Knowledge of Mathematical Equivalence in Children with Specific Language Impairment: Evidence from Gesture and Speech

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Abstract

This study investigated understanding of mathematical equivalence in children with Specific Language Impairment (SLI) and their typically developing peers (ages 8;1-11;7). 17 children with SLI (Expressive-SLI = 9; Expressive-Receptive-SLI = 8) and 17 chronological-age-matched (CA) typically developing controls completed addition and mathematical equivalence problems. Problem solutions and explanations were coded for accuracy and problem-solving strategies. Children with SLI were less accurate than their CA peers in solving both types of problems. Analysis of children's gestured and spoken explanations indicated that the children with SLI were at a developmentally earlier point in their acquisition of equivalence than children in the CA group. Children in the E-SLI group frequently expressed correct strategies in gestures, but incorrect strategies in the accompanying speech. These findings suggest that children with E-SLI may have conceptual understanding of equivalence that is represented in a nonverbal, perceptual format. Overall, children with SLI appear to experience delays in acquiring knowledge of mathematical equivalence, and children with ER-SLI experience greater delays than children with E-SLI.

Introduction

- Children with Specific Language Impairment (SLI) evidence deficits, not only in language, but also in mathematical skills, including counting and arithmetic (Donlan, 2003; Fazio, 1994, 1996).
- This study investigated understanding of **mathematical equivalence**, assessed using problems such as 3 + 4 + 6 = 3 + __, in children with SLI and typically developing peers.
- To gain insight into children's knowledge, we investigated the information children expressed in both gestures and speech.
- If children with SLI have knowledge about mathematical equivalence that is represented in a nonverbal, perceptual format, they may express such knowledge in gestures and not in speech.
- Such gesture-speech "mismatches" have been observed in typically-developing children as they acquire the concept of equivalence (Perry, Church, & Goldin-Meadow, 1988).

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Method

Participants

- 17 children with SLI and 17 chronological-age-matched (CA) typically-developing controls participated (ages 8;1-11;7).
- 9 of the children with SLI displayed deficits in *expressive language only* (E-SLI), and the remaining 8 displayed deficits in *both expressive and receptive language* (ER-SLI).

Procedure

- Children solved and explained a set of addition and equivalence problems.
- Problem solutions were coded as correct or incorrect.
- The strategies children expressed in their gestured and verbal responses were assessed using systems developed by Perry et al. (1988). See table below.
- The relationship between gesture and speech (match or mismatch) was assessed for each response. If the two modalities expressed the same strategy, this was coded as a *match*. If they expressed different strategies, this was coded as a *mismatch* (see Perry, et al., 1988, for details).

Strategies Expressed in Speech and Gesture For the Problem 6 + 5 + 4 = 6 + __

Strategy	*Speech*	*Gesture*
Add All	6 plus 5 is 11 plus 4 is 15 plus 6 is 21.	Right hand point: left 6, 5, 4, right 6.
Add to Equal Sign	6 and 5 is 11. And plus 4 is 15.	Left hand point: left 6, 5, 4, solution.
Equalize	There's 6 plus 5 is 11 plus 4 is 15, so 9 plus 6 would be 15.	Left hand point: left 6, 5, 4, hand down. Right hand point: solution, right 6.
Grouping	The sixes were taken care of, and 5 plus 4 is 9.	Left and right hand palms: cover left and right 6s; left hand point: 5, 4.

Results

Overall level of performance

Addition problems. Children with SLI solved fewer addition problems correctly than their CA peers, $t(32) = 2.86$, $p = .01$.

Equivalence problems. Children with SLI solved fewer equivalence problems correctly than their CA peers, $t(32) = 3.07$, $p < .01$. No child in the ER-SLI group solved any of the problems correctly, whereas the proportion of children who solved at least one problem correctly did not differ for the E-SLI and CA groups, $\chi 2(1) = 1.53$.

Path of Development, Manifested in Gesture-Speech Responses

Past research. Past research indicates that *typically developing children* traverse a 3-step path (Alibali & Goldin-Meadow, 1993).

- They start by considering a single, incorrect strategy, reflected in responses that express the same, incorrect strategy in gesture and speech (*match-incorrect* responses).
- Children then progress to considering multiple strategies, reflected in responses in which gesture and speech express different strategies (*mismatch* responses).
- Finally, they again consider a single correct strategy, reflected in responses that express the same, correct strategy in gesture and speech (*match-correct* responses).

This study. Children with SLI were at a developmentally earlier point in acquiring equivalence than their CA peers. Children in the ER-SLI group showed a more marked delay than children in the E-SLI group, $\chi 2(2) = 7.62$, $p = .02$.

Figure 1. Proportion of children at each point along the path of acquiring equivalence, as manifested in predominant gesture-speech response. Children in the ER-SLI group showed the most immature pattern, children in the CA group the most mature pattern.

Results

Nature of gesture-speech mismatches

In mismatch responses, children in the ER-SLI group tended to express incorrect strategies in both gesture and speech, whereas children in the E-SLI group tended to express correct strategies in gestures, but incorrect strategies in speech.

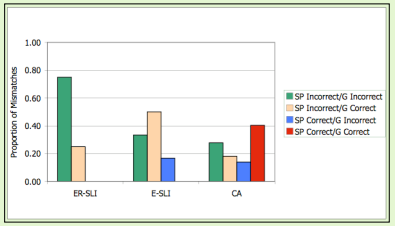

Figure 2. Average proportion of mismatches of each type produced by children in the ER-SLI, E-SLI and Chronological Age-Matched groups.

Discussion and Implications

- Children with SLI experience delays in acquiring mathematical equivalence, relative to their typically developing peers.
- Children with ER-SLI experience greater delays in acquiring mathematical equivalence than children with E-SLI.
- Children with E-SLI often express knowledge about equivalence in gestures and not in speech. Such children may have conceptual understanding of equivalence that is represented in a nonverbal, perceptual format.

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