Maternal Regulation of Children's Problem-solving Behavior and Its Impact on Children's Performance

Lisa S. Freund

University of Maryland Baltimore County

FREUND, LISA S. *Maternal Regulation of Children's Problem-solving Behavior and Its Impact on Children's Performance.* CHILD DEVELOPMENT, 1990, **61**, 113–126. This study focused on a social interaction theory of the development of cognitive self-regulation. Specifically, the effect of mother-child interaction on the child's ability to problem solve was investigated. The general predictions were (1) children who interacted with their mothers throughout a problem-solving task would subsequently exhibit improved independent performance over practice-control children, who received corrective feedback from a female experimenter at the end of the task; (2) mothers would be more responsible for task activities, would more often regulate their child's task behaviors, and offer more specific verbal content when task demands on child competence increased than when they decreased. 60 3- and 5-year-olds either worked with their mothers or practiced alone and were given corrective feedback on a sorting task in which miniature pieces of furniture were placed in a doll house. As predicted, children who interacted with their mothers subsequently created more correct, adult-like groupings independently than children who received corrective feedback. Mothers displayed more task responsibility and regulation with younger children and when task demands on children of both age groups increased. Maternal verbal content became less specific when task demands decreased. Child performance was related to (1) variation in maternal regulation of the child; and (2) degree of specificity of maternal verbal content.

The development of cognitive self-regulation during learning and problem-solving activities is an important aspect of cognitive growth and change. Cognitive self-regulation refers to the use of control processes necessary for successful completion of a task, such as planning task activities, monitoring success or failure of actions, staying aware of task goals, and coordinating strategies to reach those goals (Baker & Brown, 1984; Brown, 1978; Wertsch, 1977). Cognitive self-regulation is considered one component of metacognition, a concept referring to two separate forms of cognition: (1) knowledge about one's own cognitive processes, and (2) regulation of those processes (Baker & Brown, 1984). Thus, cognitive self-regulation refers to the latter component.

Several investigators have suggested that in order to understand the development of cognitive self-regulation, one must look to the social context in which young children's problem-solving activities are conducted (Vygotsky, 1978; Wertsch, Minick, & Arns, 1984; Wertsch & Rogoff, 1984; Wood, 1980). A major impetus for this view is Vygotsky's (1962, 1978) theory of cognitive development. This theory proposes that cognitive self-regulation develops through early social interactions between the young child and more competent individuals such as parents. During even simple parent-child activities, the parent's social interactions consist primarily of regulating the child's behavioral responses, such as directing the child's attention, maintaining goal direction, reminding the child where he or she is in the task, and/or evaluating the success or failure of the child's task behaviors (Wertsch, 1977). According to Vygotsky's theory, the cognitive regulatory processes the child must master to solve problems independently are

This article is based on the author's doctoral dissertation approved by the faculty of the Graduate School of the University of Maryland Baltimore County. I thank Linda Baker, my dissertation advisor, for her guidance throughout this research and her many helpful comments on this article. I am grateful to my dissertation committee, Mary Ann Metzger, Susan Sonnenschein, Douglas Teti, and Lowell Groninger, for their support and suggestions during this research project. In addition, I thank Kim Collison and Susan Rasmussen for their assistance in coding videotapes. I also thank the anonymous reviewers who provided invaluable critiques of an earlier version of this manuscript. Address reprint requests to the author at the Johns Hopkins University School of Medicine, Department of Child Psychiatry, the Kennedy Institute, 707 N. Broadway, Room 106, Baltimore, MD 21205.

[*Child Development*, 1990, **61**, 113–126. 0009-3920/90/6101-0014$01.00]

similar to the regulating acts originally imposed upon the child by the parent during joint activities. Cognitive development proceeds when parent regulatory acts become internalized by the child to the degree that the child can eventually regulate his or her cognitive processes independently.

Vygotsky specifies that adults facilitate the child's internalization of cognitive self-regulation by the manner in which strategic task responsibilities are divided between adult and child and the manner in which the child's task behaviors are regulated. Specifically, internalization is facilitated by three adult actions during joint problem solving with a child: (1) taking responsibility for those task components that are clearly beyond the child's capabilities; (2) restricting regulation of the child's behavior (i.e., directing attention, maintaining goal direction, guiding, monitoring and evaluating behaviors) to those aspects of a task that are just beyond the child's mastery level; and (3) transferring task responsibilities to the child during those aspects of the task that have been mastered by the child. The adult's sensitivity to the "zone" between what the child can do with assistance and what the child has mastered is a key factor within Vygotsky's theory of cognitive development.

When Vygotsky refers to adult regulation of the child's problem-solving activities, he is proposing something more than the adult's instruction of the child (Wertsch, McNamee, McLane, & Budwig, 1980). First, adult regulation results in the development of higher-level, general control processes (i.e., planning, monitoring, etc.) and is not confined to the acquisition of instructed, task-specific skills. Adult regulation allows the child to learn how to learn, that is, how to solve problems beyond the specificity of instructed skills (Bransford, Stein, Shelton, & Owings, 1981; Brown, Bransford, Ferrara, & Campione, 1983). Second, in Vygotsky's conception of adult regulation of the child, it is the division of problem-solving responsibilities in a social context that will best explain how such activities will later be performed by the child independently. Alternatively, the traditional concept of instruction suggests that it is the acquisition of the content taught that predicts later independent performance. Of course, adult instruction, division of task responsibilities, and adult regulation of the child can coexist during the same joint activity. The distinction among the three, however, allows for a more thorough understanding of the child's cognitive development.

Vygotsky's theory leads to the conclusion that understanding how a parent interacts with the child during joint problem-solving activities will provide insight into how the child will function later while problem solving on his or her own. The theory has motivated a small body of literature analyzing parent-child interactions during a variety of problem-solving tasks such as puzzle completion (Kontos, 1983; Kontos & Nicholas, 1986; Wertsch et al., 1980), classification (Rogoff, Ellis, & Gardner, 1984), and number correspondence (Saxe, Guberman, & Gearhart, 1987). A consistent finding has been that adults vary the nature of their interaction during joint problem solving in accordance with child age. Adults are more directive, offer more guidance, and offer more specific information to younger children (Kontos, 1983; Rogoff et al., 1984; Saxe et al., 1987; Wertsch et al., 1980).

A major difficulty with interpreting this literature is that most adult-child interaction studies vary child age as a means of varying child competency without actually measuring independent child task performance at all. Without assessing the child's level of mastery, it cannot be determined (1) whether the variation in adult regulation is appropriate, or (2) whether differences in adult regulation are related to differences in actual child competency or other age-related variables such as developmental language level or adult expectations. Indeed, analyses of mothers' interactions with younger and older children during classification tasks led Rogoff et al. (1984) to suggest that task regulation is related more to age-related expectations of task difficulty than actual child competence.

Evidence for differences in adult regulation as a function of changing child competence within the same adult-child dyad would eliminate the confounding of age and competence. In general, however, such a finding has not been consistently obtained. For example, Wertsch et al. (1980) found no evidence that mothers differed in their degree of child regulation during the first and second halves of their interaction during a puzzle-completion task even though one would expect the child's task competency to increase during the second half. Saxe et al. (1987) disentangled age and competency variables by assessing 2- and 4-year-old children's unassisted performance before the children interacted with their mothers on counting tasks that varied in difficulty. Mothers of less able and younger children provided more specific instruction than mothers of more able

and older children. Mothers of children in both age groups instructed with greater specificity in the more difficult task. Although variations in the specificity of maternal instruction are an indirect measure of maternal regulation of the child, they do not directly measure the division of task responsibilities. When a mother is more specific in her instruction, she may be guiding the child's actions or taking over the responsibility of a task action herself.

A major limitation in the adult-child interaction literature has been the lack of evidence for a beneficial effect of adult interaction on the child's independent problem solving. In general, the benefits of adult interaction on child cognitive development or learning have been assumed or based on correlational results. For example, Wood and Middleton (1975) assessed the success and failure of child task behaviors and maternal behaviors contingent to those child behaviors during a joint problem-solving task. Children of mothers who provided more assistance following failures and less during successes were more likely to demonstrate better independent task performance following the joint task interaction. In controlled studies, there has been no evidence of better child performance among the adult-child interaction group than a practice control group (Kontos, 1983; Kontos & Nicholas, 1986). A few studies have shown that children receiving adult guidance adjusted to their level of competency performed better on a problem-solving task than children who observed a demonstration (Goncu & Rogoff, 1987; Wood, Wood, & Middleton, 1978). However, the ecological validity of these studies is compromised because the guiding adult was given very specific instructions on how to interact with the child.

The need for a comprehensive assessment of the relation between the adults' interaction with the child and the child's ability to solve problems independently, as well as consideration of the limitations identified in previous adult-child interaction studies, led to the design of the present study. There were two major purposes of the study: (1) to investigate the effect of mother-child interaction during a problem-solving task on subsequent, independent child performance; (2) to investigate the variability in the division of task responsibilities and maternal regulation of the child as a function of task difficulty, child age, and task component. In order to achieve these goals, the independent performance of 3- and 5-year-old children who had previously interacted with their mothers throughout a categorization task was compared to that of same-aged children who had received only corrective feedback from an adult experimenter. This specific control comparison was important for establishing that the full process of social interaction with an adult improves child performance more than simply correcting the performance itself at the end of the task. The task required the sorting of several pieces of miniature furniture into a one-story, doll house–like structure. The goal was to group the furniture to represent rooms found in a typical home (e.g., bathroom, bedroom, etc.). It was predicted that children who interacted with their mothers throughout the categorization task would subsequently exhibit improved independent performance over children who received corrective feedback only.

Easy and difficult versions of the task were used to assess mother variation in the allocation of task responsibilities, maternal regulation of the child, and maternal verbal content as a function of the child's changing task competency. Among the mother-child dyads, it was expected that mothers would exhibit less task regulation, take less personal responsibility for task activities, and offer more specific, concrete verbal content during an easy version of the task than a difficult version. Because of age-related factors not associated with competence, it was expected that mothers would more often regulate and offer more specific, concrete verbal content to younger children than older children regardless of task difficulty. Mothers of older children were expected to offer more general monitoring and planning verbalizations. Work by other researchers has suggested that certain task components may be more conducive to adult regulation than others (Arns, 1981; Wertsch et al., 1980). Therefore, task regulation and responsibility was assessed by task component with the expectation that mothers would be more responsible for and more often regulate the task component deemed most critical to successful task solution. Finally, the relation of child independent task performance with (1) maternal verbal content and (2) variation in maternal task responsibility and regulation of the child was explored.

Method

Subjects

Thirty 3-year-olds and 30 5-year-olds were assigned in equal numbers to one of two conditions: Mother Interaction (Interaction) or Corrective Feedback (Feedback). Mothers

and children were recruited from several preschools in middle-class, racially mixed suburban communities. Random assignment to groups was not conducted because only 38 of the 320 mothers contacted through recruitment agreed to participate in the Interaction condition. Although random assignment was not possible, statistical analyses indicated that the groups were comparable on initial performance measures and mothers' demographic data. A *t* test showed no evidence that mothers differed in age. Chi-square analyses revealed no evidence of differences in education level or work status between the Interaction or Feedback mothers.

The 3-year-old Feedback group (seven girls, eight boys) had a mean age of 3.5 years (SD = 2.0 months). The 3-year-old Interaction group (six girls, nine boys) had a mean age of 3.4 years (SD = 2.5 months). The 5-year-old Feedback and Interaction groups (eight girls, seven boys each) had mean ages of 5.3 years (SD = 3.5 months) and 5.4 years (SD = 3.5 months), respectively. The mean age of the 30 participating mothers was 35 years. All of these mothers had at least some college education; 12 of the mothers had a graduate-level degree. There was a fairly equal distribution among the participating mothers of those who did not work outside the home (eight mothers), those who worked part time (10 mothers), and those who worked full time (12 mothers).

Materials

The task presented to all participants utilized scale miniature replicas (1 inch to 1 foot) of common household furniture and appliances. The goal of the task was to sort the items into two to six rooms in a one-level, doll house–like structure. The doll house was a wooden frame, 78 cm long, 62 cm wide, and 8 cm high. Within this frame were placed wood partitions such that six equal-sized spaces were created. These spaces were referred to as "rooms." The materials included 36 pieces of the miniature furniture and appliance reproductions found in a typical middle-class home and six same-scale distractor items that would not be found in a typical house (e.g., a lamppost, a boat, a deer, etc.). Pilot testing showed that adults arranged the items into the same room groupings with a high degree of agreement. Agreement among the adults was 92% or better on all items. For example, all adults placed the bathtub, sink, toilet, and towel rack together and called the room a bathroom. Other room groups included a kitchen (e.g., stove, refrigerator, kitchen sink, table, and chairs), a living room (e.g., couch, matching overstuffed chairs, coffee table, TV, bookshelf), a dining room (e.g., table, chairs, and hutch), a baby nursery (e.g., matching crib, rocker, playpen), and an adult bedroom and a child bedroom (each with bed, end tables, and dressers) differentiated by color of items. Not all items are listed here; a complete listing is available in Freund (1988). Adult agreement was only 65% on two of the items—the television and bookshelf. Placement of these two items was subsequently ignored when assessing children's arrangements of the items. There were more possible room groupings of items than doll house rooms in order to allow for variation in sorting presentations. Three-year-olds and 5-year-olds who participated in pilot work and a subsequent study using the room-sorting task (Freund, Baker, & Sonnenshein, 1988) were able to name or provide an appropriate function for each of the items, including distractors. Distractors were included to make the sorting task more challenging.

The study design required difficult and easy versions of the task, with difficulty being comparable for each age group. The difficult and easy levels of the task for each age group were determined by pilot work in which 3- and 5-year-olds sorted the same miniature items used in this study. The difficult level was established first. A six-room doll house with 35 furniture items and six distractor items was determined to be of a moderate to high difficulty level for 5-year-olds; the 5-year-olds in the Freund et al. study attained an average of 43% correctly grouped items. The same presentation given to 3-year-olds took too long for the children to finish; most 3-year-olds stopped before they had placed half of the items. It was important that the 3-year-olds have the same opportunity as 5-year-olds to display their level of competency from start to finish of the task. By reducing the six-room doll house to a 28-item, four-room doll house (24 items and four distractors), most 3-year-olds could finish the task in approximately the same amount of time that the 5-year-olds finished the six-room doll house. The reduced number of rooms resulted in comparable difficulty for the two age groups. With the four-room doll house, 3-year-olds in the Freund et al. study achieved an average score of 40% correctly grouped items, which was not significantly different from the 5-year-old performance.

The easy levels of the task were derived by cutting in half the number of room groupings to be sorted by each age group. Piloting showed that a two-room, eight-item doll

house presented to 3-year-olds and a four-room, 16-item doll house presented to 5-year-olds resulted in an average increase of 35% correctly grouped items over the mean percent correct for the difficult level for both age groups.

Procedure

All children in the Feedback condition and all mother-child Interaction group dyads were seen individually in sessions lasting 40–55 min. Each session was videotaped with the camera visible to all participants. A three-phase procedure was used. In phase 1, all children were presented a difficult level of the task to complete independently. In phase 2, the Interaction groups were presented two levels of the task (easy and difficult) to complete with their mothers. Feedback groups completed the same two tasks independently. In phase 3, all children were presented a difficult level of the task to complete alone once again. Different room combinations were presented in each phase. For example, the difficult version of the task in phase 1 had a different set of possible item groupings than the difficult version of the task in phase 3. For each phase, participants were seated in front of the empty doll house, next to which were the sorting items. Items were randomly arranged in the same array across subjects. The same female experimenter ran all phases of the experiment with all participants.

In phase 1, children in each group were introduced to the task through the context of helping a puppet move his furniture into his new house. The child was told to pick out all the things that belonged in a house and put them into the rooms where they belonged, just like a regular house. The child was also told to leave outside the doll house anything not belonging inside a house. Children were not told the names of the rooms into which they were to sort the items, nor were children expected to arrange rooms in any specific floorplan design. Children were not expecting any formal evaluation of their sorts. While the child sorted items, the experimenter remained at a distance but in view of the child. If the child's mother was participating, she remained separated from the child by a large screen and was not able to observe her child during this phase.

During phase 2, the procedures for the Interaction and Feedback conditions differed as follows:

Interaction condition.—Children in the Interaction groups were presented two levels of the task (easy and difficult) with their mothers while the experimenter left the room. Each level was presented separately with order counterbalanced across subjects. Before phase 2 sorting began, the mother was shown the task materials while her child played with toys unrelated to the sorting task behind a large screen. Mothers were instructed to help their child group items as an adult would for rooms in a typical house. Mothers were not told to teach their child but encouraged to help in any manner with which they felt comfortable. They were also told that when they finished, their child would once more complete the task alone with different items. Mothers were then given a card listing the names of the rooms into which the items should be grouped. Pilot work had shown that mothers were not as likely to guide their child's behavior toward an adult-like sort of the items when they were not informed of room categories. Mothers were responsible for informing the experimenter when finished with a difficulty level.

Feedback condition.—Children in the Feedback group were presented the two task levels to solve independently. The order of presentation of the task levels was counterbalanced among the children. After completing each difficulty level, the child was praised for working hard. Most of these children made errors in their groupings for each level. They were told that they had made mistakes, and then the experimenter corrected any item groupings to conform with the established adult groupings. Children whose sorts were entirely correct were told they were correct. Following a short break after phase 2, children in both conditions completed a difficult level of the task independently once again in phase 3.

Scoring

Child performance.—The criteria for assessing the accuracy of child room groupings were based on the groupings adults created with high agreement in pilot testing. These adult groupings were considered the correct groupings. To determine child accuracy for each sorting presentation, each room was assessed separately for degree of correct grouping. If a child's room contained at least three items that adults had consistently grouped together, those items were considered correct for that room grouping. For example, adults consistently grouped the tub, the toilet, the wash basin, and the towel rack together and called the grouping a bathroom. If a child grouped the toilet, tub, towel rack, and a kitchen chair in one room (four items placed), then the toilet, tub, and towel rack were con-

sidered correct and a score of 3 was given to the room. In this way children were given credit for groupings that were at least partially consistent with adult groupings. A minimum of three correctly grouped items per room was used because several of the items to be sorted came in matching pairs (e.g., the living room chairs, the bedroom end tables). Since the purpose of the correct grouping score was to assess the accuracy of groupings based on functional relations and *not* the ability to match items, the three-item minimum prevents confounding a functional-grouping strategy with a matching-items strategy.

For each sorting presentation, every room in the doll house was given a score representing the number of correctly grouped items in that room. If a room contained items associated with two different types of rooms, then the larger number of items was considered correct. In the rare case in which all available items were grouped in one room, no credit for correct groupings was given. A proportion-correct score was computed by summing the scores associated with each room of the doll house plus the number of distractors remaining outside the doll house. This sum was then divided by the total number of items (including distractors) that had been presented to the child.

Maternal task responsibilities and regulation of the child.—In order to differentiate the mother-child activities during the task, the mother-child interaction was broken down into discrete units or episodes in a manner similar to that described in Arns (1981) and Wertsch et al. (1980). An episode was defined as a segment of the interaction focused on the selection and placement of one item in a room within the doll house. For successful completion of the sorting task, certain steps were necessary in order to place an item in an appropriate room. These steps (or episode components) included: (1) selection of an item; (2) selection of an appropriate room category (e.g., kitchen, bathroom, etc.) or functional association (e.g., where you sleep, where you eat, etc.) to which an item belonged; and (3) placement of the item within the chosen room. The order of components 1 and 2 could vary depending on the strategy chosen to complete the task (i.e., one can decide upon a room category and look for items belonging to that room, or one can select an item and look for the room to which it belongs). The room-selection component was considered the most crucial component to successful task completion because success hinged upon identification of appropriate functional relationships (room categories). Task success did not hinge on the order in which items were selected or where exactly they were placed within rooms.

In order to evaluate maternal task activities, it was necessary to differentiate between when the mother performed an episode component for the child and when the mother guided or prompted the child to perform a component. The mother was considered *responsible* for a component if she physically performed the component for the child. That is, mother was responsible for item selection if she picked up an item when the child made no reference to it, was responsible for room selection if she placed an item in a room when the child made no reference to a room or functional association, or was responsible for item placement if she placed an item in a room when the child made no reference to a specific location. The mother was considered to be *regulating* the child's performance of a component if she directed or guided the child's action. More specifically, a mother was considered regulating a child action if she pointed to, named, directed, or in some manner cued the selection of an item, the selection of a room or functional association, or the placement of an item in a specific room location. In addition, it was possible for a child to self-regulate performance of a component. A component was considered *self-regulated* if the child selected an item, selected a room, or placed an item without any direction or guidance from mother. Thus each episode component was coded for one of three mutually exclusive, task-control categories: mother responsible (MR), mother regulation of child (MRC), or child self-regulated (CSR).

Frequencies for each task-control category for each of the three episode components were determined for each dyad. These frequencies were converted to proportions by dividing by the total number of episodes completed by the dyad. Easy and difficult versions of the task were coded separately. The investigator coded all mother-child interactions. An independent coder coded a random selection of 25% of the mother-child dyad interactions. The percentage of agreement across episodes was 86%. Broken down by task control category across episode component, percentage of agreement was 93% for MR, 84% for CSR, and 81% for MRC. Although it was necessary to differentiate the CSR category from the MR and MRC categories for coding purposes, the CSR proportional frequencies offered no unique information (i.e., as MR or MRC category proportions

increased or decreased, the CSR proportions decreased or increased perforce). For this reason, only the MR and MRC proportional frequencies were retained as dependent variables representing control of task activities, and the CSR proportions were dropped from analyses.

Maternal verbal content.—Maternal task-relevant verbalizations were analyzed in order to determine how mothers verbally instructed their children throughout the task interaction. In this study, verbal instruction was defined as any task-relevant speech. In order to code mothers' verbal content, transcripts of mothers' verbalizations were divided into message units. A message unit was defined as any single, meaningful statement or question (Davis & Lange, 1973), including single-word utterances. Categorization of message units was made while viewing the videotape of the mother-child interaction.

Five mother-child dyads participated in a pilot study used to define the content coding system. The coding system differentiated mothers' task-irrelevant speech ("It's raining outside") from task-relevant speech. The content categories of task-relevant speech were based on Kontos's (1983) system. Kontos differentiated between "task-variables" content (e.g., references to item attributes, item locations, etc.) and "strategy-variables" content (e.g., references to strategies, goal direction, monitoring success/failure). No specific strategies were defined in Kontos's system; therefore, strategy references could have included both specific strategies and more general planning and organizing strategies. Thus, "references to strategies" and the other types of "strategy-variables" content were grouped together. From the pilot study for the present research, maternal references to several specific strategies were identified. In the interest of greater specificity, the verbalizations considered "strategy variables" under Kontos's system were further differentiated between references to specific strategies and references to general planning/organizing strategies, goal direction, and monitoring. This resulted in three mutually exclusive categories—"task-specific materials," "strategies," and "goals, plans, and monitoring." These categories were considered to be hierarchically arranged in degree of specificity of content, with "task-specific materials" the most specific and "goals, plans, and monitoring" the least specific. Category descriptions were as follows:

Task-specific materials.—This category included all references to item/room descriptions, labels, functions, and/or locations (e.g., "It's a big bed," or "That stove goes in a kitchen").

Strategies.—The strategies included: (1) associations between a specific room and selection of an associated item (e.g., "Find something for the living room"); (2) associations between a specific item and selection of its associated room (e.g., "What room does the refrigerator belong in?"); (3) reference to matching properties of items (e.g., "Are there other red chairs that go with that one?"); (4) reference to child's knowledge of how furniture is grouped or used in their home, a friend's home, or a relative's home (e.g., "Where do we keep our refrigerator at home?"). Only verbalizations related to these four strategies were coded in this category.

Plans, goals, and monitoring.—This category included references to plans which were verbalizations specifying a sequence of activities (e.g., "Let's make the bedroom and then the kitchen"). References to goal direction were included, such as "Let's make a kitchen." Also included were monitoring statements such as, "That's not right. That chair doesn't belong there."

Other.—This final category included utterances encouraging the child to participate, or offering unelaborated positive feedback or attention-directing statements (such as "O.K." or "Look"). Verbalizations that could not be coded into one of the three categories defined above were included.

The investigator was the principal coder. An independent coder coded a random selection of 25% of the Interaction subjects' transcripts. Agreement was 96% for designating task-relevant from task-irrelevant utterances. The percentage of agreement across task-relevant categories was 91%. The breakdown of agreement by task-relevant verbalization content code was 96% for references to task-specific materials, 81% for strategies, 88% for plans, goals, and monitoring, and 97% for other. Frequencies of each verbal content category were determined for each dyad. These frequencies were converted to proportions by dividing by the total number of maternal task-relevant verbalizations. Proportions for easy and difficult versions of the task were determined separately.

Results

Child Performance

The phase 1 and phase 3 independent performance of the 3- and 5-year-olds in the Interaction and Feedback group is repre-

TABLE 1

MEAN PHASE 1 AND PHASE 3 PROPORTION CORRECT BY CORRECTIVE FEEDBACK AND MOTHER INTERACTION CONDITIONS FOR 3- AND 5-YEAR-OLDS

	CORRECTIVE FEEDBACK		MOTHER INTERACTION	
AGE	Phase 1	Phase 3	Phase 1	Phase 3
3 years:				
M	.41	.36	.46	.70
SD	.14	.15	.17	.19
5 years:				
M	.51	.64	.52	.94
SD	.15	.18	.16	.08

sented by mean proportions of items correctly grouped in Table 1. In order to assess the impact of mother interaction on subsequent independent child performance, a 2 (age) × 2 (condition) analysis of covariance was conducted with phase 3 proportion-correct scores as the dependent variable and phase 1 proportion correct as the covariate. The use of proportions necessitated the transformation of the scores via an arc sine transformation as suggested by Cohen and Cohen (1975). Transformed scores were used in statistical analysis, but untransformed mean scores are reported. The covariate was significantly related to phase 3 proportion correct, $t(56) = 3.10$, $p < .01$. Only the two main effects were significant. As predicted, children who interacted with their mothers had a higher mean proportion correct ($M = .82$) than children who received corrective feedback ($M = .50$), $F(1,56) = 12.52$, $p < .01$. It is apparent from the means in Table 1 that mother interaction greatly improved both 3- and 5-year-olds' sorting performance. Indeed, the 5-year-old Interaction group approached ceiling levels of sorting performance, and 3-year-olds in the Interaction group performed similarly to 5-year-olds in the Feedback group. Across conditions, 5-year-olds had a higher mean proportion correct ($M = .79$) than 3-year-olds ($M = .53$) in phase 3, $F(1,56) = 26.52$, $p < .01$. Thus, the 5-year-olds improved performance more than 3-year-olds when experiencing either corrective feedback or interaction with their mothers.

Maternal Task Responsibilities and Regulation of the Child

Variation in maternal task responsibilities and regulation of the child were investigated by comparing the mean proportional frequencies of the MR and MRC categories between the easy and difficult levels of the task for each age group. These comparisons were conducted for the three episode components—item selection, room selection, and item placement. Preliminary analyses revealed no significant effect associated with order of task difficulty presentation. Thus results are reported with order of presentation eliminated.

Mean proportional frequencies of both dependent variables for the item-placement component fell below .10 regardless of age or task difficulty. Since mothers had so little to do with item placement, allowing children to be responsible for item placement about 90% of the time, proportions for the component were dropped from further analyses. The mean proportional frequencies of the MR and MRC categories are shown in Table 2 for the item-selection and room-selection components × age group and task difficulty level.

The means indicate that children, regardless of age or task difficulty, self-regulated the item-selection and/or room-selection components in approximately 60% of the task episodes on the average. When children were not self-regulating, mothers regulated their child's item and/or room selection in approximately 31% of the task episodes and were responsible for the components themselves in only 9% of the task episodes (averaging over difficulty level and child age group).

Analysis of the relation between the MR and MRC variables suggested that the variables were indeed tapping different behaviors. MR and MRC variables were arc sine transformed. Collapsing proportional frequencies over difficulty level, the Pearson product-moment correlation coefficients between MR and MRC were .18 for the item selection component and −.19 for the room selection component, neither of which were significant. Correlations were also conducted with the MR and MRC proportional frequencies at each difficulty level with phase 1 proportion-correct scores. None of these correla-

TABLE 2

PROPORTIONS OF TASK EPISODES THAT MOTHERS WERE RESPONSIBLE FOR TASK COMPONENTS AND MOTHERS REGULATED CHILD TASK COMPONENT ACTIVITY BY TASK DIFFICULTY LEVEL AND CHILD AGE

TASK COMPONENT AND AGE	DIFFICULTY LEVEL			
	Easy		Difficult	
	MR	MRC	MR	MRC
Item selection:				
3 years:				
M	.13	.21	.17	.30
SD	.08	.18	.18	.20
5 years:				
M	.08	.18	.13	.26
SD	.03	.17	.14	.11
Room selection:				
3 years:				
M	.02	.40	.06	.55
SD	.03	.17	.11	.14
5 years:				
M	.02	.24	.07	.34
SD	.03	.13	.11	.11

NOTE.—MR = mother responsible for task component; MRC = mother regulation of child's task component activity. Proportions within task difficulty level for each age group add to 1.0 when child self-regulation (CS-R) proportions are included.

tions exceeded ± .20 or was significant. There appeared no evidence of a relation between a child's initial independent skill and maternal regulation of or responsibility for the item- and room-selection components when mother and child worked together. Therefore, phase 1 proportion correct was not considered for inclusion as a covariate in subsequent analyses of mean differences.

In order to investigate the mean differences, a mixed multivariate analysis of variance was conducted once the MR and MRC proportional frequencies were arc sine transformed. The between-subjects factor was child age. The within-subjects factors were difficulty level and task component. Planned within-subjects contrasts were applied to the dependent variables as follows: (1) easy versus difficult conditions for item-selection component; (2) easy versus difficult conditions for room-selection component; (3) item selection versus room selection (across difficulty conditions). Multivariate results were assessed with the Wilks's criterion. All simple mean comparisons were conducted with protected *t* tests at the .05 level.

The multivariate effect associated with age was not significant. However, the multivariate interaction of the age factor with the within-subjects contrasts of the MRC variable indicated that mothers varied how often they regulated their child's task activity depending on child age, difficulty level, and the task component involved, $F(3,26) = 3.15$, $p < .05$. Univariate analyses showed a significant age × difficulty level interaction for the room-selection component only, $F(1,28) = 8.47$, $p < .01$. Mean comparisons indicated that mothers of both 3- and 5-year-olds regulated their child's room selection proportionately more often during the difficult level of the task than the easy level, but mothers of 3-year-olds increased regulation to a greater degree during the more difficult task than mothers of 5-year-olds. Regardless of child age, mothers did not vary the regulation of their child's selection of items between difficulty levels. A significant interaction of the age factor and the item and room component contrast of the MRC variable, $F(1,28) = 5.92$, $p < .05$, showed that only mothers of 3-year-olds regulated their child's room selection to a greater degree than item selection. Mothers of 5-year-olds did not differ in their regulation of these two components. Thus, the analysis of the MRC variable indicates that mothers of children from both age groups more often regulated the crucial task component of room selection during the difficult version of the task, and that across difficulty levels, mothers of younger children regulated that task component more than the less crucial task component of item selection.

TABLE 3

MEAN PROPORTIONS OF MOTHERS' VERBALIZATIONS BY CONTENT CATEGORY, CHILD AGE, AND TASK DIFFICULTY

	DIFFICULTY LEVEL							
	Easy				Difficult			
AGE	Task	Strategy	Plans/Goals/ Monitor	Other	Task	Strategy	Plans/Goals/ Monitor	Other
3 years:								
M	.42	.23	.29	.06	.43	.38	.16	.03
SD	.15	.13	.13	.03	.10	.09	.08	.05
5 years:								
M	.32	.29	.34	.05	.41	.36	.21	.02
SD	.16	.13	.17	.05	.13	.13	.11	.03

NOTE.—Task = task-specific materials category; Strategy = strategies category; Plans/Goals/Monitor = plans, goals, monitoring category.

Mothers also varied how often they were responsible for task activity depending on the task component and difficulty level, as shown by the significant multivariate test of the MR within-subjects contrasts, $F(3,26) = 7.54$, $p < .01$. Univariate analysis of the MR contrasts revealed that mothers among both child age groups were more often responsible for the room-selection component in the difficult condition than the easy condition, $F(1,28) = 9.62$, $p < .05$, yet did not vary how often they were responsible for the item-selection component between difficulty levels. Mothers were more often responsible for the item-selection component than the room-selection component across difficulty levels, $F(1,28) = 6.34$, $p < .05$. The MR analysis showed that mothers were more often responsible for room selection during the difficult version of the task than the easy version, even though across difficulty levels, mothers were more often responsible for the less crucial component of item selection.

The relation between variation in task regulation and child performance was explored. Mothers who regulated their child's item and room selection more during the difficult task and less during the easy task ($n = 17$) demonstrated the theoretically expected variation in regulation based on the task difficulty manipulation and were therefore designated task-consistent regulators. The remaining mothers ($n = 13$), who either regulated more during the easy task than the difficult task or did not vary regulation at all, were task-inconsistent regulators. An analysis of covariance was conducted on children's phase 3 proportion-correct scores × type of mother regulation. Phase 1 proportion correct served as the covariate and was significant, $F(1,27) = 17.9$, $p < .01$. The mean phase 3 proportion-correct scores were .86 for children of task-consistent regulators and .77 for children of task-inconsistent regulators, $F(1,27) = 5.81$, $p < .01$. Thus, better child performance was associated with task-consistent maternal regulation than with task-inconsistent maternal regulation during phase 2.

Maternal Verbal Content

Task-relevant verbalizations accounted for 92% of all maternal verbalizations. An analysis of the mean number of task-relevant verbalizations × child age group and task difficulty revealed a significant difference in the number of verbalizations made as a function of difficulty level, $F(1,28) = 9.38$, $p < .001$. Mothers emitted more verbalizations during the difficult task ($M = 63.3$) than the easy task ($M = 25.09$). This was expected given that the difficult task contained more items and required more episodes to complete for both age groups. There was no evidence that mothers of children in one age group spoke more than the other mothers, even though 5-years-olds had more items to sort than 3-year-olds.

The mean proportional frequencies for each content category are shown in Table 3. Because very few "other" verbalizations occurred, this variable was dropped from further analyses. Pearson product-moment correlations among the categories, collapsed across difficulty level, showed that the "plans, goals, and monitoring" category was negatively correlated with the "task-specific materials" category, $r(28) = -.42$, $p < .05$, and the "strategies" category, $r(28) = -.43$, $p < .05$. The latter two categories were not significantly related. Thus, no one content category ac-

counted for a major portion of the variance of any other category.

In order to investigate the mean differences for "task-specific materials," "strategies," and the "plans, goals, and monitoring" content categories, proportional frequencies were transformed via an arc sine transformation. Because the proportional frequencies were based on widely differing numbers of total task-relevant verbalizations, the assumptions of a standard analysis of variance could not be met. A goodness-of-fit statistic, the Q-statistic (Hedges & Olkin, 1985), was used instead, which could adjust for the differences in total task-relevant speech.

The three verbal content categories were assessed separately by a 2 (age) × 2 (order) × 2 (difficulty level) Q-statistic analysis. An adjusted significance level of $p < .016$ was adopted to maintain the overall significance criterion at .05. Mean comparisons, when necessary, were conducted with the Bonferroni method using a $p < .01$ criterion. The order factor was not a significant effect and was eliminated from reported results.

The verbal content analysis demonstrated that mothers varied their content verbalizations as a function of child age and/or task difficult level depending on the content category. Analysis of the "task-specific materials" category revealed that mothers of 3-year-olds offered more concrete, specific content to their children than mothers of 5-year-olds, $Q(1, N = 30) = 10.25$, $p < .001$. Contrary to expectations, mothers did not increase their references to task-specific materials during the more difficult version of the task. Mothers proportionately increased their references to strategies, however, as a function of an interaction of task difficulty level and child age, $Q(3, N = 30) = 27.28$, $p < .001$. Mean comparisons indicated that mothers of 3-year-olds made references to strategies more often during the difficult than the easy task, but mothers of 5-year-olds did not vary their strategy references between difficulty levels. As predicted, mothers of 5-year-olds made a significantly greater proportion of references to plans, goals, and monitoring than mothers of 3-year-olds, $Q(1, N = 30) = 13.62$, $p < .001$, and mothers of both age groups made such references more often during the easy than the difficult version of the task, $Q(1, N = 30) = 38.96$, $p < .001$. No other effects for the three verbal content categories were significant.

The relation between maternal verbal content and child phase 3 performance was investigated. As a means of simplifying the analysis, the three categories were dichotomized into lower-level, more specific category and a higher-level, less specific category. The three verbal content categories were reorganized on the basis of Kontos's (1983) two categories, "task variables" and "strategy variables," which distinguished between low-level and high-level content, respectively. The "task-specific materials" category used in this study represents the lower-level category of "task variables." The two categories, "strategies" and "plans, goals, and monitoring," were representative of Kontos's higher-level category, "strategy variables." Mothers were designated as offering more high-level, strategy-variables content or more low-level, task-variables content. To compute each mother's level-of-content score, the frequencies for each of the three original codes were summed across the easy and difficult levels of the task and divided by total task-relevant utterances across both difficulty levels. The resulting proportion for "task-specific materials" code represented low-level content; the sum of the proportions for the "strategies" and "goals, plans, and monitoring" categories represented high-level content. The proportional frequency of high-level content was subtracted from the proportional frequency of low-level content, resulting in a final level of content proportional frequency. A median split was made on the level of content proportions. Mothers with scores above the median were considered providers of more low-level verbal content, and mothers below the median were considered providers of more high-level content.

An analysis of covariance was conducted on children's phase 3 proportion-correct scores by maternal level of content and child age. Phase 1 proportion correct was the covariate and found to be significant, $F(1,25) = 17.9$, $p < .01$. The significant age effect found in the child performance analysis was duplicated, $F(1,25) = 26.26$, $p < .001$. More important to this analysis, children of mothers who emphasized more specific, low-level content had a lower mean phase 3, proportion-correct score ($M = .73$, SD = .11) than children whose mothers emphasized less specific, high-level content ($M = .87$, SD = .13), $F(1,25) = 5.6$, $p < .02$. The interaction between age and level of content was not significant.

Discussion

The results of this study supported the prediction that social interaction between an

adult and child during a problem-solving task would lead to improved independent child performance. Children who interacted with their mother throughout the furniture-sorting task subsequently created more correct, adult-like groupings on their own than children who practiced the task on their own and were shown the correct solution at the end of each trial. Since mothers offered correct solutions to the task while they interacted with their child, it was important to include a presentation of correct solution to the practice-control group. This control allowed the inference to be made that it is the process of adult-child interaction itself, not just the learning of a correct solution, that leads to improved performance.

The beneficial effect of adult-child interaction on child performance found in this study has only been suggested by the correlational study of Wood and Middleton (1975) and studies using nonspontaneous adult interaction (Goncu & Rogoff, 1987; Wood et al., 1978). The present results are contrary to those reported in Kontos (1983) and Kontos and Nicholas (1986) in which adult interaction proved no more beneficial to subsequent, independent child performance than self-directed practice. Although there were several methodological differences between the prior studies and the present one to account for the discrepant results, perhaps the crucial difference was in the type of task. The puzzle task used in the earlier studies was highly challenging, unique, and certain to be unfamiliar to the child. The furniture-sorting task was also highly challenging, but utilized familiar items within a context that was meaningful to both child and mother, that is, mother and child shared a common knowledge-base. Mothers in the present study may have had not only more to interact about but more that was meaningful to the child. Thus, more meaningful interaction led to greater internalization and improvement in the child's independent performance. In accordance with this view, Rogoff (1987) has suggested that social interaction may not benefit children's cognitive development in all circumstances; beneficial effects may depend on the ease with which the task invokes shared thinking.

The analysis of the division of task responsibilities and maternal regulation of the child's task activities generally supported the prediction that mothers would be sensitive to the increased demands on the child's competency during the difficult version of the task. Mothers were more responsible themselves and more often regulated the child's activity during the difficult task but only for the most crucial task component, room selection. Mothers offered less general verbal instruction during the difficult task than the easy. When demands on the child's competency were decreased during the easy version of the task, mothers were responsible for and regulated the crucial task component to a lesser degree and offered more general goal direction, planning, and monitoring information. These mother behaviors allowed the child to manage the crucial task component more often and identify relevant task-specific information and strategies on his or her own when the task demand was lessened. Thus, the division of task responsibilities and variation in maternal regulation of the child were indeed implemented in the manner proposed by Vygotsky (1962, 1978) to facilitate cognitive growth.

The task responsibility and regulation results are consistent with other studies finding that mothers vary their regulation of the child and specificity of verbal content when child competency is assumed to vary with age (Kontos, 1983; Rogoff et al., 1984; Wertsch et al., 1980). The present study manipulated task demands with results similar to those of Saxe et al. (1987) but, contrary to that study, found no relation between initial child competence and mother regulation of the child (as shown by the lack of relation between phase 1 performance and the mother responsibility [MR] and mother regulation of child [MRC] variables).

Mothers were also shown to vary their task responsibility and regulation of the child on the basis of child age, beyond what they varied on the basis of task demands on the child. Mothers of 3-year-olds regulated the crucial task component to a greater degree than mothers of 5-year-olds. Mothers of the younger children used more task-specific, concrete verbalizations than mothers of older children, who used more planning, goal directing, and monitoring verbalizations. The age-related factors that could possibly be implicated include language competence, prior problem-solving experience, the ability to stay on-task during the interaction, and/or, as proposed by Rogoff et al. (1984), the adult perceptions of the child's need in specific problem-solving circumstances.

Individual differences in child performance were explored and yielded significant relations with maternal task behaviors and verbal content. The greatest improvement in

children's independent problem solving resulted when mothers varied their regulation of their children in a manner consistent with task demands and offered more strategy, planning, goal directing, and monitoring content in their verbalizations. This result is in direct accord with Vygotsky's theory that the more sensitive the adult is to the child's competency (which can vary with changing task demands) and the more the adult exposes the child to processes necessary for successful problem solving (e.g., strategies, planning, etc.), the more child performance can improve and cognitive development proceed.

Isolating the task components in order to assess maternal task behaviors by component proved to be a major methodological strength in this study. It is unlikely that the predicted variation in mother behavior would have been detected if the crucial task component had not been identified and analyzed separately from other task components. A major limitation of this research, however, is that the analysis of the mother-child interaction is short term. Longitudinal assessment providing evidence of the child's transition from mother regulation to complete self-regulation over a period of time would offer even stronger validation of Vygotsky's social interaction theory of cognitive development. Another limitation of the study is that the focus of the mother-child interaction is one-sided. The effect of the child's behavior on the mother's behavior throughout the joint interaction session is never addressed. Without assessment of the child's part in the adult-child interaction, it is impossible to determine to what extent the child directly elicits maternal regulation or to specify the child's developing understanding during the interaction (Saxe et al., 1987).

By addressing some of the limitations in the emergent adult-child interaction literature, the present study provides a comprehensive evaluation of maternal behavior during mother-child interaction and its effect on the child's ability to problem solve. The study provides support for Vygotsky's social interaction theory of cognitive development, although both child and adult assessment during joint activities are undoubtedly necessary to fully characterize the child's cognitive development. In addition, joint problem solving may not be the only route to successful, independent problem solving. Children's self-directed problem-solving activity occurs, can be successful, and can lead to increased cognitive skill (Kontos & Nicholas, 1986). However, the origins of such self-directed activity may be best explained through the understanding of the child's early, joint problem-solving activities.

References

Arns, P. J. (1981). Joint problem-solving activity in adult-child dyads: A cross-cultural study (Doctoral dissertation, Northwestern University, 1981). *Dissertation Abstracts International*, **42**, 5A, 2112.

Baker, L., & Brown, A. L. (1984). Metacognitive skills and reading. In P. D. Pearson (Ed.), *Handbook of reading research* (pp. 353–394). New York: Longman.

Bransford, J. D., Stein, B. S., Shelton, T. S., & Owings, R. A. (1981). Cognition and adaptation: The importance of learning to learn. In J. Harvey (Ed.), *Cognition, social behavior, and the environment* (pp. 93–110). Hillsdale, NJ: Erlbaum.

Brown, A. L. (1978). Knowing when, where, and how to remember: A problem of metacognition. In R. Glaser (Ed.), *Advances in instructional psychology* (Vol. 1, pp. 99–151). Hillsdale, NJ: Erlbaum.

Brown, A. L., Bransford, J., Ferrara, R., & Campione, J. (1983). Learning, remembering, and understanding. In J. Flavell & E. Markman (Eds.), P. H. Mussen (Series Ed.), *Handbook of child psychology*: Vol. 3. *Cognitive development* (pp. 77–166). New York: Wiley.

Cohen, J., & Cohen, P. (1975). *Applied multiple regression/correlation analysis for the behavioral sciences*. Hillsdale, NJ: Erlbaum.

Davis, A., & Lange, G. (1973). Parent-child communication and the development of categorization styles in preschool children. *Child Development*, **44**, 624–629.

Freund, L. (1988). The child's transition from mother regulation to self-regulation during a problem-solving task (Doctoral dissertation, University of Maryland, 1988). *Dissertation Abstracts International*, **49**, 0419-4217.

Freund, L., Baker, L., & Sonnenshein, S. (1987, April). *Developmental differences in the strategies used to classify items two different ways*. Paper presented at the Society for Research in Child Development, Baltimore, MD.

Goncu, A., & Rogoff, B. (1987, April). *Nature of adult guidance as a moderator of social influence on children's cognition*. Paper presented at the Society for Research in Child Development, Baltimore, MD.

Hedges, L. V., & Olkin, I. (1985). *Statistical methods for meta-analysis*. New York: Academic Press.

Kontos, S. (1983). Adult-child interaction and the origin of metacognition. *Journal of Educational Research*, **77**, 43–64.

Kontos, S., & Nicholas, J. G. (1986). Independent problem solving in the development of metacognition. *Journal of Genetic Psychology*, **147**, 481–495.

Rogoff, B. (1987). Commentary on social processes in early number development. *Monographs of the Society for Research in Child Development*, **52**(2, Serial No. 216).

Rogoff, B., Ellis, S., & Gardner, W. (1984). Adjustment of adult-child instruction according to child's age and task. *Developmental Psychology*, **20**, 193–199.

Saxe, G., Guberman, S., & Gearhart, M. (1987). Social processes in early number development. *Monographs of the Society for Research in Child Development*, **52**(2, Serial No. 216).

Vygotsky, L. S. (1962). *Thought and language* (E. Hanfmann & G. Vakar, Eds. and Trans.). Cambridge, MA: MIT Press.

Vygotsky, L. S. (1978). *Mind in society* (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds. and Trans.). Cambridge, MA: MIT Press.

Wertsch, J. (1977, May). *Metacognition and adult-child interaction*. Paper presented at Northwestern University annual conference on learning disabilities, Evanston, IL.

Wertsch, J., McNamee, G. D., McLane, J., & Budwig, N. A. (1980). The adult-child dyad as a problem-solving system. *Child Development*, **51**, 1215–1221.

Wertsch, J., Minick, N., & Arns, F. (1984). The creation of context in joint problem solving. In B. Rogoff & J. Lave (Eds.), *Everyday cognition: Its development in social context* (pp. 151–171). Cambridge, MA: Harvard University Press.

Wertsch, J., & Rogoff, B. (1984). Editor's notes. In B. Rogoff & J. Wertsch (Eds.), *Children's learning in the "zone of proximal development": New directions for child development research* (pp. 1–6). San Francisco: Jossey-Bass.

Wood, D. (1980). Teaching the young child—some relationships between social interaction, language, and thought. In D. Olson (Ed.), *Social foundation of language and cognition* (pp. 94–112). New York: Norton.

Wood, D., & Middleton, D. (1975). A study of assisted problem-solving. *British Journal of Psychology*, **66**, 181–191.

Wood, D., Wood, H., & Middleton, D. (1978). An experimental evaluation of four face-to-face teaching strategies. *International Journal of Behavioral Development*, **1**, 131–147.