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ABSTRACT

Involving children 7 and 10 years of age, two experiments aimed to clarify the basis of children's confusion about actions they performed and actions they imagined performing. In experiment 1, subjects were assigned to one of three conditions, each involving two different types of tracing exercises. Children traced simple or complex pictures by choosing to use either a pencil or a finger, a stylus or a finger, or a pencil or a stylus, thereby gaining differing amounts of kinesthetic and visual feedback in the different conditions. Results indicated that discrimination scores measuring memory for type of activity were not just another measure of picture recognition. Children were not equally confused about any two types of activities performed. They were least confused when they performed with a pencil. Experiment 2 tested the implication that differences in the degree of confusion between memories of tracing and imagining depend on the tool involved. Children using a pencil were expected to be less confused than others about what they traced and what they imagined tracing. Results indicated that children were least confused about tracing and imagining when they used a pencil. Children were not uniformly more confused about memories involving imagination. In general, results suggest that the content of memory is very important for discrimination performance. (RH)

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Remembering Actions:

An Analysis of the Sources of Children's Confusions

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Abstract

Although confusions about memories for performed and imagined actions have been observed from both adults and children alike, children have more difficulty than adults distinguishing actions they performed from actions they imagined performing (Foley & Johnson, 1985). The present experiments were designed to seek a clarification of the basis of children's confusion between actions and imaginations. In Experiment 1, 7 and 10 year olds engaged in two types of tracing exercises (using a pencil and a finger; a pencil and a stylus; <u>or</u> a finger and a stylus). In Experiment 2, children traced and imagined tracing pictures using one of these three tools. In both experiments, the degree of confusion varied with condition. In some cases, confusions involving different types of tracing were greater than those involving imaginal memories. A theoretical interpretation is developed that emphasizes the importance of specific information associated with motor programs for children's decision processes.

Remembering Actions: An Analysis of the Sources of Children's Confusions

The thought processes involved in imagining actions often include physiological components similar to those involved in the actual performance of those actions (e.g. MacKay, 1981). For example, quite some time ago, Washburn (1916) suggested that tentative movements accompany imaginations, and Jacobsen (1930) added empirical support, showing changes in electromyographic activity during imagined movement. More recently, investigators have reported mental practice of some sports activities (e.g., free-shooting in basketball, dart throwing) are effective rehearsal exercises, and, sometimes as effective as physical practice (e.g., Feltz & Landers, 1983; Hardy & Ringland, 1984; MacKay, 1981; Mendoza & Wichman, 1978; Minas, 1978; 1980).

Interestingly, the effect of mental practice is greater when subjects actually imagine themselves performing actions than when they imagine seeing themselves performing those actions (Nigro & Neisser, 1983). Furthermore, mental practice seems to be more effective when the individuals involved in the exercise routines are already somewhat skilled (e.g., Corbin, 1972; Richardson, 1967). These latter two findings suggest that the motor programs for the actions that were practiced mentally were already represented in memory, and that mental rehearsal seems to activate the same motor programs involved in physical rehearsal.

If imagined actions are actually similar to those that are performed, people ought to be confused at times about what they did and what they imagined doing, and, in fact, they sometimes are. Adults are sometimes more confused about what they said and

what they imagined saying (Foley, Johnson, & Raye, 1983) and, on occasion, they are confused about what they did and what they imagined doing (Anderson, 1985; Foley & Johnson, 1985).

Developmental theorists (e.g., Piaget, 1929; Werner, 1948) would argue children ought to be more confused about memories because of general confusion between the real and the psychical. Werner (1948), for example, suggested that objective reality (based on perceptual experiences) and subjective events (e.g., fantasies) are clearly separated in adults but not in children. "In the young child ... there is a relatively close connection between perception and imagery. This is grounded, first of all, on the fact that the real percept possesses a great deal more of the character of an image than is the case with the adult...On the other hand, images are (for the child) much more perceptual in nature...than with the normal adult. Because of this, small children may consider an image not as something privy to them alone, but as an objective phenomenon" (pp. 389-390). Werner further suggests that children become conscious of this distinction between reality and fantasy between 6 and 8 years of age. Piaget (1929) was even more doubtful about children's abilities to separate the origin of their memories, indicating that children under 11 do not reliably discriminate between the "psychical and internal (vs.) the material and external".

Using these theoretical writings as guidelines for the selection of age groups to compare, recent studies have indeed shown that children are even more likely to confuse what they did and what they imagined doing. Six and seven year olds were more confused than adults about what they said and what they imagined saying (Foley et al., 1983) and both younger and older children (9 and 10 year olds) were more confused than adults about what they did and what they imagined doing. For example, in one study including a variety of actions, children were much more confused than adults about what they traced with their index finger and what they imagined tracing with their index finger (Foley & Johnson, 1985).

The purpose of the present experiments is to seek a clarification of the basis of children's confusions between memories for performed and imagined actions. Several alternative explanations for this memory confusion have been eliminated. For example, Foley, et al., (1983) asked children to imagine themselves saying words and to listen to another person say other words. When later asked to discriminate memories for words they imagined saying from words they heard another person say, children's performance was quite good (about 85% accurate). In contrast, their age mates did considerably worse (about 60% accuracy) when discriminating memories for words they imagined saying from words they said performed. This difference in performance in the two discrimination conditions supported the conclusion that children's confusions between memories for performed and imagined actions is not because of a general problem with decisions involving memories for imaginations (Foley, et al., 1983; Johnson & Foley, 1984). This difference also supported the conclusion that young children are not uniformly more confused about the origin of their memories as Werner and Piaget would lead us to expect.

Furthermore, children's confusions about memories for performed and imagined actions is not due to their having difficulty with any discriminations involving events from the same general class of experience. For example, young children are as good as adults in discriminating which of two adults performed actions, a discrimination involving memories from the same general class of perceptual experience (Foley, et al., 1983; Foley & Johnson, 1985). Yet, they were worse discriminating actions they performed from those they imagined performing, a discrimination involving memories that are both related to the self.

In these two types of discriminations -- i.e., distinguishing memories for who performed which actions <u>and</u> distinguishing memories associated with the self (perceived and imagined actions) -- the use of specific information is helpful in resolving the discrimination. For example, when deciding who performed a particular action, both adults and children may try to remember where they were looking or exactly what the person looked like when performing a particular action, and, responses during metamemory interviews provided an indication that adults and children alike draw on this specific information when deciding who performed what actions (Foley & Johnson, 1984). Since children's discrimination was better when they were differentiating between two perceptual sources (i.e., who did what) than when differentiating between two self-generations (i.e., did I do that or imagine doing that), apparently, for children, specific perceptual cues associated with the actions of other people may be more readily available in memories than specific cues associated with their own actions. What sorts of cues might then be available to facilitate discriminating between memories for one's actions?

There are many potentially interesting components of the memories for self-generations (Brunia, 1984; Norman, 1981; Raye, Johnson, & Taylor, 1980; Rosenbaum, 1984), any of which might be useful cues for discriminations involving self-generated memories (Foley, et al., 1983; Raye, et al., 1980). These components may include aspects of cognitive operations leading to the activation of a concept in memory. However, they may also include information related to the initiation of specific motor programs as well as information related to the enactment of those programs. For example, kinesthetic feedback associated with the production of an action as well as feedback to the "distant" senses (hearing, seeing) from the products of one's own actions may be a part of action memories (Raye, et al., 1980). These cues related to kinesthetic feedback following the production of actions are based on immediate consequences following action enactment. More long-term consequences may also be a part of detailed mental records of actions (Raye, et al., 1980).

Children's confusions involving performed and imagined actions may reflect a general problem with <u>any</u> two types of action memories. Thus, they may also be confused about any two actions they actually perform (e.g., trace with a pencil vs. trace with a finger). Such a general confusion between any two self-generated memories could occur for at least two reasons. Children's memories may be less differentiated, thus, cues associated with the initiation, production and consequences of their actions would be unavailable to facilitate discrimination. Or, children's

decision processes may be dominated by the use of one of these types of cues. For example, they may focus on the fact that a motor program was <u>initiated</u> (when performing or imagining an action), with little consideration given to information about detailed records of the actual actions.

However, it is premature to suggest either of these explanations as the basis for children's memory confusions. In the previous studies, children simply said words or performed simple actions like those included in a Simon-says game (Foley, et al., 1983; Foley & Johnson, 1985). Thus, there were minimal cues associated with kinesthetic feedback from one's own activities (e.g., pronouncing individual words or tracing with one's index finger does not involve a great deal of feedback). Also, there were no visible consequences following pronouncing words or tracing exercises. Children may need tangible records of the consequences of their own actions to help them differentiate, for example, what they traced from what they imagined tracing.

The present studies examined the consequences for memory discriminations of both kinesthetic feedback and visible records following one's actions. Kinesthetic feedback and visible consequences were manipulated by including different types of pictures (simple and complex line drawings) and different types of tracing "tools" (finger, stylus and pencil).

Tracing exercises are effective for assessing the relative amount of information associated with the initiation, production (e.g., kinesthetic feedback) and consequences following one's efforts. There is very little coordination involved in tracing over the lines in a drawing using one's index finger. However, the use of a pencil or a stylus (an instrument shaped exactly like a pencil, and of the same size, but having no lead) to trace a picture of a giraffe or a traffic light involves fine motor coordination in that it takes effort to hold the tool and keep its point on the lines in the drawing). Thus, the relative amount of information about kinesthetic feedback is greater when tracing with a pencil or a stylus than when tracing with a finger. And, since both simple and complex pictures were included, the amount of information associated about kinesthetic feedback should be greater for complex pictures than simple ones.

The consequences following tracing exercises are also more evident depending on what tool is used. The use of the pencil, in contrast to the other two, produces more long-term consequences (e.g., noticing and then remembering how accurately one traced over a particular picture). There are no visible outlines when tracing is done with a finger, and the visible outlines produced by the stylus are, at best, faint.

In both experiments, subjects were from 2 age groups (7 and 10 year olds). In Experiment 1, there were three conditions, each involving two different types of tracing exercises (using a pencil vs. a finger; using a pencil vs. a stylus; or using a finger vs. a stylus). In Experiment 2, there were three conditions each involving tracing vs. imagining; the only difference was in the tool involved (pencil, stylus or finger).

Experiment 1

There were three conditions in Experiment 1. In the Pencil vs. Finger condition, children traced some simple and complex pictures using a pencil, and others using an index finger. In the

Stylus vs. Finger condition, children traced some pictures using a pencil and others using a stylus. In the Pencil vs. Stylus condition, children traced some pictures using a finger and others using a stylus.

If children's action memories are undifferentiated or if their decision processes are dominated by one type of information (e.g., the fact that an action was initiated) then their confusions about which tools they used to trace particular pictures should be comparable across these three conditions. On the other hand, if children's action memories include specific information associated with kinesthetic feedback and its consequences, and if children use these cues when discriminating between self-generations, then confusions should differ across conditions.

Specifically, assuming that children do use specific cues related to kinesthetic feedback and the visible consequences of actions when making decisions, the differences in the relative amounts of information associated with these kinds of cues lead to specific predictions for the results of Experiment 1. First, when discriminating between pictures traced with a pencil from those traced with a finger, since kinesthetic feedback and visible consequences are greater following the use of a pencil compared with the use of a finger, performance should be relatively good in this condition. Secondly, the primary difference between tracing with a finger and with a stylus is in the availability of kinesthetic cues since visible consequences following both kinds of tracing exercises are minimal. Thus, we might expect performance to be worse in this condition compared to the first one (pencil vs. finger). Finally, when discriminating between pictures traced with a pencil and a stylus, cues based on kinesthetic feedback are fairly equivalent, and the only difference between these two tracing exercises involves the visible consequences following the use of the pencil. If <u>only</u> cues associated with consequences are important, since there are considerable differences in this type of information associated with the use of a pencil and a stylus, then discrimination in this condition should resemble discrimination in the first condition (finger vs. pencil). However, if kinesthetic cues are also important, since their overlap is considerable when using a pencil and a stylus, discrimination performance should be also be lower in this third condition compared with the first.

Method

<u>Subjects</u>. Thirty children from each of two age groups were randomly assigned to one of the three conditions ($N = 60$). Children were from two parochial schools (in Saratoga Springs and Rochester, New York). Their mean ages were 7.5 (range 7.0 - 7.11) and 10.5 (range 9.11 - 10.9). The socioeconomic and cultural backgrounds of the children were quite similar (middle class) and children from the two schools were represented proportionally across the conditions. Male and female subjects were also represented equivalently across conditions.

<u>Materials</u>. Twenty four pictures (12 simple and 12 complex) were chosen from a set of 260 for which Snodgrass and Vanderward (1980) published complexity ratings. The mean complexity or detail (i.e., the amount of detail or intricacy of the lines) was 1.47 and 4.0 (out of 5) for simple and complex ratings. The

standard deviations were .35 and .51. for simple and complex pictures, respectively. In addition, for the simple and complex pictures included here, the mean ratings were comparable and high for familiarity and for image variability (i.e., the degree to which the pictures resembled subjects' mental images of the pictures) (Snodgrass & Vanderward, 1980).

Eight simple and 8 complex pictures were selected randomly from the set of 24 as targets and the remaining pictures were distractor items on the subsequent memory test. The pictures were drawn by one of the authors on individual sheets of white paper (3" x 5"), photocopied and bound into booklets. Simple and complex pictures occurred equally often under both tracing exercises in each condition (e.g., tracing with a pencil vs. tracing with a finger). The order of occurence of the pictures during the tracing phase was random with the restriction that both picture types (simple vs. complex) and tracing exercises (trace with a pencil or stylus) occurred equally often in each quarter in the trial sequence.

<u>Procedure</u>. All subjects, randomly selected and assigned to one of the three tracing conditions, were tested individually in school rooms such as the library by one of three female experimenters each of whom was represented proportionally across conditions. Children were invited to play a detective game, a cover story used successfully in previous studies (e.g., Foley et al., 1983). Children were told "that good detectives do all sorts of things and look for clues about what they are doing. So sometimes I will ask you to trace over the lines in a picture like this one with a pencil and other times I will ask you to trace

over all the lines in a picture like this with this tool" (e.g., the stylus).

Though given unlimited time to finish the tracing exercises, children completed the first phase in 15 minutes. As children finished each picture, it was removed from view. Following a brief retention interval, children were surprised with a memory test. They were shown the original 24 pictures plus 12 fillers and, for each, they were asked to indicate how they traced the picture previously. For example, they were asked to decide if it was one they traced using the pencil, one they traced using their finger, or a new picture not included in the previous set. Following this test, they were asked how they could tell which pictures they traced with a pencil and which they traced with a finger.

Results

The results are discussed in terms of two dependent variables: Picture recognition and discrimination for the type of self-generated activity involved (e.g., tracing with a finger vs. pencil). The discrimination score provides a measure of the subject's ability to remember how they traced each picture given that they recognized the picture as an old one, included in the first phase of the experiment.

Preliminary analyses indicated that there were no sex differences nor differences in the performance of the children from the two schools, thus, the analyses reported here collapse across these two variables. For subsequent analyses, Scheffe's test was used; only those results significant at the .05 level or less are reported.

Picture Recognition. Subjects' classifications of the pictures were first scored for simple recognition -- i.e., the number of pictures mistakenly called "new" (misses) and the number of pictures mistakenly called "old" (false positives). In a 2(age) x 3(condition) x 2(type of picture) analysis of variance on misses, there was only one significant effect. The mean number of misses on simple pictures (M = .35) was higher than the mean on complex pictures (M = .12), $F(1,54)$ = 7.60, p < .008. The same type of analysis on the false positive data indicated that there were no main effects nor interactions. As the data in Table 1 indicate, misses are quite low, thus recognition of the pictures was close to ceiling. Nevertheless, it is important to include these data because memory for the type of activity (e.g., trace with pencil vs. stylus) was not close to ceiling, as the next section shows, and it is important to realize that the discrimination scores measuring memory for type of activity are not just another measure of picture recognition.

Insert Table 1 about here

Discrimination Performance. Subjects' responses on the memory test were also scored for discrimination performance by computing a proportion. For example, the number of pictures the subject correctly identified as those traced with a pencil plus the number identified as those traced with a finger were divided by the total number of pictures correctly recognized as "old ones." These proportions were computed separately for simple and complex pictures, and they are shown in Table 2.

Insert Table 2 about here

In a 2(age) x 3(condition) x 2(type of picture) analysis of variance on the discrimination scores, there were no overall age differences. There was a significant interaction between age and picture complexity, $F(1,54) = 6.17$, $p<.02$. Scheffe's test showed that, for older children, there was a significant difference in the scores for simple ($M = .72$) and complex pictures ($M = .86$). However, for younger children, this difference was not significant ($M = .83$ and $.86$ for simple and complex pictures, respectively). We expected that the manipulation of picture type would affect discrimination performance, and these results suggest that it did, but, interestingly, only for older children.

Also as expected, discrimination scores varied across the three conditions (see Table 2), $F(2,54) = 4.00$, $p < .02$. The results of Scheffe's test showed that the mean discrimination score for subjects discriminating between the use of a pencil and a finger was significantly higher ($M = .89$) than in either of the othe two conditions. The mean discrimination scores for subjects discriminating between the use of a finger and a stylus ($M = .79$) did not differ from those discriminating between the use of a stylus and a pencil ($M = .77$).

In summary, the results of Experiment 1 are important for two reasons. First, they show that children are not equally confused about any two types of self-generations. Secondly, the fact that children were less confused when using a pencil indicates that cues related to the consequences of children's actions are

important for discrimination performance. If our emphasis on the role of consequences is correct, then we should also see differences in the degree of confusion between memories for tracing and imagining depending on the tool involved. This idea was tested in Experiment 2.

Experiment 2

Seven and 10 year olds were assigned to one of three conditions. They traced vs. imagined tracing simple and complex pictures using one of three tools: an index finger, a stylus or a pencil. Based on the outcomes of Experiment 1, we expected that children would be less confused about what they traced and what they imagined tracing when using a pencil because kinesthetic cues and visible consequences associated with the use of the pencil should facilitate the discrimination process. Confusions should be greater, by comparison, when tracing and imagining tracing with a stylus because of the absence of visible consequences. However, there is more kinesthetic information associated with the use of a stylus than the use of a finger, thus, we expected that discrimination performance would be better when tracing and imagining involved a stylus compared with when they involved the use of a finger.

Method

Subjects. Thirty children from each of two age groups were randomly assigned to one of three condition (N=90). Children were from the Saratoga Springs school district with males and females represented proportionally across conditions. Their mean ages were 7.4 (range 7.0 - 7.9) and 10.6 (range 10.0 - 10.9).

Materials and Procedure. The materials and counterbalancing procedures used in Experiment 1 were identical with those used in Experiment 2. When involved in imagining, children were encouraged to sit comfortably but very still during imagining so that they would not give the experimenter any "clues" about what they were imagining. For example, in one condition, children were told that "good detectives are very careful not to give any clues about what they are thinking. So sometimes I will ask you to trace over all the lines in a picture like this one with your finger and other times I will ask you to imagine using your finger to trace over all the lines in a picture like this one. Now when you are imagining yourself tracing be careful not to give me any clues or hints about what you ar imagining."

Several practice trials were included. Children did not seem to have any trouble understanding the nature of the tasks, and, their spontaneous reactions while tracing indicated that they were, in fact, imagining as we requested them to do. For example, children from both age groups would say "Oops! I have to erase an error in my mind, I went off the line...(or) Oh, I'm glad I'm tracing this in my mind because you can't see my mistakes on this one....(or) Oh, I missed that part, let me go back in my mind and finish." Children were given unlimited time to finish the tracing exercises, and, as they finished each picture, it was removed from view.

Results

Preliminary analyses indicated that there were no sex differences; thus, the analyses reported below collapse across

sex. Scheffe's test was used for subsequent analyses; only results significant at the .05 level or less are reported.

As in Experiment 1, misses and false positives were extremely low, indicating picture memory was near ceiling. For this reason, the analyses are not reported. (They were largely nonsignificant.) However, as the analysis of the discrimination data shows, memory for pictures traced and imagined was not close to ceiling. Since all three conditions in Experiment 2 involved tracing and imagining, this factor was included as a variable along with the three other factors of interest (age, condition and type of picture). A 2(age) x 3(condition) x 2(type of picture) x 2(trace vs. imagine) analysis of variance showed there were no differences between the age groups; thus, the means in Table 3 collapse across age. As shown in Table 3, discrimination scores were significantly lower for simple pictures compared with complex ones, $F(1,54) = 5.0$, $p<.03$.

Insert Table 3 about here

There was also a main effect for condition, $F(2,54) = 7.9$, $p<.001$, and this can be seen by looking at the overall discrimination scores for tracing vs. imagining in each condition in Table 3. The interaction between condition and tracing activity (trace vs. imagine) was also significant, $F(1,54) = 3.9$, $p<.02$. Subsequent analyses using Scheffe's indicated that the difference in the discrimination scores for pictures that were traced vs. imagined varied with condition. The difference was greatest when a finger was used, and smallest when a pencil was used.

In summary, the results of Experiment 2 are important in demonstrating that the extent to which children are confused about memories for performed and imagined actions depends upon the particular memories involved. Since the results are also in the direction that we predicted, the findings also emphasize the role of kinethetic cues and visible consequences for discriminations involving these sorts of memories related to the self.

General Discussion

Foley and Johnson (1985) reported that children were more confused than adults about memories for performed and imagined actions whereas children were no more confused than adults when discriminating what they did from what they saw someone else do, or when discriminating between what two other people did. What remained unclear from previous studies was how to interpret children's trouble in separating memories based on performed (speech or actions) and imagined activities. Was their difficulty in separating memories for performed and imagined actions independent of the content of those memories? And, more generally, was children's difficulty an indication of a general problem associated with differentiating between any two types of self-generated memories?

The results of Experiments 1 and 2 suggest that the answer to both of these questions is no. The present studies indicate that children are not equally confused about any two types of self-generations. In Experiment 1, the extent to which they were confused about two types of actions actually performed depended on

the actions involved. Children were not particularly confused about what they traced when using a pencil and a finger, accuracy was 89%. In contrast, they did much worse when tracing with a pencil and a stylus or when tracing with a stylus and finger (accuracy was 79% and 77%, respectively). In Experiment 2, children were more confused in some conditions than in others about what they traced vs. what they imagined tracing. Children were more confused about tracing and imagining when using a finger or a stylus than when using a pencil. Finally, when comparing Experiments 1 and 2 (Tables 2 and 3), it is clear that children are not uniformly more confused about memories involving imaginations.

The relative amount of information associated with kinesthetic feedback was varied in these studies by asking children to trace simple and complex pictures and to use one of three tools to trace. The use of a pencil and a stylus both involved more fine motor coordination relative to one's index finger for tracing the lines in the pictures. Thus, the relative amount of information based on kinesthetic feedback was greater in cases involving the use of a pencil or a stylus.

Also, the use of the pencil, in contrast to the other tools, meant that there were more obvious visible consequences following the completion of the exercises, providing additonal cues to facilitate discrimination performance. And, since some pictures were more complex than others, visible effects were even more evident in some instances than in others. As we mentioned, children held tools very securely, and carefully traced along the lines in the pictures. Thus, there was a fair amount of effort involved in producing the responses. How might these specific cues mediate discrimination performance?

Performance was typically good when tracing with a pencil. Presumably pencil tracing produced a considerable amount of information about kinesthetic feedback and visible consequences, thus increasing the identification of pictures that were traced with a pencil. The one exception involved discriminating between pictures traced with a pencil vs. those traced with a stylus (Experiment 1). While the visible consequences associated with the use of a pencil were greater than those associated with the use of a stylus, the similarity between the kinesthetic feedback associated with each tool was considerable, reducing the discriminability between the memories, and thereby reducing discrimination performance in this condition (see Table 2).

The role of kinesthetic cues and visible consequences are again evident when examining what happens when tracing involved the use of a finger or a stylus (Experiment 1). While the kinesthetic feedback associated with tracing exceeds that associated with the use of a finger, there is still considerable overlap between the information associated with tracing when a finger and a stylus are used because of the absence of visible consequences following the use of these two tools. This increase in the similarity between the two sets of memories evidently decreased their discriminability, and hence, discrimination performance was worse when discriminating between these two memories (Table 2, Experiment 1). Discrimination was also poorer (compared to that observed when a pencil was used) when either of these tools was involved in discriminations involving tracing and

imagining (Table 3, Experiment 2). When using a pencil, the relative difference between tracing and imagining is considerable, increasing the discriminability between these two types of memories. If there is greater overlap between these two memory classes, then there should be greater confusion and, indeed, there was in Experiment 2. For example, when using a finger or a stylus, the relative differences between tracing and imagining are reduced, increasing the similarity between the memory types, and decreasing their discriminability. Since the presence of kinesthetic cues did not seem to facilitate performance in cases involving the stylus, we can conclude that the presence of visible consequences are particularly important to children.

Our results suggest that the content of memory is very important for discrimination performance; relative differences in specific information based on kinesthetic feedback as well as tangible records following one's actions are important for children's discrimination between memories related to the self. Their problems reported in previous studies seem to occur because the information associated with the enactment of motor programs associated with speech (Foley, et al., 1983) or simple actions (Foley & Johnson, 1985) did not include "external marker" (e.g., how one felt when finishing the tracing with a pencil nor how one's tracing results looked upon completion). Thus, in order to differentiate performed from imagined actions in these cases, one might have to rely on more internally-based cues such as those associated with the cognitive operations involved in imagining (Foley, et al., 1983).

Now, why might there be a developmental change in the ability to use these internal cues to facilitate memory? With increases in age, children are exposed to and called upon to use their cognitive operations (e.g., rehearsing, systematically searching memory) in more formal settings for explicit purposes or goals (e.g., school assignments; homework assignments). Perhaps after these operations themselves have become more differentiated from other knowledge structures, they are then useful as discriminative cues (Robinson, Foley, Santini, & Barrett, 1987).

There is an alternative way of interpreting our findings, a way that does not draw on specific information present in the memories for one's own actions. The difficulty in imagining tracing may have varied with the tool children were asked to use during imagining. It could have been, for example, that it was more difficult to imagine using a pencil than it was to imagine using a finger. And, as a result, children may have been less successful with imagined tracing exercises that involved pencils compared with those involving fingers. The consequence of this could have been to reduce the similarity between real and imagined tracing in some cases, thereby increasing the discriminability between the memories associated with pictures that were traced and those that were imagined. This could account for the superiority of children's performance when pencils were involved. Essentially, this alternative interpretation rests on the assumption that children have trouble engaging in imaginal activity "on demand."

However, we are not persuaded by this alternative interpretation, in part, because there are ample examples of

deliberate symbolic play activities (one type of self-generation) that involve children's deliberate control over imaginal activities (Fein, 1975; Yawkey & Pellegrino, 1984). More importantly, there is evidence to suggest that children can follow explicit imagery instructions, generating visual images in a fashion similar to adults (Johnson, Raye, Hasher & Chromiak, 1979). Also, the way in which children manipulate visual images apparently resembles that of adults (Kail, 1985; Marmor, 1975). Not only can they follow explicit imagery instructions, but they also seem to spontaneously generate images in a fashion similar to adults. For example, Kosslyn and Bower (1973) reported that if a new sentence on a recognition test produced a visual image similar to an image produced by an old sentence, children make recogniton errors. And, in some recent work, children as young as 7 engage in spontaneous and elaborative imaginal activities involving auditory and visual images in a manner similar to adults (Foley & Santini, 1987).

Children's spontaneous remarks during the tracing and testing phases of Experiments 1 and 2 are also inconsistent with the idea that children are unable to engage in imaginal activities on demand. They spontaneously commented (e.g., "phew!") about the effort involved in tracing with a pencil or a stylus and they frequently commented about the "products" of their efforts. Some expressed pleasure that this "was not a test" because of the number of times they went off the lines. When imagining, children often commented that they were "relieved" because we could not see their mistakes produced by the pencil as they were "tracing in my mind." It is interesting to note that implicit in these remarks are children's self-evaluations or affective reactions to their own work, reactions that we suspect are important for discrimination processes. In fact, children's spontaneous remarks are consisent with our preferred interpretation, one emphasizing the role of specific cues associated with motor programs for discriminating between different types of activities.

Our studies suggest that children's memory confusions depend on the extent to which those memories share common and specific features associated with their production and consequences (or lack thereof). The more similar the memories, the more likely it will be that children need to "inspect" those memories more carefully, examining cues based on fine distinctions differentiating those memories. When these fine distinctions have specific external markers (e.g., self-initiated effects on the environment), children's confusions are noticeably reduced. However, when even finer distinctions are required, perhaps involving the use of cognitive operations associated with the initiation of activities (real or imagined) children seem to be very confused.

Our emphasis on the role of information associated with motor programs also implies that the involvement of the self as the agent in the imaginations is critical. If cues associated with specific motor programs mediating one's actions are important, then who one imagines (oneself or someone else) should have important and different consequences for memory confusions. Some new work we are doing suggests that this is, in fact the case. When children imagine themselves, they are more confused about

what they did and what they imagined than when they imagine someone else (e.g., parent, friend) (Foley & Santini, 1987).

Concluding on a more general point, the assumption that children are uniformly confused about the origin of their memories is quite prevalent (Johnson & Foley, 1984; Flavell, 1986). However, our studies suggest that careful attention must be given to the types of memories we are considering before predicting children's memory problems. Furthermore, an analysis of action memories in terms of recent models of action systems seems to be a fruitful way to begin the specific sources of children's memory confusions.

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Footnote

1. The discrimination scores were slightly skewed in a positive direction. Therefore their arcsin transformations were calculated and the analyses of variance were calculated for these transformations. The results were the same as those reported for the nontransformed scores. For purposes of clarity, the discrimination scores themselves are reported.

Table 1. Mean Number of Misses: Picture Recognition, Experiment 1

	Pictures	
	Simple	Complex
Trace with		
Pencil vs. Finger	.35	.05
Stylus vs. Finger	.35	.30
Pencil vs. Stylus	.35	.00

Table 2. Mean Proportion Discrimination Scores for Simple and Complex Pictures, Experiment 1

	Pictures	
	Simple	Complex
Trace with		
Pencil vs. Finger	.85	.93
Stylus vs. Finger	.72	.83
Stulus vs. Pencil	.76	.83

Table 3. Mean Proportion Discrimination Scores for Simple and Complex Pictures, Experiment 2

	Pictures	
	Simple	Complex
Tracing & Imagining Tracing		
Using a finger		
while tracing	.92	.97
while imagining	.61	.75
trace vs. imagining:		
overall discrimination	.77	.86
Using a stylus		
while tracing	.82	.83
while imagining	.78	.80
trace vs. imagining:		
overall discrimination	.80	.81
Using a pencil		
while tracing	.97	.98
while imagining	.92	.95
trace vs. imagining:		
overall discrimination	.94	.96