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ABSTRACT

This study examined the ability of 59 2- and 3-year-old children to monitor goal-directed activities with respect to an anticipated outcome. The study focused on two skills: error monitoring and error avoidance through anticipatory monitoring. To elicit monitoring, a variety of simple tasks were presented to the children. In each, a successful outcome required some amount of anticipation or correction of errors during the course of acting. The tasks included carrying water without spilling, tracking, nesting cups, handling blocks according to a rule, and pouring a specified amount of water into a funnel. The results indicated that task success increased with age: 2-year-olds were successful on about a quarter of the tasks, the older children on three quarters. This increased success was described in terms of two differences. The first concerned the change in the importance of the goal for the child, and the second involved a change in the ability to anticipate, as well as detect and correct, errors. (RJC)

ACTION REGULATION SKILLS IN TODDLERS

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Overview

Much of our behavior is intentional: We act to attain desired goals, and to avoid undesired ones. Although the ability to implement intentions probably begins in infancy, there is general consensus that it increases dramatically as children come to understand task demands, and to develop procedural skills for applying their knowledge.

However, knowing what to do and how to do it is not always sufficient for achieving an intended goal: When reaching an outcome entails several steps, takes place over time, is difficult, or competes with other action incentives, it may be necessary to employ additional, regulatory skills. These include such behaviors as inhibiting or delaying an action, directing attention, anticipating obstacles, correcting errors, checking progress toward a goal, ignoring distractions, and so on. To employ such regulatory skills requires more than simply being able to represent an intended goal and the means of achieving it. It requires an ability to compare the momentary state of affairs with this representation, and to take steps to correct actual or anticipated discrepancies, that is, to monitor ongoing activities with respect to progress toward a goal. When problems in reaching the goal are detected, one can correct errors; when they are anticipated, one can modulate the current activities to avoid errors.

Although we are beginning to know a good deal about the regulatory skills of older preschoolers and school children

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across a variety of domains (e.g., attentional, mnemonic, problem solving skills and strategies; emotional control; delay of gratification) much less is known about what skills are available to younger children, nor about the situations in which they can be observed.

The goal of this study was to look at the ability to monitor goal-directed activities with respect to an anticipated outcome in 2- and 3- year old children across a variety of tasks. We focussed on two specific skills: Error monitoring (corrections) and error avoidance through anticipatory monitoring. We expected that younger children would be more likely to detect and correct errors than to anticipate and avoid them, as corrections can be prompted and guided by an actual discrepancy between what one is doing and what one intends to do, whereas avoiding errors requires imagining and anticipating a not yet present discrepancy.

Design

To elicit monitoring, we presented a variety of simple tasks to 59 2 and 3 year old children. In each, a successful outcome required some amount of anticipation or correction of errors during the course of acting. The tasks included carrying water without spilling, tracking, nesting cups, handling blocks according to a rule, and pouring a specified amount of water into a funnel. For each task, and for the set of tasks as a whole, we observed how accurately children performed, and whether and how they regulated their activities with respect to the task goal (e.g., modulated their performance, checked progress toward the goal, corrected errors when they occurred).

Tasks and Measures

1. Water Carrying. Children were given a full glass of water and asked to carry it across the room to their mother without spilling.

   Measures:

-- Successful performance: no or very little water spilled
-- Error Monitoring : child walked more slowly/looked at glass more frequently only after some water spilled out
-- Anticipatory monitoring: Child walked slowly and/or looked at glass from the beginning of the trial

2. Duck Walking (tracking): The child pushed a toy duck along a circular path drawn on the floor.
Measures:
-- Successful performance: at least 75% of circle accurately tracked
-- Error monitoring: Child adjusted direction to return duck to track after error in tracking
-- Anticipatory monitoring: Child made small continual adjustments to keep the duck on the track

3. Nesting Cups: The child was given a set of 7 nesting cups and asked to seriate them inside one another.
Measures:
-- Successful performance: At least 6 of 7 cups seriated
-- Error Monitoring: Incorrect cup placement corrected (tried in different order, other cups tried, etc.)
-- Anticipatory monitoring: Cup placement altered before incorrect cup touched to other cups

4. Block - Handling: The child wore a blue bracelet on one hand and a yellow bracelet on the other. The task was to sort blocks following a rule that specified that blue blocks could only be held by the "blue" hand and yellow blocks could only be held by the "yellow" hand.
Measures:
-- Successful performance: More than 65% correct hand-block matches
-- Error Monitoring: Mismatch corrected as child grasped or was about to grasp an incorrect block

-- Anticipatory monitoring: Hand-Block match checked before child began to reach for block

5. Water Pouring: A small doll was moved up an elevator to its house by pouring water into a funnel connected to the apparatus. To succeed, the child had to stop pouring when the doll reached its house, or it would continue moving and disappear. To check the doll's progress, it was necessary to interrupt pouring and turn to look at the doll.

Measures:

-- Successful performance: Doll moved just to its house on at least 1 trial
-- Error Monitoring: none possible in this task
-- Anticipatory Monitoring: Longer looking time to the doll in the second versus first half of the trial (e.g., as it approached the house)

Results

1. Performance Level

	Age Group		
	2 years	21/2 years	3 years
Water Carrying (percent who spilled no or very little water)	11	65	67
Duck Walking (percent who accurately tracked at least 75% of circle)	20	90	73
Nesting Cups (percent who seriated at least 6 of 7 cups)	37	79	75
Block-Handling (percent with over 65% correct hand-block matches)	29	89	81
Water Pouring (percent who stopped on at least one trial)	59	75	94

2. Error Monitoring

	Age Group		
	2 years	21/2 years	3 years
Water Carrying * (percent who first monitored walking/looking after error)	37	15	7
Duck Walking (percent who adjusted tracking after an error)	75	68	80
Nesting Cups (percent who corrected non-seriated cups)	100	95	100
Block-Handling (percent who corrected mismatch after or during grasping)	86	94	100

3. Anticipatory Monitoring

	Age Group		
	2 years	21/2 years	3 years
Water Carrying (percent who monitored walking/looking from start)	16	75	87
Duck Walking (percent who continuously adjusted tracking)	25	79	73
Nesting Cups (percent who corrected false cup before touching it to others)	42	53	69
Block Handling (percent who checked hand block match before reaching)	43	61	94
Water Pouring (percent who looked longer in 2nd half of trial on at least 50% of the trials)	41	60	88

4. Consistency across tasks

	Age Group		
	2years	21/2 years	3 years
Mean percent tasks with:			
Success	23	76	77
Error Monitoring	58	54	58
Anticipatory Monitoring	35	75	85

* note: the low level of corrections in the Water Carrying task is due to our mutually exclusive classification of children as showing either error or anticipatory monitoring

5. Function of Monitoring: Correlations Success, Error Monitoring, and Anticipatory Monitoring (coefficients with age partialled out in parentheses)

	Success	
Error Monitoring	-.20	(-.25)
Anticipatory Monitoring	.71	(.49)

Conclusions

Not surprising, task success increased with age: the 2-year-olds were successful on about a quarter of the tasks, the older children on three quarters. This increased success can be described in terms of two differences. One concerns a change in the importance of the goal for the child. The older children seemed more "outcome-oriented," concentrating on achieving the particular task goal set in the testing situation, whereas the younger children often seemed more "activity-oriented," becoming involved in performing the activities for themselves rather than as a means to producing a particular outcome. The second was a change in the ability to anticipate as well as detect and correct errors. Although the frequency of error monitoring was relatively consistent across age, anticipatory monitoring increased: The older children were more likely to modulate their activities before errors occurred.

We speculate that each of these changes arise as the representation of actions becomes more differentiated and organized in a hierarchical goal-related structure. Specifically, we hypothesize that for younger children, goals and the means to achieve them are represented more as undifferentiated sequences in which the goal (or outcome) is simply the end element. This has several possible effects: (a) When the steps of a sequence are not differentiated, actions are more likely to be "ballistic": once begun, it is difficult to modulate the activities when difficulties arise; when an error is made it is difficult to resume the

activities where they were interrupted for corrections, (b) When a goal is simply one part of a sequence, activities do not necessarily culminate when it is reached. Rather, they are more likely to "run off" until the materials and/or the child's interest are exhausted; (c) When a goal and the means to achieve it are linked sequentially and non-hierarchically, alternative means to the same end are not automatically taken into account, and the possible need to alter the means is not anticipated.

For older children, in contrast, we hypothesize that the goal and the means of achieving it are more separable and hierarchically related. This means that activities can be performed more flexibly -- altered, changed, or substituted as the situation demands. In addition, anticipatory monitoring becomes more likely because the activities are guided by, not merely prior to a goal.

The age patterns reported here are similar to those reported for early memory and search skills: Somewhere in the middle of the third year, children begin not just to anticipate future outcomes (e.g., finding something, remembering something), but to regulate their goal-directed activities to ensure that those intended outcomes can occur despite difficulties and distractions. Of course, the developmental story does not end with being able to anticipate and monitor possible problems. Rather, we see this skill as a forerunner of later, conscious plans and strategies, skills that allow a child not just to anticipate difficulties, but also to efficiently and successfully avoid them.