Differential effects of dexamphetamine and phenidylate on auditory detection

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This study investigated the effects of two phrenotropic agents on human auditory detection. The auditory stimuli were varied in complexity by changing the number of frequencies contained in a signal ensemble. The stimulus intensity required to maintain equal detectability was measured for each signal ensemble, both before and after drug administration. A significant improvement in the detection of complex signals was observed after dexamphetamine administration, with no improvement evidenced after phenidylate administration. The possible relationship of this differential effect to the concept of attention is discussed.

The influence of various phrenotropic drugs on human performance has been the object of a considerable amount of research in the last decade. The effects of such drugs range from significant improvement of performance to significant impairment of performance, depending on the particular task and drug. Dexamphetamine, for example, has been shown to improve performance on various mental and motor tasks, including pursuit-rotor tasks (Payne & Moore, 1955), mathematical reasoning tasks (Nash, 1962; Legge & Steinberg, 1962), sustained work tasks (Kornetsky, 1959), as well as on a wide variety of more specific tasks (Nash, 1962; Payne & Hauty, 1954; Lehmann & Csank, 1957). However, accuracy of setting controls (Eysenck & Easterbrook, 1960), reaction time (Lehmann & Csank, 1957), and the accuracy of certain forms of judgment (Hauty & Payne, 1957) show a decrement in performance in response to dexamphetamine administration.

Pipradrol and phenidylate, phrenotropic drugs differing from the amphetamine group in lacking adrenergic action, have received limited attention, but their influence on human performance appears to parallel, to some extent, that of dexamphetamine (Payne & Moore, 1955; Gutewa, 1957).

This study was designed to assess the effects of two phrenotropic drugs on the detection of single and multiple ensemble auditory signals. Dexamphetamine was selected as representative of that group of stimulants which exert their effect by activation of central neural structures, while

phenidylate was chosen as representative of the group of stimulants which exert a depressive action on limbic structures.

METHOD

Twelve volunteer male adults (ages 22-31) were selected, six of whom had been prescribed dexamphetamine and six of whom had been prescribed phenidylate. These Os were then assigned to one of three experimental groups. Group 1 (G1) contained two Os prescribed dexamphetamine and two Os prescribed phenidylate. Group 2 (G2) contained four Os prescribed dexamphetamine, and Group 3 (G3) contained four Os prescribed phenidylate. None of the Os had used the drugs more than a month prior to selection and refrained from using the drugs for 1 month prior to experimentation. Each O was then given an auditory binary-decision task in which he was to respond "yes" if he decided a signal was present or "no" if he decided a signal was not present during a well-defined temporal interval. The signal, 100 msec in duration with a 10-msec rise-decay time, occurred with an a priori probability of occurrence of approximately 0.50 and was presented against a continuous background of wide-band noise (100 to 10,000 Hz), with a spectrum level of 40-dB SPL. For any one block of 100 observation intervals (constituting a "run"), the signal had a frequency of 500, 750, 1,000, or 2,000 Hz. Detectability was measured, using the theory of signal detectability index, d' , after each run and averaged over the four members of each group. The signal level of each frequency was then adjusted to yield an average d' of 1.5 for each group.

Having established "equally detectable" levels for the four signal frequencies presented singly, these frequencies were then presented at their established levels as 2-, 3-, or 4-frequency ensembles. In the 2-frequency ensemble, for any one block of 100 observation intervals, the 500-Hz signal occurred with a probability of 0.25, and the 750-Hz signal occurred with a probability of 0.25. In the 3-frequency ensemble, the 500-, 750-, and 1,000-Hz signals each occurred with a probability of 0.16. In the 4-frequency ensemble, the 500-, 750-, 1,000-, and 2,000-Hz signals each occurred with an a priori probability of 0.13. The signal level for each of the multifrequency ensembles was then adjusted to again yield an average d' of 1.5. These "equally detectable" signal levels for the multifrequency ensembles were compared

to the single-frequency levels and compared across groups.

This rather complex procedure was used to allow comparisons not only of detection *per se* but also changes in detection as a function of increasing stimulus complexity. Multifrequency signal ensembles result in a degradation of detection performance which is, within limits, proportional to the number of frequencies in the ensemble (Bourbon et al, 1966).

Having established the intensity levels which yield a $d' = 1.5$ for the 1-, 2-, 3-, and 4-frequency signal ensembles, the groups were then administered one of three drug preparations. Group 1 (G1) received a capsule containing 10 mg of common table sugar (placebo), Group 2 (G2) received 10 mg po of dexamphetamine (Dexadrine), and Group 3 (G3) received 10 mg po of phenidylate (Ritalin). Ninety minutes after drug administration, the entire detection procedure was repeated and new detection- and signal-level measurements were taken. Comparisons of performance were made within each group and between groups before and after drug administration.

RESULTS

The results are shown in Figs. 1 and 2. In both figures, the abscissa represents the number of frequencies in a signal ensemble, and the ordinate represents the signal level required to maintain detection at $d' = 1.5$. The level represented for the 1-frequency ensemble is the average of the four single-frequency levels. As seen in Fig. 1, detection performance before drug administration is not significantly different for the three groups, with all three groups showing a degradation of performance as the complexity of the signal ensemble increases. In Fig. 2, which shows detection performance after drug administration, no significant difference in performance is seen between G3 and G1 ($p > .10$), although the variability of responses increased under phenidylate (1 SD ± 0.5 dB) relative to prior performance (1 SD ± 0.25 dB) and G1 performance (1 SD ± 0.25 dB). G2, however, showed a significant ($p < .01$) increase in performance compared to G1 and G3. Although detection of the single-frequency ensemble was not different for the three groups, the degradation observed for G1 and G3 as a result of stimulus complexity was not observed for G2.

DISCUSSION

The observed effects of dexamphetamine administration appear to be related to effects of the drug on the attentive capacity of the individual. An explanation based on sensory "sensitization" is precluded by the observation that detection of single-frequency ensembles is not different for the three groups. Further opposition to a

FIG 1 SIGNAL LEVEL REQUIRED TO MAINTAIN CONSTANT DETECTABILITY ($d' = 1.5$): PRE-DRUG CONDITION

FIG 2 SIGNAL LEVEL REQUIRED TO MAINTAIN CONSTANT DETECTABILITY ($d' = 1.5$): POST-DRUG CONDITION

"sensitization" hypothesis is provided by Miller and associates (1960) who found that 15 mg of dexamphetamine produced no change in either sensory, perceptual, memory, or decision-making variables associated with an auditory signal-detection task in which single-frequency signals were presented. However, the relatively superior performance of the amphetamine group under conditions of increasing signal complexity is explainable if one can postulate a differential alteration of attention as an effect of dexamphetamine. Although phenidylate and dexamphetamine are both stimulants, their respective sites of activity allow a possible differentiation of their effects on attention. Phenidylate is a stimulant which produces its effect through a depressant action on limbic structures (Sigg & Schneider, 1957). Increased arousal under phenidylate, then, could result in an increase in attention to the extent that "inhibitory" influences associated with the limbic system on the cortex are reduced. Such a simplistic description would suggest that the attentive capacity of the individual would not be increased for a specific stimulus only, but would be increased for all stimuli, including peripheral stimuli such as interval lights, discomfort, etc., associated with the detection situation (as opposed to the stimulus situation). Perhaps this is an explanation for the increased variability and slightly degraded performance of G3 after drug administration.

Dexamphetamine, on the other hand, exerts its effect by direct cortical and

reticular stimulation. If the functional capabilities of the cortex were augmented by this stimulation, an increased ability to focus one's attention on a specific stimulus, to the exclusion of peripheral stimuli, would be expected through increased efferent control of sensory filtering. Processing of more complex stimuli, such as the multifrequency signal ensembles, would be facilitated, therefore, by an increased ability to maintain one's focus of attention on the signals to be detected. Indirect support for this hypothesis is provided by Teitelbaum & Derks (1958), who found that amphetamine appeared to limit the ability of the rat to make use of peripheral aspects of a conditioning situation, while at the same time increasing the animal's responsiveness to the more central aspects (pertinent to the task) of the situation. Whether these results can be validly generalized to the effects observed in this study remains to be demonstrated. Neuropsychological assessment of this "focus-of-attention" hypothesis is currently being conducted.

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