The Development of Verbal Control over Motor Behavior: A Replication and Extension of Luria's Findings

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Luna's theory of verbal self-regulation during early childhood has received considerable attention from North American psychologists (e.g., Cole & Maltzman 1969, Zivin 1979). Briefly, the theory concerns the relationships among language, thought, and behavior and describes a progression from little control by language over motor behavior, to control by overt (but not silent) vocalization, to internalized (i.e., not overt) control. Initially, the child's control over motor behavior is limited and is primarily responsive to overt verbalizations from others. In the next phase, a child's own verbalizations influence and can help control motor behavior, but the effect is primarily to trigger or terminate behavior, and the semantic content of the verbalization has little effect on the form of the behavior. For example, in a classic experiment, Luria (1959, 1961) asked children to perform a single squeeze of a rubber bulb. He found that without verbal accompaniment children squeezed the bulb but did not follow the instruction to squeeze only once. However, a single overt verbalization to "squeeze" allowed the child to perform correctly. Luria emphasized that this effect depends more on the pulse of the speech sound than on its semantic content, and indeed the verbalization "don't squeeze" also facilitates single-squeeze performance. In the final phase, a child is able to use the semantic content of overt verbalizations to regulate motor behavior. Moreover, the dominance of semantic content over the impulse of the speech sound in this stage enables the child to use language to control motor behavior even when it is produced covertly (i.e., internally [spoken silently]).

Translation of Luna's work into English led to several attempts to replicate his basic findings. Unfortunately, the results were not consistently positive (e.g., Jarvis 1968, Wilder, Note 1). In 1970, Miller, Shelton, and Flavell indicated that the lack of detailed description of subject populations, methods, and results that characterized the translated studies made it difficult to perform literal replications. The experimenter is forced to interpret or extrapolate detail in designing a replication and thus negative results could have a procedural basis. In view of the importance of Luna's work and the increasing attention to its contrast with Piagetian theory, Miller et al. (1970) proposed yet another replication attempt using Luria's bulb-squeeze task, they tested the hypothesis that
verbal control, in Luna's sense, involved emission of a vocal response prior to performing the required motor response. Children were instructed to say "squeeze" whenever a blue light appeared and then squeeze the bulb. Emphasis was placed on speaking first and squeezing afterward. As in previous studies, the results did not indicate that instructions to verbalize facilitated correct motor performance. Miller et al. (1970) concluded that there is no evidence from this study for a clearcut verbal-then-motor order of responding, and therefore no reason to believe that the verbal response could function to mediate motor behavior.

In a detailed review of the relevant Soviet and American literature, Wozniak (1972) proposed that verbal mediation was not the mode of influence to which Luna's theory of verbal self-regulation was addressed. Instead, he suggested that Luna intended the verbal response to occur simultaneously with the motor response. That is, the verbal instructions for performing a particular motor task should occur along with the execution of the motor act rather than precede and initiate the motor act. Given these differing interpretations of Luna's intentions and the continued interest in verbal self-regulation, it seems reasonable to attempt a replication in which we can compare the relative effects of the Miller et al. (1970) and Wozniak (1972) procedures on children's use of language to control motor acts. Furthermore, since no published research has as yet provided information highlighting developmental trends in the performance of motor tasks which require increasingly difficult skills, an attempt to examine such trends also seemed warranted and potentially informative.

The present paper reports two experiments designed to assess (1) the differential effects of the semantic, impulse, and mediating aspects of language and (2) the effects of covert and overt verbalizations on children's performances on simple and difficult versions of a pegboard hammering task. This particular task was chosen because it involves an easily defined discrete motor response (hit the peg) and because it is relatively easy for even the youngest children to learn. The pegboard task was first developed and demonstrated by Wozniak (Note 2).

The first experiment was designed not only to replicate Luna's findings but also to investigate the effects of verbal mediators on motor behavior. First, if the semantic aspect of speech helps control a young child's motor behavior, the child should be aided by accompanying the motor act with a semantically relevant verbal instruction. If the activity of speech is the primary facilitator at the early age, any verbalized instruction should be effective. Children were asked to hit a single peg in the pegboard once. In the silent version of that task, no verbalizations were requested. In the overt version, one group of children was asked to say "one" while simultaneously hitting the peg; a second group was instructed to say "toy." If the overt verbalizations facilitate hitting the peg only once, then Luna's findings with bulb squeezing would be replicated in the pegboard task. If there is no difference between the semantically relevant verbalization, "one," and the semantically irrelevant, "toy," Luna's hypothesis that language initially controls behavior through the activity of speaking would also be supported.

Finally, the hypothesis that verbal instructions serve as mediators which precede and help initiate the motor act was examined in a third group asked to say "one" and then hit the peg. The procedure parallels that used by Miller et al. (1970) and, if successful, would indicate that verbalizations can facilitate control of motor behavior by preceding and mediating the motor act in question. If not successful, the verbal mediation model would not be an adequate description of the phenomenon studied by Luna.

Experiment 2 was conducted to examine developmental trends in children's use of language to guide motor behavior. The roles of both covert and overt verbalizations in guiding motor behaviors of younger (2-4 to 3 years) and older (3-4 years) children were examined with simple (hit the peg once) and difficult (hit three pegs in succession) tasks. While Luna seems to suggest that the usefulness of overt verbalization for correct motor performance reflects an age-specific level of developing verbal self-regulation, we hypothesized that even with children who are old enough to use covert verbalization to facilitate performance on simple tasks, overt would be more effective if the task is relatively difficult.

**Experiment 1**

**Method**

**Subjects and design—** Sixty-nine children between the ages of 2-0 and 2-11 were recruited from day-care centers and preschools to participate in the experiment. Twenty-three children were randomly assigned to each of
three groups. All groups were tested in two conditions, each consisting of six trials. The requirements for the first condition (silent performance), in which the children were asked to perform a motor task without verbal instructions, were the same for all three groups. The three groups differed from each other with respect to the instructions given during the second condition (overt instructions). Children in the first group were told to say "one" while simultaneously hitting a wooden peg with a wooden toy hammer. Children in the second group were told to say "toy" while simultaneously performing the motor task. Children in the third group were asked to verbalize "one" and then hit the peg.

All children were asked to do the silent version of the task first in order to obtain a baseline of performance against which to measure the experimental intervention. Because instructions to verbalize might reasonably cue children to use a verbalization strategy in the silent version of the task, the silent and overt versions were not counterbalanced. Differences between silent and overt conditions across trials were not expected to arise from practice effects. To confirm this, practice effects for the present data are evaluated in the Results and Discussion section.

Materials — One children's wooden hammering board, containing six colored pegs, and one wooden toy hammer were used. During testing conditions only one peg remained in the hammering board to prevent the children from hitting additional pegs.

Procedure — Each child was taken individually to an experimental room for testing. As the experimenter and the child entered the room, the experimenter asked if the child had played with a hammering board such as the one used. A few minutes were then set aside to allow the child to become familiar with hitting the peg with a hammer.

All children prior to testing were questioned on their understanding of the concept "one." This was done by asking a variety of questions, such as, "How many fingers am I holding up?" and "Can you show me one finger?" Eleven children who did not demonstrate an understanding of "one" were eliminated from the study.

During the first condition, children in all three groups were given the same instructions. For each of the six trials, they were told to watch the experimenter hit the peg and then to hit the peg in the same manner as the experimenter had. If the child correctly hit the peg once, the experimenter praised the child and then asked him or her to repeat the motor act. Each time the child performed incorrectly (i.e., hit the peg more than once), the experimenter asked questions to determine the child's awareness of his mistake. For example, if the child hit the peg more than once, the experimenter asked, "Did you do just what I did?" or "Did you hit it this way [one hit]?" or "Did you hit it this way [several hits]?" After questioning, the experimenter proceeded to the next trial, once more demonstrating how to hit the peg once.

The instructions for the three groups during the second condition differed. For children in the "one" group, the experimenter demonstrated the task which consisted of hitting the peg once while saying "one" at the same time. For children in the "toy" group, the experimenter demonstrated hitting the peg once while saying "toy" simultaneously. For children in the "one"-then-hit group, the task was to first say "one" and then immediately follow the verbalization with a single hit of the peg.

As in the first condition, if the child correctly hit the peg with the appropriate accompanying verbal response, the experimenter praised the child and went on to the next trial. If the child performed incorrectly, the experimenter first questioned the child concerning his or her mistake and then asked the child to observe as she modeled the appropriate behavior.

Every opportunity was given the children to perform correctly throughout both testing conditions. Even if the children had performed correctly, the experimenter demonstrated the motor act again after two or three trials to ensure that the child would not forget the instructions of the task.

Observation scale — Based on observations of children's performance during an initial pilot study and on their responses to questions concerning mistakes, a six-point scoring system was developed for and used to record performance during the experiment. Scores ranging from 0 to 5 were given for each of the six trials. Thus, a total of 30 points was possible for each condition. The six different scoring categories, listed from the lowest score value to the highest score value, were as follows: no recognition of error when asked, recognition of error when asked, spontaneous recognition of...
error, initiation and inhibition of an incorrect response, correct response with deliberation/delay before or between responses, correct response without deliberation/delay.

Results and Discussion

The entire range of responses (0-5) was observed in the present sample of 2-year-olds. Examination of these scores for intermediate values indicated, however, that only 10% were in the middle range of the scale. For this reason, scores from each trial were dichotomized (0-3 = failure, 4-5 = success) and summed across trials. Total scores ranged from 0 (no successes) to 6 (success on all six trials in a particular condition). An examination of trial data in the silent conditions showed no change in rate of success across the six trials, 65%-62% from trial 1 to trial 6. Similarly, within the three verbalization conditions, success rate did not change, 68%-67% from trial 1 to trial 6. The children experienced no practice effects on these tasks in spite of the fact they received six trials and had ample opportunity to demonstrate such an effect. The change across silent and overt versions of the task may now be examined and interpreted without reference to practice as an alternative explanation.

Mean performance scores for each group across both conditions are presented in Table 1. A 2 (conditions) × 3 (groups) analysis of variance with verbalization as within-subjects variable was performed on the data. The rationale for the use of the analysis of variance with ordinal data is explained by Gaito (1980). There was a significant main effect of group, F(2,66) = 6.11, p < 0.05. The mean scores for the “one,” “toy,” and “one”-then-hit groups were 4.67, 4.48, and 2.70, respectively. Individual t tests comparisons were used to compare means (Bailey 1971). The post hoc tests indicated that the “one” and “toy” groups did not differ from one another but that both differed significantly from the “one”-then-hit group, t(66) = 3.18, p < 0.01, and t(66) = 2.87, p < 0.05, respectively. In addition, there was a significant conditions × groups interaction, F(2,66) = 13.70, p < 0.001. Post hoc t tests revealed significant differences between the performance means of the silent and overt conditions for all three groups. There was a significant increase in mean performance for the “one” group, t(66) = 3.25, p < 0.01, and for the “toy” group, t(66) = 3.16, p < 0.01, indicating that children’s performances were significantly better when given an overt verbal accompaniment. In the “one”-then-hit group, there was a significant decrease in motor performance, t(66) = 3.16, p < 0.01, indicating that words placed where verbal mediators would occur in the action chain do not appear to mediate action—they appear to hamper motor performance. Finally, the difference between the means for the “one” and the “toy” groups for overt verbalization conditions was not significant, indicating that at this early age, the mere activity of language is as facilitative as semantically relevant language in serving to guide behavior.

These findings support Luria’s theory concerning verbal self-regulation. That is, children’s motor performances are facilitated not only when verbal instructions are spoken aloud but even when the verbal instructions are not directly related to the task itself. Children performed equally well when given a semantically relevant instruction and when given an irrelevant instruction. Furthermore, these results do not support the verbal mediation hypothesis. Providing a verbal mediator for the present task was detrimental to task performance. In many instances, the young children could not perform this task at all. The experimenter had to repeatedly demonstrate saying “one” before hitting the peg. Children were often prone to hit the peg while simultaneously saying “one,” that is, the instructions given children in the “one” group. Apparently, the task in the verbal mediation condition required the execution of two responses rather than the single speech-motor response necessary under the other two conditions, which made it a more difficult task for these children.

Experiment 2

Method

Subjects and design—Sixty-four children, age range 2½-4½ years, were recruited from preschool centers for participation in experiment 2. The children were equally divided into two age groups. The young group, con-
sisting of 32 children, ranged in age from 2\% to 3\% years (mean age = 3-1), while the remaining 32 children of the older group were between the ages of 3\% and 4\% (mean age = 4-0)

All children were given two motor tasks, one simple and one more difficult, to perform. Children were asked to perform both tasks, first silently and then with accompanying overt verbal instructions. The simple task preceded the difficult task. There were six trials in each silent and overt condition of each of the two tasks.

Materials — One children’s wooden hammering board, containing six colored pegs, and one wooden toy hammer were used. During the first task, only one peg remained on the hammering board to prevent the children from hitting additional pegs. During the second task, three pegs (one red, one green, and one blue) remained on the hammering board.

Procedure — The procedure was similar to the one described in experiment 1. The child was escorted by the experimenter to a nearby room for testing. Once in the room, the experimenter asked if the child had played with a hammering board such as the one used. All children were then given a few minutes to play with the hammering board and hammer.

All children prior to testing were asked a number of questions to assess their understanding of the concepts “one,” “red,” “green,” and “blue.” Thirteen children who did not demonstrate an understanding of all four concepts were not included in this experiment.

Instructions for the simple task were identical to those given children in the “one” group of experiment 1. That is, children watched as the experimenter demonstrated hitting the peg one time without any accompanying overt verbalizations. Following the silent condition, all children were asked to say “one” while simultaneously hitting the peg with the hammer.

Each time the child correctly performed the motor task, the experimenter praised him. If the child performed incorrectly, the experimenter questioned the child to determine whether the child understood the mistakes made. This procedure was the same as the one used in experiment 1.

After completing the first simple task, children were asked to perform a more difficult task. Three pegs—one red, one green, and one blue—were placed in the board such that the red peg was in the bottom-left-corner hole, the green peg was in the bottom-right-corner hole, and the blue peg was in the top-middle hole. The child was asked to hit the peg in the manner demonstrated by the experimenter. The experimenter then hit the pegs in the following order: red, green, and then blue. This sequence was chosen because it was believed that this pattern would be more difficult to follow than a red, blue, green pattern in which the child would be basically hitting in a left-to-right sequence. The red, green, blue pattern required the child to hit first on the right, then the left, and then move upward to hit the blue peg in the middle.

Children’s performances were assessed first without any verbal accompaniment. Following this condition, children were asked to say “red, green, blue” as they hit the respective colored pegs.

Performance scores were assigned based on the observation scale described in experiment 1.

Results and Discussion

Based on the observation scale used, scores could range from 0 to 5 on any of the six trials in each condition of each task. Examination of these scores for intermediate values indicated 24\% in the middle range of the scale. Because of the relatively large number of intermediate values, the complete scale scores were used in the present analysis. Performance means for the two age groups across both task and condition are presented in Table 2. A 2 (tasks) × 2 (conditions) × 6 (trials) × 2 (ages) repeated-measures analysis of variance was performed on the data. Significant main effects were obtained for age, $F(1,62) = 9.04$, $p < 0.005$, task, $F(1,62) = 92.74$, $p < 0.001$, and condition, $F(1,62) = 31.52$, $p < 0.001$. Older children did better than younger children.

| TABLE 2 |

| Performance Means across Age, Task, and Verbalization Condition |
|-----------------|-----------------|-----------------|-----------------|
| AGE (YEARS)     | SIMPLE          | DIFFICULT       |
| Silent          | Overt           | Silent          | Overt           |
| Simple          | Difficult       |
|-----------------|-----------------|-----------------|-----------------|
| 2 5-3 5         | 4 39            | 1 98            | 2 92            |
| 3 5-4 5         | 4 73            | 3 28            | 3 82            |

Note — Maximum score = 5
dren did better on the simple task than on the more difficult one, and children's performances were facilitated when they were given overt verbal instructions to accompany the tasks.

There was also a significant main effect of trials, $F(5,310) = 4.85, p < 0.001$. The overall mean performances across the six trials were as follows: 2.65, 2.54, 2.53, 2.43, 2.58, and 2.64. The difference between the first and the sixth means was only 0.1, suggesting that the significant effect was due to fluctuations across trials and was not a result of any type of practice effect.

Of interest are three interactions. First, there was a significant task × age interaction, $F(1,62) = 4.96, p < 0.05$, indicating that while the older children performed slightly better than the younger children on the simple task, there was a much larger difference between performances of the young and old on the difficult task. That is, the difference between the simple and difficult tasks was greater in the younger children. The means were 4.62 and 2.45 for the simple and difficult tasks in the young age group, and 4.84 and 3.55 in the older group. Individual $t$ test comparisons indicated that the difference in the younger group was significant, $t(62) = 2.49, p < 0.02$, while the difference in mean performance did not reach significance in the older age group, $t(62) = 1.48, p < 0.20$.

In addition, there was a significant interaction between conditions and task, $F(1,62) = 4.35, p < 0.05$, indicating that while overt verbalizations did facilitate performance on the simple task, the effect of verbalizing aloud was much stronger on the difficult task for all children. The means were 4.56 and 4.90 for the silent and overt versions of the simple task, and 2.63 and 3.37 for the difficult task. Individual $t$ test comparisons indicated that the difference in verbalization conditions for the difficult task was significant, $t(62) = 2.18, p < 0.05$, while the difference was not for the simple task, $t(62) = 1.71$.

Finally, there was an interaction between verbalizations and age, $F(1,62) = 3.05, p < 0.08$. Young children appeared to show greater improvement when they were provided with verbal instructions for both tasks. The means were 3.19 and 3.89 for silent and overt conditions in the younger age group, and 4.01 and 4.39 in the older group. Although these findings do not reach statistical significance, they are consistent with Luria's hypothesis concerning an apparent decrease in the effect of verbalizations with age. Older children did not seem likely to benefit from the use of overt verbalizations to guide behavior. This is presumably due to increasing internalization of verbal regulation with age (i.e., the ability to use covert speech to facilitate performance).

**General Discussion**

The present studies replicate and extend Luria's findings on the development of verbal control over motor behavior. They also place previous, unsuccessful attempts to replicate his findings in a useful context. Our procedures were based on Woznak's (1972) analysis of Luria's writings and on his interpretation of Luria's methodology. Experiment 1 compared a simultaneous verbalize/hit procedure, which reflects Luria's emphasis on the impulse of the speech sound, with a verbalize-then-hit sequence, which assumes that speech mediates control of the motor act. Since the verbalize/hit procedure replicated Luria's results in detail, and the verbalize-then-hit sequence did not, the former is probably closest to the procedure Luria actually employed.

These results do not imply that studies in which verbalization precedes the motor act have been in error or do not provide useful data. As indicated in the introduction, reports of Soviet research methods and results are not always adequate to allow literal replication, and they may suffer somewhat in translation and editing as well. Studies like the one reported by Miller et al. (1970) have tested plausible interpretations of Luria's methodology. In view of the results of experiment 1, the Miller et al. (1970) study can no longer be viewed as a decisive failure to replicate Luria's results. It can be viewed, however, as a powerful test of one interpretation or explanation of the results replicated in experiment 1. As such, the Miller et al. (1970) study seems to rule out verbal mediation (verbalization precedes onset of the behavior) as an explanation of verbalization effects on motor performance. The verbalize-then-hit sequence in experiment 1 reinforces this conclusion. Thus, verbal control or regulation of motor behavior and verbal mediation in problem solving and memory tasks appear to be examples of distinct roles that language can play in relation to behavior and cognition. These do not represent competing hypotheses. Instead, they complement one an-
other and challenge us to broaden our view of interactions among language, thought, and behavior.

In addition to replicating Luria's findings on overt verbalization and correct motor performance, experiment 1 addressed Luria's hypothesis concerning the relative importance of impulse (i.e., physical) and semantic (i.e., cognitive) aspects of speech on behavior at different ages. Luria has suggested that overt verbalizations initially have their effects on motor performance through the impulse of the speech sound. Insofar as both the speech act and the motor act coincide, starting and stopping at the same points, overt verbalization can both trigger and terminate the motor act. The content of the verbalization is not important until the child is older. The present results, which indicate that semantically relevant ("one") and semantically irrelevant ("toy") verbalization are equally effective in control of a single peg hit, support Luria's hypothesis. Further support can be found in studies that illustrate the disinhibition of behavior by speech (e.g., Kopp, in press, Strommen 1973). The results indicate that semantic control of behavioral and cognitive systems must develop. In a sense, speech does not imply language.

Experiment 2 highlights the importance of age and task difficulty in evaluating the effects of overt verbalization on correct motor performance. Interactions among age of the child, verbalization condition, and task difficulty indicate that the facilitative effect of overt verbalization decreases with age and is less evident with simpler tasks. The results with verbalization condition and age (p < 0.08) are consistent with Luria's emphasis on the 2-5-year age range as an important one for the development of language and thought. They are also consistent with Luria's hypothesis that integration of language with motor and cognitive systems precedes the effective use of language without overt verbalization. Thus, coordination among systems may be a condition for the internalization of language.

Despite Luria's emphasis on the period from 2 to 5 years, our results with the task-difficulty variable suggest that the facilitative effects of overt verbalization can apply to older children as well and perhaps also to adults. Since the verbalization effect is stronger with more difficult tasks, increasingly difficult tasks designed to challenge the cognitive and motor skills of older children and adults might well reveal facilitation of motor performance by overt verbalization throughout a wide age range. These results would be consistent with our own experience of difficult and novel motor tasks and would have important implications for Luria's theory of language and behavioral development.

In conclusion, the present studies offer more than a successful replication of Luria's findings on verbal control of motor behavior. They suggest that language can play an active and integrative role in the development of behavioral and cognitive systems. In this respect, lines of investigation initiated by Soviet psychology contrast sharply with Piaget's consistent emphasis on language as a reflection rather than a catalyst of cognitive growth (e.g., Piaget 1926, 1962, Sinclair-de-Zwart 1969). The present results should encourage a new look at the interactions among language, thought, and behavior. Western psychology may have underestimated the need for an integrative perspective that would do justice to the many roles that language plays in behavior and development at different ages.

Reference Notes


2. Wozniak, R H. Personal communication, 1976

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