspeaker placed two feet in front of the infant. (The stimuli were never presented when an infant was active or fussing. Thus, on a number of trials for all infants, an intertrain interval of greater than 30 seconds was used). The repetition rate of the stimuli was one stimulus every two seconds. Each infant's state was monitored continuously during the experiment by a trained observer. The stimuli were presented only when the infants were awake (eyes open) and quiet.

The infants were held in their mothers' laps and were either bottle or breast fed during the test session. The mothers were instructed to hold the infants as quietly as possible and not to move the infant's bottle during the presentation of the stimuli.

Analysis of the AERs

The amplitude of the N1-P2 response was determined from the *X-Y* plots by measuring the difference in millimeters between the maximum peak of negativity between 75 and 150 msec after stimulus onset (N1) and the maximum peak of positivity between 175 and 275 msec (P2). The responses to each member of the stimulus train were averaged separately. The first 10 good responses (trials with no infant movement) out of the 15 possible responses were accumulated for each average.

RESULTS

The amplitude and range of the N1-P2 response as a function of the position of the stimulus in the train is shown in Figure 1. The amplitudes of the second,

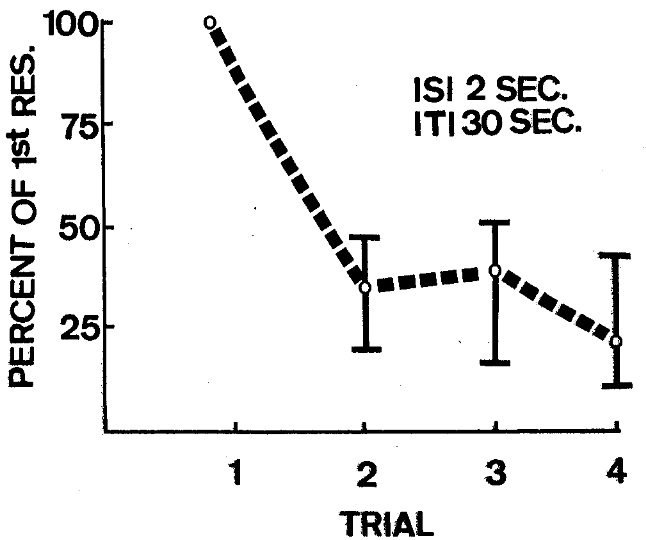

FIGURE 1. Amplitude and range of the second, third, and fourth stimuli in the stimulus train expressed as a percentage of the first stimulus amplitude. The interstimulus interval was two seconds (ISI two seconds). The interval between successive trains of stimuli was 30 seconds (ITI 30 seconds).

third, and fourth stimuli in the train are expressed as a percentage of the first stimulus amplitude. The mean amplitudes of the second, third, and fourth stimuli in the train were 36.0, 41.0, and 21.7% of the first stimulus amplitude. All amplitude reductions were significantly different from the first stimulus amplitude ($p < 0.01$) using a rank sum test.

DISCUSSION

Relatively little difficulty was encountered in collecting artifact-free AERs from the awake infants. As long as the infants were brought into the laboratory hungry and were fed during the recording session, EEG artifacts due to infant movement were minimal. The use of FM telemetry rather than long cables to convey the EEG data to the recording apparatus undoubtedly helped minimize movement artifacts.

The N1-P2 amplitude of the vertex AER in the awake infants decreased rapidly as a function of the repeated presentation of the syllable [ba] in a stimulus train. The magnitude and time course of the decrease in N1-P2 amplitude of the infant AER is consistent with the findings of both Ritter et al. (1968) and Fruhstorfer et al. (1970) on the short-term habituation of the adult AER. However, because of the differences in the interstimulus and intertrain intervals between the present study and the previously cited studies with adults, the rates of habituation of the infant and adult AERs cannot be directly compared.

When the stimulus train was withheld during the 30-second intertrain interval, the N1-P2 amplitude recovered spontaneously. This was evidenced in the difference in N1-P2 amplitude to the first and fourth members of the stimulus train. Thus, the decrease in the amplitude of the N1-P2 component of the infant AER in response to the repeated presentation of the syllable [ba] satisfies two of the characteristics of short-term AER habituation: (1) a rapid decrease in AER amplitude over the first four presentations of a stimulus in a train and (2) recovery of AER amplitude when stimuli are withheld (Fruhstorfer, 1971). This conclusion is, of course, limited to the N1-P2 response. Further studies should determine whether other AER components behave similarly. If the occurrence of habituation is contingent upon a functional short-term memory as Sokolov (1963) and Jeffrey and Cohen (1971) have suggested, then the present results indicate at least a rudimentary short-term memory in 10- to 14-week-old infants.

The results of the present study are in marked contrast to Weber's (1972) report of no short-term habituation of the infant AER. Weber's experimental design, however, does not appear appropriate for assessing short-term habituation. Instead, it seems to have asked the question whether a habituated AER can be dishabituated by a change in stimulus parameters within a continuous stimulus train. On this view, Weber's results may be interpreted as a failure to demonstrate recovery of AER amplitude as a function of stimulus change rather than as a failure to observe short-term habituation.

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