Habituation and conditioning of the orienting reflex in intellectually gifted and average children

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Habituation and conditioning of the OR were studied in two groups of children aged 7-12. One group of 45 children had individual IQs between 90 and 110 (average) and another group of 45 had IQs between 130 and 160 (gifted). All of the children received 18 series of habituation presentations of simple visual stimuli, each series being followed by a dishabituation trial in which either the color or the shape of the stimulus was changed. Half of the subjects in each IQ group received money reinforcement in conjunction with the dishabituation trial, while the other half did not. It was found that the gifted children's initial SCRs were significantly larger than those of the average children and that these responses habituated significantly more slowly in the gifted children. The dishabituated ORs in the children receiving money reinforcement were significantly larger than those in the children who received no reinforcement, and this difference was present throughout the experiment in the gifted children but came into existence gradually in the average children. These results extend the earlier findings showing smaller ORs and more rapid habituation of the OR in intellectually retarded children as compared to average children. It was concluded that the OR is involved in cognitive-attentional performance and that measured IQ involves primitive neurophysiological processes.

The orienting reflex (OR) consists of somatic and autonomic reactions to novel stimuli which are assumed to facilitate stimulus reception and registration (Sokolov, 1963). Autonomic OR components include vasomotor, cardiac, pupillary, and electrodermal responses. The last of these, the skin conductance response (SCR), was used in the present study as a measure of the OR.

It is widely assumed that the OR is related to intelligence and learning. For example, Grings, Lockhart, and Dameron (1962) compared magnitudes of the OR and rates of habituation of the OR in normal and intellectually retarded adults. They found that retarded subjects make smaller initial SCRs to innocuous stimuli and that these reactions habituate more rapidly than in normal controls. Maltzman and Raskin (1965) found that subjects who were initially high orienters learned more rapidly in verbal conditioning tasks and were more often able to report reinforcement contingencies. Kimmel, Pendergrass, and Kimmel (1967) confirmed the basic findings of Grings et al. (1963), using retarded and normal children, as well as demonstrating that instrumental reinforcement of ORs of retarded children had an influence on subsequent Seguin Formboard performance.

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In the present study, intellectually gifted children were compared with controls of average intelligence. The children received repeated habituation and dishabituation experiences with visual stimuli, with money reinforcement being administered temporally contiguous with dishabituation in half of the subjects but not in the others. It was hypothesized that the intellectually gifted children would make initially larger ORs than the average children and that the intellectually gifted children would habituate more slowly than the average children. In addition, it was hypothesized that reinforcement associated with dishabituation of the OR would have the effect of maintaining or increasing the strength of the OR, in comparison with nonreinforcement. For control purposes, half of the subjects in the intelligence-reinforcement subgroups received a stimulus that was changed in color but not in shape on the dishabituation trial. The other half of each subgroup received a dishabituating stimulus that was changed in shape but not in color. No specific hypotheses relating to this contrast were specified.

METHOD

Subjects

The subjects were 90 children between the ages of 7-12 years, with equal numbers at each age in each subgroup in the study. All children were tested individually on the Stanford-Binet, Form L-M, and then categorized into average and gifted IQ groups. The 45 gifted subjects had IQ scores ranging from 130 to 170, with average IQs ranging between 143.6 and 145.2 in

the gifted subgroups. The 45 average subjects had IQ scores ranging from 90 to 110, with means ranging from 99.3 to 102.1 in the average subgroups. The mean age ranged between 9.8 and 9.9 in the various subgroups. Of the 15 children in each of the eight subgroups (see Procedure section), 8 were male and 7 were female and all were white. The subjects were instructed to remain alert and comfortably motionless.

Apparatus and Stimuli

A series of nine geometric stimuli was presented twice to each subject via a Grason-Stadler multiple-stimulus projector. The stimuli consisted of nine possible combinations of three shapes (circle, square, triangle) and three colors (red, green, blue). The projector was located in front of the subject at approximately eye level and 1.07 m away. It was activated by the experimenter, who sat in another room. A Gerbrand's penny dispenser was mounted on the wall at the subject's left side and was manually controlled by the experimenter. A chute through which the pennies dropped extended from the dispenser to a plastic cup that was on a small table next to the subject's chair.

The SCR was picked up by Beckman biopotential skin electrodes (children's size) attached to the palm and back of the subject's left hand. Responses were recorded and amplified by a Grass polygraph (5 PI preamplifier) with a paper speed of 1 mm/sec. All SCR responses were transformed into units of change in log conductance.

Procedure

The subject sat in a cushioned chair in a 2.44 × 3.05 m living-room-style experimental chamber. Skin electrodes were attached to the subject prior to his entrance into this chamber, and then the subject was seated in the chamber facing the projector. The subject was instructed to sit quietly in the chair and attend to the projector. The child was told that differently colored shapes would be presented and that pennies would sometimes drop into the plastic cup, pennies that the child could keep at the end of the experiment (money reinforcement group only). Nonreinforcement subjects were told that they would receive 20 cents at the end.

Projected visual stimuli of 3 sec duration were then presented at variable intertrial intervals between 20 and 35 sec. The initial stimulus was presented repeatedly until it failed to elicit a criterion response, 500 ohms or 1% of the basal resistance at stimulus onset, whichever was greater. A new stimulus was then presented and, at its termination, reinforcement given in the money-reinforced group. Thus, the GSR to the stimulus was habituated prior to stimulus-change and, in the money-reinforced group, reinforcement followed the OR evoked by stimulus-change. A second stimulus series was then begun with a new stimulus until habituation occurred. This was again followed by stimulus change. A second stimulus series was then begun with a new stimulus until habituation occurred. This was again followed by stimulus change and reinforcement (in the money group). This procedure was followed until each of the nine stimuli was habituated and followed by stimulus change (and reinforcement in the money group). The entire sequence of habituation series was repeated. Thus, there were 18 habituation series in all and 18 stimulus changes which were either followed by money reinforcement or not.

For half of the subjects in each intelligence-reinforcement subgroup, stimulus change consisted of changing the color but not the shape of the stimulus that had just been habituated. This is referred to as the color-change condition. For the other half of each subgroup, the shape but not the color of the just-habituated stimulus was changed. This is referred to as the shape-change condition. The overall experimental plan was thus a 2 by 2 by 2 arrangement of intelligence (gifted vs. normal), reinforcement (money vs. no money), and stimulus change (color vs. shape).

RESULTS

Magnitude of OR

The size of the SCR elicited by the first presentation of each to-be-habituated stimulus was taken to be an indication of the degree to which an initial OR occurred. This response was measured as the maximum change in skin conductance, beginning in the 1-3-sec interval following stimulus onset. Figure 1 presents these measures averaged in blocks of three across the 18 stimulus series, separately for the gifted and normal subjects. As can be seen in Figure 1, the gifted children made larger initial ORs throughout the entire session. In addition, money reinforcement appeared to influence the initial ORs of the intellectually normal subjects more than those of the gifted. Analysis of variance of these data showed that the effects of Intelligence [$F(1,89) = 5.97, p < .05$] and Trials [$F(17,1530) = 3.97, p < .001$] were both significant, and that the interaction of Intelligence, Reinforcement, and Trials [$F(17,1530) = 2.15, p < .01$] was also significant. None of the other effects approached significance. The significant three-way interaction appears to have resulted from the consistent influence across trials of money reinforcement in the average children

Figure 1. Mean magnitudes of ORs in six three-trial blocks in the money-reinforcement and no-money groups, shown separately for the gifted and average subjects.

Table 1
Mean Number of Trials to Habituation

	Gifted					Average				
	Money		No Money		Overall Mean	Money		No Money		Overall Mean
	Mean	n	Mean	n		Mean	n	Mean	n	
Color Change	1.92	15	2.27	7	2.03	1.60	15	1.14	6	1.47
Shape Change	2.49	15	1.30	8	1.11	2.52	15	1.74	9	2.23
Overall Mean	2.20		1.81			2.06		1.50		

Table 2
Mean Number of Trials to Habituation in First Three Stimulus Series

	Stimulus Series					
	1		2		3	
	Mean	SD	Mean	SD	Mean	SD
Gifted	4.20	3.22	2.31	1.89	2.62	2.99
Average	2.40	1.78	2.11	2.42	2.56	2.59

as contrasted with a reversal of its smaller effect from early to later trials in the gifted subjects.

Trials to Habituation of the OR

The number of times a stimulus was presented until it failed to elicit a criterion response was obtained for each of the 18 stimulus series, providing measures of number of trials to habituation. Table 1 shows these measures averaged for all 18 stimulus series. As is shown in Table 1, the gifted children habituated more slowly than the intellectually average ones. Also, subjects receiving money reinforcement following stimulus changes took somewhat longer to habituate than those who did not. Finally, color-change subjects habituated slightly more rapidly than shape-change subjects. Analysis of variance showed that none of these effects was significant.

Because habituation became progressively faster across series, an additional analysis was done to determine whether significant differences may have existed in the early part of the sequence which dissipated after a few stimulus series. Table 2 presents the mean number of trials to habituation for each of the first three stimulus series for the gifted and average children. The gifted children habituated to the first stimulus in 4.20 trials and the average children took 2.40 trials. This difference reduced considerably for the second and third stimulus series. The differences between gifted and average children in average number of trials to habituation was significant only for the first stimulus series [$t(88) = 3.33, p < .05$], but not for subsequent ones.

Conditioned OR

When the habituation criterion was reached within each of the 18 stimulus series, a novel stimulus was presented on the immediately subsequent trial and, in

the money-reinforcement groups, a penny was delivered to the child at the termination of this stimulus. The conditioned OR was defined as the maximum conductance change, beginning in the interval 1-3 sec following each of these occasions of stimulus change. Figure 2 shows these measures averaged in six blocks of three trials for all four subgroups. As can be seen in this figure, the money-reinforced children tended to make larger responses than those not receiving money reinforcement. Also, while this difference was more or less consistent across the 18 series in the gifted children, it increased noticeably across the 18 series in the intellectually average subjects.

Figure 2. Mean magnitude of conditioned ORs across six three-trial blocks in the money-reinforcement and no-money groups, shown separately for the gifted and average subjects.

Analysis of variance of the conditioned OR measures indicated that the effect of money reinforcement was significant [$F(1,89) = 4.43$, $p < .05$]. As can be seen in Figure 2, the three-way interaction of Intelligence, Reinforcement, and Trials was also significant [$F(17,1394) = 2.13$, $p < .01$], stemming from the fact that the conditioned ORs of the intellectually average children tended to decline across successive series without money reinforcement while they increased over the same period when the average children received money reinforcement. This divergence was not present in the gifted children's conditioned ORs.

DISCUSSION

The results of this study indicate that intellectually gifted children differ from intellectually average ones in initial orienting reactivity to innocuous stimuli and in rapidity of habituation of the OR, and that these differences are in the same direction as those previously found in comparisons of average and retarded children. Specifically, where Kimmel et al. (1967) found that intellectually average children made larger ORs and habituated more slowly than severely retarded children, intellectually gifted children in the present study were found to make larger ORs and habituate more slowly than average children did. Thus, the relationship between measured intelligence and both strength and persistence of ORs has now been shown to be positive and monotonic from IQ levels below 30 through IQ levels above 160. Although this confirmation and extension of the relationship between autonomic attentional reactivity to innocuous stimulation and children's performance on individual intelligence tests may seem self-evident a priori, its implication of fundamental neurobiological functioning in intelligence rests more firmly on empirical than on logical grounds.

Pendergrass (1969), in a somewhat similar study, reported no conditioning effects in her OR data, while the present classical conditioning procedure resulted in larger conditioned ORs in the money-reinforced groups than in those not receiving money. This difference was substantial and consistently present in the intellectually gifted children, while it came into existence more gradually in the average children. It is possible that procedural differences between the Pendergrass (1969) and present studies were responsible for this difference in outcome, since Pendergrass employed intertrial intervals ranging from 10 to 60 sec, a small piece of candy as reinforcement, and a habituation criterion of two nonresponses, while intervals ranging from 20 to 35 sec, money reinforcement, and a habituation criterion of one non-response were used in the present study. The decision to shift to money for the present study was based upon our belief that the candy was less potent than money and that its repeated presentation was more likely to result in depletion of its effectiveness. The present

results showing conditioning of elicited ORs are in agreement with the findings of Shnidman (1970) and Shnidman and Shaprio (1970), although response-contingent reinforcement was used in their studies. But, since the stimulus-change procedure in the present study effectively elicited an OR on all occasions, our classical reinforcement procedure is indistinguishable from their instrumental one. Thus, we are presently unable to tie the conditioning effect to one or the other conditioning procedure.

As was noted above, the combined results of the Kimmel et al. (1967) and the present studies imply fundamental neurophysiological processes in the substrate of measured individual intelligence. The subjects in these studies were instructed simply to remain alert and reasonably motionless during the presentations of visual stimuli. No task was given and the verbal behavior of the children gave us no reason to assume that a task was inferred. The stimuli were simple and innocuous. The establishment of a clear and orderly relationship between autonomic reactivity in a situation as simple as this and performance over a period of 1 to 2 h in an intelligence testing situation, however, self-evident it may seem, is a highly significant indication of the extent to which presumably primitive neurophysiological mechanisms (i.e., those underlying the OR) are involved in complex intellectual functioning (i.e., intelligence test performance) in children. Results of this type provide support for the assumption that the OR is indeed involved in attentional-cognitive performance and, more importantly, that a biological interpretation of measured intelligence is not without empirical foundation.

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