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Research Article

Child Modifiability as a Predictor of Language Abilities in Deaf Children Who Use American Sign Language

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Purpose: This research explored the use of dynamic assessment (DA) for language-learning abilities in signing deaf children from deaf and hearing families.
Method: Thirty-seven deaf children, aged 6 to 11 years, were identified as either stronger (*n* = 26) or weaker (*n* = 11) language learners according to teacher or speech-language pathologist report. All children received 2 scripted, mediated learning experience sessions targeting vocabulary knowledge—specifically, the use of semantic categories that were carried out in American Sign Language. Participant responses to learning were measured in terms of an index of child modifiability. This index was determined separately at the end of the 2 individual sessions. It combined ratings reflecting each child's learning abilities and responses to mediation, including social–emotional behavior, cognitive arousal, and cognitive elaboration.
Results: Group results showed that modifiability ratings were significantly better for stronger language learners than for weaker language learners. The strongest predictors of language ability were cognitive arousal and cognitive elaboration.
Conclusion: Mediator ratings of child modifiability (i.e., combined score of social-emotional factors and cognitive factors) are highly sensitive to language-learning abilities in deaf children who use sign language as their primary mode of communication. This method can be used to design targeted interventions.

There is a perennial problem in studying children's language development in that it is difficult to distinguish between impairment and delays due to natural variations in the learning backgrounds (Hart & Risley, 1995). For example, many bilingual children who are English-language learners and/or come from culturally and linguistically diverse backgrounds tend to perform poorly on standardized tests of English (Gutiérrez-Clellen, Simon-Cereijido, & Sweet, 2012; Jackson-Maldonado, 1999; Pray, 2003; Sullivan, 2011). Low performance can be due to their unfamiliarity with standardized testing (Peña, Iglesias, & Lidz, 2001) or because of differences between their home and school language experiences (Blount, 1982; Flanagan, Ortiz, & Alfonso, 2013; Fletcher-Janzen & Ortiz, 2006; Heath, 1983, 1986; Rogoff, 2003; Schieffelin & Ochs, 1986; Williams & McLeod, 2012). These children may be at risk for misdiagnosis of language impairment and for receiving intervention that does not target their needs.

Another group that can be difficult to assess with standardized language tests are deaf children[1] who use American Sign Language (ASL). Only a small number (5%–10%) of all deaf children have deaf parents (DCDP; Mitchell & Karchmer, 2004) and acquire a natural signed language (e.g., ASL) from birth. In contrast to artificial systems of manual communication (e.g., Signed English, Cued Speech, Makaton), natural signed languages have great similarities with spoken languages, including how they are processed by the brain (Bavelier, Newport, & Supalla, 2003) and acquired as first languages. For example, children in the DCDP group keep pace with typically developing hearing peers in their vocabulary development (Anderson & Reilly, 2002; Woolfe, Herman, Roy, & Woll, 2010).

The majority of deaf children, however, are born with hearing parents (DCHP), who are not typically able to provide them with fluent signed language input (Marschark, 1997). As a consequence, their signed language development is often delayed compared with children in the DCDP group (Hermans, Knoors, & Verhoeven, 2010; Maller, Singleton,

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[1]We use the term *deaf* because it is the accepted language in the Deaf community and is accepted in related scholarship of deaf individuals.

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Supalla, & Wix, 1999; Musselman & Akamatsu, 1999). Although deaf children show increasing ability to perceive and acquire spoken language as a result of earlier identification of hearing loss and improved digital hearing aids or cochlear implants (Knoors & Marschark, 2012), a considerable number remain significantly delayed in spoken as well as signed language (Lederberg, Schick, & Spencer, 2012). Therefore, we can say that deaf children experience atypical language input, and even those children who sign have a reduced number of conversation partners compared with hearing children acquiring spoken language. Such limitations might lead to the development of more sparse semantic categories and/or more limited flexibility in understanding that lexemes can be linked in different ways. The large variability in deaf children's early language experience makes it is difficult to determine if low performance on a language measure is due to lack of language experience or to a more serious impairment.

With this issue in mind, the focus of the current research is twofold: First, we are interested in whether dynamic assessment (DA) is sensitive to variation in deaf children's language skills. This profiling may lead to targeted interventions focusing on deaf children's strengths and weaknesses. Second, we see this as a first step to using DA to distinguish among weaker and stronger language-learning groups of children that may eventually lead to better identification of deaf children who may have language impairment.

Purpose

There is a lack of instruments that allow appropriate assessments of language ability in deaf children and that can help with an identification of delays versus disorders that are not associated with experience. DA is one method that can help shed light on this problem by focusing on language learning by the child. In our study, we explored this potential by including children with long-term (mostly from birth) exposure to ASL at home and school. In addition, we used highly skilled teachers and speech-language pathologists who are fluent in ASL as our language assessors. We specifically investigated the language-learning abilities of signing deaf children by means of DA, which has been successfully used with hearing bilingual children learning English.

DA combines teaching and assessment processes within a single procedure to measure learning potential and evaluates the enhanced performance that results. It is theoretically motivated by Vygotsky's concept of the *zone of proximal development* (Vygotsky, 1978), which suggests that a child can develop higher mental functioning through collaboration and/or interaction with a more experienced peer or adult. Vygotsky's ideas of promoting higher functioning within the zone of proximal development have been applied by others (Feuerstein, 1979; Lidz, 1987, 1991) in their descriptions of the mediation interaction (mediated learning experience [MLE]) that occurs during the teaching phase of dynamic interaction (Peña et al., 2001). DA has been used most frequently as an alternative approach to static (i.e., one-time) assessments for testing children from culturally and linguistically diverse hearing populations, although there is some research on its use with deaf children.

Within this context, we propose that observation of modifiability (i.e., the qualitative evaluation of children's responsiveness to instruction) can be used to understand differences in language-learning abilities by deaf children.

Modifiability

Modifiability is generally defined as the cognitive and emotional tools associated with learning potential (Kozulin, 2011; Tzuriel, Bengio, & Kashy-Rosenbaum, 2011). Measures of modifiability focus on aspects of learning that indicate child responsivity relative to examiner effort (Budoff, 1987; Lidz, 1991, 1995; Sternberg & Grigorenko, 2002). Limitations in child responsivity during language-learning tasks have been associated with language impairment (Peña et al., 2001; Schneider & Ganschow, 2000; Ukrainetz, Harpell, Walsh, & Coyle, 2000). Much of the early research on DA with deaf populations compared dynamic and static assessments to depict deaf children's learning potential (Huberty & Koller, 1984; Katz & Buchholz, 1984; Lidz, 2004; Olswang & Bain, 1996; Tzuriel & Caspi, 1992). The results demonstrated that deaf children, when given proper training, could perform similarly to hearing peers on complex problem-solving tasks.

The application of DA procedures with deaf children has more recently been extended to a language-learning context. Asad, Hand, Fairgray, and Purdy (2013) examined responsiveness of three deaf children (ages 7–12 years) to a mediation targeting oral narrative skills. Two participants showed good responsiveness and modifiability during the MLE sessions that was consistent with their performance on the subsequent narratives tasks. In addition, they produced better stories during the posttest measure. These findings were interpreted as a possible sign of normal language ability, suggesting that participants' language difficulties may have resulted from a lack of appropriate input rather than an inability to learn language. Both of the participants had experienced limited exposure to language as a result of their hearing loss, which reduced their ability to comprehend heard narratives. In addition, their speech impairment affected their experience with telling and retelling stories to others. However, when given the opportunity to learn how to generate narratives along with the language that was provided during the mediation, both participants were able to improve their narratives.

The third participant demonstrated no improvement in narrative performance on the pretest and posttest measures, and showed only low responsiveness and modifiability during the MLE sessions. Both findings were interpreted as an indication that his limited language may be due to poor language-learning ability. These results highlight the importance of examining learning behavior with children who do not match typical developmental trajectories for speech and language (this generally applies to children with hearing loss) to provide more in-depth information than one-time test scores (Asad et al., 2013).

DA can show learning behavior in deaf children, which can provide broader information than that offered by static test scores alone (Asad et al., 2013). Mann, Peña, and Morgan (2014) used DA in a pilot with two children from the DCDP group on a set of semantic categorization tasks. The findings were consistent with Asad et al. (2013) and revealed differences between the children's response to mediation and their abilities to make semantic categories. The child with poor scores on the categorization task also required more support in MLE compared to her peer with better language skills in categorization. In addition, the two children differed in their use of cognitive strategies, most notably in the ability to use multiple strategies and the willingness to accept alternative strategies. The observations made during MLE were consistent with teacher reports.

We used the interventions described in Mann et al. (2014) to further refine the scripts for the learning sessions and to expand the tasks somewhat. In addition, we incorporated some of the experiences from the pilot into the mediator training for this study.

Semantic Categorization

In this study, we focused on the same aspect of language learning as in Mann et al. (2014): semantic categorization. Learning to form associations among words and putting words into categories are important language skills (Bowerman & Choi, 2001). Children are exposed to massive amounts of information during their school years when they are acquiring much of their vocabulary. For instance, a typical school-age child acquires between 3,000–5,000 new words each year, or about 10–13 words per day (Miller & Gildea, 1987). Children's ability to manage this input by organizing newly learned words into semantic categories is a crucial prerequisite to successful language use and reading comprehension, both in formal educational settings and in everyday activities (Marschark, Convertino, McEvoy, & Masteller, 2004).

Studies of category development and construction of semantic networks have traditionally focused on spoken languages, which exploited the auditory modality (for a review, see Clark, 1993). In comparison, little is known about the way category development takes place in children with hearing loss who sign. Studying signing children, who acquire language in a different modality (visual–spatial), offers the ability to test questions of how and in what ways the physical modality of language transmission influences semantic organization.

Previous studies with deaf populations have predominantly examined spoken English skills (in deaf adults, MacSweeney, Grossi, & Neville, 2004; Marschark et al., 2004; McEvoy, Marschark, & Nelson, 1999; and in deaf children, Green & Shepherd, 1975; Ormel et al., 2010). These studies in general find less finely differentiated semantic categories in the deaf groups. However, studies that assessed deaf participants' semantic knowledge in a signed language reported similar performances between deaf and hearing groups (Courtin, 1997; Mann, Sheng, & Morgan, 2015; Tweney & Hoemann, 1973).

In this study, we examined semantic categorization in deaf children who use ASL as a first language. We identified two groups of children with weaker and stronger ASL abilities. Both groups received training in the use of semantic categories in MLE sessions. We investigated the extent to which cognitive arousal, cognitive elaboration, and social–emotional behaviors, together and alone, predict children's language ability levels based on teacher and clinician report, following the guidelines for accurate discrimination by Plante and Vance (1994). According to these guidelines, a diagnostic procedure is considered "fair" if it has at least 80% specificity and 80% sensitivity; a "good" diagnostic procedure would need to have 90% specificity and sensitivity.

The following research questions were addressed in this article.

1. Does DA of signing deaf children's knowledge of semantic categorization in ASL distinguish children identified as stronger language learners (SL) and weaker language learners (WL) through modifiability ratings?
2. Which individual measure(s) of child modifiability show differences between language ability groups (SL vs. WL)?
3. Which combination(s) of predictors best predict language ability groups?

Method

Participants

Thirty-seven children (15 female, 22 male) aged 6–11 years (M = 102.8 months, SD = 16.9, range = 75–135 months) participated in the study. Of these, 28 children had at least one deaf parent, and nine children had hearing parents. Participants were recruited from a residential school that served deaf children in Central Texas where ASL was the language of instruction. Overall, they were balanced for grade (first through fifth grades).

Grouping Measure

Sign Language Proficiency Rating Scale

Teachers (N = 11, seven deaf, seven hearing) rated participants' signed language proficiency based on five aspects: sign proficiency, sentence production, grammatical proficiency, sign comprehension (using a 5-point Likert scale), and vocabulary (using a 3-point Likert scale; rating scale adapted from Peña, Gutiérrez-Clellen, Iglesias, Goldstein, & Bedore, 2014; Quinto-Pozos, Forber-Pratt, & Singleton, 2011). Sign proficiency was rated based on participants' ability to make themselves understood in ASL. The ratings for sentence production were based on the typical length of participants' signed sentences, ranging from one to two signs to five or more signs. Participants' grammatical proficiency was rated based on the consistency with which children produced well-formed sentences in ASL when conversing or telling stories, including the use of classifier handshapes. Participants' comprehension proficiency was based on how frequently participants understood what was signed in ASL. Teachers' rating scales of participants' signed language proficiency were averaged to produce a mean score for language proficiency. To minimize threats to validity from ascertainment bias, ratings of all participants were completed using the same procedures. For validity purposes, teachers self-assessed their own ASL skills using the Sign Language Proficiency Rating Scale (Haug, 2011), which we adapted for ASL. The two scales rate overall proficiency in signed language perception and production. All teachers rated their signing proficiency as high (M = 4.87 out of 5.00).

Descriptive Measures

American Sign Language Vocabulary Test

The American Sign Language Vocabulary Test (Mann, Roy, & Morgan, 2015) was used to measure participants' signed vocabulary knowledge. We adapted this test in collaboration with a team of deaf native signers from the British Sign Language Vocabulary Test (Mann & Marshall, 2012), which is currently being standardized on a larger sample. Like the British Sign Language Vocabulary Test, the American Sign Language Vocabulary Test consists of four vocabulary tasks—meaning recognition, form recognition, meaning recall, and form recall—that measure deaf children's knowledge of different form-meaning mappings in ASL. Each task consists of 40 items, which are presented in randomized order.

Universal Nonverbal Intelligence Test

In order to measure nonverbal IQ, we used the abbreviated version of the Universal Nonverbal Intelligence Test (UNIT; Bracken & McCallum, 1998), which is composed of the subtests, Cube Design and Symbolic Memory. The tasks are presented nonverbally, and previous studies demonstrate that they are an appropriate measure for use with deaf children (Krivitski, Mcintosh, Rothlisberg, & Finch, 2004).

Experimental Measures

Mediated Learning Observation

Two hearing mediators, both children of deaf adults with native fluency in ASL and English, completed the Mediated Learning Observation (MLO) form (Peña & Villarreal, 2000; see Appendix) to rate their impression of child modifiability. The form consists of 12 items. Items are divided into two main types: social–emotional behavior and cognitive features of learning. These sections are further subdivided into internal and external social–emotional behaviors, and arousal and elaboration aspects of cognitive features with three ratings each. Each aspect is rated on a 5-point scale (1 = *little examiner support needed,* 5 = *high need in a particular area*).

Procedures

Identification of Low Sign Language Proficiency

There is a lack of any agreed-upon, validated measures for identifying language ability in deaf children. To identify participants as weaker language learners, we adapted two of the criteria used by Peña et al. (2006) and added a third:

1. A child is identified as a weaker language learner by the signing certified speech-language pathologist.
2. A teacher has concern about a child's performance in the classroom.
3. A child has achieved a mean score below 3.00 on the sign language proficiency rating scale.

Children who met at least two of these criteria were assigned to the WL group. This was the case for 11 participants. Assignments were made after completion of the study to ensure that everyone who worked with the participants was blind to child ability. The remaining 26 children were assigned to the SL group. Of the children in the SL group, 81% had exposure to ASL from birth, and 64% in the WL group had exposure from birth. The high proportion of children in the DCDP group (who make up 5% of the deaf population) in our sample is very unusual. The SL group (M = 101.5 months, SD = 16.3, range = 75–131 months; 13 girls, 11 boys) showed overall strong ASL skills, based on teacher mean ratings on the Sign Language Proficiency Rating Scale (M = 3.73, SD = 0.85, n = 24), whereas the WL group (M = 105.7 months, SD = 18.8, range = 75–135; two girls, seven boys) received considerably lower mean ratings (M = 2.78, SD = 0.76, n = 9). This difference was significant, $F(1, 36) = 8.769$, $p = .006$. In each group, there was incomplete data for two participants, who are not included. All participants completed four ASL vocabulary tasks, following the same procedures described for the British Sign Language Vocabulary Test (Mann & Marshall, 2012), and also completed the abbreviated version of the UNIT. The tasks were administered by a deaf native signer who had been trained in administering both tasks by the first author. Table 1 displays the mean scores for each group. There were no significant differences between the two groups on nonverbal IQ, $F(1, 35) = 1.506$, $p = .58$.

Table 1. Vocabulary and nonverbal IQ scores.

	SL		WL			
Language scores	***M***	***SD***	***M***	***SD***	***t***	***p***
Vocabulary scores						
Form recall	83.89	7.24	73.41	15.42	2.157	.52
Form recognition	88.94	6.56	77.27	14.72	2.524	.027
Meaning recall	58.83	9.01	47.62	16.84	2.086	.058
Meaning recognition	90.19	19.05	86.82	12.40	2.026	.066
Nonverbal IQ scores						
UNIT	126.84	11.20	126.64	7.80	0.557	.581

Note. SL = stronger language learners; WL = weaker language learners; UNIT = Universal Nonverbal Intelligence Test.

Intervention

MLE

All children participated in two, 30-min individual MLE sessions focusing on the use of semantic categories. Two hearing mediators, both children of deaf adults and fluent in ASL and English, carried out these sessions. Both were unaware of participants' language abilities or teacher ratings. All of the children had one mediator per session, and mediators were rotated so that each child had a different mediator for the first and second sessions. The sessions took place in the speech-language lab of the school and were videotaped using a CANON HD digital video camera. MLE sessions were carried out over the course of 3–4 weeks. Each session focused on training children to (a) use semantic categories as a way to group objects and/or signs and (b) use categories as a way to organize their existing vocabulary, following the procedures described in Mann et al. (2014). Activities were adapted from the *Bright Start* curriculum (Haywood, Brooks, & Burns, 1992), an educational program with a focus on teaching young children to acquire, elaborate, and apply the fundamental thinking skills that are essential for learning the academic material appropriate for primary grade level. Materials included cutouts, pictures, and prerecorded videos of ASL signs, which were presented on a laptop computer.

During the first session, the mediator introduced the concept of categories, or special groups, and worked with the child to classify objects, pictures, and ASL signs into categories and to understand that categories or groups can be subdivided. In the first activity, participants were asked to sort a set of cutouts, which came in different colors, shapes, and sizes, any way they wanted. Once they completed the task, the mediator would ask them if there was another way to classify the cutouts. Another activity required participants to match different target pictures (e.g., *dog, cat, toy*) with another picture out of a set of four and to explain their choice. The mediator would then point to a different picture and ask participants whether or not this picture belonged in the same group as the target.

The format of the second session was similar, though with a stronger focus on using special groups within a language context. In one of the activities, participants were shown videos of prerecorded ASL signs on a laptop computer, including one target (e.g., *apple*) and four responses (e.g., *fruit, cherry, tea, car*), and had to select the sign belonging to the same semantic group.

We developed the MLE scripts with a focus on teaching children to understand the reasons for using special groups or categories; to be able to classify objects in different ways; and to apply the particulars of each session within a language context. We incorporated the five mediation strategies of (a) intention to teach, (b) mediation of meaning, (c) mediation of transcendence, (d) mediation of competence, and (e) mediation of transfer (Lidz, 1991). At the beginning of each session, the mediator used mediation of intentionality (intention to teach) to explain the learning goal to the child (e.g., "Today we're going to look at shapes, pictures and signs. We're going to think about and talk about special ways of grouping things or pictures or signs."). *Mediation of meaning* demonstrated that the goal was important (e.g., "How does it help us to group things? It tells us how they are related."). *Mediation of transcendence* helped the child relate the goal to everyday activities (e.g., "What happens if your mom wants you to clean your room and she asks you to put the all the big toys in the same box but you also put the small ones in the same box? Will your mom think that you understood her? No, she'll think you weren't paying attention. So, using special groups helps us understand what things go together."). *Mediation of competence* encouraged the child to think about the overall goals (e.g., "Tell me what are we going to group today?"), and, finally, *mediation of transfer* empowered the child to apply the strategies they were taught during the mediation (e.g., "How do special groups help us? They help us to understand how things are similar and how they go together.").

At the end of each MLE session, mediators rated their impression of child modifiability by completing the MLO form. Examiners generally carried out MLE sessions with a given child once. That way, children received intervention from two different mediators.

Mediator Training

Both mediators were trained by the second author on how to use the MLE script and how to complete the MLO. This training was completed through the use of video recordings of MLE sessions from our pilot study (Mann et al., 2014). The recordings were critiqued by using the MLE Rating Scale (Lidz, 1991), which operationalizes components of MLE that constitute the teaching portion of the DA (e.g., intentionality, transcendence, meaning, and competence). Further experience and practice were provided during training sessions until the mediators were confident with the procedure.

Fidelity of Treatment

A trained graduate student with background in communication science and disorders performed independent ratings on 10% of the MLE sessions. She was provided with English translations of the video-recorded MLE sessions and rated the mediators, using the MLE Rating Scale (Lidz, 1991). As discussed earlier in this article, this scale consists of four MLE components, including intentionality, transcendence, meaning, and competence. Each component is rated on a 4-point rating scale of 0–3, for a total possible score of 12. A score of 0 indicates no evidence of inclusion, a rating of 1 means that the component is present but unelaborated, a rating of 2 indicates consistency in the use of the component while providing elaborations, and a rating of 3 demonstrates the highest level of mediation in which a general rule is provided. The mean rating was 2.65, indicating that the examiners consistently implemented MLE during the sessions.

Reliability of Mediator Rankings

A Pearson product–moment correlation of mediators' ratings on the MLO form for the two sessions, MLE 1 and

MLE 2, was run to determine the degree of consistency for their rankings of modifiability as an internal measure. Ratings were strongly correlated for all 12 items ($r = .57$, $p < .001$).

Results

Distinguishing Language Ability Through Child Modifiability Ratings

We carried out a 4 × 2 × 2 mixed model, repeated measures analysis of variance (ANOVA) with MLO subscales (affect, arousal, elaboration, and behavior) and sessions (MLE 1 and MLE 2) as the within-subjects factors and group (SL, WL) as the between-subjects factor. Modifiability ratings served as the dependent measure. The Greenhouse–Geisser conservative *F* test was applied to control for potential violations of sphericity assumptions. Effect sizes are reported as partial eta-squared coefficients (η_p^2). Group means and standard deviations for the four MLO subscales for each mediation are presented in Table 2. We found significant main effects for group, $F(1, 35) = 16.279$, $p < .001$; $\eta_p^2 = .317$, and MLO subscales, $F(3, 105) = 19.182$, $p < .001$; $\eta_p^2 = .354$. In addition, results showed interactions between MLO subscales and group, $F(3, 105) = 4.261$, $p < .05$; $\eta_p^2 = .109$, and between MLO subscales and session, $F(3, 105) = 5.994$, $p < .05$, $\eta_p^2 = .145$, but not between group and session, $F(1, 35) = 1.698$, $p = .20$, $\eta_p^2 = .046$. Significant effects were small to moderate. For the Group × MLO Subscales interaction, post hoc pairwise comparisons indicated that WLs required significantly more support on both cognitive measures ($p < .001$) and behavior measures ($p < .05$) than did SLs. A within-group comparison revealed that weaker language learners required significantly more help on cognitive arousal (AR) and cognitive elaboration (EL) than on affect (AF) and behavior (BE)—AR, $M = 8.09$; EL, $M = 9.14$; AF, $M = 6.41$; BE, $M = 6.55$; $p < .001$—whereas SLs only differed significantly in their needs for cognitive elaboration and behavior—EL, $M = 5.56$; BE, $M = 4.35$; $p < .05$. For the MLO Subscales × Session interaction, post hoc pairwise comparisons revealed different patterns of participants' need for support across sessions. In each session, participants required significantly ($p < .05$) more support in the EL domain (MLE 1, $M = 7.25$; MLE 2, $M = 7.44$) than in the AF domain (MLE 1, $M = 5.84$; MLE 2, $M = 5.24$) and BE domain (MLE 1, $M = 5.80$; MLE 2, $M = 5.09$). In addition, their need for support in the AR domain during MLE 2 ($M = 7.23$) was significantly higher ($p < .05$) than in the AF and BE domains. Between-ratings differences showed that participants' levels of support in the AF domain (MLE 1, $M = 5.84$; MLE 2, $M = 5.24$) and BE domain (MLE 1, $M = 5.80$; MLE 2, $M = 5.09$) remained the same in MLE 1 and MLE 2. In comparison, the need for support in the AR domain increased significantly by MLE 2 (MLE 1, $M = 5.80$; MLE 2, $M = 7.23$; $p < .05$), whereas their need for support on the elaboration domain (MLE 1, $M = 7.25$; MLE 2, $M = 7.44$) remained the same across sessions.

Group Differences in Individual Measures of Modifiability

Next, we conducted a one-way multivariate analysis of variance (MANOVA) to address our second question: Which individual measures of modifiability show differences between the language ability groups? Because elaboration and arousal demonstrated the greatest differences for WLs and SLs, we compared children's performance on each of the three scales associated with these domains. There was a main effect of group difference across the six categories, Wilks's $\lambda = .365$, $F(12, 24) = 3.472$, $p < .01$. The multivariate η_p^2 based on Wilks's λ was large, .635. Table 3 contains the means and standard deviations on the dependent variables for the two groups. We then carried out ANOVAs on each of the six dependent variables. Using the Bonferroni method, each ANOVA was tested at the .008 level. Table 4 presents the results of the univariate follow-up tests to the significant MANOVA tests of between-subjects effects. Only the self-reward category failed to reach significance. In all other cases, participants in the SL group required significantly less effort from the examiner than their peers in the WL group, as indicated by their lower MLO ratings.

Table 2. Group means and standard deviations for the four types of ratings at each mediated learning experience (MLE) session.

MLO ratings	SL		WL	
	MLE 1	MLE 2	MLE 1	MLE 2
AR	4.15 (2.51)	5.73 (2.57)	7.46 (2.34)	8.73 (3.04)
EL	5.50 (2.53)	5.61 (2.64)	9.00 (2.79)	9.27 (3.74)
AF	4.50 (2.21)	4.85 (2.68)	7.18 (3.71)	5.64 (2.11)
BE	4.15 (1.62)	4.54 (2.57)	7.46 (3.01)	5.64 (2.20)

Note. MLO = Mediated Learning Observation; SL = stronger language learners; WL = weaker language learners; AR = arousal; EL = elaboration; AF = affect; BE = behavior.

Table 3. Means (*M*s) and standard deviations (*SD*s) for ratings that comprised the arousal and elaboration indices.

Rating	SL		WL	
	M	*SD*	*M*	*SD*
Arousal				
Task orientation	1.85	0.82	3.09	1.04
Metacognition	2.15	0.88	3.50	1.20
Self-reward	1.73	0.95	2.50	1.25
Elaboration				
Problem solving	1.69	0.72	2.82	1.33
Verbal mediation	1.85	0.72	3.05	1.21
Flexibility	2.02	1.00	3.73	1.23

Note. SL = stronger language learners; WL = weaker language learners.

Table 4. Univariate follow-up tests to the significant multivariate analysis of variance (MANOVA) test of between-subjects effects.

Dependent variable of squares	Type III sum square	*df*	*M*	*F*	*p*	η_p^2
Arousal						
Task orientation	11.977	1	11.977	15.082	< .001	.301
Metacognition	14.007	1	14.007	14.468	.001	.292
Self-reward	4.574	1	4.574	4.200	.048	.107
Elaboration						
Problem solving	9.798	1	9.798	11.180	.002	.242
Verbal mediation	11.112	1	11.112	14.093	.001	.287
Flexibility	22.551	1	22.551	19.770	< .001	.361

Modifiability Measures as a Predictor of Group Membership

To address our last question, we conducted a series of discriminant analyses. The goal was to identify the smallest (most parsimonious) number of modifiability predictors that maximally classified SLs and WLs. As a first step, all 12 modifiability items were entered into the analysis. Next, in order to test whether a smaller set of predictors would retain the classification accuracy, we entered the five modifiability items for arousal and cognitive elaboration measures (task orientation, metacognition, problem solving, verbal mediation, and flexibility) into the analysis, based on our findings that the two language ability groups primarily differed on these measures. To further reduce the number of predictors, we conducted a stepwise discriminant analysis to explore which modifiability measures together best predicted group assignment. Results indicated that, when entered into the discriminant analysis, the combination of all 12 items from the MLO scale demonstrated good classification in the first analysis. Examination of Box's *M* indicated that the assumption of equality of covariance matrices was not met (p = .036), and the log determinants were dissimilar (WL group = .633, SL group = –.436). The overall chi-square test was significant (Wilks's λ = .365, χ^2 = 29.190, df = 12, canonical correlation = .797, p = .004). This combination of predictors classified 95% of the cases accurately with 100% sensitivity and 82% specificity. Because our assumption of equality of covariance matrices was not met, we reran the analysis using separate covariance matrices. There was no improvement in classification accuracy, so we retained the initial result.

Next, the combination of the five of six significant cognitive scores in the second analysis demonstrated fair overall classification. Examination of Box's *M* indicated that the assumption of equality of covariance matrices was met (p = .152) and the log determinants were similar (WL group = –6.114, SL group = –5.298). The overall chi-square test was significant (Wilks's λ = .625, χ^2 = 14.921, df = 5, canonical correlation = .607, p = .011). This combination of predictors accurately classified 84% of the original cases, with 97% sensitivity and 55% specificity.

Stepwise discriminant analysis indicated that one factor, flexibility, was entered into the discriminant solution. Overall classification was poor. Examination of Box's *M* indicated that the assumption of equality of covariance matrices was met (p = .414), and the log determinants were dissimilar (WL group = –0.10, SL group = .418). The overall chi-square test was significant (Wilks's λ = .639, χ^2 = 15.449, df = 1, canonical correlation = .601, p < .001). However, this predictor accurately classified only 78% of the original cases, with 89% sensitivity and 55% specificity.

Discussion

The purpose of the present study was to investigate if child modifiability can differentiate SLs and WLs in a novel group of early ASL-exposed children. Two domains of modifiability were assessed: social–emotional behaviors (comprised of internal and external components) and cognitive measures (comprised of arousal and elaboration).

There were three main findings. First, mediator ratings of modifiability were highly sensitive to language-learning ability. Second, the most apparent group differences were found in the use of cognitive strategies during the mediated sessions. Ratings of flexibility demonstrated the greatest magnitude of difference between SLs and WLs. Third, the best classification of language-learning ability was obtained by a composite score of all behavioral and cognitive items from the MLO. We discuss each of these findings in turn.

Mediator Ratings of Child Modifiability

Modifiability ratings were highly receptive to language-learning ability and showed significant group differences for both behavioral and cognitive measures. These findings are consistent with previous work on language learning (e.g., Asad et al., 2013; Kapantzoglou, Restrepo, & Thompson, 2012; Peña, 2000; Peña et al., 2006; Peña, Reséndiz, & Gillam, 2007; Ukrainetz et al., 2000). We also show that mediator observations of child responsivity in the cognitive and social domains reliably distinguishes between weak and strong language learners who are deaf. For the first time at the group level, this finding demonstrates that the use of child modifiability ratings applied to language learning is not limited to hearing populations or spoken language but can be extended to signing deaf children.

In the present study, we observed via MLE that deaf children identified as WLs had difficulty learning the use of semantic categories and required more help compared to children identified as SLs. These patterns are similar to patterns reported for hearing children with specific language impairment (e.g., Sheng & McGregor, 2010). Moreover, both the SL and WL groups in our study included children of both deaf and hearing parents with significant levels of exposure to ASL, which suggests that observed difficulties in modifiability on a semantic categorization task are not just about delayed exposure to ASL.

Group Differences in Deaf Children's Use of Cognitive Strategies

Mediators' ratings for SLs and WLs indicated significant differences on five of the six components of arousal and elaboration: flexibility, task orientation, metacognition, verbal mediation, and problem solving. Effect sizes for these differences were moderate. These measures involve the ability to avoid distraction and focus on the task (arousal) and to integrate, organize, and analyze information that is needed to complete a specific task (elaboration). Within the context of language learning, cognitive arousal is important because of the impact it has on memory. Children tend to remember tasks learned during high arousal better than those learned during low arousal (Sharot & Phelps, 2004). In addition, a child's ability to maintain focused attention both on the learning task and on instructional discourse benefits reading acquisition (Lepola, Niemi, Kuikka, & Hannula, 2005; Onatsu-Arvilommi & Nurmi, 2000).

In our model, arousal was comprised of task orientation, metacognition, and self-reward. Out of these, task orientation was identified as the best predictor of language ability. The ability to process information that is relevant for task completion is equally important for language learning. Problems in this area relate to limited planning behavior, difficulty with verbal elaboration of concepts, and limitations in hypothetical thinking and testing (Feuerstein, 1979; Feuerstein, Miller, Rand, & Jensen, 1981). In our elaboration category, which consisted of problem solving, verbal mediation, and flexibility, it was flexibility that showed the largest effect size. The ability to have multiple strategies or to willingly accept alternate strategies plays an important role in problem solving. Further, it aids the individual in successfully processing the information needed to perform a specific task (Das, 2002; Lidz, 1991). We found that WLs, on average, showed limitations of strategy and struggled with finding and/or accepting alternative solutions, whereas SLs seemed comfortable with using multiple strategies and were willing to change or accept alternative strategies when necessary. These observations resonate with findings from studies on hearing populations of atypical language learners that reported limited problem-solving skills and the need for additional support by these participants (Fidler, Most, & Philofsky, 2008; Fidler, Philofsky, Hepburn, & Rogers, 2005; Lidstone, Meins, and Fernyhough, 2012; Reiter, Tucha, & Lange, 2005; Stevens & Bliss, 1995).

One surprising finding was the lack of any effect of parental hearing status. There were few differences on the vocabulary tasks between DCDP and DCHP groups: form recall, $t(8.724) = -2.032$, $p = .07$; form recognition, $t(8.823) = -2.221$, $p = .05$; meaning recall, $t(35) = -0.033$, $p = .98$; meaning recognition, $t(8.539) = -2.098$, $p = .07$. This could be due in part to the uneven number of participants in each group, especially the unusually small percentage of deaf children with hearing parents (24%). Another aspect that made our sample unique is that all the children were attending a residential school that used ASL as the main means of communication and instruction. Many of the DCHP group members were enrolled at an early age and thus had early and consistent access to ASL. These children do not represent the majority of deaf children with hearing parents who, as summarized in the introduction, experience delayed language exposure.

Classification of Language Learning Ability

In the present study, ratings of flexibility showed the greatest magnitude of difference between language ability groups, followed by task orientation, metacognition, verbal mediation, and problem solving. However, neither flexibility alone nor a composite score of these five measures yielded high classification ratings. This finding is in line with previous studies that used DA within a language-learning context. Peña, Gillam, and Bedore (2014) found that kindergarten-age ability group differences were greatest for metacognition, compliance, problem solving, and flexibility (in that order) for DA of narratives. In earlier work with first- and second-grade English-speaking children with and without language impairments, Peña et al. (2007) found that metacognition and flexibility together accounted for the greatest variance in the data set. Ratings of task orientation, problem solving, and verbal mediation resulted in large effect sizes individually as well. Overall, there are consistencies across these studies in the modifiability ratings that yielded the greatest differences among WLs and SLs in this study and among children with and without language impairment in the previous studies. However, some variation exists in the combination of items that result in a high level of correct classification. These variations in patterns of findings may be due to different language tasks, age of participants, and first language of participants. Nonetheless, the finding that children with language difficulty struggle with using many of the same cognitive strategies across these different studies is suggestive of which cognitive functions are related to language-learning ability.

In our study, a composite score of all 12 modifiability items, including behaviors and cognitive measures, resulted in the highest classification accuracy and was the only score to meet the guidelines for accurate discrimination (Plante & Vance, 1994). The full observation checklist, consisting of 12 items, takes only about 5 min to complete; consequently, from a diagnostic perspective, we would want to be able to make as accurate a judgment as possible in determining language ability. Thus, for application of the approach described here, it is recommended that the full modifiability scale be used.

Future Directions

The current study provides data on the use of DA procedures with deaf signers from one recruitment site. The study needs to be replicated with a larger sample from different sites to substantiate any conclusions. In the future, we are interested in discovering if DA procedures can help identify deaf signing children with potential language impairments. By testing more children, a larger study would allow us to confirm if low performance scores are the likely result of a language-learning problem. In the current study, we controlled for exposure to sign language by focusing on children with long-term exposure to ASL at home and at school. This is critical in differentiating between children with language delay due to late exposure but who have typical language-learning ability and those with potential language disorder. Future studies could look at deaf children with different levels of exposure to differentiate difference and disorder. The language impairment literature with deaf children is small, but at this point, we have established that DA with WLs is consistent with static assessments and teacher reports for this group.

An additional area of study that we propose with this group is to have a reference standard by asking expert judges to complete a severity rating scale independent of the DA or other testing. In our study, the judges were teachers and speech-language pathologists who were highly fluent signers with an average of 10 or more years of experience working with deaf children. Through this approach, we can test the feasibility of using DA and apply the DA procedure to interpret learning in a population that is more variable, and in which there may or may not be someone who can make these expert judgments.

Clinical Implications

The findings emphasize the important contribution of research on deaf children exposed to signed languages to the discussion of profiles of language impairments. Data obtained from DA assessment procedures with signing deaf populations can aid future investigations of how different language impairments originate from different parts of the cognitive system, as it offers a way to teach strategies in deaf individuals with different language experiences. The results suggest that children's social–emotional and cognitive strategies are important for understanding more about language-learning difficulties. This is relevant for practice by encouraging clinicians to carefully profile and respond to the kinds of strategies that we measured during mediation. One major obstacle for clinicians and teachers working with signing deaf children is the general lack of assessment instruments, including diagnostic tools, and accepted intervention strategies within the field. This makes the task of distinguishing between delay and disorder extremely difficult (Quinto-Pozos et al., 2011). Furthermore, similar to bilingual hearing children, language proficiency and dominance in signing deaf children varies—especially among those with hearing parents—and may change with age and/or improved amplification, based on children's experiences in each language. Our findings highlight the potential use of DA to help profile language skills and learning in deaf children and to identify which children benefit from which targeted interventions. Future research should evaluate if DA can be part of a systematic assessment battery for deaf children.

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Appendix

Mediated Learning Observation Form

		Internal social–emotional (1–5)			
Anxiety	Calm (1)	Fidgety (2)	Uncomfortable (3)	Distressed (4)	Distraught (5)
Motivation	Enthusiastic (1)	Curious (2)	Ambivalent (3)	Guarded (4)	Avoidant (5)
Tolerance of frustration	Persistent (1)	Contrite (2)	Tentative (3)	Frustrated (4)	Rejecting (5)
		Cognitive arousal (1–5)			
Task orientation	Completely understands (1)	Mostly understands (2)	Understands some (3)	Rudimentary understanding (4)	Does not understand (5)
Metacognition	Aware of all errors (1)	Aware of most errors (2)	Aware of some errors (3)	Unaware of most errors (4)	Unaware of any errors (4)
Nonverbal self-reward	Positive about task (1)	Positive about task difficulty (2)	Ambivalent (3)	Negative about task difficulty (4)	Negative about task (5)
		Cognitive elaboration (1–5)			
Problem solving	Systematic and efficient (1)	Organized but inefficient (2)	Sketchy plan (3)	Disorganized (4)	No plan (5)
Verbal mediation	Elaborates clearly (1)	Talks through problem (2)	Talks occasionally (3)	One to two word utterances (4)	No verbal mediation (5)
Flexibility	Multiple strategies ready (1)	Preferred strategies but can change (2)	Occasional use of more than one strategy (3)	Recognizes limitations but cannot see alternatives (4)	Persists with one strategy (5)
		External social–emotional (1–5)			
Response to feedback	Very (1) positive	Positive but hesitant (2)	No response (3)	Negative, disheartened (4)	Very negative (5)
Attention	Attentive and focused (1)	Focused but distractible (2)	Distractible but can refocus (3)	Distracted, difficult to refocus (4)	Distracted and off task (5)
Compliance	Cooperative (1)	Insecure (2)	Hesitant (3)	Uncooperative (4)	Refusing (5)

Note. A higher score indicates an increased need for mediator support. Retrieved from Peña and Villareal (2000). Reprinted with permission from the authors.