Categorical encoding in short-term memory by 4- to 11-year-old children*

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One hundred and sixty children, ages 4 to 11, were tested in a STM task similar to that used by Wickens, Born, & Allen (1963). Special interest focused on the buildup and release of proactive interference (PI). All age groups show PI when conceptual categories (toys or kitchen utensils) were the to-be-remembered items. In addition, all groups which shifted to a different conventional category on the last trial, show release from PI. The theoretical significance of the presence of PI and its release in preschool children is discussed.

While the volume of literature on human short-term memory (STM) has increased enormously in the past 10 to 15 years, there have been relatively few developmental studies of STM in young children. This absence of literature reflects the theoretical interests that have stimulated much of the previous memory research. The focus has been on memory processes rather than on the remembering organisms, and researchers have typically considered it to be more important to explore theoretical issues, such as whether short- and long-term memory can be explained on the basis of the same principles, rather than to embark on programmatic research on the genesis and development of memory in children.

Do preschool children's memories function in essentially the same manner as those of older children, or are their memory processes fundamentally different? The present study was designed to provide a partial answer to this question by assessing whether or not preschool as well as school-age children manifest proactive interference (PI) for material that is similar on a dimension appropriate for their developmental level and whether or not they show a release from PI when additional material to be recalled is drawn from a different point on the dimension. In the case of adult Ss, the presence of PI and its release has been taken as evidence that Ss are encoding on semantic dimensions in STM (Wickens, 1970). If the same phenomena are observed in preschool children, their STM would appear to be functionally similar to that of adults, even though significant differences in performance may be observed between age samples.

A recent study by Cann, Liberty, Shafto, & Ornstein (1973) has demonstrated that 7- and 8-year-olds do show both a build-up of PI and a release of PI. Their concern was primarily in demonstrating the effect with young children when obvious classes of stimuli were used (e.g., consonants and digits). The present study will explore the theoretically important possibility that PI can be obtained with younger children (4-year-olds and 6-year-olds).

*This investigation was supported by National Institutes of Health Research Grant NS-09590-03 from the National Institute of Neurological Diseases and Stroke to the senior author.

METHOD

Subjects

Forty children were tested at each of four age levels, CA 4, CA 6, CA 8, and CA 11, for a total of 160 Ss. Mean ages in years and months were 4-7, 6-7, 8-9, and 11-9, and standard deviations in months were 3.0, 5.4, 5.9, and 6.7, respectively. The sex division was approximately equal at all age levels. The preschool children were enrolled in nursery schools in Sylvania and Toledo, Ohio, and the older Ss were enrolled in a public school in Fremont, Ohio. Children were selected for testing who were making normal progress in school, who had no known visual handicap uncorrected by glasses, and whose parents gave their consent.

Apparatus

The stimuli were shown by means of a Kodak Carousel slide projector. Slides were projected onto an 8½ x 11 in. rear projection screen, approximately 3 ft from S. The projector was controlled by a Lehigh Valley program timer.

Experimental Conditions and Stimuli

The design for the present study was based on the paradigm developed by Wickens, Born, & Allen (1963) to induce PI in a STM task in adults and to demonstrate its release. Typically, Ss are presented a subspan set of items which are in some way similar. For example, the items might all be drawn from the same conceptual category. An interpolated task follows the series and is used to prevent rehearsal. Finally, S is required to recall the previously presented items. Half the Ss are ordinarily given a series of four or five trials in succession, using items from the same conceptual category, while the experimental Ss are switched to a different conceptual category on the last trial.

In the present study, two lists of 16 items each were selected from the categories of toys and kitchen utensils of the Battig & Montague (1969) category norms derived from college students. Items from each category were assigned randomly to sets of four each, resulting in four items from each of the two categories. The choice of four items per set was made after pilot data revealed that four items provided appropriate task difficulty for the most mature Ss that would be tested. Colored drawings of each set of four items were made by an artist, and 2 x 2 slides were prepared for presenting the test stimuli. Half the Ss at each age level were given the class of toys, and the other half were given the class of kitchen utensils. The same four-trial sequence was used for all Ss assigned to the same treatment group. The Ss who were switched out of their assigned category on Trial 4 were shown the set of pictures corresponding to Trial 4 of the other category.

Stimuli for the interpolated task were slides showing a 3 x 3 matrix of rectangular areas of various colors. Ss were required to name as many colors as they could. Three slides with different colored areas were presented after each set of test stimuli. A typical trial consisted of the presentation of a picture of a pair of eyes as a signal to Ss to pay attention. The eyes remained on for 3 sec and were followed by a slide which depicted the four to-be-remembered items and which remained on for 3 sec. The three color slides that followed each shown for 5 sec, resulting in a 15-sec retention interval. Finally, a slide with four blank lines

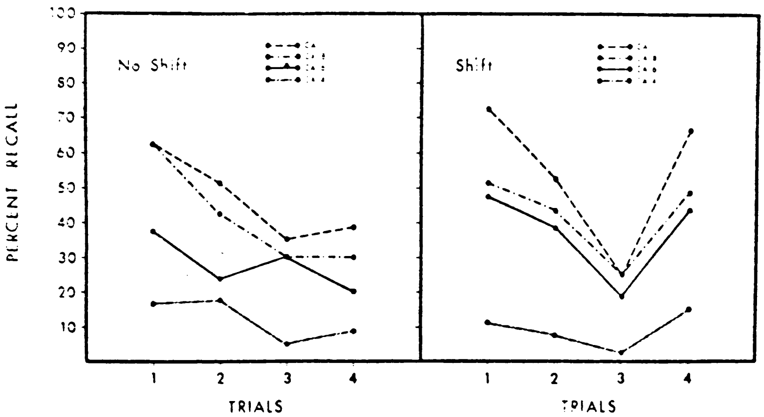

Fig. 1. Mean percent recall for each age level as a function of trials for the no-shift (left panel) and shift (right panel) conditions.

was presented. This slide served as a cue for recall of the four previously presented pictures. The recall period was 10 sec.

Procedure

Ss were tested individually in sessions lasting about 5 min. They were seated about 3 ft from the rear-projection screen, with E seated at their side. Two practice trials were administered, using four digits as the stimuli to be recalled. In the first practice trial, E controlled the timer and allowed time to explain the role of the slides showing the pair of eyes, to assist Ss in scanning the set of the test stimuli, to demonstrate the way in which the colors were to be named, and to explain that the four blank lines were a signal to name the four previously presented numerals. In the second practice trial, the timer was activated so that Ss would have some experience with the speed with which each trial sequence would be administered. Then Ss were cautioned that they would see pictures instead of numerals, and the four experimental trials were presented without interruption. As each set of test stimuli was presented, E named their labels aloud. This precaution was taken in case 4-year-old Ss might not be able to think of a label during the short period of time that the test slide was presented. The E recorded Ss' spoken responses after each trial.

RESULTS AND DISCUSSION

The data for the eight groups of Ss are shown in Fig. 1. Percent recall is plotted as a function of trials for each group. The left panel of the figure presents the data for the no shift condition, while the right panel depicts the data for groups in the shift condition. The data are summarized over stimulus category (toys and utensils) since stimulus category was not a significant variable, $F(1,144) = 1.104$, $p > .05$.

For the moment, attention will focus on the data in the left panel of Fig. 1, the no shift condition. All four functions show the typical PI effect in that performance declines as a function of trials. Trials was a highly significant variable, $F(3,76) = 16.074$, $p < .001$. In addition, age is also a significant variable $F(3,228) = 8.889$, $p < .001$. In all four groups, there is a clear PI effect in that performance on Trials 3 and 4 is always below the level observed on the initial trial. Furthermore, the decline is greater in the older groups since their initial level of performance was higher than that of the younger groups. This difference in rate of decline is the apparent reason for a significant Age by Trials interaction, $F(9,228) = 3.34$, $p < .05$.

The shift condition depicted in the right panel presents a markedly different pattern of results. Again, a PI effect is evidenced for all four groups through Trial 3. However, on Trial 4, when the shift in conceptual categories occurred, all groups show a rise to approximately the level of performance observed on Trial 1. That is, all groups show release from PI. These observations are borne out statistically in the following way. For all age groups, t tests conducted between the means of Trial 3 and Trial 4 resulted in significant ($p < .05$) ts ($df = 19$) for the shift condition. Furthermore, in no cases were the comparable tests significant for the no-shift condition. Finally, an added indication of the strength of the release effect is the fact that the Trials by Conditions interaction was significant in an overall analysis of the data in Fig. 1, $F(3,144) = 7.585$, $p < .01$. This same interaction failed to reach significance when the data for Trial 4 were not included. That is, the Trials by Condition interaction was not significant for Trials 1 through 3, $F(2,144) = 1.526$, $p < .05$, but, as noted above, the interaction was significant when Trial 4 was included in the analysis.

A noteworthy aspect of the data which is not shown in Fig. 1 is the fact that three-way interactions were observed between age, stimulus category, and trials [$F(9,432) = 2.05$, $p < .05$] and between conditions, stimulus category, and trials [$F(3,432) = 4.537$, $p < .01$]. These results reflect in part the greater effectiveness of kitchen utensils for inducing PI and of switching to toys for effecting release. This result was not anticipated, since toys were considered to be at least as well established as a class of items for young children as kitchen utensils. In retrospect, however, the result is plausible, since some of the toys may have been construed to be life-size means of transportation, for example, the train, car, truck, and airplane.

The significant age differences in this study must be interpreted with caution since they occur in the presence of fundamentally similar behavior patterns (cf. Fig. 1). It is our position that these age differences reflect the very reliable but theoretically less interesting result that young children's performance in memory tasks are generally poorer than older children's performances.

Instead of focusing on the differences between the age samples, represented by the spread between the functions in Fig. 1, we prefer to emphasize the basic similarity in all of the age samples. Namely, because all groups encode categorically in STM, they all show the effects of PI in appropriate circumstances. Qualitatively similar behavior by preschool and school-age children in STM is especially impressive, since striking changes have been observed to occur in young children's cognitive, social, and linguistic behaviors at about age 6, corresponding to an important stage boundary in Piaget's developmental theory (Piaget, 1950) and to the hypothesized onset of verbal mediation by learning theorists (Kendler & Kendler, 1962).

This is not to suggest that developmental differences in STM do not occur. Categorical encoding requires that Ss respond to a group of stimuli as members of the same class. A previous study of school-age children's performance in tasks using these procedures (Wagner, 1970) reported that taxonomic classes (animals and colors) were the only classes for which the youngest Ss tested (CA 9) showed evidence of any PI or its release. Phonemic classes (words that rhyme) showed PI but no release, while sense impression classes (round things and white things) showed no PI and, of course, no release. Differential susceptibility to PI as a function of stimulus category suggests that these procedures can be used to assess concept formation in young children. A special advantage of the procedure is that the individual does not have to be able to name the class to which the stimuli belong or even to be consciously aware that they come from a particular category (Wickens, 1970).

An invariant memory function that manifests performance differences as a function of the extent to which the stimulus classes are psychologically relevant also lends support to Piaget's theory, which interprets limitations in children's memory as a result of incompletely developed schemes for dealing with classes and relations rather than restricted ranges of experience or shorter conditioning histories.

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(Received for publication October 5, 1973.)

Effects of grouping and crowding on learning in isolation-reared adult rats*

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Rats reared in isolated and overcrowded environments are inferior to those from small groups in complex learning tasks. To examine the age dependence of this phenomenon, adult rats isolated from weaning were placed in groups of 1, 4, and 16 for either 1 or 4 weeks. One week of grouping enhanced Lashley III maze performance, while 4 weeks' grouping did not. One week of grouping did not affect shock avoidance brightness discrimination, but after 4 weeks, the group of 16 was superior. Hence, grouping or crowding in adulthood tends to reverse learning deficits produced by isolation rearing.

*Research performed while first author was a predoctoral trainee in biopsychology supported by US PHS 5 T01 MH 10715; research also supported by National Institute of Human Development Grant HD 06862, PHS Grant FR07030, and the University of Illinois Research Board. Address for reprints: William T. Greenough, Department of Psychology, University of Illinois, Champaign, Ill. 61820.

The role of the developmental and adult social environment in behavioral performance has received considerable attention, although it is often ignored in experiments in which other variables are examined. Much research has focused upon the extremes of social density: isolation and crowding. Both extremes appear to be stressful, at least in rodents, in terms of adrenal