Evaluation of an Explicit Instructional Approach to Teach Novel Grammatical Forms to Children with Autism Spectrum Disorders

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Abstract

Purpose: Limited or unusual syntax may reduce the functional use of language for children with ASD and exacerbate difficulties with academic and social skill development. The current study evaluated an explicit instructional approach to teach novel grammatical forms to children with ASD**.**

Method: Eleven children with ASD between the ages of 4:4 and 9:9 years who demonstrated weaknesses in expressive grammatical language were randomly assigned to complete two space-themed computer games. In each game participants attempted to learn a novel grammatical form after receiving explicit or implicit instruction. During explicit instruction, the examiner presented a rule guiding the novel form to be learned as well as models of the form. During implicit instruction, only models of the grammatical form were presented. Learning was assessed during each of four treatment sessions and after a 1-week delay in two contexts.

Results: Nonparametric analyses revealed a trending advantage for learning novel grammatical morphemes with an explicit instructional approach**.** Successful learners tended to have stronger expressive language skills then unsuccessful learners. Successful and unsuccessful learners did not differ in nonverbal intelligence or severity of autism-related behaviors.

Conclusions: Explicit instruction may lead to more robust learning of targeted grammatical forms for children with ASD. Future research should continue to examine this effect using true grammatical forms.

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Introduction

Autism spectrum disorder (ASD) is a diagnosis based on delayed or impaired development of social communication and restricted or repetitive behaviors and interests that result in functional impairment (American Psychiatric Association, 2013). Impairments in social interactions are the most universal and specific to the autism spectrum such that a widely-reported feature of ASD is a delay in the acquisition of language (Eigsti, Bennetto, & Dadlani, 2007). Delayed or abnormal language development is the primary reason for diagnostic referral and is a critical prognostic indicator for developmental trajectory (Howlin, Goode, Hutton, & Rutter, 2004; Kjelgaard & Tager-Flusberg, 2001; Lord & Pickles, 1996; Rice, Warren, & Betz, 2005; Stone & Yoder, 2001). Some children with ASD exhibit specific delays or impairments in grammatical language similar to children with specific language impairment (SLI; Roberts, Rice, & Tager-Flusberg, 2001). However, few studies have evaluated any form of intervention specifically targeting these expressive impairments among children with ASD. The purpose of the present study is to evaluate an explicit instructional approach to teach novel grammatical morphemes to children with ASD.

Language Profiles of Children with ASD

Despite impairments in language being a widely-reported component of ASD, the language skills of children with ASD vary widely and the language domains impacted differ across individuals. Some children with ASD acquire proficient knowledge and use of vocabulary, grammatical markers, and articulation of speech sounds, while others remain nonverbal or significantly impaired in all domains of language. Among those children with ASD who acquire language, the trajectory may follow delayed but similar milestone achievement as children with typical development, or may manifest as deviant language skills, such as echolalia and confused use of deictic terms including pronouns (Rice et al., 2005; Tager-Flusberg, Paul, & Lord; 2005).

Kjelgaard and Tager-Flusberg (2001) investigated the receptive and expressive language skills of a large group of children diagnosed with ASD between the ages of 4 and 14 years. Researchers used several standardized measures, including the Peabody Picture Vocabulary Test – III (PPVT; Dunn & Dunn, 1997) and Clinical Evaluation of Lanugage Fundamentals – Preschool/III (CELF; Wiig, Secord, & Semel, 1992; Semel, Wiig, & Secord, 1992) to characterize the language skills of the children in this group. Comparisons between the receptive and expressive lexical knowledge of the group revealed that the majority of children did not demonstrate more than one standard deviation difference between receptive and expressive lexical abilities. However, in their sample of 89 children, only 50% were able to complete the CELF (n = 44), due to some children's inability to understand the task demands and reach a basal on the least complex subtest of the CELF measuring one-word labeling. Researchers further divided the group into normal-, borderline- and impaired-language subgroups based on performance on the CELF. In the sample, 23% (n = 10) comprised the normal-language subgroup and nearly 50% (n = 21) comprised the language-impaired subgroup, receiving standard scores more than 2 standard deviations below the mean standard score of 100. For the language-impaired group, a consistent profile emerged such that vocabulary skills were stronger than syntax and semantic knowledge, as measured by the CELF. Thus, among the children with ASD with low language skills, vocabulary was less impaired than higher order morphosyntax skills. These findings among language-impaired children with ASD are similar to those of children with SLI (Rice et al., 2005).

Consistent with these findings, early evidence from Bartolucci, Pierce and Streiner (1980) suggested that children with ASD show more deficits in grammatical ability than typically developing peers or peers with intellectual delays matched for nonverbal mental age. Bartolucci et al. collected spontaneous language samples from elementary-aged children with ASD (n = 10), intellectual delay (n= 10), or typical development (n = 10). A corpus of 50 utterances from each child was analyzed for obligatory contexts of Brown's 14 grammatical morphemes. Results showed that children with autism omitted grammatical morphemes in nearly 12% of required contexts. In comparison, the intellectual delay group omitted grammatical markings in 3.77% of contexts and the typically developing group omitted markings in 1.13% of contexts. Further analysis revealed that the children with autism omitted the present progressive, past regular, third person regular, and uncontracted copula or auxiliary in obligatory contexts.

Condouris, Meyer, and Tager-Flusberg (2003) also assessed the vocabulary and grammatical abilities of children with ASD. The participants in the Condouris et al. study included 44 children with ASD aged 4-14 years. The investigators examined structural and lexical language deficits in the spontaneous language samples relative to performance on standardized language tasks, including the PPVT and CELF–P/III. For the language sample, children played with their parents until they accumulated a corpus of 100 consecutive, complete, and intelligible utterances. Researchers calculated each child's mean length of utterance (MLU) and number of different word roots (NDWR) using procedures of the Systematic Analysis of Language Transcripts (SALT; Miller & Chapman, 2000). Researchers used the Index of Productive Syntax (IPSyn; Scarborough, 1990) to further characterize the children's emerging morphological and syntactic development. Results of these analyses revealed mean MLU and NDWR values 2 standard deviations below the mean performance data reported in the SALT reference database. The group's mean performance on the IPsyn was also below the performance level expected for the children's ages (Scarborough, 1990). Mean scores on standardized measures revealed that these children with ASD generally performed more than 1 standard deviation below the mean. These scores were significantly correlated with both NDWR and MLU measures. These results provide further evidence that many children with ASD have significant impairments in structural and formal aspects of language in conjunction with diagnostically relevant aspects of social communication.

Follow-up investigations of these language weaknesses suggest that there is a subgroup of children with ASD who exhibit specific delays in the use of grammatical inflections similar to the forms that have been used as clinical markers seen in children with SLI (Rice & Wexler, 1996). Roberts, Rice, and Tager-Flusberg (2004) further examined the morphology and syntax skills of children included in the Kjelgaard and Tager-Flusberg (2001) study. The researchers administered experimental probes targeting third-person singular forms (i.e., *he runs*) and regular/irregular past tense forms (i.e., *she danced; he swam*). As in Kjelgaard and Tager-Flusberg's (2001) analyses, Roberts et al. divided participants into language-level subgroups based on performance on the PPVT. Children in the impaired language group (PPVT < 70; *n* = 19) had significantly lower scores on both the third-person singular and past-tense probes than children in either the normal language group (PPVT > 85; *n* = 27) or language borderline group (70 < PPVT < 85; *n* = 16). However, it is important to note that children in the language-impaired group tended to produce more echolalic forms or responses that were classified as "non-responses" on both experimental probes than either of the other groups.

Roberts et al. (2004) found that the language-impaired children with ASD performed better on these probes assessing tense morphology than 5-year-old children with SLI. However, the language-impaired children with ASD performed poorer than children with SLI in the same age range (8-9 years old). Together, these findings suggest that language-impaired children with ASD present with unique error patterns in expressive morphology, which remain impaired for a longer period of development when compared to other language-disordered groups.

Eigsti, Bennetto, and Dadlani (2007) further investigated the morphosyntactic development of preschool aged children with ASD (*n* =16) in comparison to equal samples of children with non-specific developmental delays (DD) and typically developing (TD) children. All groups were matched on non-verbal IQ, gender, and receptive vocabulary skills, as measured by the PPVT. The DD and ASD groups were further matched on chronological age. Each child participated in a 30-minute free-play session with a researcher to collect a spontaneous speech sample. Researchers derived MLU and IPSyn scores from these language samples. Results demonstrated that the children with ASD had a shorter mean MLU than the children with DD, and trended towards a shorter mean MLU than the TD group. IPSyn scores for the ASD group were significantly lower than both the DD and TD groups. Furthermore, the pattern of responses for the ASD group differed signficantly from the DD and TD groups and revealed that children with ASD performed significantly worse on the IPSyn subscale measuring questions and negations. This pattern of low performance on question and negation use was also found by Scarborough, Rescorla, Tager-Flusberg, and Fowler (1991) in a sample of children with ASD. Subsequent analyses revealed that the ASD group was signifcantly less likely to make reference to physically nonpresent items than either the DD or TD groups. Thus, Eigsti et al..(2007) suggested that children with ASD may use more grammatically simple language than other children because of conceptual limitations and weaknesses in the use of language for social purposes to converse about more abstract or nonpresent topics.

Structural Language and Social Awareness in Children with ASD

To investigate the potential link between conceptual limitations in children with ASD and their grammar and vocabulary skills, Fisher, Happé and Dunn (2005) examined the relationship between theory of mind (ToM) skills and language ability in children with ASD. ToM reflects the ability to attribute representational mental states of others, and relies heavily on language skills developed through discourse and conversation. Researchers assessed receptive vocabulary and grammar skills, and performance on ToM false belief tasks in 58 children with ASD between ages 5-16 years. A comparison group of 118 children between the ages of 5-14 years receiving special education services for moderate learning and cognitive delays (MLD) also completed these tasks. Results demonstrated that nearly 50% of children with ASD failed each of the three false belief questions, while 63-86% of children with MLD passed the false belief questions. Regression analyses for each group revealed that receptive grammar and vocabulary scores strongly predicted ToM performance in children with ASD, but weakly predicted performance in children with MLD. Moreover, receptive grammar scores (as measured by the Test for Reception of Grammar; Bishop, 1989) contributed unique and significant variance to ToM above that contributed by receptive vocabulary performance.

Whyte, Nelson, and Scherf (2014) further investigated how syntactic abilities influence ToM and figurative language abilities. They compared the performance of 26 children with ASD between the ages of 5-12 years to two control groups: one matched on chronological age and nonverbal IQ and another matched on syntax age-equivalence and raw scores from the Syntax Construction subtest of the Comprehensive Assessment of Spoken Language (CASL; Carrow-Woolfolk, 1999). Each participant completed the syntax subtest of the CASL and an idiom comprehension probe consisting of 20 vignettes of familiar idioms for which investigators asked the particpants to verbally define the idiom's meaning. Participants also completed several advanced ToM tasks requiring interpretation of the mental states of individuals in strange stories and identification of the emotion expressed in cropped pictures of the eye region of photographed faces. Results revealed that the group matched on chronological age performed significantly higher than the group with ASD on idiom comprehension and ToM tasks. However, the group matched on syntax abilities did not signficantly outperform the ASD group in idiom comprehension or the ToM task requiring interpretation of eye gaze expressions. These findings further suggest that structural language abilities are important to the development of social cognition skills in children with ASD.

In an earlier study, Rollins and Snow (1998) investigated the relationship between structural and social language development. This study included six children with ASD between the ages of 4 and 7 years who were followed across a period of 15 to 26 months. Researchers used the IPSyn to assess morphosyntax and the Inventory of Communicative Acts-Abridged (INCA-A; Ninio, Snow, Pan & Rollins, 1994) to assess the frequency of social-pragmatic communicative acts during bi-monthly unstructured parent-child interactions. The INCA-A consists of two subsystems that code at the level of social interchange and level of the utterance. Researchers found a strong relationship between per month change in IPSyn scores and the frequency of communicative acts categorized as mutual attention. Regression models suggested approximately 89% of the variation in the monthly rate of change in IPSyn scores was accounted for by frequency of mutual attention acts. In contrast, IPSyn change was not related to IQ, frequency of maternal utterances, or ratio of child-centered speech to directive speech.

These studies suggest that social-pragmatic skills, one of the core deficits of ASD, may be closely related to structural language development, including morphosyntax. Weak language skills may prevent children with ASD from accessing the social experiences that allow them to develop sophisicated representational understanding required for ToM and idiom comprehension. This relationship likely acts in both directions, such that weak social skills and limitations in social awareness preclude children with ASD from opportunities to develop a full repertoire of structural language skills acquired through discourse and conversation. These limitations in language development, specifically morphosyntactic development, may reduce the functional use of language for children with ASD and exacerbate difficulties with academic and social skill development (Fischer, Howard, Sparkman, & Moore, 2010). Despite these significant weaknesses in morphosyntax for many children with ASD, few studies have examined the effects of grammatical intervention for children with ASD.

Grammatical Interventions for Children with ASD

The literature base of interventions specifically targeting grammar and morphosyntax skills in children with ASD has remained small despite the body of evidence previously discussed revealing significant deficits in these areas for many children with ASD. Much of the evidence base for interventions targeting morphosyntax have focused on children with SLI (Proctor-Williams, 2009). Most published intervention studies among children with ASD have used single-subject designs and have targeted a wide range of structural forms ranging from pronoun use to correct sentence structure.

A study by Hendler, Weisberg, and O'Dell (1988) reported on an intervention used to teach a single 4-year-old child with autism how to understand and express proper use of pronouns, including personal pronouns and gender pronouns. During instruction, a pair of researchers modeled correct pronoun use with body parts (e.g., *my knees, your foot*) as target referents. During teaching, researcher prompted the learner to produce the correct pronoun plus body part. Reinforcement and corrective feedback was provided for appropriate and incorrect productions. Researchers also assessed comprehension of pronouns using yes/no questions. The learner was able to acquire appropriate use of *my/your* pronouns during training sessions, but this performance failed to generalize to untrained verbal probes. Additonal training improved receptive understanding of these reflexive pronouns during instruction without generalization to untrained probes. However, instruction of gender pronouns improved the learner's expressive use of these referents and resulted in immediate generalization at the expressive and receptive levels.

Yamamoto and Miya (1999) reported on efforts to teach three, 6-10 year-old Japanese students with ASD how to construct grammatically complete sentences using computer-based training and a multiple-baseline across subjects design. Researchers used a matrix training approach to teach a select set of syntactical constructions with the aim of generalized learning to untrained items. The target construction was a complete sentence containing person, object, and action/verb referents, as well as two relevant particles that indicate the subjective and objective case in Japanese. Experimenters presented students with picture stimuli and required the students to select the correct referent choices from an array on the computer to construct the appropriate sentence. In the training phase, experimenters provided corrective feedback to students' sentence constructions. Subsequent generalization probes assessed students' sentence construction performance on untrained items, and also verbal sentence production. Each learner was able to generalize correct syntactic construction to the untrained picture stimuli and also learned to verbally produce responses after only receiving training on three specific sentence models. However, the intervention did not require independent sentence formulation or production without specific choices presented. Thus, it is unknown if the participants could independently formulate correct sentence structures in obligatory contexts.

Additional work by Fischer, Howard, Sparkman and Moore (2010) investigated the effectiveness of a picture instruction technique to increase the syntactic complexity and length of utterances by four children with autism between 3 and 4 years old. The participants had borderline to midly-impaired cognitive abilities and limited expressive vocabulary. Researchers used stylized drawings to depict components of subject-verb-object sentence structure, including articles and auxiliary verbs. Realistic photographs showing children and adults engaged in routine daily living activities were also used to address generalization to more naturalistic stimuli. In the first phase of instruction, the clinician showed each participant a training set of picture cards and modeled the target sentence structure ‘‘The *noun* is *verb*ing.” During the second phase of instruction, the target structure was expanded to ‘‘The *noun* is *verb*ing the *object*.” The clinician modeled a grammatically and syntactically correct utterance using the picture stimuli, and faded the model until the learner was able to independently respond to a prompt to formulate an utterance. The child received reinforcement for correct responses, or corrective feedback for errrors involving morphology or syntax. On these incorrect trials, the clinician prompted the participants to imitate the corrective feedback model before re-completing the trial. Instruction continued until the child demonstrated 100% syntactically correct responses on both stylized picture and photograph trials for three consecutive training sessions.

Study results indicated that children required between 6 and 18 hours of instruction to achieve mastery of the target form. Children increased utterance length from 1-3 words on pre-training probes to approximately 6 words on post-training probes. Moreover, more than 90% of all children's post-training responses contained the syntax targeted during intervention (e.g., ''The *noun* is *verb*ing the *object*.'') in comparison to 23% or less of children's pre-training responses. These findings demonstrate preliminary evidence of a language intervention targeting specific syntactic structures in children with ASD. However, the small sample size prevents generalization of these findings to a broader population of language-impaired children with ASD.

The body of evidence reviewed here addressing the effects of syntactic interventions for children with ASD have employed single-subject design, which provide clinically relevant case study evidence, but are difficult to generalize. Furthermore, these instruction procedures relied heavily on inductive approaches in which the clinician provided models of problematic forms at a high frequency and the learner was expected to implicitly acquire and generalize the target grammatical form (i.e. Fischer et al, 2010; Yamamoto & Miya, 1999). Evidence exists in other language-related disciplines, including phonological awareness, that the inclusion of an alternative deductive teaching approach is more effective than inductive approaches alone (Norris & Ortega, 2000). Unlike traditional inductive approaches, deductive instruction aims to make the learner explicitly aware of the underlying language pattern by directly presenting the pedagogic pattern. Having been told the basic form, the learner is then able to deduce the rule when given specific examples.

Deductive Instruction for Children with ASD

Finestack and Fey (2009) conducted an efficacy study of a deductive, explicit instruction approach to teaching children with primary language impairment novel grammatical inflections. Participants included 34 children, aged 6 to 8 years, who had a confirmed language impairment as measured by a Spoken Language Quotient of 80 or below on the Test of Language Development-Primary/Third Edition (TOLD; Newcomer & Hammill, 1997) and a standard score of 70 or greater on the Matrices nonverbal scale of the Kaufman Brief Intelligence Test, Second Edition (KBIT-2; Kaufman & Kaufman, 2004). Children with identified neurological or neurodevelopmental disorders were excluded. Researchers randomly assigned each child to an explicit, deductive teaching condition or a traditional inductive teaching condition. In both conditions, the teaching target was a novel grammatical morpheme (*-pa* or *–po*) that marked the gender of the subject on the verb of the sentence. Each participant completed four teaching sessions, each consisting of a maintenance probe, a teaching task, a teaching probe, and a generalization probe. The teaching sessions were presented via a computer in the context that the children were to learn to talk like a space creature who mostly used English words but talked a little differently. Participants in the deductive teaching condition received explicit instruction regarding the grammatical pattern during the teaching task and teaching probe ("If it is a boy, you have to add *–pa* to the end. If it is a girl, you have to add *–po* to the end."). Participants in the inductive teaching condition received nonspecific instruction ("Listen closely so you can talk just like *Tiki.*"). The children viewed stylized pictures of characters engaging in common actions (e.g., dance, run, drink) and were prompted to complete sentences using the space creature's language, such as "*Mike can* _____."

The investigators classified participants as pattern-users if they acheived accuracy scores at or near 80-100%, reflecting acquisition of the inflection and correct marking of gender using the appropriate novel morpheme. Results revealed that significantly more children who received deductive instruction became pattern-users by the fourth day of instruction and generalized the novel inflection to untrained trials than those who received inductive instruction. Analyses of participant characteristics suggested there were no associations between language performance, nonverbal intelligence, and task performance. These findings suggest an advantage for a deductive intervention procedure over an inductive intervention procedure for teaching children with primary language impairment to accurately use a novel grammatical morpheme in a highly controlled environment.

An explicit, deductive approach to teaching grammatical forms may be particularly beneficial for children with ASD. Klinger, Klinger, and Pohlig (2007) hypothesized that deficits in implicit learning for individuals with ASD leads them to use more effortful, explicit approaches to accomplish tasks that appear effortless for typically developing children, such as learning the grammar and semantic relationships that underlie language. Klinger and colleagues investigated the relationship between performance on implicit learning tasks, social symptoms, communication symptoms, and restricted interest and repetitive behaviors in 50 children with ASD, aged 5 to 17 years. Researchers assessed implicit learning in a prototype category task and an artificial grammar task. The prototype category task required particpants to synthesize a summary representation of a novel category of animals when given multiple examples. The artificial grammar task required participants to discriminate between sequences of shapes generated by a complex set of rules used to determine the ordering of the shapes. Children with ASD performed signficantly worse on probes assessing learning in these tasks than a comparison group of typically developing peers. Analyses suggested that implicit learning performance was strongly related to both social and communication symptoms in children with ASD such that poorer performance on implicit learning was correlated to more severe symptoms. Thus, these findings based on a large sample of children with ASD suggest a positive relationship between weaknesses in implicit learning and language development in ASD.

In contrast to the Klinger, Klinger, and Pohlig (2007) results, there is some evidence to suggest children with ASD do not exhibit impairments in implicit learning. Brown, Azcel, Jiménez, Kaufman, and Grant (2010) measured implicit learning across five tasks in an equal-numbered group of children with ASD (n =26) and a typically developing comparison group aged 8 to 14 years. The groups were strictly matched on chronological age, gender, and both verbal and non-verbal cognitive performance. Participants completed a contextual cuing task, serial reaction time task, artificial grammar task, and probabilistic learning task to assess implicit learning, and a paired associates task to assess explicit learning. Results revealed that the group of children with ASD and the comparison group of typically developing children were not statistically different in their overall performance on each implicit learning task.

However, during the learning phase of the artificial grammar task the group of children with ASD made significantly more errors than typically developing participants before correctly reproducing each letter string., which the authors suggested may be more indicative of impairments in the use of explicit strategies to remember and reproduce the target letter patterns than impairments in implicit learning.

Although these findings suggest that implicit learning may be preserved in children with ASD, the tasks used by Brown et al. (2010) to assess implicit learning targeted spatial relationships and temporal patterns. The tasks did not assess implicit learning as it may relate more closely to language. The artificial grammar task used letter strings and may conceiveably be related to language domains due to the orthography of the stimuli; however, the strings conformed to an artificial, semantically meaningless output and could have been replaced by abstract novel symbols to assess rule-based pattern construction. Thus, findings from studies using these tasks may not extrapolate to language domains, such that implicit learning of language may be impaired even when implicit learning of visuospatial skills is preserved.

In sum, a mounting body of evidence suggests that impairments in morphology and syntax are evident for a subgroup of children with ASD (Condouris et al, 2001; Eigsti et al., 2007; Roberts et al., 2004). These impairments relate to conceptual limitations in the use of language and deficits in representational and social understanding in children with ASD which are core to the disorder (Fisher et al., 2005; Rollins & Snow, 1998). There have been few studies aimed at ameliorating these structural deficits in children with ASD (i.e., Fischer et al., 2010), all of which have relied on implicit instruction procedures. There is mixed evidence regarding implicit learning processes in children with ASD, with some researchers hypothesizing that language-impairment in this population relates to deficits in implicit learning needed to make sense out of the complex and tacit rules that govern social and language development (Klinger et al., 2007). Previous work by Finestack and Fey (2009) revealed an advantage for an explicit, deductive approach when teaching children with primary language impairment to acquire a novel grammatical form. However, it is unknown of children with ASD would benefit from this alternative approach as well.

Current Study

This study aims to determine if language-impaired children with ASD will be able to produce a novel grammatical inflection when taught with an explicit instruction approach than when taught with an implicit approach, both in a computer-based intervention paradigm. Both explicit and implicit instruction will include computer models of the target language form and provide corrective feedback to the learner during teaching opportunities. However, explicit instruction will also include presentations of the guiding rules for the target grammatical morphemes. The current study aims to answer each of the following questions:

1. Do children with ASD learn to contingently apply a novel grammatical form with greater accuracy if taught using an an explicit rather than implicit intervention approach?

2. Do children with ASD who learn to apply a novel grammatical form maintain accurate use after a 1-week delay and generalize the novel grammatical form to a play context?
3. Is an explicit intervention approach differentially efficacious for children with ASD when teaching two novel grammatical forms varying in complexity?
4. Do the language, cognitive, or behavioral profiles of children with ASD who learn to apply the novel grammatical form differ significantly from those who do not learn the marking?

Based on findings from Finestack and Fey (2009) and Klinger et al. (2007) we predicted that more children with ASD would learn to contingently apply a novel grammatical form after receiving explicit instruction than after receiving implicit instruction. We further predicted that more children with ASD who learned to produce the novel grammatical form will maintain the form after a 1-week delay and generalize the form if the form was taught with explicit instruction than if taught with implicit instruction.

Moreover, we predicted differences in learning based on the novel target form. The novel gender marking included in the study was more sematically based and less complex than the novel first-person singular marking. The marking of person requires referential awareness, similar to pronoun use. Personal pronouns are particularly difficult intervention concepts for children with ASD due to their changing referential nature based on social context (Hendler et al., 1988; Tager-Flusberg et al., 2005). Thus, we hypothesized that more children with ASD would learn the novel gender marking than the person marking after receiving explicit instruction.

Finally, we predicted that children with ASD who learned to contingently apply the novel grammatical form would present with different language profiles than children who did not learn the marking. Finestack and Fey (2009) found no associations between language performance, nonverbal intelligence, and task performance in their sample of children with primarly language impairment. Roberts et al. (2004) found that language-impaired children with ASD performed poorer than children with SLI in the same age range (8-9 years old). Thus, although there may be no association between language performance and successful learning in children with SLI, this association may present in children with ASD due to comparatively weaker skills. We hypothesized that children who did not learn the novel grammatical markings would present with weaker language profiles than children who did learn the novel markings.

Method

Participants

Researchers recruited children with ASD between the ages of 4:0 and 9:11 to participate in this study. The researchers asked speech-language pathologists at local center-based intervention programs for children with ASD and other neurodevelopmental disabilities to give information packets that included a consent form approved by a university human subjects institutional review board and a demographic form to parents of children for whom the study may be appropriate. Families who wished to participate in the study completed a form indicating that they wanted to be contacted to learn more about the study. Parents returned the forms to the speech-language pathologist, who then gave these forms to the researchers. Additional participants were recruited through two research registries maintained by a university-based ASD clinic and research collaborative.

To be eligible to participate in the study, children needed to be previously diagnosed with an ASD (including Asperger's Syndrome or PDD-NOS) and live in a monolingual English home. For the purposes of this study, we included children with a documented medical diagnosis or educational qualification status of ASD. Researchers asked parents to provide a copy of their child's diagnostic evaluation report.

To be included in the study, participants had to meet inclusionary and exclusionary criteria based on preliminary assessments administered by the researchers, including the Structured Photographic Expressive Language Test – 3rd Edition (SPELT-3; Dawson, Stout & Ever, 2003) and the brief form of the Leiter International Performance Scale –Revised (Leiter-R; Roid & Miller, 1997). The SPELT-3 includes 54 full color photographs of everyday situations and objects paired with verbal questions and statements to elicit specific morphological and syntactic structures. The Leiter-R is a non-verbal IQ test administered completely non-verbally through the use of pantomimes, gestures, and facial expressions on the part of the administrator. The brief form assesses visualization and reasoning skills, including pattern repetition and figure-ground identification.

Researchers included eligible children who obtained a standard score on the SPELT-3 below 95 to confirm structural language impairment and a standard score on the Leiter-R above 70 to rule out cognitive delay. A cut-off of 95 on the SPELT-3 was chosen because it has previously been shown to have high sensitivity (90%) and specificity (100%) for identifying young children with expressive language impairments (Perona, Plante, & Vance, 2005; Spaulding, Plante, & Farinella, 2006). A child was deemed ineligible and excluded from the study if they failed a hearing screening (detect 25 dB pure tones at 1000, 2000, and 4000 Hz in at least one ear) or failed a phonological probe requiring the child to produce the target phonemes /ʃ/ and /f/ used in this study's experimental tasks. Participants named or answered questions regarding 10 photographs to elicit word-final productions of the target phonemes. The child had to produce at least four correct productions for each phoneme to confirm they could articulate the novel grammatical forms. If the child used a consistent sound distortion of the target phoneme (e.g., lateralization of /ʃ/), the child also passed the screening.

We recruited a total of 18 children with a previously documented medical diagnosis or educational classification of ASD for this study. Per the inclusion and exclusion criteria described above, we excluded four participants whose SPELT scores were too high (range 96-104) and one participant whose Leiter score was too low. Two participants did not complete the initial eligibility testing and withdrew from the study. No participants failed the hearing screening or phonological probe. Thus, eleven participants (two female; nine male) completed all activities and were included in this study's analyses. Ages (yr:mo) of participants ranged from 4:4-9:9. Table 2-1 includes participant group demographics and descriptive characteristics.

Table 2-1
Participant group characteristics (*n* = 11).

Characteristic	Mean	SD	Range
Age (months)	78.7	18.02	52-116
Nonverbal Intelligence[a]	91.8	14.6	71-115
Expressive Language[b]	73.0	14.9	47-93
Receptive Language[c]	89.2	22.6	55-128
Autism Symptoms[d]			
CARS-HF (*n* = 7)	28.4	3.6	24-34.5
CARS-ST (*n* =4)	36.3	9.9	30-51

[a]Standard score with Mean = 100, *SD* = 15 based on the Leiter-R [b]Scaled score with Mean = 100, *SD* = 15 based on the SPELT-3 [c]Scaled score with Mean = 100, *SD* = 15 based on the TACL-3. [d]Raw score on CARS-HF where a cut-off of 28 or higher indicates mild to moderate symptoms of ASD or CARS-ST where a cut-off of 37 or higher indicates severe symptoms of ASD

In addition to the eligibility assessments, each participant completed several assessments to further characterize the child's language abilities and two sets of grammatical-learning experimental tasks. Parents provided a copy of their child's diagnostic evaluation report to the research team if willing. Participants completed all activities in 8-11 sessions across 28-70 days (mean = 46) depending on family availability and scheduling needs.

Additional Participant Measures

In addition to the assessments of expressive language and nonverbal intelligence used for inclusion, participants completed assessments of receptive language and degree of autism severity. The Test for Auditory Comprehension of Language- 3rd edition

(TACL-3; Carrow-Woolfolk, 1999) is a standardized, norm-referenced test for children ages 3 through 9 years. Each participant completed the TACL-3 to assess comprehension of aurally presented English vocabulary, grammatical forms, and elaborated phrases. Participants listened to vocabulary items or short phrases and pointed to a picture among three choices that matched the aural stimuli.

The primary researcher completed the Childhood Autism Rating Scale-2nd Edition (CARS-2; Schopler, Van Bourgondien, Wellman & Love, 2010) to support participants' previous ASD diagnoses and further qualify participants' ASD symptomology. The standard version (CARS-ST) rating scale is for children between the ages of 2 and 6 years, or children age 2 years or older with significantly impaired communication and/or cognitive abilities. The high-functioning version (CARS-HF) rating scale is for children 6 years or older who are verbally fluent and have an IQ above 80. Items require judgments of behaviors central to ASD, including nonverbal communication, relationships, repetitive behaviors, rituals and routines, and presence of hyper/hypo-sensitivity. The CARS-HF rating scale has a reported sensitivity of .81 and specificity of .87 (Schopler et al., 2010). In the current sample, four children received ratings on the CARS-ST scale, and seven children received ratings on the CARS-HF scale. Raw scores on each scale are interpreted relative to a clinical sample of individuals diagnosed with ASD to categorize a child's degree of autism-related behaviors as minimal, moderate, or severe. Three children in the current sample who received ratings on the CARS-HF scale scored in the minimal-to-no symptoms severity category. All other children who received ratings on the CARS-HF or CARS-ST scored in the mild-to-moderate symptoms or severe symptoms categories.

Researchers administered these assessment measures across experimental sessions such that no session exceeded 1 hour. For all sessions, researchers provided participants with short breaks as needed and participants received small prizes as incentives. Researchers tailored session lengths to accommodate the participants and their families as necessary. Researchers used redirection and visual schedule techniques (e.g., a visual map of planned activities to be checked off upon completion) with participants who needed additional support to remain engaged during tasks.

Group Assignment

Upon qualifying for the study, researchers randomly assigned each participant to one of eight sequences specifying the order of presentation of the experimental tasks addressing the novel grammatical forms (gender vs. person), the type of instruction provided during the experimental task (implicit vs. explicit), and the phonological form used as the gender or person marking (/ʃ/ or /f/). These counterbalanced sequences were randomized in blocks such that after every eighth participant, half of the participants would have completed the gender task first with either explicit or implicit instruction. Table 2-2 contains the details of each randomization sequence. Figure 2-1 illustrates the manner of counterbalancing for each participant.

Table 2-2

Randomization Sequence for Experimental Tasks

Sequence	**Game 1**	**Game 2**	**Gender Instruction**	**Gender Marking**	**Person Instruction**	**Person Marking**
A	Gender	Person	Implicit	/ʃ/	Explicit	/f/
B	Person	Gender	Explicit	/f/	Implicit	/ʃ/
C	Gender	Person	Implicit	/f/	Explicit	/ʃ/
D	Person	Gender	Explicit	/ʃ/	Implicit	/f/
E	Gender	Person	Explicit	/f/	Implicit	/ʃ/
F	Person	Gender	Implicit	/ʃ/	Explicit	/f/
G	Gender	Person	Explicit	/ʃ/	Implicit	/f/
H	Person	Gender	Implicit	/f/	Explicit	/ʃ/

Figure 2-1

Manner of Counterbalancing for Each Participant

		Grammatical Form	
		Gender Form	Person Form
Intervention Method	Explicit Instruction	Explicit Gender	Explicit Person
	Implicit Instruction	Implicit Gender	Implicit Person

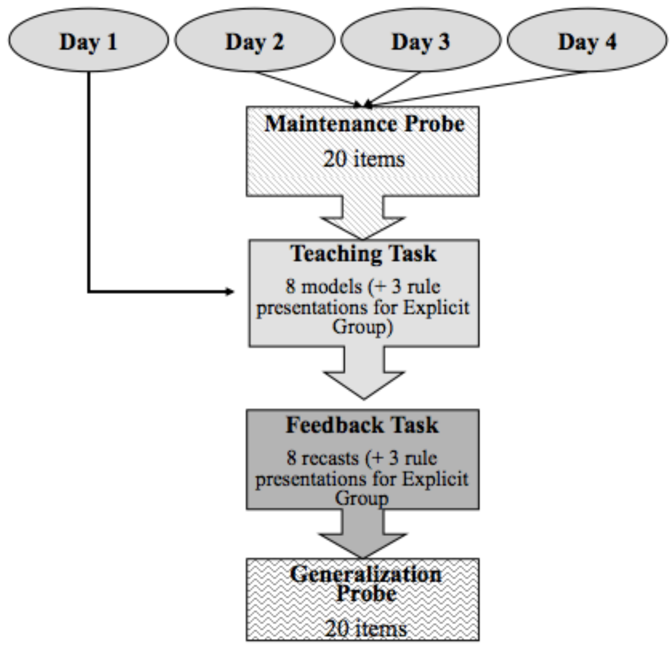
Experimental Sessions

Researchers addressed each grammatical target in up to four computer-based teaching sessions. These sessions were proceeded by one 1-week follow-up maintenance session. During each teaching session, participants played a space-themed computer game. The goal of each game was for the participant to learn the novel language of a space creature. In each game, participants attempted to learn either a gender or a person novel grammatical form. The gender form marked the action of a male sentence subject (e.g., “Mark can swim-*f*”), while the person form marked the action of a first person subject (e.g., “Now I drive-*sh*”). In a counterbalanced manner, one game provided explicit instruction of the grammatical pattern (i.e., “When it is a boy, you have to add -*sh* to the end. When it is a girl, you don’t add anything to the end”) while the other game only provided implicit instruction of the grammatical pattern (“Listen carefully, so you can talk just like the creature”). Additionally, the phoneme used for the grammatical marking was counterbalanced across conditions. All sessions were either audio- or video- recorded.

During each experimental teaching session, the primary researcher or a trained research assistant presented the experimental task using a laptop computer. All teaching sessions included a maintenance probe, teaching task, a teaching probe, and a generalization probe with the exclusion of the first day, which did not include a maintenance probe. Figure 2-2 illustrates the structure of each experimental teaching session for each space game.

Figure 2-2

Structure of Each Experimental Session



Teaching Task. At the beginning of the teaching task, the examiner instructed the participant that a creature had just arrived to Earth and that while the creature uses many of the same words that we do, there is something different about the way the creature talks. The examiner instructed participants to try and learn the creature's language so that they can talk just like the creature. Participants then viewed eight separate color graphics and listened to corresponding sentences describing the graphic using the novel grammatical form. Participants did not produce the targeted form during any of these trials. Before the first, after the fourth, and after the eighth trials, participants assigned to the explicit condition heard a description of the pattern governing the novel grammatical marker (e.g., "When you or the creature talks about yourself, you have to add *–sh* to the end. When you or the creature talks about someone else, do you don't add anything to the end"). Participants assigned to the implicit condition did not hear the novel rule description. Instead, they received a prompt before the first, after the fourth, and after the eighth trials to attend to the space creature's language (i.e., "Listen carefully, so you can talk just like the space creature").

Feedback Task. Immediately following the modeling trials, participants had eight opportunities to produce the grammatical marking using the pattern exemplified in the models. The creature began the sentences describing the pictures and the examiner prompted the participant to complete the sentences as the creature would. If the participant completed a given sentence correctly, they received positive feedback and heard the sentence again (e.g., "That was right. Listen to the creature again, 'Mike can dance-*sh*'"). If the participant did not respond or produced an incorrect response, they received feedback and heard the sentence again (e.g., "Oops, that isn't how the creature talks. Listen to the creature again, 'Mike can dance-*sh*'"). After the feedback, the computer presented the next trial. Additionally, during the feedback task, participants heard three additional explicit or implicit prompts regarding the space creature's pattern distributed before the first, after the fourth, and after the eighth trials.

Generalization Probe. The generalization probe occurred at the end of each session to evaluate learning. Just as in the feedback task of the teaching phase, participants viewed a computer illustration for each item and the researcher prompted the participant to complete the sentence just as the space creature would (i.e., the creature only began the sentence: "Mike can..."). Researchers guided participants to respond as quickly and correctly as they could. In contrast to the feedback trials, participants did not receive feedback regarding their responses. In addition, these probes did not include explicit or implicit instructions regarding the creature's language. Each generalization probe included 20 randomized items: 10 identical to the subject + verb depictions used during the teaching task and 10 unique items depicting subject + verb depictions not used during the teaching task. The probe included an equal number of items requiring the novel marker (e.g., gender marked: "Nick can read-*f*") and items not requiring a novel marking (e.g., gender unmarked: "Ashley can swim").

Maintenance Probe. For each targeted form, the maintenance probe occurred at the beginning of Sessions 2, 3, and 4. The maintenance probe allowed monitoring of maintenance effects and preserved learning between sessions and served as the criterion for determining progression to the second novel grammatical marker or task completion. The format of the maintenance probe was the same as the generalization probe and the items included in the probe were identical to the previous session's generalization probe.

Maintenance Sessions

Follow-up Maintenance Session. One week following the completion of intervention for each target (Mean = 7.77 days; Range = 5-16 days), participants completed a follow-up maintenance probe. The follow-up maintenance probe included 20 computer-based items similar to those used in the generalization and maintenance probes during the intervention sessions. This probe did not include explicit or implicit instructions regarding the creature's language or constructive feedback.

Generalization Probe. In the same session, participants played a game with the examiner in which they manipulated toys and plush alien creatures similar to those depicted in the computer graphics. During this toy play, the experimenter prompted participants to use the target forms as they did during the computer activity. The participant completed a randomized sequence of 20 items evenly distributed across those requiring the novel marker and those not requiring it.

Intervention Dosage Parameters. Warren, Fey, and Yoder (2007) outlined a set of common variables to be included in intervention methodology to aid in understanding treatment implementation. They suggested that dose, dose form, dose frequency, and total duration are critical components of an intervention. All contribute to the cumulative intervention intensity, which is the product of dose, dose frequency and total duration. The current experimental intervention is a low-intensity intervention, with a maximum cumulative intervention intensity of 128 teaching episodes for both grammatical markings. Table 2-3 summarizes the current treatment dosage variables described previously according to Warren et al.'s taxonomy.

Table 2-3

Intervention Dosage Parameters

Treatment Variable	**Warren et al. definition**	**Current Study**
Dose	Number of properly administered teaching episodes during a single intervention session	16 teaching episodes per 5-8 minute period
Dose Form	Activity within which the intervention is administered	Structured artificial language learning task using models and recasts
Dose Frequency	Number of times a dose of intervention is provided a week	2 sessions/week
Total Intervention Duration	Time period over which the specified intervention is presented	4-5 weeks

Examiner Prompting

Across all probes, if the participant provided an incorrect verb or expressed confusion regarding the action depicted in the image, the experimenter provided a prompt modeling the target verb in the present progressive form. For example, the experimenter provided the prompt "I think Wobo is *driving*. Wobo would say *Now I…*". If the child refused to say anything, this prompt was repeated up to two additional times with opportunities for the child to respond. If the child provided any response or did not respond after these additional attempts, the experimenter progressed to the next trial.

Progression of Experimental Sessions

Completion of all sessions for both grammatical targets required approximately 4-5 weeks for each participant (Mean = 33.63 days, Range = 21-51 days). The number of teaching sessions for each grammatical target was determined by the performance of the participant. If a criterion of 80% or higher successful responding was attained during the maintenance probe of the session, the researcher discontinued the progression of tasks for that game. At this point, the participant either moved on to the next grammatical target or ended the session. This progression criterion was used because researchers determined that if the participant demonstrated sufficient mastery of the target form during maintenance, it was unnecessary to re-administer the teaching task. All participants progressed, either to the following game or to the final 1-week wait period before the follow-up session, after a maximum of four sessions for each grammatical target. Figure 2-3 depicts a hypothetical progression of sessions for a participant.

Figure 2-3

Sample Intervention Session Progression

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	Game 1 Day 1		Game 1 Day 2			
	Game 1 Day 3 *(participant reaches 80% criterion during Maintenance Probe)*		Game 2 Day 1			
	Game 2 Day 2 Game 1 Follow-Up Maintenance Probe		Game 2 Day 3			
	Game 2 Day 4					
	Game 2 Follow-Up Maintenance Probe					

Novel Grammatical Markings

For each experimental task, researchers asked the participants to learn a novel grammatical marking which was either a gender marking or a person marking. For the novel gender marking pattern, if the sentence subject was male, the verb carried a phonemic marking (/ʃ/ or /f/). If the sentence subject was female, the verb did not carry a marking. Each gender model sentence had the following syntactic structure: subject + *can* + infinitive form of the verb + (marking or no marking). Examples following the gender-marking pattern include: *Matt can read-f* (or *Matt can read-ʃ*, depending on the sequence) and *Maddy can swim*. To present this model, a computer displayed one cartoon graphic of a girl or a boy character performing an action. Some actions (e.g., *laugh*) included just the character performing the action; other actions required the inclusion of props to model the grammatical form (e.g., the graphic for the target verb *swim* included a pool). This marking and the model items are identical to those used by Finestack and Fey (2009). Figure 2-4 illustrates an example cartoon used for the gender marking; the written text did not appear on the computer display, but is included in the figure for descriptive purpose.

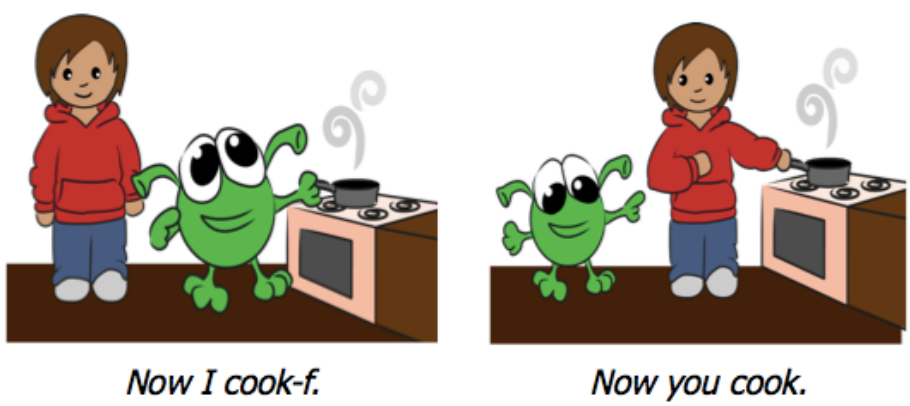
Figure 2-4

Sample Visual Stimuli for Gender Marking

For the novel person marking, the end of the verb carried a phonemic marker if the creature was the agent of action. If another individual was the agent of action, the end of the verb did not carry a marking. Each model sentence had the following syntactic structure: *Now* + subject (*I/You*) + infinitive form of verb + (marking or no marking). Examples following the person-marking pattern include: *Now I drive-ʃ* (or *Now I drive-f,* depending on the sequence) and *Now you paint.* To present this model, a computer displayed one cartoon graphic of the space creature ("Wobo") and a cartoon boy, one of whom performed an action while the other was present. Figure 2-5 illustrates an example cartoon used for the person marking; the written text did not appear on the computer display, but is included in the figure for descriptive purpose.

Figure 2-5

Sample Visual Stimuli for Person Marking



All subject stimuli names or versions of the names (e.g., Matthew/Matt, Madison/Maddy) used with the gender marking appeared on the Social Security Administration's top 20 names list each year from 2000 to 2008 (Social Security Administration, 2013, April 21). All of the verbs, except for *laugh*, appear on the

MacArthur-Bates Communication Developmental Inventory: Words and Gestures (MCDI; Fenson et al., 1993). The MCDI is a language assessment tool designed for children 8- through 16- months old. Thus, it is reasonable to believe that verbal children with ASD aged 4- to 9-years had acquired these verbs. All of the verbs used with both markings were monosyllabic verbs. The researchers randomized combinations of the subjects and verbs for the gender marking and person marking, yielding 64 possible combinations for the gender marking and 40 possible combinations for the person marking. The possible sentence subjects and verbs for the gender and person marking are detailed in Table 2-4.

Table 2-4

Experimental Task Stimuli

	Subjects		**Verbs**	
Gender Marking	Mike	Matt	Dance	Swim
	Jake	John	Laugh	Cry
	Sara	Ashley	Write	Read
	Maddy	Emma	Drink	Eat
Person Marking	You		Swing	Paint
	I		Push	Drive
			Skate	Clap
			Catch	Cut
			Hear	Slide
			Build	Talk
			Pull	Hit
			Sing	Ride
			Sweep	Look
			Knock	Cook

Data Coding

The examiners recorded each session using the internal microphone of a portable audio recorder (Marantz PMD661 or Marantz PMD620). A trained coder blinded to the instruction (explicit or implicit), session number, and probe type (maintenance or generalization) scored each participant's response using these recordings. The coder scored responses as correct or incorrect. A response was correct if the child produced the correct or an accurately substituted verb and marking (e.g., *smile* for *laugh*); or the child added the marking to an object of the sentence (e.g., *Jake can eat pizza-f).* The coder scored responses including a consistent phonetic distortion of the marking as correct. The coder also scored a child's response as correct if the child used a consistent substitution of the target marking, other than /ʃ/ or /f/. For example, if the child consistently used /b/ in place of /f/, the coder scored these responses as correct.

The coder scored all other responses as incorrect, including addition of the target phoneme to items that did not require the target phoneme (e.g., female subjects: *Ashley can eat-sh* or second-person agents: *Now you look-f*), production of a bare verb that required a marking (e.g., male subject or first-person agent), or inconsistent substitution of a phoneme other than /f/ or /ʃ/. A response received a separate code if the utterance was inaudible or unintelligible.

A second coder independently re-scored and re-coded 14% of all maintenance probes, selected randomly, to determine inter-rater reliability. Applying the absolute agreement definition, researchers calculated the intraclass correlation coefficient (ICC). The ICC provides a measure of reliability between the judges, indicating the proportion of variance in the scores that is related to the participants' performance rather than that of the judges (Berk, 1979; Suen & Ary, 1989). A cronbach alpha level of .80 and above indicates good reliability (Field, 2009). The ICC for the maintenance probe was .84, and revealed one data point with a large discrepancy between coders. Further investigation revealed that the participant who provided the data was frequently echolalic and added "ok" to the ending of some verbs (e.g. "*Jake can eat-ok*"). One coder ignored this addition while the other coder treated it as an incorrect, random marking. This difference did not affect the participant's overall performance. When this single case was omitted, ICC increased to .97, indicating that the judges contributed only a very small part of the variance in the children's scores.

Fidelity of Treatment

To determine fidelity of intervention implementation, the trained coder also scored the presentation of feedback responses during the feedback task of each teaching session. The coder scored whether the experimenter prompted the computer to provide the correct feedback (i.e., the participant was correct and the experimenter provided reinforcing feedback, or the participant was incorrect and the experimenter provided corrective feedback) or whether the experimenter prompted the computer to provide incorrect feedback (i.e., the participant was incorrect and the experimenter provided reinforcing feedback, or the participant was correct and the experimenter provided corrective feedback).

Researchers calculated fidelity by aggregating experimenter performance for each participant across all days of feedback. Average experimenter fidelity was 95.9% with a standard deviation of 8%. The majority of experimenter errors were instances where the child produced the correct response and the experimenter provided incorrect feedback.

These were often cases where the child produced the grammatical marking after an extended delay following the verb, and the experimenter had already initiated the incorrect feedback response. These instances accounted for 22 out of 24 erroneous feedback trials.

Statistical Design

The researchers used maintenance probe performance to classify each participant as a "pattern user" (PU) or a "non-pattern user" (NonPU) for each novel marking. PUs were defined as participants whose performance was not significantly different than 90% accuracy on the maintenance probe. Using this 90% benchmark to determine a score to differentiate the PUs and NonPUs, the researchers calculated binomial p-values using corresponding z-scores. This calculation indicated that participants who correctly produced the target form less than 16 times during the maintenance probe attained scores with cumulative probabilities less than 0.05, thereby scoring significantly below the 90% mastery level. Thus, the PU cutoff was operationally defined as an accuracy score greater than or equal to 16 out of 20 trials (80%).

If the participant attained a criterion of 80% or higher accurate responding during the 20-item maintenance probe of a single teaching session, researchers categorized the participant as a PU for that grammatical marker. If the participant did not attain a criterion of 80% or higher accuracy during the maintenance probe of any experimental session for that particular grammatical marking, researchers categorized the participant as a Non-PU for that grammatical marking. The 80% accuracy cut-off was also used to categorize pattern use for the follow-up maintenance probe and toy generalization probe.

The researchers completed all analyses using within-subject and between-subject nonparametric 2x2 contingency tables. The number of participants categorized as PUs served as the dependent variable. Teaching condition and grammatical marking served as independent variables for individual tables. An alpha level of .05 or lower was set to reject the null hypothesis for each research question. Researchers also calculated Phi (Φ) values, where applicable, to represent effect size. Phi values range from 0 to 1.0 and indicate the strength of the relationship between two variables, with values of 0.10, 0.30, and 0.50 respectfully representing small, medium, and large effect sizes (Green & Salkind, 2003).

Results

Research Question 1

The first aim of this study was to determine if participants with ASD produce and maintain a novel grammatical form with greater accuracy if taught using an explicit intervention approach than an implicit approach. The researchers used participants' performances on the 20-item maintenance tasks to determine pattern-use of the target grammatical form. Researchers collapsed participant classification across the two grammatical targets to examine the main effect of instruction type. Table 3-1 presents the number of participants who became PUs with each instructional approach.

Table 3-1

Comparison of Participant Pattern Use[1] after Explicit versus Implicit Instruction

		Implicit Instruction	
		PU	NonPU
Explicit Instruction	PU	0	5
	NonPU	0	6

[1]As discussed in the statistical design, if the participant attained a criterion of 80% or higher accurate responding on any maintenance probe, researchers categorized the participant as a pattern-user (PU) for that grammatical marker. Participants below this accuracy criterion were non-pattern-users (NonPUs).

Five participants became PUs after receiving explicit instruction, while six participants remained NonPUs after receiving explicit instruction. In comparison, no participants became PUs after receiving implicit instruction. Results from the non-parametric related samples McNemar's test revealed that distribution trended towards, but did not reach, a statistically significant difference between the number of children with ASD who became PUs after explicit instruction versus implicit instruction (p = .06). Effect size was not calculated due to cells with zero values in the contingency table.

Research Question 2

A secondary research aim was to examine follow-up maintenance of learning for the novel grammatical forms among participants who became PUs during the intervention sessions. One week post-intervention, examiners assessed the participants' ability to use the target forms on a probe identical to those used during the teaching sessions and on a toy-based generalization probe compared to performance on the immediate maintenance probe. Of the five participants who became PUs with explicit instruction, four continued to demonstrate their learning of the grammatical pattern on the computer probe. Results from the McNemar's test demonstrated this difference in pattern-use performance on the immediate maintenance probe and the 1-week follow-up maintenance probe was not significantly different (p = 1.0). Table 3-2 displays the number of pattern-users at each learning time.

Table 3-2

Immediate Maintenance and Follow-up Maintenance Probes

		Immediate Maintenance Probe	
		PU	Non-PU
Follow-up Maintenance Probe	PU	4	0
	NonPU	1	6

Furthermore, three of the five participants generalized their pattern use to the play-based manipulation of toys after the 1-week delay. Results from the McNemar's test demonstrated this different in pattern-use performance on the immediate maintenance probe and the generalization probe was not significantly different (p = .5). Table 3-2 presents the number of PUs based on each probe. Table 3-3 displays the number of pattern-users during the immediate generalization probe in comparison to the toy-based generalization probe.

Table 3-3

Comparison of PUs and NonPUs based on Immediate Maintenance and Generalization

		Immediate Maintenance Probe	
		PU	Non-PU
Toy-based Generalization Probe	PU	3	0
	NonPU	2	6

An additional comparison between pattern-use performances on the 1-week maintenance probe and the toy-based generalization probe demonstrated the gradual reduction of pattern-use performance among the five participants who were classified as PUs after receiving explicit instruction. Results from the McNemar's test revealed this difference in pattern-use across contexts was not statistically significant (p = 1.0). Table 3-4 displays the number of PUs in each probe context.

Table 3-4

1-week Maintenance and Generalizations of PUs after Explicit Instruction

		Follow-Up Maintenance Probe	
		PU	Non-PU
Toy-based Generalization Probe	PU	3	0
	NonPU	1	1

Research Question 3

The third research aim was to investigate if the number of PUs with explicit or implicit instruction differed based on the target form. Similar to procedures used to address the first research question, researchers used participants' performances on the intervention session maintenance probes to determine pattern use of the target grammatical form. With explicit instruction, two of six participants became gender-form PUs and three of five participants became person-form PUs. Results from the Fischer's Exact test revealed this difference was not significantly different (p = .57). The effect size of the comparison was small (Φ = .27). Table 3-5 presents the number of PUs for each grammatical marking with explicit instruction.

Table 3-5

PU comparison for each Grammatical Marking after Explicit Instruction

	Gender	Person
PU	2	3
NonPU	4	2

With implicit instruction, none of the participants became gender-form PUs and none became person-form PUs. Results from the Fischer's Exact test revealed that this difference was not statistically significant (p = 1.0). Table 3-6 presents the number of PUs for each grammatical marking after receiving implicit instruction.

Table 3-6

PU comparison for each Grammatical Marking after Implicit Instruction

	Gender	Person
PU	0	0
NonPU	5	6

Research Question 4

To determine whether the language, cognitive, or behavioral profiles differed significantly between participants classified as PUs and those classified as NonPUs, researchers compared the two groups' performance on standardized measures. Due to the small sample size and likelihood of outlying scores skewing results, researchers used the non-parametric Wilcoxon signed rank tests to evaluate group differences. Results indicated that participants who became PUs trended towards, but did not reach, statistically significant higher expressive language skills (mean rank = 8) than participants who remained NonPUs (mean rank = 4.3), as measured by the SPELT-3 (z = -1.83 p = .082). PUs did not have significantly higher receptive language skills (mean rank = 7.2) than NonPUs (mean rank = 5.0), as measured by the TACL (z = -1.1, p = .329). There was no significant difference in the nonverbal cognitive skills of participants who became PUs (mean rank = 5.9) versus those who did not (mean rank = 6.1), as measured by the Leiter-R (z = .09, p = 1.0). Moreover, there was no significant difference in severity of autism symptoms of PUs (mean rank = 7.1) and NonPUs (mean rank= 5.1) as measured by CARS-2 percentile ranks (z = -1.01, p = .329). Additionally, there was no significant difference (z = -1.19, p = .247) in chronological age of PUs (mean rank = 7.3) and NonPUs (mean rank = 4.9). Table 3-7 includes participant mean-rank performance on these variables based on their pattern-use status. Figure 3-1 depicts each participant's score on these variables.

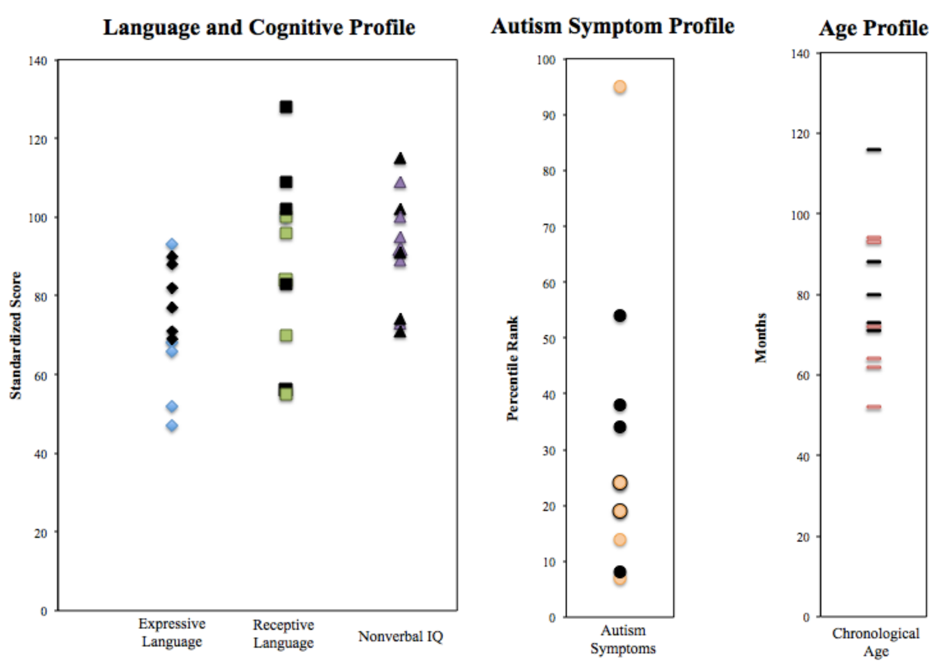
Table 3-7
Language, Cognitive, and Behavioral Characteristics of PUs and NonPUs

Domain	PU mean rank	NonPU mean rank	*p* value
Expressive Language[a]	8.0	4.3	.082
Receptive Language[b]	7.2	5.0	.329
Nonverbal IQ[c]	5.9	6.1	1.000
Autism Symptoms[d]	7.1	5.1	.329
Chronological Age[e]	7.3	4.9	.247

[a]Based on standard scores from the SPELT-3 [b]Based on standard scores from the TACL-3 [c]Based on standard scores from the Leiter-R [d]Based on percentile rank of symptom severity from the CARS-HF or CARS-ST [e]Measured in months.

Figure 3-1

Participant Scores on Language, Cognitive, and Behavioral Characteristics



[a]For each variable, black data points indicate PUs. Shaded data points indicate NonPUs.

Post-hoc Analysis

To better understand the performance of the participants who did not attain a criterion of 80% or higher accuracy on a maintenance probe in any experimental session and subsequently classified as NonPUs, we examined the specific response patterns of the participants for each marking. According to the response coding protocol, the blinded judge coded a child's incorrect response as an overapplication of the marking (i.e., a female or second-person subject), a bare production that required a marking (i.e., a male or first-person subject), or an absent or unintelligible response. Researchers examined each participant's pattern of errors across all maintenance probes for each marking. Researchers categorized participants under a certain error type if at least 50% of their errors aligned with a consistent coding on two or more days of intervention.

For the gender marking, of the nine participants who remained NonPUs, seven children did not attempt to apply the marking in any trial, while two children overgeneralized the marking to all trials. Table 3-8 displays the error patterns for each NonPU of the gender marking.

Table 3-8

Error Patterns of NonPUs for Gender Marking

		Instruction Type	
		Explicit	Implicit
Error Type	Overgeneralize	1	1
	Bare	2	5

For the person marking, of the eight participants who remained NonPUs, six children did not attempt to apply the marking, while one child overgeneralized the marking, producing it in all trials. Additionally, one child provided mostly unintelligible or absent responses during the maintenance probes. Table 3-9 displays the error patterns for each NonPU of the person marking.

Table 3-9

Error Patterns of NonPUs for Person Marking

		Instruction Type	
		Explicit	Implicit
Error Type	Overgeneralize	0	1
	Bare	2	4
	Unintelligible/ No Response	1	0

Discussion

The current study had four research aims. The primary research aim was to determine if children with ASD who exhibit expressive delays in morphosyntax better learn to contingently apply a novel grammatical form if taught using an explicit rather than implicit intervention approach. The second research aim was to compare follow-up maintenance and generalization of learning after a 1-week gap among participants who learned to contingently apply the form during intervention sessions. The third research objective was to determine if learning differed based on the novel grammatical form targeted in intervention. The final research aim was to determine if the language, cognitive, or behavioral profiles differed between the participants classified as PUs and those classified as NonPUs with explicit instruction. Researchers addressed these questions using an experimental computer-based novel language learning game. Each participant received implicit instruction for one novel grammatical marking and explicit instruction for another novel grammatical marking. Both the implicit and explicit instruction approaches included models of the target language form and provided corrective feedback to the learner during teaching opportunities. Additionally, the explicit approach overtly provided the pattern guiding use of the novel target forms. Researchers classified participants as pattern users (PU) or non-pattern users (NonPU) based on a criterion of 80% or higher accurate responding during the 20-item maintenance probe administered during teaching sessions.

For the first study question, we predicted that children with ASD who demonstrate deficits in expressive morphosyntax would learn to contingently apply a novel grammatical form with greater accuracy after receiving explicit instruction than implicit instruction. This outcome was predicted based on previous work (Finestack & Fey, 2009) that suggests an advantage for a explicit intervention procedure over an implicit procedure for teaching children with primary language impairment to accurately use a novel grammatical morpheme in a highly structured environment. We predicted that explicit instruction would encourage children with ASD to utilize a rule-bound pattern when given specific examples of a novel language form. Additionally, findings from Klinger et al. (2007) suggest the implicit instruction would emphasize weaknesses in implicit learning among children with ASD and preclude them from accurately applying the rule-bound pattern when only given implicit models and recasts of target forms.

Study results trended towards confirming this prediction (p = .06). Five children (45%) became PUs of the novel grammatical marking after receiving explicit instruction, while all ten children (0%) remained NonPUs after receiving implicit instruction. The same children who were able to accurately and contingently apply the novel grammatical marking with explicit instruction were unable to accomplish a similar criterion with implicit instruction. These within-subject findings suggest a meaningful advantage for learning with an explicit instructional approach.

Similarly, for the second research question, we predicted that children with ASD who learned to produce the novel grammatical form would maintain the form after a 1-week delay and generalize the form to a play-based context after receiving explicit instruction. This within-subjects comparison demonstrated that four of the five participants who became PUs on the computer probe maintained their learning after a 1-week delay and three of the five participants generalized their learning to the play-based probe. This difference was not significantly different; most participants who were able to learn the novel forms maintained and generalized their learning.

Yamamoto and Miya (1998) and Fischer et al. (2010) demonstrated that children with ASD could generalize syntactic structures to untrained picture stimuli in an identical context to that used during intervention training. The current findings support this finding. Children with ASD who learn novel morphosyntactic rules are likely to maintain their learning in an identical context after a 1-week delay, and generalize the morphological rule to untrained stimuli in a dissimilar context to that used during intervention training. Three children were able to maintain *and* generalize a novel grammatical morpheme that was explicitly taught to a novel language context 1-week after finishing the intervention program. These same children were unable to accomplish this for a grammatical morpheme that was implicity taught. Thus, in the current study explicit instruction aided acquisition, maintenance, and generalization of a novel grammatical morpheme.

For the third research question, we predicted that participants would be more successful learners of the less referentially complex novel gender form than the referentially complex person form. Hendler et al. (1988) and Tager-Flusberg et al. (2005) suggested that personal pronouns are particularly difficult intervention concepts for children with ASD due to their deixis. Deixis is an aspect of language that signifies shifting reference depending on the perspective of the speaker and listener. For example, an individual can be referred to as “you” or “I” depending on whether they are the speaker or listener during a communication interaction. We operationally defined a gender-based grammatical pattern as less complex than a person-based grammatical pattern. However, results demonstrated that the number of explicitly-instructed PUs of the gender marking was statistically equivalent to the number of explicitly-instructed PUs for the person marking. The effect size of the comparison was small, demonstrating a minor association between marking complexity and pattern use. Thus, it seems that explicit instruction is equally beneficial for forms varying in referential complexity.

The fourth study question asked whether there are difference in the language, cognitive, or behavioral profiles of the participants with ASD classified as PUs and those classified as NonPUs. In the current sample, there was an emerging distinction in expressive morphosyntactic language skills of the children who became PUs after explicit instruction and those who remained NonPUs in both conditions, as measured by their performance on the SPELT-3. Although this difference between the groups did not reach statistical significance, visual inspection of participants' scores on the SPELT-3 indicate a single outlier who obtained a high standard score on this assessment but remained a NonPU. Without this outlier, there is a clear distinction between SPELT-3 scores of PUs and NonPUs.

Despite the PU group trending towards higher expressive language skills relative to the NonPU group, they still demonstrated deficits in morphosyntax not unsimilar to those found by previous researchers (i.e., Eigsti et al. 2007; Roberts et al., 2004). According to Perona et al. (2005), a score below 95 on the SPELT-3 has high sensitivity and specificity for identifying children with language impairment. As Landa and Goldberg (2005) suggest, a child with ASD who speaks in full sentences may not have a completely intact grammatical system. It appears that the children in the current sample who benefited most from explicit instruction fall towards that end of the continuum. However, given that there were no statistically significant group differences based on mesures reflecting expressive language skills, receptive language skills, nonverbal IQ, or severity of autism symptomology, it seems that a variety of children with ASD may be able to benefit from an explicit approach to language intervention.

Limitations of Observed Effects

The findings from this study must be qualified in several ways. A primary limitation is the small sample size of the current study. Several of the results closely approached statistical significance, but due to the limited power of a small sample, were unable to cross that threshold. A larger sample size would likely yield statistically significant differences between an explicit intervention approach and an implicit intervention approach and would demonstrate an association between intervention condition and pattern-use.

A second qualification of the current study is the limited number of intervention sessions that each participant completed. Participants were exposed to each novel grammatical marking in no more than four treatment sessions. Using the dose definition provided by Warren et al. (2007), each child completed a maximum of 64 teaching episodes for each grammatical marking. Thus, the cumulative treatment intensity of the current intervention was very low. It is possible that if we had extended the number of intervention sessions, or increased the dose of teaching episodes witin each session, more participants may have become PUs. Indeed, most language intervention programs in a clinical setting include more than four sessions. Fischer et al. (2010) reported a range of 399-1320 training trials to establish generalized responses to targeted sentence syntax in four young children with ASD. The error patterns for the majority of NonPUs in the current sample indicated that they were leaving all verbs bare and not attempting to mark any trials with the novel morpheme. Children with ASD may require many more exemplars and feedback opportunities to acquire a new language form compared to children with primary language impairment. However, in this light it seems impressive that five of the 11 children (45%) were able to reach 80% or higher accurate use of the novel form in such a limited intervention period. An explicit approach to intervention may create more robust learning of a targeted form and do so in a shorter period of time than an implicit approach to intervention. Future research should examine the relative treatment intensity parameters it would take a child to reach a highly accurate level of pattern-use in each intervention condition.

An additional limitation of the current study is the use of novel grammatical morphemes not found in English. Although this increased the internal validity of the research design, it remains unknown whether children with ASD would demonstrate similar differences for explicit and implicit instruction with a naturally occuring English morpheme, such as third person singular *–s* or past tense *–ed*. Future research should examine the use of explicit instruction with real morphosyntactic features of English.

Study Strengths

Although there are study limitations that must be taken into account with the observed effects, there are also strengths to the current study. One of the strengths is the stringent criterion (80% accuracy or higher) that was set for a participant to be classified as a PU. To meet this criterion, participants had to reach 80% accuracy during an immediate maintenance probe, which provided no "warm-up" or explicit prompting of the grammatical marking. Instead, participants had to remember the pattern from a previous day of intervention and apply it at a high level of accuracy. This stringent criterion points to the level of mastery that a child had to attain to be classified as a PU.

Another strength of the current study is the high internal validity of the design. Researchers evaluated the two intervention approaches through randomized assignment to an artificial language learning task. Although the novel grammatical markings mimicked morphological distinctions found in English and used phonemes similar to those used in English to mark morphology, they were completely novel and applicable only within the experimental paradigm. Thus, any outside treatment or speech and language services the children received before or during their participation is unlikely to have affected their performance in the experimental tasks. This internal validity is also paired with ecological and clinical validity by excluding those participants for whom grammar treatment would not likely occur in a realistic therapy setting. By only including children for whom clinical intervention in this area would be relevant, the current study findings are generalizable to children with ASD found in clinical settings.

Conclusion

The purpose of the present study was to evaluate an explicit intervention approach to teaching novel grammatical morphemes to children with ASD who demonstrate deficits in expressive morphosyntax. Study results revealed a trending advantage for the explicit approach over the implicit approach, such that more children with ASD became pattern-users of a novel grammatical marking after receiving explicit instruction of the pattern guiding the application of the marking. No children with ASD became pattern-users after receiving implicit instruction, wherein they were only instructed to attend closely to models and provided with recasts including the targted form. The effects of the explicit instruction were greatest during the intervention phase with nonsignificant attrition occurring at a 1-week follow-up session. The explicit approach was equally efficacious when targeting a complex grammatical marking of a deictic concept known to be difficult for children with ASD, and when targeting a relatively simpler grammatical marking not known to be difficult for children with ASD.

Results of the current study are consistent with previous findings that demonstrate an advantage to an explicit intervention approach when targeting morphosyntactic forms. Finestack and Fey (2009) demonstrated this advantage in a group of children with primary language impairment. The current study begins to provide evidence supporting the expansion of explicit instruction of grammatical forms to a group of children with ASD. In a clinical setting, this explicit approach may produce more robust learning of targeted language forms, even when used in small dosages, than the traditional implicit approach. More participants need to be added to this study to fully power the study design and provide more conclusive results. Moreover, future research should continue to define the morphosyntax deficits that present in some children with ASD, and further explore the best intervention approaches that target these and other pertinent areas of language development in children with ASD.

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