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THE USE OF KINETIC IMAGERY BY CHILDREN AND ADULTS

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In this study, we examined developmental improvement in kinetic imagery skills as related to differences in the utilizability vs. evocability of those skills. Analyses were conducted on performance levels and response times for task trials in which participants were required to determine which of 3 larger blocks could be "made" by combining (through imagery) 2 smaller blocks. Adults performed better than did 9- or 11-year-olds, especially for trials that required mental representation of rotation as well as horizontal movement. Examination of the effects of 2 conditions of task administration indicated no developmental changes in the adjustment of methods of task solution to specific instructions. However, analyses of response times suggested that age differences in performance levels could be attributed to differences in the degree to which possibilities of ways in which blocks could be combined through mental imagery were exhaustively examined.

Keywords: kinetic imagery, mental imagery, mental representation, children, adults, performance levels, response times.

Piaget and Inhelder (1971), who conducted the most extensive study of mental imagery in children, emphasized the inability of preoperational children to represent any movement or transformation in their mental imagery. In contrast, Marmor (1977) used simpler task instructions and procedures, and found that both 4- and 5-year-old children were capable of using kinetic imagery. We designed this study to examine the nature of later developmental changes in kinetic

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imagery abilities, and selected a task that contained more diversity of difficulty level than Marmor's mental rotation task. A correct solution for a specific trial always required anticipating the result of moving two block forms together (horizontally). However, more difficult trials also required mental rotation of one form or both forms (differently) before anticipating the result of the horizontal movement. We predicted, on the basis of Marmor's (1977) findings, that developmental differences would be greater for the latter trial types than for trials that required only the representation of a single horizontal movement.

Marmor (1975, 1977) considered Flavell's (1971) distinction between utilizability and evocability in addressing the problem of specifying the nature of development change in kinetic imagery abilities. The initial suggestion (Marmor, 1975) was that little (or no) developmental change was associated with the utilizability of kinetic imagery, but that children became increasingly more able to sense the fit between those imagery abilities and the specific task at hand (through evocability). However, a later study with 4-and 5-year-old children who did not receive training for the rotation task, provided clear evidence for mental rotation (Marmor, 1977). This finding supports the conclusion that young, preoperational children both evoke and utilize kinetic imagery.

Marmor (1977) also confirmed the findings of Anooshian and Carlson (1973), that kinetic imagery abilities develop independently of operational thought processes (as measured by Piagetian tasks). However, Anooshian and Carlson suggested that even 7-year-old children did not evoke kinetic imagery abilities in performing a task similar to the one selected for the present study. This suggestion follows from the examination of three specific findings of that study: (1) performance was close to chance levels for the block combination task, (2) similar performance levels were obtained for three trial types, each requiring increasingly more complex imagery abilities, and (3) total performance scores loaded on a factor that appeared to tap simple visual recognition skills (reproductive imagery).

Anooshian and Carlson's (1973) task was selected for further study to examine two major thrusts for development change in kinetic imagery tasks. First, in selecting three age groups beyond the 7-year-old level—9-year-olds, 11-year-olds, and adults—we aimed to determine the point at which kinetic imagery abilities would be evoked for this more difficult task. Second, as indicated earlier, the task allows for further examination of the development of specific imagery abilities. For example, while a 9-year-old child might be quite able to anticipate the results of a horizontal movement (as required by the simplest trial type), he/she may not be able to combine mental rotation (of individual forms) with horizontal movement in deriving a task solution (as required by other trial types).

We also examined another avenue of development change that suggested itself through consideration of the evocability issue: while the nature of instructions may determine whether appropriate abilities are evoked, there may also be developmental change in the degree to which participants will use specific task instructions to modify methods of task solution. The importance of this issue has been recognized in other areas of research, although with somewhat younger children. For example, Rogoff, Newcombe, and Kagan (1974) found that, if children were told that they would be studying pictures in order to recognize them after different delay periods, 8-year-olds adjusted their study times in accordance with the stated length of delay, whereas 4- and 6-year-olds did not. For the present study, some participants were given different types of trials (no, one, and two rotations) of the block combination task in distinct sections, with separate instructions specific to each section (separate condition). The remaining participants were given combined instructions at the beginning of the task; trials were then administered in a random order (random condition), per Anooshian and Carlson (1973). Separate instructions were designed to decrease the number of possible ways in which stimulus blocks could potentially be mentally combined to “make” a correct response block (for any single trial type). For example, for the most complex trial type (two rotations), a participant who was attentive to instructions would be able to limit attempts at task solution (specifically, to six possibilities). That is, there would be a limited number of ways in which individual blocks could be rotated (differently) before anticipating the result of horizontal movement. However, a participant in the random condition would be at a clear disadvantage here; the results of simpler (incorrect) possibilities—involving no mental rotation, or rotation of only a single form—would probably be assessed before the more complex possibilities were even considered. In addition to assessing performance levels, we also measured response times; adjustment of task solutions to specific instructions would be apparent in smaller response times for the separate, compared to random, condition.

Method

Participants

Groups of 24 males and 24 females were selected from both the third (M_{age} = 8 years, 10 months) and fifth (M_{age} = 10 years, 10 months) grades of schools serving a middle-class community in San Antonio, TX, USA. Further, 24 male and 24 female college students received extra course credit for participation. Twelve participants from each age/gender group were randomly assigned to the two experimental conditions.

Procedure

Stimulus and response forms were similar to those used by Anooshian and Carlson (1973). There was some indication in that study that children attempted to solve the task by matching up similar-looking parts in stimulus and response forms. While the children were younger than those selected for the present study and performed at near chance levels, modifications were nevertheless made to assure minimal similarity in parts of stimulus and response forms. Similarity that could not be completely eliminated was as likely to lead to an incorrect as a correct choice.

Each participant was individually tested with a notebook on a table in front of him/her; pages were arranged so that the participant simultaneously saw the stimulus sheet on the left and the response sheet on the right (see Figure 1). The stimulus sheet contained two solid black blocks; the response sheet contained three larger blocks. The notebook was placed on a larger board, such that three buttons to be pressed by the participant were lined up with the three response choices.

Each of the three choices on the response sheet had the same area as the combined area of the stimulus blocks; however, two of the choices were impossible to make by combining the two stimulus blocks. For one third of the trials, the correct response represented the result of moving the two stimulus blocks together (no rotation). Another third of the trials had a correct response that represented the result of rotating one of the stimulus blocks before moving the two together (one rotation). The required rotations were 90° clockwise, 90° counterclockwise, or 180°. The final third of the trials had a correct response that represented the result of rotating both blocks differently before moving them together (two rotations).

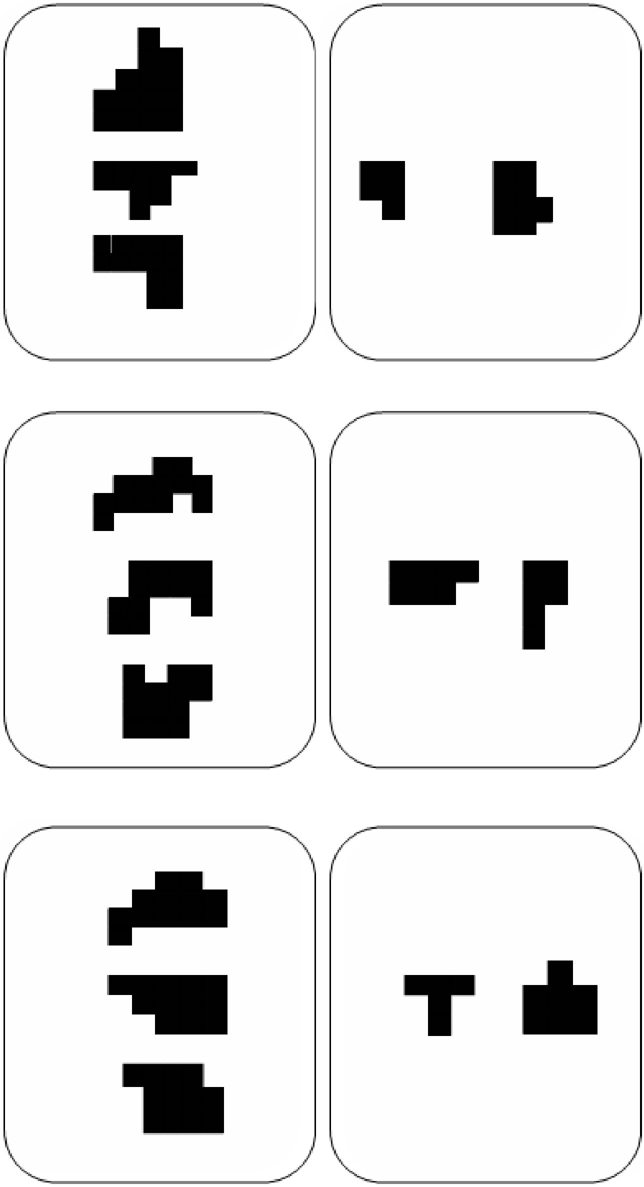

Figure 1. *Stimulus (left) and response (right) blocks as simultaneously seen in three different trials.*

Note. The no rotation, one rotation, and two rotations trial types appear in the top, middle, and bottom positions, respectively.

The two experimental conditions (separate and random) differed only in the arrangement of the practice and test trials. The experimental procedure for participants in the random condition started with the administration of six practice trials, two for each trial type (no, one, and two rotations). The experimenter told the participant to look at the two blocks on the left sheet and to point to the bigger block on the right sheet that he/she could make by moving the two smaller blocks together. To ensure that the participant understood the nature of the task, the experimenter showed the participant two cardboard blocks that were the same size and shape as those on the stimulus sheet. The experimenter held these forms in front of the participant until he/she agreed that they were the same as those on the left sheet. The experimenter then moved the two blocks together (after rotating one or both blocks for the last four trials) and asked the participant to point to the bigger block on his/her right sheet that was the same as the block the experimenter had made by moving the two smaller blocks together. The demonstration blocks were also used to assure that participants knew that blocks could only be rotated in a two-dimensional space (not flipped over) and that stimulus blocks maintained their left and right positions in response forms (were just moved together). The experimenter did not proceed to the next practice trial until the participant had pointed to the correct choice.

There were nine stimulus sheets used in the 27 test trials, which each used three times (once for each trial type). The correct response appeared once in each position (top, middle, bottom) for each corresponding set of stimulus blocks. The incorrect choices for response sheets that corresponded to identical stimulus sheets were identical. Trial order was completely randomized.

For participants in the separate condition, the same practice and test trials were administered as were used for participants in the random condition. However, the three trial types (no rotation, one rotation, two rotations) were divided into three distinct sections comprising nine trials each, before being randomly ordered in test notebooks. Each section was preceded by the appropriate two practice trials and corresponding instructions during task administration. Thus, participants knew beforehand how many rotations would be demanded for each trial. The order of presentation of the three sections was counterbalanced.

For each of the test trials, for both random and separate conditions, the participant responded by pressing the button next to the correct response block, (rather than pointing directly at the chosen response block; Anooshian & Carlson, 1973). After recording the response and response time, the experimenter reset the clock, starting the clock again simultaneously with the turning of the page in the participant's notebook.

Results

Performance Levels

Numbers of correct responses were analyzed with a 2 × 3 × 2 × 3 (gender, age, condition, and trial type) analysis of variance (ANOVA) design with repeated measures for trial type. A significant main effect was obtained for gender, with males (M = 22.41, out of a possible 27) performing better than females (M = 21.18), $F(1, 132) = 4.77$, $p < .05$. The main effect for age was also significant, $F(2, 132) = 25.95$, $p < .01$. However, as predicted, age differences were greater for the one and two rotation trials than for the no rotation trials (see Table 1), as reflected in a significant interaction between age and trial type, $F(4, 264) = 3.07$, $p < .05$. Further comparisons of means (post hoc Scheffé test) revealed that adults performed significantly better than both 9- and 11-year-olds for one rotation ($p < .01$) and two rotation trials ($p < .01$), but not for the simplest no rotation trials.

Table 1. *Mean Number of Correct Responses and Means for Average Log Response Times (For Correct Responses) For Each of the Three Trial Types*

	Trial type		
Age group	*No rotation*	*One rotation*	*Two rotations*
		Number of correct responses	
9-year-olds	7.56	6.08	6.25
11-year-olds	7.77	6.63	6.50
Adults	8.52	8.19	7.88
		Response time	
9-year-olds	0.96 (11.46)	1.07 (18.37)	1.08 (19.35)
11-year-olds	0.98 (12.57)	1.11 (16.12)	1.10 (16.25)
Adults	0.89 (11.07)	1.10 (19.08)	1.17 (21.44)

Note. Maximum correct score = 9. n = for each group. Numbers in parentheses are mean response times in seconds, without transformation.

A significant main effect was also found for trial type, $F(2, 264) = 36.12$, $p < .01$; however, further examination of the significant age × trial type interaction (reported earlier) revealed that the trial type effect was primarily limited to the performance of 9-and 11-year-olds. For both groups of children, but not for adults, performance on no rotation trials was significantly ($p < .01$) better (Scheffé test).

Response Times

Because preliminary analyses of response time data revealed a fairly large number of extreme (long) times intermixed through trial types and age groups, a logarithmic transformation was used. The average log response times for correct trials were then analyzed in another four-way ANOVA (gender, age, condition, and trial type). A significant main effect was found for condition, with shorter response times for the separate compared to the random condition, $F(1, 132) = 6.17$, $p < .05$. However, examination of a significant condition by trial type interaction, $F(2, 264) = 29.50$, $p < .01$, revealed that the effect of condition was limited to no rotation trials. Scheffé comparisons confirmed that participants in the separate condition took significantly less time ($M = .83$) to respond than participants in the random condition ($M = 1.05$) for no rotation trials ($p < .01$). However, this difference was not significant for either one rotation trials (*M*s = 1.09 and 1.09) or two rotation trials (*M*s = 1.11 and 1.12).

A significant main effect for trial type, $F(2, 264) = 73.31$, $p < .01$, was also interpreted in the context of the condition × trial type interaction. That is, differences in response times for the three trial types were greater for the separate than for the random condition. Finally, a significant age × trial type interaction, $F(4, 264) = 5.66$, $p < .01$, could be attributed to a greater difference across trial types for adults than for 9- or 11 -year-olds (see Table 1). While the average response time for no-rotation trials was significantly ($p < .05$) smaller than for rotation trials in all three groups (Scheffé test), the magnitude of the difference was greater for adults than for both child age groups.

Discussion

In summary, unlike the 7-year-olds studied by Anooshian and Carlson (1973), 9-year-olds clearly evoked imagery abilities, with their performance being well above chance levels and varying significantly by complexity of trial type. The developmental change between 7 and 9 years of age apparently involves increasing evocability of imagery skills. Further, the results confirmed the prediction that further developmental differences (beyond 9 years) would be greatest for rotation trials. All participants performed well on the simplest trials, with even 9-year-olds responded correctly an average of 7.6 out of 9 times. Thus, while representation of simple movement is possible as early as 4 years of age (Marmor, 1977), the ability to represent more complex movement (rotation as well as horizontal movement) appears to be a later developmental acquisition. Finally, comparisons of performance for the separate and random conditions revealed no developmental differences in the adjustment of methods of task solution to specific instructions.

Although the age differences confirmed our predictions, a closer examination of response times suggests caution in their interpretation. All participants spent more time on rotation than on no rotation trials; however, the magnitude of the difference varied across age groups. Children, relative to adults, showed a smaller difference in response times, and a greater difference in performance levels, for no rotation vs. rotation trials. This suggests that the age differences could simply be a function of children's premature choices for the more difficult trials. That is, adults may be more likely to complete a systematic and exhaustive search of various combination possibilities before making a response choice.

Unlike effects for age, gender differences were not specific to any particular trial type, nor were they accompanied by differences in response times (where no main effects for gender or interactions involving gender were obtained). Further, the overall effect of gender, without age interactions, was consistent with other literature, whereby the strongest and most consistent gender differences have been found with tasks that stress spatial visualization, and male superiority in spatial tasks has been demonstrated for children as young as 4 years (Harris, 1977).

In summary, our results suggest several clear, but other questionable, thrusts for developmental change in kinetic imagery tasks. We suggest that the basic ability for representing movement in imagery (utilizability) emerges at a young age and undergoes little developmental change. Further, the source of male superiority appears to be in these basic imagery abilities—for example, gender differences were equally as apparent in no rotation and rotation trials. While this gender difference remains constant across age, children's performance on imagery tasks improved as a consequence of changes in the evocability of basic imagery abilities, and changes in the degree to which task strategies are exhaustive (preventing premature choices). However, overall, we suggest caution in the interpretation of age differences in performance levels for imagery tasks. Specifically, we contend that, at the present time, there is no convincing evidence for developmental change in the utilizability of kinetic imagery abilities.

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