was no better than chance (t = 1.07, df = 20). Five of 10 Ss[1] in the OL group recalled all four stimuli in the short list. These Ss, who showed perfect retention for the stimuli in the short list, were among those in their group who reached criterion on the long list. The relative frequencies with which stimuli from the short list were recalled while learning the long list were 50% for four of these Ss and 65% for the fifth. Their recall while learning the long list were therefore not solely a matter of the availability in memory of the stimuli from the short list.

DISCUSSION

There are two conclusions from the present study. The first is that free-recall learning is facilitated when overlearning is provided S on a substantial part or subset of the learning task and, secondly, that such learning transfer is not accounted for primarily on the basis of an increase in the probability with which the previously learned subset of stimuli are recalled during practice. Since the difficulty of the learning task used in this study has been shown to be related to the form and amount of internal structure produced by the interrelationships existing in this group of stimuli (Whitman & Garner, 1963), it appears likely that the transfer effect produced with overlearning reflects a change in the variables characterizing the stimuli as these are perceived by S. Such a change would also change the internal structure in the group of stimuli constituting the long list, and since the transfer is positive, the changed internal structure would be one that facilitates free-recall learning. The change suggested here refers to how S perceives the stimuli in the learning task and would be analogous to the change that occurs when, in language learning, combinations of letters become meaningful as words.

Tulving (1966) interprets the transfer in free recall as involving the reorganization of memory units into higher order units. The material in the learning task he used consisted of meaningful words. He found negative transfer in several part-to-whole learning studies, and the learning curves shown in his report as reflecting this negative transfer are similar to those for the control and CR groups in the present study (see Fig. 2). He has suggested that subjective units were formed during the part learning which was inappropriate in the subsequent learning. Bower & Lesgold (1969) replicated Tulving's result with single-word presentation also using meaningful words, but they also found that part-to-whole transfer was highly positive when such list words were organized or grouped for S, with the whole list organization being compatible with the part list organization.

For these investigators the unit of analysis is the individual stimulus, and not the entire group of stimuli in the learning task, and the memory units are groups of stimuli. But the present study with visual figures shows that with overlearning and the consequent greater ability to recall a substantial part or group of the stimuli in the learning task, the recall of the group of overlearned stimuli is not significantly greater than it would be without such prior training, *and* still positive learning transfer occurs. This result is not consistent with an interpretation of learning transfer in which the unit for analysis is the individual stimulus.

The type of transfer in this study, however, may differ from that produced in the studies of Tulving (1966) and Bower & Lesgold (1969), whose Ss learned meaningful words. The difference between these two classes of material in the complexity of the variables descriptive of each, as well as the findings of Bower & Lesgold (1969) would suggest that such a distinction is required.

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NOTE

1. Recall from one S was excluded due to E's error.

Acoustic vigilance behavior in four-year-old children*

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Eighty 4-year-old Ss were given an acoustic vigilance task in which they were to signal the presence of pure tones which appeared irregularly, infrequently, and at faint suprathreshold levels. In several significant aspects these young Ss behaved similarly to adults. Acoustic vigilance testing is discussed as a potentially useful framework in which to assess and observe children's attentional behavior.

Vigilance is essentially that behavior observable when Ss attempt to identify the presence of signals which are faint, infrequent, and irregular. It is a potentially useful measure of human behavior because it seems to require the kind of global attention which apparently underlies performance on most tasks, and it appears to be relatively uncontaminated by the requirement of higher-level perceptual or cognitive processing.

Vigilance research, promoted mainly by military and industrial interests, seems mostly to have dealt with adults' attention to visual signals (e.g., watch keeping, quality-control inspection). Children's information processing, on the other hand, depends heavily upon the input of acoustic stimuli, and it would be helpful if some measure of their acoustic vigilance behavior were available. This paper reports an initial attempt to develop a task permitting the controlled observation of acoustic vigilance. Specifically, we were interested

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Table 1
Response Means of 80 Four-Year-Old Ss for Signals Following Five Intersignal Intervals in the First and Second Halves of the Vigilance Task

	Intervals (in Seconds)				
	5	7	12	20	26
Period 1	.60	.58	.46	.45	.47
Period 2	.50	.40	.40	.40	.43

in determining if young children's vigilance to acoustic stimuli could be measured and if it was influenced by the same parameters that affect adults' vigilance. If children perform in vigilance tasks in a fashion similar to adults, one would expect fewer signal detections (SDs): early in the test day (Colquhoun, 1962); in Ss whose response criterion, defined by fewer false positives (FPs), is strict (Buckner & McGrath, 1963); as the task progresses and as intersignal interval increases (Buckner & McGrath, 1963).

SUBJECTS

Eighty 4-year-olds, 40 males and 40 females, served as Ss. They comprised the total enrollment of a preschool program and were seen approximately 3 months after beginning daily attendance in half-day classes.

ENVIRONMENT

Ss were seen in a single, extremely quiet room (mean level of ambient noise for 250-4,000 Hz was 18 dB). Ss sat in a booth that blocked their view of E and test equipment.

PROCEDURE

The Ss were taken to the test room by E and seated in the booth. Some preliminary activities, essentially unrelated to this experiment,[2] preceded audiometric testing and the vigilance task. The entire session lasted approximately 20 min, the audiometric and vigilance tasks approximately half that. Half the Ss were tested between 9:00 and 11:00 a.m., the other half between 1:00 and 3:00 p.m.

Audiometric Testing

Each S's auditory acuity was screened (Telex audiometer, Model 5; TDH-39 earphones, MX41/AR cushions) at 15 dB (ASA) for the frequencies of 250-4,000 Hz. An approximately 50% threshold was then obtained at 2,000 Hz with a standard, ascending-descending method (Carhart & Jerger, 1959). Ss responded by depressing a hand-held button.

Acoustic Vigilance Task

The vigilance task used the same signal generator and earphones employed in threshold testing. Earphone seal was uninterrupted. Stimulus intensity was uniformly increased 15 dB from each S's threshold so the signals could be presented at levels equally loud to all Ss. The stimuli, then, were 2,000 Hz in frequency, 189 msec in duration, and 15 dB in sensation level. Each signal was presented 20 times in a single sequence of intervals randomly determined within the arbitrary restriction that no interval could be shorter than 5 sec or longer than 30 sec. The task that resulted was 5 min, 25 sec in duration.

The presentation of signals and the recording of Ss' responses were fully automated. The signal generator was cued by a voice-operated relay in response to prerecorded pulses. Both the signals and Ss' button depressions were marked in time by an event recorder (Rustrak, A-2632). E kept an independent record, classifying each response as a SD or a FP on the basis of intuitive judgment. The only instructions to S were to push the button whenever he heard a "beep," a procedure for which the previous audiometric testing served as pretraining.

RESULTS

Analysis

Because FPs were numerous, E's classifications of signals as SDs or FPs were compared to graphic recordings of Ss' button depressions in order to determine a temporal definition of a SD. Informal inspection of the data showed a high agreement between subjective and objective schemes when a SD was defined as any S response following the signal by no more than 2.5 sec, which was not part of a response pattern initiated prior to stimulus presentation.

Ss tested in the morning achieved a mean number of SDs of 9.076, a performance only slightly inferior to the 9.195 SDs of afternoon Ss. This difference was not significant ($t = 1.664$; $p > .05$; $df = 78$). There was some suggestion in the data that SDs and FPs were inversely related ($r = .287$; $p < .05$; $df = 78$).

Table 1 shows the mean number of SDs of the 80 Ss at each of five intersignal intervals presented during the first 162 sec and the last 162 sec of the task. Significantly more SDs occurred following the 5-sec interval than following the 12-, 20-, or 26-sec intervals ($p < .05$; McNemar Test in Siegel, 1956, pp. 63-67), but not after the 7-sec interval. During the second segment of the task there were no significant differences in SDs associated with variations in the duration of intersignal intervals. There were significantly more SDs summed across the five intervals of the first half than of the second half of the test ($t = 1.718$; $p < .05$; $df = 77$).

In terms of task difficulty, SDs ranged from 0-20, with a mean of 8.88 and a median of 8.00. The 40 females' mean detection (9.42) slightly, but nonsignificantly [$F(1,78) = 1.21$; $p > .05$], exceeded that of the 40 males. The 40 males' mean FPs (16.84) slightly, but nonsignificantly [$F(1,78) < 1$], exceeded that of the females (11.80).

DISCUSSION

Four-year-old children's vigilance to acoustic stimuli seems, in certain ways, to resemble that of adults. The similarities were primarily in the tendency for SDs to decrease as the vigilance task progressed and as the intersignal interval was increased. As in adults, Ss tested later in the day performed at a higher level than did Ss tested in the morning, but not significantly so.

It is of some interest that Ss whose response criterion was lax, that is, who frequently responded when no signal was present, actually detected fewer signals. This would seem to underscore the observation made during the task that a FP for young children does not mean the same thing as it does in adults. In the latter case, presumably, the S thinks he detected a signal, although, as Broadbent (1964) has shown, there is a relationship between S's degree of confidence and the actual presence of a signal. In the young children in this study, there were response strings on several occasions which we interpreted as S "playing with" the response button. Thus, numerous FPs may have been more a sign of inattentiveness than the strictness of response criteria.

The 0-20 range of SD accuracy and the mean and median agreement at approximately 50% performance suggest that the vigilance task, as structured, probably was of an appropriate difficulty for the 4-year-olds tested. Ultimately, of course, the best index of its usefulness should be the degree to which the task correlates with performance on other tasks which appear to require global attention to acoustic signals, and the degree to which it permits meaningful observation of attentional behavior generally.

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NOTE

1. Specifically, a picture articulation test and a phonetic learning experiment in which Ss were to imitate a Swedish disyllable.