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ABSTRACT

In two studies, children participated in route-planning tasks in which they were asked to find the shortest path to retrieve certain items. In Study 1, children participated in two versions of the task (standard versus feedback) differing in the amount of contextual support. Forty-eight children, ages 6, 8, and 10 years, had to help their character find the shortest route to a wizard's house on a gameboard, while avoiding dragons and collecting a boat or car to cross the river, three pots of gold, and a key. In the standard condition, the benefits associated with planning were not concrete. In the feedback condition, children received a concrete reward for efficient routes. Results indicated that 8- and 10-year-olds were near ceiling in route efficiency on both tasks. Six-year-olds were less efficient than older children, but produced more efficient routes in the feedback versus standard task. Six-year-olds spent less time studying the array than 8-year-olds but not less than 10-year-olds. However, 10-year-olds were more efficient than 6-year-olds, suggesting more productive study time. In Study 2, a total of 32 children, 7 and 9 years of age, described their plans before acting, but were later informed about changes in the nature of the routes. Children had to decide whether a change in plans was necessary, and, if so, how to modify their original plans. Findings indicated that children at both ages were proficient at determining when plan changes were necessary. Detours made by 9-year-olds were more efficient than those of 7-year-olds. The quality of detours used also showed age-related differences. (KDFB)

Developments in planning: Children respond to contextual change

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Introduction

Good planning results when one can bring together a number of important processes, e.g., recognizing the utility of planning, coordinating subgoals, incorporating relevant knowledge, and adjusting plans to changing circumstances (Rogoff, Gauvain, & Gardner, 1987). Relative to its importance, little is known about this last process and how it develops. The studies presented below were designed to examine how well children modify their planning strategies to fit different problem scenarios.

In both studies, children participated in a route-planning task in which they were asked to find the shortest path necessary to retrieve a number of items. In Study 1, children participated in two versions of the task (standard vs. feedback) that differed in the amount of contextual support children received for planning routes in advance. In Study 2, children were asked to describe their plans before acting, but were later informed about changes in the nature of the routes. Children then had to decide whether a change in plans was necessary, and, if so, how to modify their original plans.

Study 1

Subjects

Sixteen 6-year-olds (M=6;6 SD=3.1 months) sixteen 8-year-olds (M=8;5 SD=4.3 months) and sixteen 10-year-olds (M=10;5 SD=5.5 months) were tested individually by the same experimenter. There were an equal number of males and females at each age. Children were recruited from after-school programs conducted by the Tempe and Mesa Public School systems, and the Tempe YMCA.

Materials

Two different gameboards, one for each condition, were used in the study. Both consisted of a 2' x 3' piece of felt, and had the same array of paths drawn on them with fabric paint (see Figure 1.) Stickers representing buckets of gold, cars and boats, dragons, and colored keys were affixed to felt squares and placed at certain points in the array. A strip of blue felt represented a river. Small plastic bridges were placed at two locations along the river. Five wooden "wizard

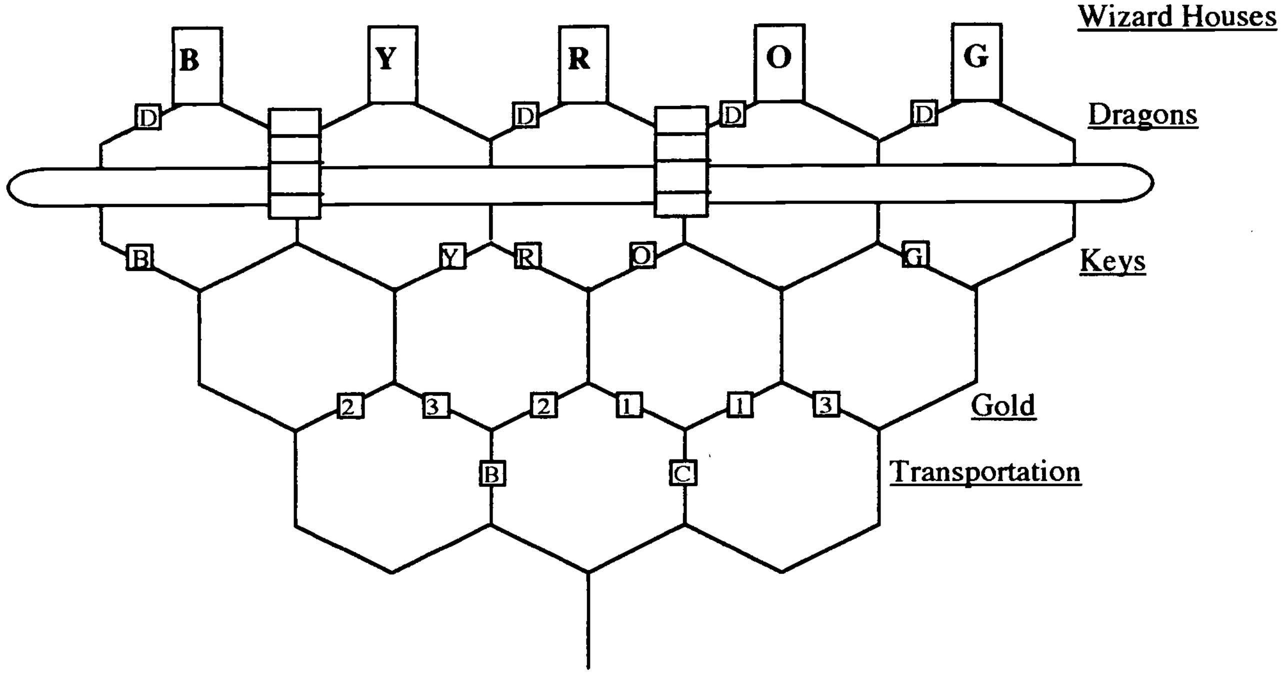


Figure 1. Study 1 array, standard condition.

houses", were positioned at the end of the path array. Children moved a Lego knight-figure along the chosen paths.

For the feedback condition only, small yellow stars were affixed to the board at certain locations to represent places where players were charged for passage. Passes consisted of index cards stamped with 6 yellow stars.

A "Wizard Game Passport" was also used. The passport had spaces clearly marked for the necessary items, so children would remember what to collect.

Procedure

The task was introduced to children as a board game in which they had to help their character find the shortest way to a wizard's house, where they could collect pieces of a puzzle. Children were told that if they made enough visits to the wizards they could collect all the puzzle pieces and receive a prize for putting the puzzle together. In addition to finding the shortest way, children were directed to select a route that allowed them to collect the following items: (1) A boat or a car for crossing the river; (2) three pots of gold; and (3) a key whose color matched that of the wizard house to be visited. Children were told that if they needed to use a bridge to get over the river they should take the car with them on the trip, but that to cross in the water, they would need the boat. The boat/car decision was the first choice facing children, yet it could only be made correctly and reliably if they anticipated features they would encounter at the end of the trip.

To narrow the number of potential routes and reward looking ahead, children also had to avoid "dragons" that appeared next to some of the wizard houses.

Children also earned stickers for participating in the game. The contingencies for earning stickers varied across conditions. On feedback trials, children were told that they needed a pass to get through the forest. The gameboard in this condition displayed yellow metallic stars at certain points throughout the array. Children were told that each time they passed one of the stars, a yellow star would be punched out on their pass. If the child could reach a wizard's house with at least one star remaining on the pass, she could trade that pass in for a sticker at the end of the game.

In the standard condition, children were also given stickers for their participation, however, they received stickers just for completing a trip.

Thus, the tasks differed in the support (and rewards) children received for making advance plans. In the standard condition, children chose routes to a wizard's house where the benefits associated with planning were not concrete. In the feedback condition, children received a concrete reward for taking efficient routes. In addition, the feedback task supported children's planning efforts by making it easier to compare alternative routes, (i.e., by counting the number of stars spent on each route) and by providing feedback about efficiency after each trial.

Each child completed 5 trials of each type (standard vs. feedback). Each block of trials was given in a separate session with the order of the blocks counterbalanced across subjects. All sessions were videotaped.

Results and Discussion

Eight- and 10-year-olds were near ceiling in route efficiency (number of intersections traversed) on both the standard and feedback tasks. This suggests they planned routes effectively with or without contextual support. Six-year-olds were less efficient than older children but did produce more efficient routes in the feedback vs. standard task, $t(15) = 1.60$, $p = .06$, one-tailed, (see Figure 2).

The best performance for children of all ages appeared when both feedback and practice were operating (see Figure 3). Interestingly, however, the benefits of the feedback outweighed the benefits of practice for three of the 6-year-olds.

A second index of planning was study time before action. There was a U-shaped trend between age and study time wherein 6-year-olds spent significantly less time studying the array than 8-year-olds ($M = 11.3$ vs. 18.0 sec), $t(30) = 3.18$, $p < .01$, but not 10-year-olds ($M = 15.0$ sec). Ten-year-olds were more efficient than 6-year-olds, however, suggesting that their study time was more productive.

Study 1 provides important information regarding children's sensitivity to task characteristics that support planning behavior. Whereas 6-year-olds both needed and were able to

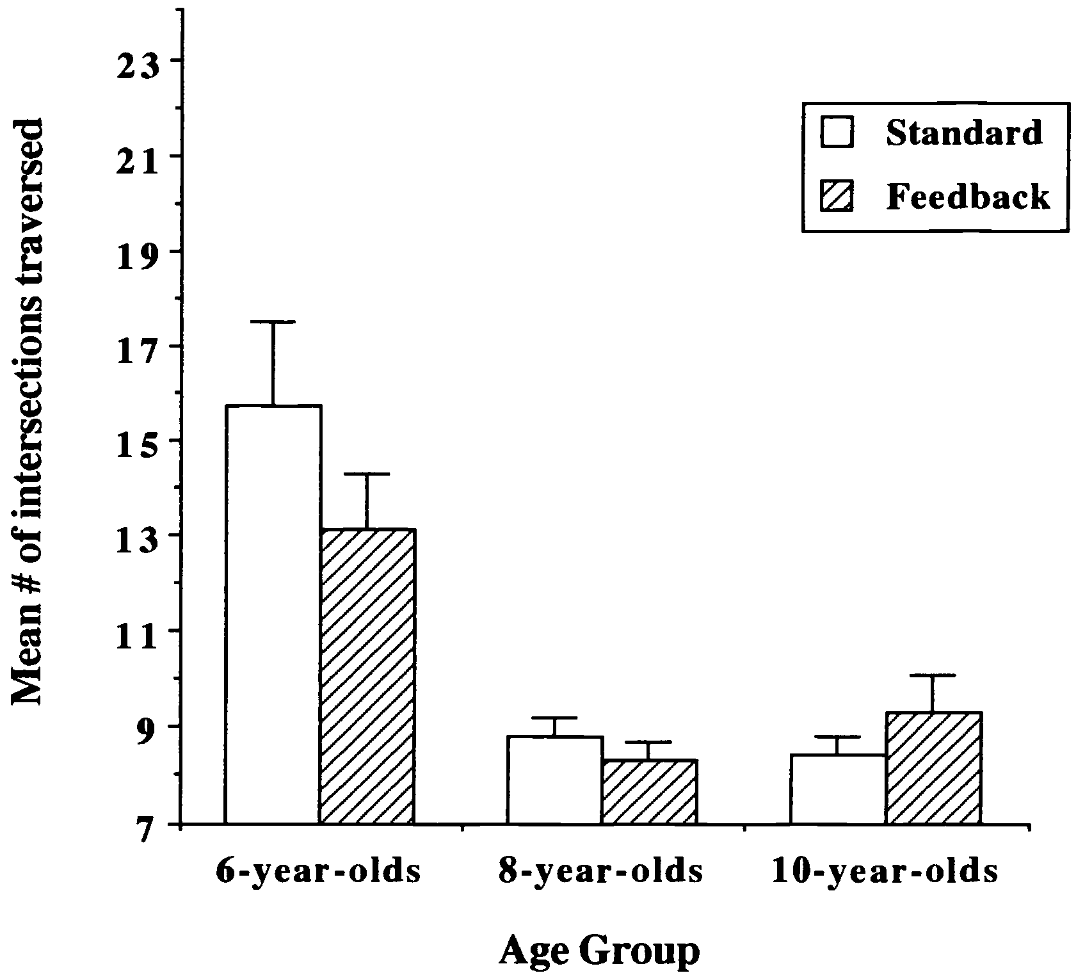
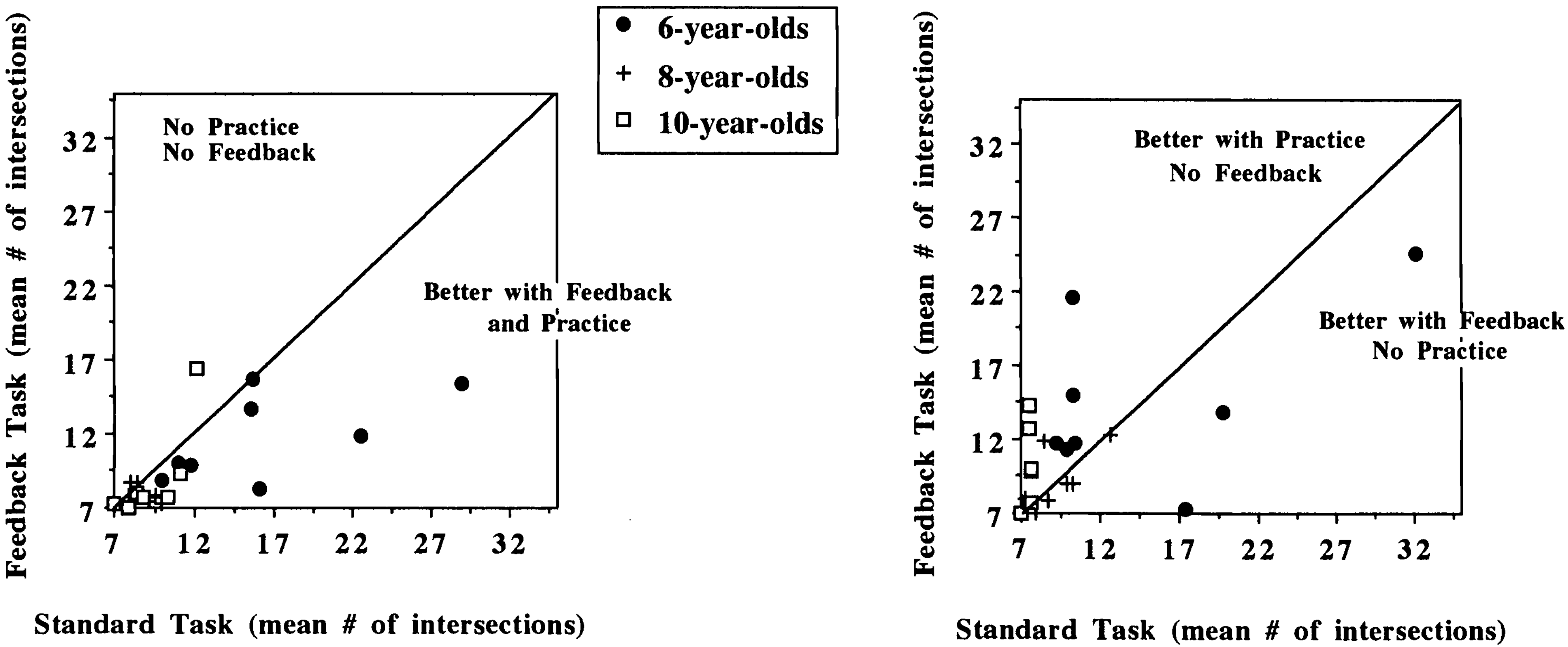


Figure 2. Mean number of intersections traversed (+ SE) as a function of age group and condition, Study 1.



(a) Order 1: Standard-->Feedback

(b) Order 2: Feedback-->Standard

Figure 3. Mean number of intersections traversed in feedback condition vs. mean number traversed in standard condition for task orders 1, (a), and 2, (b), and by age group, Study 1.

benefit from the support provided in the feedback task, 8- and 10-year-olds performed well even without such support. But to be adaptive problem-solvers, children must also learn to recognize that the appropriateness of a particular plan may change if new information is uncovered during the course of action. The second study presented here was designed to address this issue.

Study 2

Subjects

Sixteen 7-year-olds (M=7;1 SD=5 months) and sixteen 9-year-olds (M=8;11 SD=5 months) participated. There were an equal number of males and females at each age. Children were recruited through after-school programs offered by Tempe and Mesa Public Schools. All children were tested individually by the same experimenter.

Materials

The materials were the same as those used in the feedback condition of Study 1, with minor changes. Three bridges were used instead of two, and troll stickers, displayed on red felt squares, were also used. The array in this study was also structured so that it would be easier to discern the most efficient path.

Procedure

Children were tested individually in a modified version of the feedback task used in Study 1. In this game, however, children were told that they needed to tell the experimenter their plans prior to moving their character. Children were also told that they would meet a troll on their journey. It was explained that the trolls liked to "mess things up in the game" and that the trolls might change important features of the routes. Children were instructed to stop their character upon meeting a troll so they could find out what it had done (e.g., the troll added another dragon to the path ahead). They were given no instruction in how to modify their paths, however, and had to generate feasible detours for themselves.

Children completed 6 trials of this kind, 4 in which a change in plans was warranted and 2 in which no change was warranted.

On change trials, children could modify their plans in two ways: continuing on to the original destination, or changing their destination. For example, if a child planned to go to the orange house using the car, but was later told that the bridge was out of service, she could go back to the beginning of the array, pick up the boat, then continue to the orange house, thus adhering to the original destination. Alternatively, she could find another place to cross the river by car, and switch to the green house as her new destination. Although either detour would allow the child to collect a puzzle piece, changing destinations was always the most efficient solution.

Results and Discussion

Children of both ages were very proficient at determining when changes to existing plans were warranted. Only 5 of 32 children changed their routes on a no change trial, and each of the children did this only once. This suggests that it was easy for children to recognize when new information was irrelevant to their plan.

At a quantitative level, detours made by 9-year-olds were more efficient than those made by 7-year-olds, although performance at both ages was far from perfect. Analyses showed that 7-year-olds produced detours that were almost 3 times as long as necessary whereas detours produced by 9-year-olds were only twice as long as necessary, $\underline{F}(1,30)=4.75$, $\underline{p}<.05$, $Eta^2=.14$.

The quality of detours used also showed age-related differences. Each child's detours were classified as an "adhere to destination", "change destination" or "mixed response" pattern. The adhere and change categories were reserved for children who used each of those detours exclusively. Table 1 shows that whereas 8 of the 9-year-olds consistently used change destination detours, only 2 of the 7-year-olds did so. When the "mixed response" children were removed from the table, there was a significant relation between age group and type of detour used, Fisher's Exact Test, $\underline{p}<.05$. The large number of 7-year-olds using both kinds of detours suggests that they may be in transition from one stable state (always adhering to destination) to another (always changing destinations).

Table 1

Number of Children Exhibiting each Response Pattern as a function of Age Group, Study 2

Response Pattern	Age Group 7-year-olds	9-year-olds
Adhere to destination*	4	1
Change destinations*	2	8
Mixed response	10	7

* 5 out of 5 trials

General Discussion

The studies presented above make important contributions to our understanding of planning. They provide evidence, both at the individual and group level, that children notice and capitalize on changes in the context of planning scenarios. It is also important to note that children's performance in this set of tasks reflects a joint influence of age and context. Although the data describe a general trend toward more efficient and adaptive planning with age, children also show context-driven variations in performance. Even individual children produce different levels of sophistication in planning depending on whether the context supports or detracts from their efforts. Specifically, the present studies illustrate that planning behavior can hinge on factors such as whether the rewards for planning are concrete or implicit, and whether modifications to an existing plan must also be considered. Finally, the task described represents a new and versatile format for studying the many questions that remain about children's planning.

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