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Language Learning of Children With Typical Development Using a Deductive Metalinguistic Procedure

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Abstract

Purpose—In the current study, the author aimed to determine whether 4- to 6-year-old typically developing children possess requisite problem-solving and language abilities to produce, generalize, and retain a novel verb inflection when taught using an explicit, deductive teaching procedure.

Method—Study participants included a cross-sectional sample of 4-, 5-, and 6-year-old children with typical cognitive and language development. The 66 participants were randomly assigned to either a deductive or inductive teaching condition in which they were taught a novel gender morphological inflection across 4 sessions. Learning was assessed on the basis of performance on learning, generalization, and maintenance probes.

Results—Across all age groups, children were more likely to successfully use the novel gender form when taught using the deductive procedure than if taught using the inductive procedure (Φ range: .33–.73). Analyses within each age group revealed a robust effect for the 5-year-old children, with less consistent effects across the other age groups.

Conclusions—Study results suggest that 4- to 6-year-old children with typical language and cognitive abilities are able to make use of a deductive language teaching procedure when learning a novel gender inflection. Evidence also suggests that this effect is driven by expressive and receptive language ability.

Metalinguistic awareness refers to the ability to think overtly about language; to manipulate the structural features of language whether at the phoneme, word, or sentence level; and to focus on the language form rather than the meaning (Chaney, 1992). Typically, language interventions for preschool children with primary language impairment (LI) that target morphosyntactic forms do not ask the child to utilize metalinguistic skills. Instead, most child language interventions rely on inductive or implicit methods to teach morphosyntactic forms. That is, the clinician uses techniques such as modeling, imitation, and recasting to increase the frequency of input and the saliency of the target form (see Fey, Long, & Finestack, 2003; Leonard, 1998). The clinician does not deliberately attempt to make the child consciously aware of the target form or the conditions under which the morphosyntactic target must be used.

One alternative approach to teaching morphosyntactic forms to children with primary LI is one in which the clinician aims to help the child to learn a new construction by explicitly presenting the principles or patterns underlying the target form's use to the child. In contrast to traditional, inductive approaches, this alternative approach relies on explicit, deductive processes and the child's metalinguistic abilities to learn language. One reason explicit, deductive approaches have not been thoroughly examined as a viable treatment approach for teaching grammatical forms to preschool children with LI is that it has been assumed that young children lack the metalinguistic skills necessary to make sense of language rules presented in an explicit manner (Connell, 1982). However, evidence in related areas, such as phonological awareness instruction, indicates that preschool- and kindergarten-age children are best served through direct, deductive instructions (Bus & van Ijzendoorn, 1999; Schuele & Boudreau, 2008). Thus, the current study aimed to determine whether 4-, 5-, and 6-year-old children possess the necessary language, problem-solving, and metalinguistic skills to successfully learn grammatical forms when taught using an approach that includes an explicit, deductive teaching procedure.

Some researchers of child language intervention (e.g., Spekman & Roth, 1982) have argued that environmental manipulations alone are insufficient for the child to learn target forms and that instead it may be necessary to use deductive approaches that explicitly present the rule to be learned along with opportunities for the child to observe and use the target form. This argument is supported by evidence that indicates current approaches, which rely on traditional inductive procedures such as modeling and recasting, yield variable outcomes (see Law, Garrett, & Nye, 2004) and modest gains are evident only after very long treatment periods (e.g., Leonard, Camarata, Brown, & Camarata, 2004; Leonard, Camarata, Pawlowska, Brown, & Camarata, 2006). Thus, there is an increased need to identify and evaluate alternative treatment approaches, such as a deductive approach.

Explicit, deductive teaching approaches aim to focus the learner's attention to the form of the language target in a manner that draws upon the learner's metalinguistic awareness. Bialystok (1986) provided a metalinguistic awareness framework that includes two distinct skills. The first skill is *analyzed language knowledge*, or the ability to represent the structure of language in addition to its meaning. This knowledge may include recognizing language units such as words, syllables, and phonemes, understanding the relation between forms (e.g., a word) and meanings, and syntactic awareness (e.g., grammatical judgment). The second skill is cognitive control, which includes the ability to select and process information. Often times this requires the learner to focus on language forms while suppressing the meaning of the form in tasks such as sentence segmentation, symbol substitution, and repetition of meaningless sentences (Bialystok, 1988). Explicit approaches requiring metalinguistic awareness will be beneficial only for learners who have requisite skills in both areas.

One population for whom explicit instruction may be particularly beneficial is children with primary LI. Children with primary LI demonstrate significant weaknesses in language ability, although there is considerable variability in performance across domains (e.g., phonology, morphology, syntax, pragmatics) and expressive and receptive abilities (Leonard, 1998; Tomblin et al., 1997). Grammatical inflections are particularly difficult for

children with primary LI to master (Eadie, Fey, Douglas, & Parsons, 2002; Rice, Cleave, & Oetting, 2000; Rice & Wexler, 1996). Although primary LI is diagnosed on the basis of criteria that exclude significant deficit in nonverbal cognitive abilities (Stark & Tallal, 1981), investigators have identified significant cognitive weaknesses across a variety of cognitive domains, including processing speed (C. A. Miller, Kail, Leonard, & Tomblin, 2001), attention (Finneran, Francis, & Leonard, 2009; Spaulding, Plante, & Vance, 2008), and working memory (Montgomery & Evans, 2009; Montgomery & Windsor, 2007). Given these significant and subtle weaknesses in the two domains directly implicated in Bialystok's (1986) metalinguistic awareness framework, it is unclear whether children with primary LI could benefit from an explicit, deductive approach for teaching morphosyntactic forms.

Two existing studies have examined the use of an alternative explicit approach to teach morphosyntax to children with primary LI (i.e., Finestack & Fey, 2009; Swisher, Restrepo, Plante, & Lowell, 1995). In the Swisher et al. (1995) study, examiners taught 4- through 6-year-old children with typical language development (TL) and children with primary LI a novel morpheme. For participants assigned to the explicit, deductive teaching condition, during training sessions, examiners presented explicit information delineating the pattern or rule underlying the use of the novel morpheme. For participants assigned to the implicit, inductive condition, examiners provided only models of the target form. The examiners never told the children the guiding rule or required the children to think about language patterns. Both the participants with TL and the participants with LI demonstrated difficulty learning the novel morphological form. Moreover, the children with LI did not demonstrate as much learning from explicit cues as did the children with TL. In the implicit condition, there was no significant difference between the children with TL who generalized and the children with LI who generalized. The authors concluded that some explicit approaches to teaching language may not be effective for children with LI.

The children in the Swisher et al. (1995) study were as young as 4 years of age. Thus, one reason both the participants with TL and LI may have had difficulty learning the target form is that they may not have had sufficient morphosyntactic language abilities and cognitive processing skills to apply the provided rules. However, evidence from a study designed to better understand early development of metalinguistic abilities suggests that children as young as 3 years of age have strong metalinguistic skills (Chaney, 1992). Specifically, Chaney (1992) examined the metalinguistic awareness abilities of 3-year-old children with typical development across phonological, lexical, and structural domains. The structural metalinguistic tasks comprised morphological- and syntactic-level items that required the children to complete sentences, make grammaticality judgments, and correct structural errors as necessary. Although there was a large range of variability (i.e., 18%–91% correct on structural awareness tasks), Chaney found that the 3-year-olds were able to successfully complete the morphological and syntactic tasks, with better performance on grammaticality judgment tasks than on production tasks. Subsequent analyses revealed a positive correlation between age and performance on the metalinguistic tasks; however, the best predictor of overall metalinguistic performance was overall language proficiency, indexed as performance on the Preschool Language Scale—Revised (Zimmerman, Steiner, & Evatt Pond, 1979).

The positive correlation between child metalinguistic abilities and language development has been noted by other investigators (Bialystok & Barac, 2012; de Villiers & de Villiers, 1974; Smith & Tager Flusberg, 1982). The morphosyntactic metalinguistic tasks previously examined have included grammatical judgments, production of morphosyntactic forms in novel contexts (e.g., “Wug Task”), and corrections of morphosyntactic errors. Given that metalinguistic performance is influenced by the amount of analyzed language knowledge and cognitive control required by the task, it is likely that learning tasks such as the novel morpheme learning task included in the Swisher et al. (1995) study require a higher level of language knowledge and processing control than grammatical judgment tasks or cloze tasks that utilize familiar forms. Thus, it is probable that young children with immature language skills and cognitive abilities will perform poorly on tasks requiring the learning of novel forms using explicit, metalinguistic approaches.

The Finestack and Fey (2009) study included an experimental paradigm similar to the paradigm used in the Swisher et al. (1995) study, in which a novel morpheme was taught to 32 children (ages 6 to 8 years) with LI. As in the Swisher et al. study, half of the participants were taught the novel morpheme using an implicit, inductive approach and half were taught using an explicit, deductive approach. In this study, a clear advantage was found for the explicit teaching condition, in which 10 (63%) of the participants generalized the novel morpheme compared with 3 (19%) of the participants in the implicit condition. Thus, the participants in the Finestack and Fey study who were in the explicit condition were much more successful than the participants with LI who were in the explicit condition in the Swisher et al. study.

Both the Swisher et al. (1995) study and the Finestack and Fey (2009) study used similar experimental paradigms. Despite similarities in experimental design, there are several factors that may have contributed to differences in the performance of the children with LI in the explicit conditions across these two studies. As noted by Finestack and Fey, the language learning task in the Swisher et al. study may have been significantly more difficult than the task in the Finestack and Fey study. In addition to learning a novel marking, the participants in the Swisher et al. study were required to learn two novel nouns to which the novel morpheme was affixed. Additionally, examiners in the Swisher study presented the target novel forms in a story context, which likely increased the language processing skills required by the learners. In contrast, in the Finestack and Fey study, the target novel forms were presented in isolated sentences with uniform syntactic structures. Also, the explicit presentation of the rule guiding the target form in the Swisher study may have led the children to rely on rote memory of the target forms (i.e., *gack* and *gacku*) rather than to apply a generalizable rule such as, “For the small one you just say the name; for the big one you have to add [u] to the end.” The explicit presentation in the Finestack and Fey study was designed to draw the participants’ attention to the overarching pattern. Finally, the participants in the Finestack and Fey study received twice as many intervention sessions as the participants in the Swisher study (four sessions vs. two sessions).

Other factors that may have contributed to performance differences across the Swisher et al. (1995) and Finestack and Fey (2009) studies concern the characteristics of the participants included in each study. The participants in the Swisher et al. study were, on average, 3 years

younger than the participants in Finestack and Fey study. Inherent in this age difference are differences in the language and cognitive abilities of the participants across the two studies. On the basis of Bialystok's (1986) metalinguistic awareness framework, these are skills that directly influence metalinguistic abilities and, presumably, the ability to make use of language teaching approaches that are explicit and rely on deductive processes.

Using procedures identical to those used in the Finestack and Fey (2009) study, the current study examined whether 4- to 6-year-old children with typical development possess adequate metalinguistic abilities to make use of an explicit, deductive procedure when learning a novel morphological form. The current study was designed to determine whether young typically developing children, including preschool-age children, possess the requisite language and cognitive skills to successfully complete a metalinguistic morphosyntactic learning task, which would support Chaney's (1992) findings. If such children are unable to make use of a deductive teaching approach, this would suggest that deductive approaches may not be well suited for children with primary LI. Additionally, drawing upon Bialystok's (1986) metalinguistic awareness framework, the study aimed to examine age, language ability, and nonverbal problem-solving ability as factors contributing to the discrepant findings of the Swisher et al. (1995) and Finestack and Fey studies. Language variables included both receptive and expressive measures as well as morphosyntactic measures. The nonverbal cognitive variable included a measure of fluid thinking, which requires problem solving by perceiving relationships and completing analogies. This study addressed the following questions:

1. Do 4- through 6-year-old typically developing children produce, generalize, and retain a novel verb inflection when taught using an explicit, deductive teaching procedure?
2. Do more typically developing children produce, generalize, and retain a novel verb inflection when taught using an explicit, deductive teaching procedure than an implicit, inductive procedure?
3. Are differences in performance on deductive and inductive learning tasks significantly influenced by nonverbal problem-solving or language (expressive or receptive) abilities?

On the basis of findings from the Chaney (1992) study, which indicated that children as young as 3 years of age are able to successfully complete metalinguistic tasks focused on morphological and syntactic structures as well as the Finestack and Fey (2009) study involving successful morphological learning with deductive instruction, it was predicted that across all age groups, the participants would be successful with the deductive instruction. However, considering the findings of Swisher et al. (1995), which demonstrated that many of the typically developing children were unable to generalize the target morphological form through either implicit or explicit instruction, it was expected that the 4-year-old participants would be less successful at learning the targeted morphological form than either the 5-year-old participants or the 6-year-old participants with both the implicit and explicit teaching procedures. Additionally, on the basis of Bialystok's (1986) metalinguistic awareness framework, it was predicted that the participants who learned the targeted forms would be those with the strongest language and nonverbal cognitive abilities.

Method

Participants

Sixty-six children ages 4 through 6 years with typical language and cognitive development participated in this study. Children were recruited from daycare centers, preschools, and kindergartens. All parents signed forms approved by university institutional review boards granting permission for their children's participation in the study. All participants met the following inclusion criteria: (a) they had a Spoken Language Quotient of 85 or above (1 SD) on the Test of Language Development—Primary, Third Edition (TOLD-P:3; Newcomer & Hammill, 1997); (b) they received a standard score of 80 or above (1.33 SDs) on the Matrices nonverbal scale of the Kaufman Brief Intelligence Test—Second Edition (KBIT-2; Kaufman & Kaufman, 2004); (c) they had never received special services for language or reading weaknesses, and there were no concerns about language or cognitive development according to parent report; (d) they passed a hearing screening (i.e., detect 1000-, 2000-, and 4000-Hz tones presented at 20 dB HL in at least one ear) prior to completing experimental tasks; and (e) they could accurately produce the target morphological syllables *-pa* and *-po*. A more conservative language performance cutoff was used to ensure typical language development across all participants and to clearly differentiate the participants in the present study from the participants in the Finestack and Fey (2009) study. Additionally, parents completed a demographic form indicating their child's race and confirming that English was the only language spoken by the child and used in the home. Table 1 presents the study groups' characteristics.

Upon completing all assessments to determine study eligibility, eligible participants were randomly assigned to a treatment group: the Deductive Group or the Inductive Group. Group assignments were randomized in blocks to help ensure an equivalent number of participants in the two treatment groups across age groups. The investigator and examiners were kept blind of a potential participant's assignment until all eligibility assessments were completed. Within each age group, the Deductive and Inductive groups were compared on six preexperimental variables. Comparisons were made using nonparametric Mann–Whitney U and Pearson χ^2 analyses. Although none of the comparisons were statistically significant ($p < .05$), several of the tests resulted in p values less than .50, the level recommended for group comparisons (Mervis & Robinson, 2003). Variables with comparative p values less than .50 were accounted for in the study result interpretations. The participant group descriptives, including the p values for each analysis, are presented in Table 1.

In addition to completing the assessments described above to determine study eligibility, all participants completed the Rice/Wexler Test of Early Grammatical Impairment (TEGI; Rice & Wexler, 2001). The TEGI is a standardized test designed to evaluate grammatical deficits in children between the ages of 3 and 9 years. Examiners administered the three core TEGI probes, including the Third Person Singular Probe, the Past Tense Probe, and the Be–Do Probe. This assessment provided detailed information regarding the morphosyntactic abilities of the participants. Performance on this test was used to better understand the relationship between deductive and inductive language learning and language ability. The

Ms and *SDs* based on performance on the TEGI Elicited Grammar Composite, which is an average of performance across each probe, are presented in Table 1.

Novel Grammatical Marking

The study procedures, including the novel inflection, used in this study are identical to those used in the Finestack and Fey (2009) study. The targeted novel marking was based on the inflection used by Anderson (2001) in her study of monolingual Spanish-speaking children with specific LI. This inflection marks the sentential subject (agent) on the verb (action). In the current study, the endings *-pa* and *-po* were used to mark the sentence verb for either a female or male sentence subject. The marking was counterbalanced so that for half of the participants, the *-pa* ending marked a female subject (e.g., Lori can eat*pa*, lake can eat*po*) and for the other half, the ending was used to mark a male subject (e.g., lake can eat*pa*, Lori can eat*po*). Such gender markings occur naturally in other languages, such as Hebrew (Dromi, Leonard, Adam, & Zadunaisky-Ehrlich, 1999), but not English or Spanish.

This particular form was selected because it was thought to be especially difficult for children with primary LI to learn and would thus allow for a rigorous examination of a deductive approach. There are several plausible explanations for why this form may be difficult for children with language impairment to learn. First, grammatical morphemes marked on verbs have been shown to be particularly difficult for children with LI to acquire (Bishop, 1994; Eadie, et al., 2002; Rice & Oetting, 1993; Rice, Tomblin, Hoffman, Richman, & Marquis, 2004; Rice & Wexler, 1996; Rice, Wexler, & Hershberger, 1998). Second, in English, subject–verb agreement forms, such as the third-person singular and forms of *be*, are later developing inflections that have been shown to be a language weakness for children with LI (Rice & Oetting, 1993). Third, in English, gender marking is restricted to pronouns. Thus, English-speaking children have limited experience marking gender.

Experimental Sessions

The experimental paradigm required each study participant to complete up to four individual sessions. Depending on parental preference, the sessions took place in the children's homes, schools, or daycares, in the quietest space available. Six participants did not complete all sessions due to scheduling conflicts (a total of seven sessions). Only partial audio files were available for two participants (two sessions) due to recording errors. Thus, of the 264 possible sessions across the 66 participants, complete data for nine sessions (3.4%) were not available. Table 1 displays the *M* number of sessions completed for each study group. Additionally, the examiners aimed to complete all sessions within a 2-week period; however, for many participants, this was not possible due to poor attendance or scheduling conflicts. The *M* number of days required to complete the experimental sessions for each group is included in Table 1.

Each experimental session comprised a teaching task, a teaching probe, and a generalization probe. Additionally, all sessions except Session 1 included a maintenance probe. For all participants, the teaching task and learning probes were presented via laptop computer. At the beginning of each session, the examiner seated the participant approximately 3 ft in front

of the computer screen and adjusted the volume of the external speakers to a level comfortable for the participant. Software designed to present audio and video stimuli via computer, Direct RT (Jarvis, 2003), was used to ensure that each participant received identical presentations of the visual and auditory stimuli.

Teaching Task

During each session, examiners asked the participants to play a computer game. At the beginning of the game, a narrator informed the participants that, “Tiki, a creature from outer space, just came to Earth. Tiki uses many of the same words we do, but there is something different about the way Tiki talks.” For both the Deductive and Inductive groups, the teaching procedures for Sessions 1 and 2 incorporated a modeling approach, and the teaching procedures for Sessions 3 and 4 incorporated a recast approach.

Next, participants in both the Deductive and Inductive groups viewed 20 cartoon-like colored graphics depicting male and female children performing five different actions. To clearly differentiate the gender of the characters, the artist drew the female characters wearing dresses and the male characters wearing pants. During Sessions 1 and 2, while viewing each picture, the participants listened to the space creature describe the situation using her special language (e.g., “Sara can eat*po*”). Thus, each participant received 20 models of the target form. During Sessions 3 and 4, instead of passively viewing the models, the game provided each participant 20 opportunities to produce the novel form. During each opportunity, the computer presented a visual stimulus of a graphic of a character carrying out an action combined with an auditory prompt of the character’s name plus the modal *can* (e.g., “John can”). The participant was prompted to complete the sentence in the way Tiki would. If the participants produced the verb with the appropriate gender marking (i.e., *-pa* or *-po*; “write*pa*”), the examiner prompted the computer to present the next stimulus. If the participant omitted the gender marking or produced the incorrect marking, the examiner signaled the computer to provide a recast of the child’s attempt (e.g., “John can write*pa*”).

In both the modeling and recast sessions, after every fifth model or recast opportunity, participants in the Deductive group received the explicit prompt, “When it’s a boy, you add *-po* (*-pa*) to the end. When it’s a girl, you add *-pa* (*-po*) to the end.” In contrast, after every fifth item, the participants in the Inductive group received the implicit filler prompt, “Listen carefully so you can talk just like Tiki.” The presentation of the guiding rule or filler statement was the key distinction between the Inductive and Deductive study groups.

Learning Probes

Participants completed three separate probes to evaluate their ability to apply the targeted novel inflection: a teaching probe, a generalization probe, and a maintenance probe. In each of the probes, the computer presented a visual stimulus of a graphic of a character carrying out an action combined with an auditory prompt of the character’s name plus the modal *can* (e.g., “John can”). The participant was prompted to complete the sentence like Tiki would. This format is identical to the format used in the recast teaching casts. However, unlike the recast trials, participants were not given any sort of feedback for incorrect attempts or correct productions.

The teaching probe occurred immediately after the teaching task, followed by the generalization probe. The teaching probe contained 10 items that were randomly selected from the 20 teaching items and presented in a random order. The generalization probe comprised 30 items that included agents and actions that were not used in the teaching task or teaching probe, such that there were 10 items that included a familiar subject paired with a new verb, 10 items that included a new subject paired with a familiar verb, and 10 items that included a new subject paired with a new verb. Of the possible 20 stimulus items for each type of generalization item, 10 items of each type were selected at random to be included in the generalization probe. Within the probe, the different types of generalization items were presented randomly.

For Sessions 2, 3, and 4, prior to the presentation of the teaching task, participants completed a maintenance probe. The purpose of this probe was to assess each participant's ability to recall and apply the target inflection form at least 1 day after instruction. The maintenance probe contained 20 items. Ten of these items were identical to the teaching probe items administered during the previous session. The remaining 10 items were randomly selected from the 30 generalization probe items. The teaching and generalization probe items were presented in a random order.

Experimental Stimuli

The sentence subjects and verbs used to create the teaching task and learning probe stimuli were selected based on data indicating that children were likely to be familiar with the items. The four sentence subjects that were used in the teaching task and probe included *Sara*, *Mike*, *Lori*, and *Jake*. The four subjects used in the generalization probe included: *Ashley*, *Nick*, *Jenny*, and *John*. These proper names were all listed in the top 35 most popular names for the 1990s and 2000–2004 in the Social Security Administration's database of baby names (Social Security Administration, 2009, September 24). There were five verbs used in the teaching task and teaching probe: *laugh*, *run*, *write*, *dance*, and *drink*. Five different verbs were used in the generalization probe: *cry*, *walk*, *read*, *swim*, and *eat*. All but one of these verbs (*laugh*) are items on the MacArthur-Bates Communication Developmental Inventory: Words and Gestures (Fenson et al., 1993).

Reliability of Data

Each experimental session was audio recorded using a portable digital recorder with an internal microphone (Marantz PMD660). The audio files were spliced such that each probe was saved as a separate file. These files were then de-identified, masking the participant's identity, treatment condition, and session number. Using these de-identified files, trained research assistants coded the participants' responses. Participant responses were coded as correct if the response included the appropriate *-pal-po* marking. Substitutions were allowed and scored as correct only if either the target consonant /p/ or target vowel /a/ or /oŭ/ were present. All other responses were considered incorrect and received one of three error codes: opposite marking, bare stem marking, or "other." Responses were coded as the opposite marking if the participant applied one of the novel forms to the wrong gender (e.g., responded /pa/ when the correct response was /poŭ/). Responses were coded as the bare marking if the participant produced only the verb, omitting the gender marking (e.g.,

“laugh”). Responses were coded as “other” if the marking produced was not phonologically related to the target form, unclear, ambiguous, or inaudible.

To determine reliability of the research assistants’ coding, approximately 20% of the teaching probe, generalization probe, and maintenance probe files were independently coded by a different trained research assistant blinded to the participants’ identity, experimental group, and session. The *Ms* for percent correct of the two coders on each of the probes were extremely close: 57% (Coder 1) and 58% (Coder 2) on the teaching probe, 60% (Coder 1) and 60% (Coder 2) on the generalization probe, and 38% (Coder 1) and 37% (Coder 2) on the maintenance probe. Applying the absolute agreement definition, the intraclass correlation coefficients, based on arc sine transformed values, for the teaching, generalization, and maintenance probes were all very high (.99, .99, and .95, respectively), indicating that the judges contributed only a very small part of the variance in the participants’ scores.

To minimize potential errors related to data entry mistakes, research assistants independently entered all data into two separate spreadsheets. Upon data entry completion, the research assistants compared the two spread sheets for differences. Discrepancies were resolved by reexamining the original data files.

Fidelity of Treatment

The presentation of the teaching stimuli during Sessions 1 and 2, which incorporated a modeling teaching approach, was preprogrammed. This limited the examiners’ role to monitoring the implementation of the teaching task. During Sessions 3 and 4, the teaching task included a recast procedure. During these sessions, the examiners were required to indicate via mouse click the accuracy of participants’ responses. The examiners right-clicked the laptop mouse to indicate correct participant responses and left-clicked to indicate incorrect responses. In the event of a participant’s correct response, the examiner’s click would signal the computer to proceed to the next item and in the event of a participant’s incorrect response, provide a corrective recast.

In addition to scoring the participants’ responses, using files spliced and de-identified to mask the participants’ identity, treatment condition, and session number, research assistants scored the accuracy of the examiners’ presentations of the stimuli during the recast task. Of the 20 items presented during the recast portion, the mean percentage of items presented correctly by the examiners was 97.19 (*SD* = 4.53) during Session 3 and 98.69 (*SD* = 2.40) during Session 4. To test if there were differences in the accuracy of the treatments provided in the Deductive and Inductive groups, *t* tests were completed comparing the arc sine transformed mean percentage values of items presented correctly for the Inductive and Deductive groups during Sessions 3 and 4. The analyses did not reveal significant differences between treatment groups, Session 3: $t(62) = 0.23, p = .82$; Session 4: $t(59) = 0.90, p = .37$.

Similar to the child coding, the examiners’ presentation of the teaching task stimuli was rescored by a separate research assistant blinded to the treatment group assignments of the participants and the initial coders’ judgments. This reliability coder rescored a total of 18%

of the Session 3 and Session 4 recast stimuli presentations. The mean percentage of correctly administered trials was close for the two coders: 97% (Coder 1) and 96% (Coder 2). Because of the limited variability in scores across participants, intraclass correlation coefficients were not calculated. Coder 1 and Coder 2 had 100% agreement on 15 of the 24 recast files. In the remaining nine files, agreement differed by an average of 6% (range = 5%–10%).

Statistical Design

To determine whether typically developing children between the ages of 4 and 6 years produce, generalize, and retain a novel verb inflection when taught using an explicit, deductive teaching procedure, the nonparametric Fisher's exact probability test for 2×2 tables was completed for each learning probe (i.e., Teaching, Generalization, Maintenance) with all age groups collapsed. Similarly, to determine whether a deductive procedure is more efficacious than an inductive procedure, the nonparametric Fisher's exact probability test for 2×2 tables was completed for each learning probe (i.e., Teaching, Generalization, Maintenance) across age groups (i.e., 4-, 5-, 6-year-olds). Nonparametric tests were used because the percent accuracy scores derived from each learning probe do not reflect a continuous interval scale. Instead, these scores were categorically distributed into three distinct response patterns: (a) "Pattern-users" had accuracy scores at or near 100% such that the participant correctly marked gender using the appropriate *-pal-po* inflection with no or very few errors (b) "Undifferentiated-users" had accuracy scores near 50% such that the participant either produced the same inflection for all items (e.g., [pa] or produced both inflections in a rather random fashion; and (c) "Bare Stem-users" had accuracy scores near 0% such that the participant produced the appropriate verb but did not attempt to produce a novel inflection.

The number of participants in each treatment group who were classified as Pattern-users served as the dependent variable for each analysis. The traditional conservative value of 90% correct (Brown, 1973; J. Miller, 1981) was set as the criterion level to indicate mastery. Thus, participants who scored at a level not significantly lower than 90% correct across one or more sessions were classified as Pattern-users. The significance level was determined by calculating the binomial p value, based on the corresponding z score. All scores with cumulative probabilities less than .05 were considered to be significantly lower than 90%. For the Teaching, Generalization, and Maintenance probes; participants with scores equal to or greater than 7 out of 10 (70%), 24 out of 30 (80%), and 16 out 20 (80%), respectively, during at least one session were classified as Pattern-users. All other participants (i.e., Undifferentiated Users and Bare Stem Users) were classified as Non-users. $\Phi(\Phi; \chi^2/N)$, which includes values ranging from 0 to 1, represented the effect size for the Fisher's exact tests. Φ of .10, .30, and .50 are considered to be small, medium, and large effect sizes, respectively (Green & Salkind, 2003, p. 353).

To examine whether the participants who were classified as Pattern-users in the Deductive and Inductive groups differed on the basis of cognitive or language abilities, nonparametric Mann-Whitney U analyses were completed. The dependent variables included the KBIT-2 Matrices nonverbal standard score (Kaufman & Kaufman, 2004); the Spoken Language

Quotient derived from the TOLD-P:3 as well as the Syntax, Listening, and Speaking Composites (Newcomer & Hammill, 1997); and the Elicited Grammar Composite derived from the TEGI in addition to the Third Person Singular, Past Tense, and Be-Do probe scores (Rice & Wexler, 2001). Due to the exploratory nature of these multiple analyses, Bonferroni corrections were not made to determine statistical significance. Effect sizes, ($r = Z / N$), were calculated and interpreted such that effect sizes of .10, .30, and .50 were considered to be small, medium, and large effects, respectively (Field, 2009).

Results

Teaching Probe

To examine the abilities of the participants to *produce* a novel verb inflection when taught using an explicit, deductive teaching procedure or an implicit, inductive procedure, the responses on the 10-item Teaching probe for participants in the Deductive and Inductive groups were compared. The number of participants categorized as Pattern-users (i.e., seven or more items correct in at least one session) was compared to the number of participants categorized as Non-users within and between the Deductive and Inductive groups. These values appear in Table 2.

Collapsing all three age groups, a significant difference in the number of Pattern-users in the Deductive and Inductive groups was found ($p < .01$). This effect was medium ($\Phi = .40$). Examination of the data in Table 2 reveals there was a strong association between Pattern-users and Deductive group membership. Within the three age groups, analyses revealed a significant difference in the number of Pattern-users and Non-users across treatment groups for only the Age 5 group ($p < .01$), with a large effect size ($\Phi = .62$). Examination of the data in Table 2 reveals that for the Age 5 group, there was a strong association between Pattern-users and Deductive group membership. It is important to note that although the p values for the other age groups were nonsignificant, the effect sizes for these groups' analyses indicated moderate to strong associations between treatment group membership and inflection use (Φ s = .43 and .33). The odds ratio for Teaching probe performance, which indicates the odds of being a Pattern-user if taught with the deductive procedure rather than the inductive procedure, for the Age 5 group was 28.64, with the 95% confidence interval ranging from 1.37 to 597.53. Conservatively, 5-year-olds were 1.4 times more likely to be Pattern-users if taught using the deductive procedure than the inductive procedure. The odds ratios for the nonsignificant comparisons of the Age 4 and Age 6 groups were not calculated.

Generalization Probe

To examine the abilities of the participants to *generalize* a novel verb inflection when taught using an explicit, deductive teaching procedure or an implicit, inductive procedure, the responses on the 30-item Generalization probe for participants in the Deductive and Inductive groups were compared. The number of participants categorized as Pattern-users (i.e., 24 or more items correct in at least one session) was compared with the number of participants categorized as Non-users. These values appear in Table 2. Collapsing all three age groups, a significant difference in the number of Pattern-users in the Deductive and

Inductive groups was found ($p < .01$), with a large effect size ($\Phi = .49$). Table 2 reveals that this difference is characterized by more Pattern-users in the Deductive group.

Within the three age groups, analyses revealed a significant difference in the number of Pattern-users and Non-users between treatment groups for the Age 4 ($p = .04$) and Age 5 ($p < .01$) groups, with large effect sizes (Φ s = .50 and .73, respectively). Examination of the data in Table 2 reveals strong associations between Pattern-users and Deductive group membership. Based on the odds ratio, for the Age 4 group, the odds of being a Pattern-user on the Generalization probe was 15.4 (95% CI = 0.74–597.53) times higher if taught with the deductive procedure than if taught with the inductive procedure. For the Age 5 group, the odds ratio was 45 (95% CI = 3.47–584.34). Based on the lower end of the 95% confidence interval, the likelihood for 4-year-olds to be Pattern-users if taught using a deductive approach was not greater than chance. However, for 5-year-olds, the likelihood of being a Pattern-user was approximately 3.5 times greater if taught using a deductive approach in contrast to an inductive approach.

Table 3 includes the number of participants in each response category across the four experimental sessions for each treatment and age group. Both the Age 4 and Age 5 data suggest relatively stable response patterns across sessions. In contrast, for the Age 6 group, there was a shift in response patterns, with formerly Undifferentiated-users meeting Pattern-user criteria. For the Deductive group, this shift occurred at Session 1. For the Inductive group, this shift occurred at Session 2. The Age 4 group included the greatest number of participant meeting the Bare Stem-user criteria, with more in the Deductive group than the Inductive group. There were very few Bare Stem-users in the Age 5 and Age 6 groups, regardless of treatment condition.

Maintenance Probe

To examine the abilities of the participants to *retain* a novel verb inflection when taught using an explicit, deductive teaching procedure or an implicit, inductive procedure, the responses on the 20-item Maintenance probe for participants in the Deductive and Inductive groups were compared. The number of participants categorized as Pattern-users (i.e., 16 or more items correct in at least one session) was compared with the number of participants categorized as Non-users. These values appear in Table 2. Collapsing all three age groups, a significant difference in the number of Pattern-users in the Deductive and Inductive groups was found ($p < .01$) with a medium effect size ($\Phi = .39$). Again, there was a strong association between Pattern-users and Deductive group membership.

Within the three age groups, analyses revealed a significant difference in the number of Pattern-users and Non-users across treatment groups for only the Age 5 group ($p = .01$), with a large effect size ($\Phi = .57$). Consistent with the previous analyses, examination of Table 2 reveals that for the Age 5 group, there was a strong association between Pattern-users and Deductive group membership. Similarly, the effect sizes for the other analyses with p values less than .05 indicated moderate to strong associations between treatment group membership and inflection use (Φ s = .35 and .38). The odds ratio for the Age 5 group was 18 (95% CI = 1.65–196.31). Thus, the likelihood for 5-year-olds to be Pattern-users on the Generalization

probe was approximately 1.5 times greater if taught using a deductive approach rather than an inductive approach .

Differences in Nonverbal Problem-Solving and Language Abilities

Study Question 3 asked whether the children's performance on the learning probes was significantly influenced by their nonverbal problem-solving abilities, expressive language abilities, or receptive language abilities. Because previous analyses revealed differences in performance on the basis of Age, nonparametric Mann–Whitney *U* tests were completed for the cognitive and language measure within each age group. Due to relatively stable participant response patterns across the experimental probes and in an effort to reduce the number of analyses, only the Maintenance probe data were analyzed. The Maintenance probe data were selected because they reflected long-term learning effects. Moreover, the Maintenance probe yielded the most variable results within each age group, which facilitated comparisons of the nonverbal problem-solving and language abilities of the Pattern-users and Non-users. Thus, to better understand if problem solving or language ability differentiated Pattern-users and Non-users, analyses were completed only for treatment groups in which there were a relatively equal number of Pattern-users and Non-users. For the Age 4 group, the nonverbal cognitive and language skills of the Pattern-users and Non-users only in the Deductive group were compared. The Pattern-users and Non-users in the Inductive group were not compared because there was only one Pattern-user in this group. For the Age 5 and Age 6 groups, only the Pattern-users and Non-users in the Inductive groups were compared because the Age 5 Deductive group had only one Non-user and the Age 6 Deductive group had only two Non-users.

For the Age 4 group, based on Maintenance probe performance in the Deductive group, five participants were classified as Pattern-users and seven were classified as Non-users. Results of the Mann–Whitney *U* analyses comparing cognitive and language abilities between the Pattern-users and Non-users indicated significant group differences on five of the 10 analyses. Specifically, a significant difference between Pattern-users and Non-users in the Deductive group was found on the basis of the TOLD–P:3 Spoken Language Quotient ($U = .00, z = -2.85, p < .01, r = -.82$), Syntax Composite ($U = 3.50, z = -2.28, p = .02, r = -.66$), Listening Composite ($U = 3.50, z = -2.30, p = .02, r = -.66$), and Speaking Composite ($U = 4.00, z = -2.35, p = .02, r = -.68$), as well as the TEGI Do probe ($U = 5.00, z = -2.26, p = .02, r = -.65$). Across all comparisons, the mean ranks of the participants identified as Pattern-users were greater than those of the Non-users. Thus, for the Age 4 group, participants who received the deductive instruction who were Pattern-users had significantly stronger language skills.

For the Age 4 group, preexperimental group comparisons revealed that participants in the Deductive and Inductive conditions were not closely matched on the basis of race, caregiver education, and time required to complete all of the treatment sessions. To determine whether these differences significantly influenced treatment outcomes, the Pattern-users and Non-users based on the Maintenance probe were compared for each measure using either the nonparametric Fisher's exact probability test or the Mann–Whitney *U* test. The Fisher's exact tests for race and caregiver education failed to reveal statistically significant

differences ($ps = .61$ and 1.00 , respectively). The Mann–Whitney U test comparing time required to complete all treatment sessions also failed to reveal a significant difference between Pattern-users and Non-users ($p = .26$). Thus, differences in groups on the basis of race, caregiver education, and treatment time do not appear to account for any performance differences.

For the Age 5 group, the cognitive and language abilities of the Pattern-users and Non-users who received the Inductive treatment were compared. Based on Maintenance probe data, four participants were identified as Pattern-users and eight participants were identified as Non-users. Results of the Mann–Whitney U analyses indicated significant group differences on the TOLD–P:3 Spoken Language Quotient ($U = 4.00$, $z = -2.05$, $p = .05$, $r = -.59$). Across all comparisons, the mean ranks of the participants identified as Pattern-users were greater than those of the Non-users. Although the influence of language on the metalinguistic task is not as robust as in the Age 4 Deductive group, the participants in the Age 5 Inductive group who had stronger overall language ability were more likely to be Pattern-users than those with weaker language abilities.

For the Age 5 group, preexperimental group comparisons revealed that although the participants in the Deductive and Inductive conditions were not significantly different from each other, the p values for the comparisons based on age, the TOLD–P:3 Spoken Language Quotient, and the KBIT–2 Matrices standard score were less than $.50$, the recommended level for group comparisons. Examination of Figure 1 reveals that there is significant overlap in terms of age, cognitive, and language ability between the Deductive and Inductive groups. Additionally, for each variable, there are participants who are Pattern-users and Non-users at both ends of the distribution. To illustrate, one of the youngest participants in the Inductive group was characterized as Pattern-user and the participant with the highest Spoken Language Quotient across both groups did not become a Pattern-user with deductive instruction. Thus, the preexperimental group differences do not appear to reliably account for the observed outcomes.

In the Age 6 group, of the participants who received the Inductive instruction, five participants were identified as Pattern-users and six participants were identified as Non-users. Significant differences were found between the Pattern-users and Non-users on the basis of the TOLD–P:3 Spoken Language Quotient ($U = 3.50$, $z = -2.11$, $p = .04$, $r = -.64$) and the Listening Composite ($U = 1.50$, $z = -2.48$, $p = .01$, $r = -.75$). Across analyses, the relative mean ranks of the groups varied such that on four measures (TOLD–P:3 Syntax, Listening, Speaking and Spoken Language Quotients) the Pattern-users' mean ranks were greater than the Non-users' ranks. For each of the other measures (KBIT–2 Matrices, TEGI Elicited Grammar Composite, and the TEGI Third Person Singular, Past Tense, and Be–Do probe scores), the Non-users' ranks were greater than the Pattern-users' mean ranks. Similar to the Age 5 Inductive group, the Age 6 Inductive group participants who tended to have stronger overall language abilities were more likely to be Pattern-users than those with weaker language abilities.

Discussion

This study aimed to determine whether 4- through 6-year-old typically developing children are able to learn a novel verb inflection when taught using an explicit, deductive teaching procedure and whether an explicit teaching procedure is more efficacious than an implicit teaching procedure. Learning was assessed in three different contexts, including a teaching probe, a generalization probe, and a maintenance probe. Across all age groups, it was found that children were more likely to successfully use the novel gender form when taught using the deductive procedure than when taught using the inductive procedure. Analyses within each age group revealed that for the Age 4 group, a significant deductive advantage was found based on only the Generalization probe; for the Age 5 group, a significant deductive advantage was found based on all three probes; and for the Age 6 group, no significant instruction advantage was found. It is important to note that across all age groups and test probes, the effect sizes ranged from medium to large (Φ range = .33–.73), favoring the deductive instruction approach. Overall, on the basis of the results of this tightly controlled, novel language learning experimental task, it appears that most young children with typical development are able to learn a morphological form when taught using an explicit procedure. Additionally, on such experimental tasks, there is an advantage for language learning using a deductive instructional approach in comparison with an inductive approach, especially for young children with typical development.

A secondary aim of this study was to examine the influence of cognitive and language abilities on learning performance in the deductive and inductive teaching conditions. This aim was especially important to address because although significant group differences were found across the age groups, not all participants met the Pattern-user criterion. For three of the six instructional groups (i.e., Age 4 Inductive, Age 5 Deductive, Age 6 Deductive) nearly all participants were categorized as either Pattern-users or Non-users following instruction; thus, the problem-solving and language abilities among the Pattern-users and Non-users within these groups could not be analyzed. The problem-solving and language abilities of the Pattern-users and Non-users within each of the other three groups, which demonstrated more performance diversity, were analyzed. It was found that for the Age 4 group that received deductive instruction, the language ability (based on five language measures) of the participants who learned the target form was significantly greater than those who did not learn the target form. For the Age 5 and Age 6 groups, the cognitive and language abilities of the participants receiving inductive instruction was compared for the Pattern-users and Non-users. For these groups, significant differences were found on the basis of the broadest language measure, the Spoken Language Quotient, indicating that Pattern-users had significantly stronger language skills than the Non-users. In sum, it appears that the learning of a novel form using a deductive approach is most heavily influenced by language ability for young children and that for older children, learning using an inductive approach is influenced by language ability, but to a smaller degree than for younger children taught using deductive instruction. Given that there were no significant differences based on the cognitive measure, these findings partially support our prediction that the successful learners would be those with the strongest language and nonverbal cognitive abilities.

In this study, 70% of the children with typical language development were able to make use of deductive instruction when learning a novel grammatical form. For this particular language learning task, deductive instruction was more beneficial than inductive instruction, especially for young children (i.e., Age 4 Group 42% Pattern-users with deductive instruction vs. 10% Pattern-users with inductive instruction). However, visual inspection of the data suggests that the 6-year-old children may have been reaching a task ceiling level given that almost half of the children were successful learners with inductive instruction. Additionally, for young children, language learning using a deductive approach was significantly influenced by language ability. Although these findings support the notion that young children have the necessary metacognitive skills to make use of deductive instruction, it is important to note that not all of the 4-year-old children (i.e., 58%) were successful with the deductive instruction and that language ability is a likely factor for the discrepancies in learning within the group.

Findings from the current study suggest that the differences in study outcomes between the Swisher et al. (1995) study and the Finestack and Fey (2009) study are likely due to age differences of the participants. Finestack and Fey included children approximately 3 years older than the children in the Swisher et al. study. Current study findings suggest that young children who have relatively weak language skills are less likely to be successful learners when taught using a deductive approach. Thus, it is very probable that many of the young children with language impairment in the Swisher et al. study did not have adequate metalinguistic skills, particularly in the language domain, to make use of the deductive instruction, although the older children in the Finestack and Fey study did.

On the basis of findings from the current study, deductive instruction appears to be a more efficacious approach than inductive instruction when teaching children with typical language development. However, in the Swisher et al. (1995) study, this same trend was not found: More children with language impairment learned the target form with inductive instruction (four participants) compared with deductive instruction (two participants). The current study did not include a group of children likely to have language skills commensurate to the 4-year-old children with LI in the Swisher et al. study, such as typically developing 3-year-olds. It may be the case that for children younger than those included in the present study, inductive instruction may prove to be more efficacious.

Results from the current study partially support the metalinguistic awareness framework of Bialystok (1986), which implicates cognitive control and language knowledge. In the current study, cognitive ability based on performance on a nonverbal problem-solving subtest of the K-BIT did not significantly influence learning across age groups; however, language ability did. Our analysis of the influence of cognitive ability for the 4-year-old children was based on the performance of the participants who received deductive instruction. On the basis of Bialystok's framework, we expected that the children who were successful learners when taught using deductive instruction would have significantly stronger cognitive abilities than the children who were not successful learners; however, this was not the case. One plausible reason for the lack of significant cognitive differences between learners is that the nonverbal problem-solving subtest of the K-BIT did not measure the skills that are particularly implicated in metalinguistic awareness.

The K-BIT Matrices nonverbal subtest was designed to assess nonverbal problem solving abilities by having examinees first recognize presented relationships then accurately complete analogies based on the relationships. This task is quite similar to the language learning task presented in the current study in which participants were asked to try to figure out the language pattern of the space creature (some with explicit instruction regarding the pattern, others without) then accurately apply the pattern. Thus, it was predicted that the participants with stronger performance on the K-BIT Matrices subtest would be more likely to be successful language learners. Perhaps if measures more sensitive to cognitive processing and measures of executive functioning had been included, such as pattern recognition, working memory, and attention, differences between successful and unsuccessful learners would have been found. Additionally, measures of learning under deductive and inductive conditions in tasks with nonlanguage targets such visual (e.g., dot, light) and auditory (e.g., tones) categorization and recognition tasks (e.g., Rathus, Reber, Manza, & Kushner, 1994; Reber & Squire, 1999) may prove to be more sensitive to the cognitive abilities underlying learning under these conditions.

Consistent with Bialystok's framework, as well as the findings of Chaney (1992) and other investigations of metalinguistic development (e.g., Bialystok & Barac, 2012; de Villiers & de Villiers, 1974; Smith & Tager Flusberg, 1982), results from our study support the influence of language ability on metalinguistic awareness and, presumably, learning through deductive instruction. The 4-year-old children with stronger language abilities, including both expressive and receptive language, who received deductive instruction were more successful than the children with weaker language abilities. For the older children, few, if any, language measures influenced performance when taught using inductive instruction. There are two likely explanations for this finding. First, it is possible that for the older children, the TOLD-P:3 and TEGI measures were insensitive to group differences due to performance levels approaching a ceiling level. Second, the inductive instruction included in the present study was designed to not rely on metalinguistic abilities. Thus, metalinguistic skills likely influenced learning to a lesser extent than they would have if taught using a deductive approach.

Study Limitations

Several study limitations must be considered before drawing broader conclusions from the current study's findings. First, in this study, language learning using a metalinguistic deductive approach was assessed using a tightly controlled experimental design incorporating teaching a novel morpheme in an animated computer task. Although there are several advantages to this controlled design, including controlling for child language experience and time efficiency, there are several limitations. Because the task taught a novel morphological form in an isolated context, the generalizability of the findings is limited such that it is unknown whether teaching true morphological inflections in naturalistic contexts would generate similar results.

Second, the findings are based on limited experimental task, language, and cognitive measures. The language learning outcomes are based on a single form, and it is likely that the older children performed at a level near ceiling. It is unclear whether inflections varying

in complexity would yield similar results. Additionally, more complex inflections may have resulted in significant discrepancies between the deductive and inductive approaches for the older children. As noted above, it is also possible that our cognitive measure did not measure the particular cognitive components implicated in metalinguistic processing, such as short-term memory and executive control.

Third, the participant sample was limited in terms of ages of the participants and their cognitive and language abilities. Ideally, the sample would have included children as young as 3 years to allow for a closer comparison with the Swisher et al. (1995) study. Also, to gain a better understanding of the role of cognitive and language skills in learning using a deductive procedure, children with typical language development and children with LI with a range of cognitive and expressive and receptive language abilities should be included.

Fourth, findings from the current study further our understanding of Bialystok's metalinguistic framework as it may apply to the learning of children with typical development, and current findings offer reasonable explanations for discrepant findings between the Swisher et al. (1995) and Finestack and Fey (2009) studies; however, because this study included only children with typical language development, its implications regarding interventions for children with LI are yet to be determined. As noted in the Introduction, children with LI have significant weaknesses across multiple cognitive and language domains. These weaknesses are likely to differentially affect language learning with a deductive or inductive procedure compared with children with typical development. Although significantly more of the 6-to 8-year-old children in the Finestack and Fey study who received deductive instruction were successful learners compared with those who received inductive instruction, the children in the Finestack and Fey study were relatively homogenous in terms of age and cognitive and language abilities. Thus, future investigations of deductive instruction must include children with LI of varying ages, cognitive skills, and language abilities to fully understand the generalizability of the current findings.

Conclusions

This study examined the language learning of typically developing children under two instructional conditions: one using an explicit, deductive procedure and one using an implicit, inductive procedure. Study results suggest that across the three age groups, children with typical language and cognitive abilities are able to make use of a deductive language teaching procedure. There was a significant language learning advantage for the 4- and 5-year-old children when taught using a deductive approach compared with an inductive approach. However, it is important to note that this effect appears to be largely driven by expressive and receptive language abilities and that not all of the children were successful learners with deductive instruction. Study results support the continued examination of the use of deductive approaches when teaching inflectional forms to children with LI. Moreover, further investigation of the particular metalinguistic skills and supporting cognitive and language abilities that impact language learning using deductive procedures for children with typical language development and children with LI is warranted.

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Figure 1.

Age, language, and cognitive abilities of the Age 5 Pattern-users and Non-users based on the Maintenance probe.

Table 1

Participant group characteristics.

Participant characteristic	Age 4		Age 5		Age 6	
	Deductive (<i>n</i> = 12)	Inductive (<i>n</i> = 10)	Deductive (<i>n</i> = 10)	Inductive (<i>n</i> = 12)	Deductive (<i>n</i> = 11)	Inductive (<i>n</i> = 11)
Age (months)						
<i>M</i>	53.83	53.60	67.70	65.25	76.64	77.18
<i>SD</i>	4.09	3.69	3.16	3.42	3.59	3.76
Min–Max	47–59	49–59	63–71	60–71	72–83	72–83
<i>p</i>	.82		.14		.65	
Spoken language quotient ^{<i>a</i>}						
<i>M</i>	111.67	110.00	116.80	109.92	106.18	110.82
<i>SD</i>	12.00	10.94	9.08	7.12	9.28	9.59
Min–Max	98–133	98–132	105–133	96–125	90–124	98–124
<i>p</i>	.72		.09		.48	
Nonverbal intelligence ^{<i>b</i>}						
<i>M</i>	107.83	104.70	109.60	101.50	97.82	101.64
<i>SD</i>	9.81	9.78	10.44	9.88	15.07	16.15
Min–Max	95–127	86–118	92–126	86–115	83–133	81–122
<i>p</i>	.64		.12		.75	
Female:male						
<i>p</i>	7:5 .94		6:4 .75		7:4 .39	
White:other ^{<i>c</i>}						
<i>p</i>	9:1 .06		8:2 .48		7:3 .32	
Caregiver education						
HS/college/graduate ^{<i>d</i>}	3:7		7:3		8:2	
<i>p</i>	.07		.48		.49	
TEGI						
Grammar composite ^{<i>e</i>}						
<i>M</i>	90.98		86.75		91.50	
<i>SD</i>	10.49		9.27		8.85	
Min–Max	65–100		70–96		75–99	
<i>p</i>	.14		.84		.16	
Number of treatment sessions						

Participant characteristic	Age 4		Age 5		Age 6	
	Deductive (<i>n</i> = 12)	Inductive (<i>n</i> = 10)	Deductive (<i>n</i> = 10)	Inductive (<i>n</i> = 12)	Deductive (<i>n</i> = 11)	Inductive (<i>n</i> = 11)
<i>M</i>	3.75	3.80	3.80	4.00	3.91	3.91
<i>SD</i>	.62	.42	.63	0	.30	.30
Min–Max	2–4	3–4	2–4	4	3–4	3–4
<i>p</i>	.97		.72		1.00	
Time to complete treatment (days)						
<i>M</i>	9.25	7.40	11.30	13.58	13.64	15.55
<i>SD</i>	2.67	5.13	3.47	4.76	4.34	4.34
Min–Max	6–15	3–18	4–15	6–21	9–22	8–22
<i>p</i>	.05		.16		.27	

^a Standard score with *M* = 100, *SD* = 15 based on the TOLD–P:3.

^b Standard score with *M* = 100, *SD* = 15 based on the KBIT–2.

^c Race not reported for four participants.

^d Caregiver education not reported for five participants.

^e Average percent correct on the Third Person Singular, Past Tense, and Be–Do Probes.

Table 2

Participant response categorization by age and teaching condition.

Response type	Age 4		Age 5		Age 6	
	Deductive group (<i>n</i> = 12)	Inductive group (<i>n</i> = 10)	Deductive group (<i>n</i> = 10)	Inductive group (<i>n</i> = 12)	Deductive group (<i>n</i> = 11)	Inductive group (<i>n</i> = 11)
Teaching probe						
Pattern-user	6	1	10	5	10	7
Non-user	6	9	0	7	1	4
<i>p</i>		.07		<.01		.31
Φ		.43		.62		.33
Generalization probe						
Pattern-user	5	0	9	2	9	5
Non-user	7	10	1	10	2	6
<i>p</i>		.04		<.01		.18
Φ		.50		.73		.34
Maintenance probe						
Pattern-user	5	1	9	4	9	5
Non-user	7	9	1	8	2	6
<i>p</i>		.16		.01		.18
Φ		.35		.57		.38

Table 3

Participant response categorization by time, age, and teaching condition for the Generalization probe.

Participant variable	Cutoff criteria (number correct)	Session			
		1	2	3	4
Age 4					
Deductive					
Pattern-user	24	2	3	4	4
Undifferentiated-user	11 and 19	4	3	3	2
Bare Stem-user	5	6 ¹	4	3	4
Unclear	<24 and >19	0	2	0	0
	<11 and >5	0	0	1	0
Did not complete	n/a	0	0	1	2
Inductive					
Pattern-user	24	0	0	0	0
Undifferentiated-user	11 and 19	6	8	8	8
Bare Stem-user	5	3	2	1	1 ¹
Unclear	<24 and >19	0	0	0	0
	<11 and >5	1	0	0	0
Did not complete	n/a	0	0	1	1
Age 5					
Deductive					
Pattern-user	24	6	6	6	7
Undifferentiated-user	11 and 19	3	3	1	1
Bare Stem-user	5	0	0	0	0
Unclear	<24 and >19	1	1	2	1
	<11 and >5	0	0	0	0
Did not complete	n/a	0	0	1	1
Inductive					
Pattern-user	24	0	0	2	0
Undifferentiated-user	11 and 19	10	10	8	9
Bare Stem-user	5	2	1	1	2
Unclear	<24 and >19	0	0	0	1
	<11 and >5	0	1	1	0
Did not complete	n/a	0	0	0	0
Age 6					
Deductive					
Pattern-user	24	3	7	9	8
Undifferentiated-user	11 and 19	5	1	2	2
Bare Stem-user	5	2 ²	1 ¹	0	1 ¹
Unclear	<24 and >19	0	1	0	0
	<11 and >5	1	0	0	0
Did not complete	n/a	0	1	0	0

Participant variable	Cutoff criteria (number correct)	Session			
		1	2	3	4
Inductive					
Pattern-user	24	1	1	5	4
Undifferentiated-user	11 and 19	8	7	5	5
Bare Stem-user	5	1	1	1	1
Unclear	<24 and >19	1	2	0	0
	<11 and >5	0	0	0	0
Did not complete	n/a	0	0	0	1

Note. Superscripts represent the number of participants who consistently used the opposite markings (i.e., reversed markings) resulting in zero items correct. All but one participant (Age 4, Inductive group) obtained Pattern-user status during an alternative session.