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Developmental differences in memory and practice effects in relearning

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Developmental aspects of relearning were examined in 3-year-olds, 5-year-olds, and college students by using Nelson's (1971) revised savings paradigm. A set of picture pairs was learned to a recognition criterion of one error-free trial. After 2 weeks, the subjects returned for tests of retention and relearning. During relearning, the subjects received one study/test trial of a set composed of pairs seen previously ("old pairs") and pairs created by re-pairing pictures seen previously ("new pairs"). Significant savings was found for all age groups on old pairs relative to new pairs. A developmental trend toward decreased savings with age was noted. Results are discussed with respect to the relative contributions of savings and practice to retention.

Much of the interest in cognition and cognitive development has been directed at understanding the processes of memory. Typically, memory is studied by asking subjects to learn some information and then by testing their ability to either recognize or recall that information at a later time. Consequently, much is known about changes in recognition and recall with age (e.g., Cole, Frankel, & Sharp, 1971; Flavell, Beach, & Chinsky, 1966). In contrast, Ebbinghaus's (1885/1913) relearning method has been used infrequently by developmentalists, therefore little is known about developmental differences in savings.

Relearning assesses the amount of time or effort one "saves" in (re)learning material that was acquired at an earlier time but is presently inaccessible. Although the original procedure suffered from several methodological flaws (see Bunch, 1941; Duncan, 1960; and Luh, 1922, for specific criticisms), a revised version has remedied many of its shortcomings (Nelson, 1971, 1978, 1985). In particular, Nelson has dealt with the criticism that relearning is confounded with learning-to-learn, or the "practice effect." Ebbinghaus's (1885/1913) original procedure, which compared the learning of a serial recall list with the relearning of that same list, made practice effects quite probable. In the revised version, paired-associate tasks are used, and comparisons of original learning and relearning are made within a single session. That is, relearning of pairs acquired previously ("old pairs") is compared with learning of pairs that are comparable, but not identical, to old pairs ("new pairs"). This manipulation makes it possible to separate practice effects from savings and, thus, to more clearly distinguish between learning and memory. It is this revised version that has been used to determine the relative sensitivities of recall, recognition, and savings in assessing memory contents in adults (e.g., Groninger & Groninger, 1980; Nelson, 1971, 1978). Similar work with children would contribute substantially to the developmental literature.

The classic developmental study on relearning was conducted by Burtt (1932, 1941), who used his son as the sole subject, reading aloud to him passages in Greek and evaluating savings over an 18-year period. Burtt's son showed savings at ages 8½ and 14 but not at age 18. In addition, the magnitude of the savings decreased over time. Another early study on savings in 7-18-year-olds failed to find any age differences in savings of nonsense syllables and poetry 1-6 weeks after original learning (Stroud & Maul, 1933). Although relearning has been demonstrated in 5-6-month-old infants (Cornell, 1979), the fact remains that knowledge of children's relearning, savings, and retention, in general, is quite limited.

The present study considered developmental aspects of savings by examining relearning in 3-year-olds, 5-year-olds, and college students for picture pairs seen 2 weeks previously. A primary purpose of the study was to assess the extent to which savings and practice effects might differentially impact children of different ages in a relearning situation.

METHOD

Subjects

The subjects were 3-year-olds (n = 10, mean age = 40.3 months) and 5-year-olds (n = 12, mean age = 59.0 months) attending university or privately operated daycare centers, and college students (n = 21, mean age = 18.9 years) recruited from introductory psychology classes. Approximately equal numbers of males and females were in each group. Criteria for participation included one error-free trial in original learning and participation in both the original learning and relearning sessions. Of the 3-year-olds tested, 71.4% met the above criteria, whereas 67% and 87.5% of the 5-year-olds and college students, respectively, did so. Approximately half the 3-year-olds who were excluded were not in attendance 2 weeks later. Of the 5-year-olds tested,

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28% were excluded because they failed to achieve one error-free trial in original learning. Other reasons for excluding subjects included experimenter error and some subjects' refusal to participate 2 weeks later.

Materials

Picture pairs consisted of black and white line drawings taken from the Peabody Picture Vocabulary Test-Revised (PPVT-R; Dunn & Dunn, 1981), which were then secured to 3×5 in. white index cards. Pictures were randomly paired (cue picture-target picture) such that no two were from the same semantic category (e.g., car-truck) or formed an obvious logical association (e.g., sock-shoe). Examples of pairs included lamp-grapes, flowers-comb, and car-squirrel. A chronograph was used for timing. Decorative stickers were given to preschoolers, and college students received credit toward a course research requirement.

Procedure

Pretesting. Recognizing the importance of equating task difficulty across age, previous researchers have used different list lengths for subjects of different ages (e.g., Moely, Olson, Halwes, & Flavell, 1969). Certainly, establishing tasks with equal levels of difficulty across age, or age-equivalent tasks, is a methodological improvement over using nonequivalent tasks in developmental research (see Brainerd, Kingma, & Howe, 1985; Labouvie, 1980; Nunnally, 1973). However, no consistent criteria have been adopted for establishing equivalence, and sometimes researchers have been unclear about their bases for equivalence.

To establish age-equivalency for our tasks, we pretested 63 children and 9 adults who were similar in age and background to the subjects included in the present study. We used three objective criteria to establish age-equivalency. Tasks were deemed age-equivalent at original learning when (1) the subjects continued to participate to one error-free trial, (2) the subjects achieved one error-free trial within four or five trials, and (3) retention rates 2 weeks later were below 60%, thus insuring that a sufficient amount of forgetting occurred to make relearning meaningful. Pretesting showed that if children were not given assistance in learning the pairs, then the criterion of one error-free trial with all pairs present was unattainable. Thus, preschoolers were provided with a short sentence to facilitate learning (e.g., "The frog lived in the shoe" for a frog-shoe pairing). Even with such assistance, some children were unable to meet this criterion. Three-year-olds met all three criteria with 6 picture pairs, 5-year-olds with 10 pairs, and college students with 30 pairs. The older subjects viewed the same pairs as the younger subjects, in addition to viewing additional pairs.

Original learning phase. The subjects were tested individually either at the daycare centers (preschoolers) or at the university (college students). The children were asked to play a "memory game" with the experimenter, with whom they had become familiar in group activities at the daycare center prior to the start of testing. College students signed up for what they were told was a battery of tests held 2 weeks apart. A set of three color-shape pairs (e.g., green circle-orange square) was shown to the subjects to familiarize them with the task before original learning began.

Picture pairs were shown to the subjects at approximately a 5-sec rate. The subjects learned the pairs in a study/test, paired-associate format. Target pictures were then randomly presented, and the subjects were asked to select the one that had been previously paired with the cue picture then being shown. Selection was from all possible target pictures. Incorrectly identified pairs were then reshown in random order and retested until all pairs could be correctly identified. Correctly identified pairs were eliminated to reduce overlearning. When each pair had been correctly recognized one time, the entire set of pairs was represented. This procedure was repeated until the subjects could achieve an acquisition criterion of one error-free trial for the entire list. To be consistent with previous research (e.g., Groninger & Groninger, 1980), the adults were also asked to rate the confidence of their choice by assigning a 3 if "very sure" of their selection, a 2 if "somewhat certain," and a 1 if "just guessing." Responses assigned a 1 were counted as incorrect and reshown.

Between trials, college students read numbers for 20 sec to reduce rehearsal. Because preschoolers rarely rehearse without specific prompting, a similar task was deemed unnecessary for them.

Relearning phase. Relearning occurred 2 weeks later (±24 h). A self-paced, cued-recall test was administered. Each cue picture was shown, and the subjects were asked to say what that picture had been paired with 2 weeks earlier. The subjects were told to guess if unsure; most of the time, the subjects responded, although they were not forced to respond. To compare our results with previous research (e.g., Groninger & Groninger, 1980; Nelson, 1971, 1978), we gave the college students a recognition task after they completed the cued-recall task. To eliminate nonequivalent exposure to items, which could potentially affect relearning performance, all possible choices were presented simultaneously rather than in a forced-choice format.

The subjects worked on a jigsaw puzzle while the experimenter prepared the relearning set. For preschoolers, the relearning set was constructed by dividing the original pairs into correct and incorrect pools based on the results of the cued-recall test. For college students, the relearning set was constructed by dividing original pairs into the following four pools based on the results of the cued-recall and recognition tests: (1) correctly recalled, correctly recognized; (2) incorrectly recalled, correctly recognized; (3) incorrectly recalled, incorrectly recognized; and (4) correctly recalled, incorrectly recognized. Only two pairs fell into category 4, and, for the purposes of the relearning task, they were considered as members of category 3. For each pool, half the pairs remained the same as at original learning (old pairs), and half were randomly re-paired with items only from that same pool (new pairs).[1] Relearning pairs were randomly ordered, and the subjects learned the pairings in the same manner as during original learning, after being told that some pairings would be changed. Sample relearning pairs included car-grapes, lamp-squirrel, and dustpan-comb. Sessions continued through one test trial of the relearning set. The experimenter recorded errors during both the retention test(s) and the study/test trial of the relearning set.

RESULTS

The percentages of pairs correctly recalled 2 weeks later were 38.3%, 46.7%, and 37.3% for the 3-year-olds, the 5-year-olds, and the college students, respectively. The number of errors made on old pairs and the number of errors made on new pairs during the first relearning trial were compared by using an orthogonal binomial test of the difference between two proportions (McNemar, 1969). The performance of the 3-year-olds and the 5-year-olds on old pairs was significantly better than their performance on new pairs ($z = 3.13, p < .01$; $z = 2.85, p < .01$, respectively), indicating savings. On pairs neither correctly recalled nor correctly recognized, the college students performed significantly better on old pairs than on new pairs ($z = 2.66, p < .01$), demonstrating savings for previously presented material. On pairs incorrectly recalled but correctly recognized, old pairs were again more often correctly recognized than were new pairs ($z = 3.68, p < .01$). Figure 1 displays the percent correct for old and new pairs for all groups.

The difference between the percentages of old and new pairs correctly recognized on the first relearning trial was used as an index of savings (Groninger & Groninger, 1980). Savings for old pairs, when compared with learning of new pairs, was 55.0% and 38.2% for the 3-year-olds and the 5-year-olds, respectively (see Table 1).

Two savings scores were calculated for the college students. For pairs both incorrectly recalled and recognized, a savings of 18.5% was found (see Table 1). For pairs incorrectly recalled but correctly recognized, a savings of 14.7% was found.

A 3 (age) × 2 (pair type) analysis of variance was conducted on the percentages of old and new pairs correctly

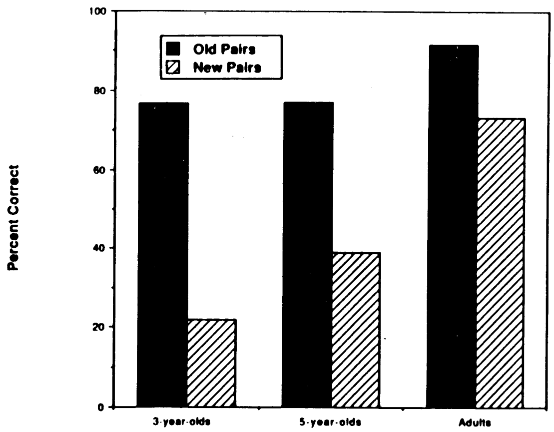

Figure 1. Percent correct of old and new pairs on the first relearning trial.

Table 1
Number and Percent Correct of Old and New Pairs, and Savings for Pairs Incorrectly Recalled 2 Weeks Later

	Total	Old Pairs		New Pairs		% Savings
	Incorrect	*n*	% Correct	*n*	% Correct	(Old-New)
3-year-olds	37	19	76.7	18	21.7	55.0
5-year-olds	64	36	77.1	28	38.9	38.2
Adults	185	90	91.6	95	73.1	18.5

recognized on the first relearning trial. A significant main effect for type of pair was found [$F(1,40) = 21.40$, $p < .01$]. The subjects were significantly more accurate on relearning old pairs than on learning new pairs. A significant main effect for age was also found [$F(2,40) = 6.96$, $p < .01$]. Post hoc testing with the use of a Newman-Keuls procedure revealed that the college students performed more accurately on new pairs than did the 3- and 5-year-olds. A regression analysis conducted on the percentages of correctly recognized new pairs verified the presence of a trend toward increased accuracy with age on new pairs ($r = .48$, $p < .01$).

DISCUSSION

Examination of relearning and savings in children is rare yet potentially useful in increasing our understanding of memory development. The present study provides a preliminary assessment of developmental differences in relearning in preschool-age children and college students. Savings for picture pairs seen 2 weeks previously was evident in both preschoolers and college students. Performance on relearning old pairs was significantly more accurate than performance on new pairs, suggesting savings for old pairs. These results with pictorial stimuli agree with previous studies reporting savings for verbal or numerical information in college students over a 2-week period (Groninger & Groninger, 1980; Nelson, 1971, 1978). In addition, we confirmed the greater sensitivity of relearning over recall and recognition, with college students showing a savings of 14.7% for pairs incorrectly recalled but correctly recognized during the retention test.

Savings—the performance difference between old and new pairs—for each age group is depicted in Figure 1. Performance on new pairs provides an index of transfer of learning. Thus, the area common to both old and new pairs represents the effect of practice, or transfer effects. When these effects are removed, a purer measure of memory remains. Therefore, the use of Nelson's revised savings paradigm eliminates, or at least equates, practice effects between old and new pairs.

A developmental trend toward greater accuracy in learning new pairs accounts for the smaller savings shown by the college students relative to the preschoolers; both the 3-year-olds and the 5-year-olds displayed greater savings than did the college students. These cross-sectional results are consistent with those from Burtt's longitudinal study (1932, 1941), which showed a decrease in savings with age. The finding that relearning changes with age is not surprising, since developmental differences have been noted in both recognition and recall (e.g., Flavell et al., 1966; Ornstein & Naus, 1978). However, the ability to save appears to decrease with age, whereas both recognition and recall increase with age. Although this is perhaps an atypical result given our present view of memory development, it is not an entirely foreign one. For example, Nelson (1988) reported age differences in the predictive accuracy of the feeling of knowing, with first graders showing more accuracy than fifth graders or college students. Similarly, Chi (1978) has documented that 10-year-olds who are highly experienced in the game of chess more accurately recall actual arrangements of chess pieces on a board than do inexperienced adults.

Our results also suggest that practice influences the performance of college students more than that of preschoolers. Unlike preschoolers, most of college students' performance on old pairs can be accounted for by the effects of practice. Compared with adults, young children are not as skilled at transferring strategies across situations. Similar results have been noted on free-recall tasks, for which little, if any, transfer effect among 5-13-year-olds has been noted (e.g., Lange, 1973; Shapiro & Moely, 1971).

The use of Nelson's procedure to assess performance on new, but comparable, pairs proved essential for detecting age differences in relearning and for evaluating the role of practice effects. Because it does not separate out the effects of savings and practice, the original procedure of Ebbinghaus would not have detected age differences in this study. The erroneous conclusion might then have been that savings, unlike recall and recognition, shows no change with age. In fact, Stroud and Maul's (1933) failure to uncover any differences in savings among 7-18-year-olds may be due to their use of the original procedure.

The developmental differences noted here are a function of performance on new, rather than old, pairs. All of the subjects performed similarly well on old pairs; percent correct ranged from 77% for 3-year-olds to 92% for college students, and no age group was significantly different from any other. Significant differences were apparent among our adult and child subjects, however, with the adults outperforming the children on learning new pairs.

The similar performance shown by preschoolers and adults on old pairs, however, occurs for very different reasons, which do not become clear until the effects of practice are removed. Preschoolers' performance on old pairs is primarily a result of savings, whereas college students' performance is primarily a function of practice. Therefore, unless provisions are made to remove practice effects, savings may appear equivalent across ages when it is not.

Young children, then, may rely more on their memories than on applying, or transferring, learning strategies. Adults, however, are quite proficient at transferring rules and strategies from one learning situation to the next. In fact, such proficiency is a likely explanation for the small savings seen in the adults. The adults performed about as well on new pairs as on old pairs. No doubt being skilled learners serves college students well, as they most likely have large demands placed on their memory. Remembering some general tools and strategies, then, can be a prudent way of extracting relevant information without overtaxing cognitive resources.

Preschoolers, on the other hand, are not required to commit large amounts of information to memory. Consequently, little else might be expected to interfere with their retaining the picture pairs. In addition, the preschoolers' memory may have been enhanced by the novelty of the experimental setting. Both minimal interference and context-dependent factors provide plausible explanations for the greater savings found in the preschoolers. One would expect then, if either or both factors are operative, that as children gain more experience in learning and memory tasks, and as increasingly greater memory demands are placed on them, they would begin to show levels of savings that approximate adult values. Further research with school-age children is needed to confirm this prediction and to explore other possible explanations for the greater savings shown by preschoolers, including the possibility that there are age differences in susceptibility to interference. Another worthy goal for future research would be to establish the shape of the relearning curve across the life span.

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NOTE

1. This mixing of pairs represents an AB–AB_r design and has been advocated by Nelson (1978) over, for example, the AB–AC or AB–CD designs as a way of insuring that any relearning differences are not due to "the extra processing required for cue learning" but instead "can be attributed to saved information about the association" (p. 459).

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