Published in final edited form as:

J Autism Dev Disord. 2016 January ; 46(1): 221–231. doi:10.1007/s10803-015-2566-7.

Parents' Translations of Child Gesture Facilitate Word Learning in Children with Autism, Down Syndrome and Typical Development

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Abstract

Typically-developing (TD) children frequently refer to objects uniquely in gesture. Parents translate these gestures into words, facilitating children's acquisition of these words (Goldin-Meadow et al., 2007). We ask whether this pattern holds for children with autism (AU) and with Down syndrome (DS) who show delayed vocabulary development. We observed 23 children with ASD, 23 with DS, and 23 TD children with their parents over a year. Children used gestures to indicate objects before labeling them and parents translated their gestures into words. Importantly, children benefited from this input, acquiring more words for the translated gestures than the not translated ones. Results highlight the role contingent parental input to child gesture plays in language development of children with developmental disorders.

Keywords

parental responsiveness; child gesture; parental verbal input; autism; Down syndrome; language development

When young children gesture, parents often respond by translating these gestures into words, providing relevant and timely spoken language input to their children (Golinkoff, 1986; Masur, 1982). Typically developing (TD) children, in turn, take advantage of this input: when a parent translates a child's gesture into a word not yet in the child's vocabulary, the child is more likely to subsequently produce the new word than when the parent does not provide a translation (Goldin-Meadow, Goodrich, Sauer, & Iverson, 2007). However, we do not yet know whether children with developmental disorders, who show distinct profiles of gesture and speech development, also benefit when parents provide new words that are targeted to their gestures. In this study, we ask whether parents of children with autism (AU)

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The authors declare that they have no conflict of interest.

and with Down syndrome (DS) are as likely to translate their children's gestures into words as parents of TD children and, if so, whether these translations facilitate their children's acquisition of these new words. Answers to these research questions will provide a strong test of the claim that children's gestures can serve as a powerful organizer of parents' language input and children's subsequent word learning.

Child Gesture and Parents' Responsiveness in Typical Development

Young children use gesture in word-like ways before producing their first words, and these gestures predict the content and size of their vocabularies in speech. For example, the earlier a child indicates an object in gesture, the earlier the word referring to that object will enter the child's spoken vocabulary (Iverson & Goldin-Meadow, 2005). Similarly, the greater number of different objects children indicate in gesture at 14 months, the greater that child's vocabulary will be at age 4 (Rowe, Özçalı kan, & Goldin-Meadow, 2008). These studies thus suggest that gesture, particularly gestures that indicate objects (e.g., pointing), serve as good indicators of the TD child's readiness to take the next step in language acquisition and the size of their spoken language vocabularies several years later.

What explains the close coupling between early gesture and subsequent spoken language development in TD children? Parents of TD children who are highly responsive to their children's gestures might play an important role in this process (Özçalı kan, & Goldin-Meadow, 2006, 2011). Parents routinely glean information from their children's gestures, providing labels for the referents children indicate in gesture (Marcos, 1991; Olson & Masur, 2011). Even more important, the verbal responses parents provide to their children's gestures benefit children's subsequent language development (Masur, 1982; Goldin-Meadow et al., 2007). Parents not only translate the majority (71%) of their children's pointing gestures into words (Masur, 1982), but these translations are also positively related to children's subsequent vocabularies. More specifically, the referents that a child conveys uniquely in gesture but not yet in speech (e.g., point at doll), when translated into words by the child's mother (e.g., 'Do you want your doll?'), are significantly more likely to enter the child's vocabulary as new words several months later, compared to the ones that are not translated (Goldin-Meadow et al., 2007), thus suggesting a close coupling between child gesture and parent's translation of this gesture as predictor of TD children's vocabulary development (see Özçalı kan & Dimitrova, 2013, for a review).

Child Gesture and Parents' Responsiveness in Autism

Children with AU show weaknesses in gesture production compared to their TD peers (e.g., Colgan, Lanter, McComish, Watson, Crais, & Baranek, 2006; Mitchell et al., 2006; Mundy, Sigman, Ungerer, & Sherman, 1986), with a particularly pronounced deficit in deictic gestures (i.e., pointing) in communicative contexts that elicit sharing of interest and attention around objects (e.g., Camaioni, Perucchini, Muratori, Parrini, & Cesari, 2003; Özçalı kan, Adamson, & Dimitrova, under review; Stone, Ousley, Yoder, Hogan, & Hepburn, 1997). This early difficulty children with AU have with pointing has in fact been identified as one of the key predictors for a diagnosis of autism (Mundy, Sigman, & Kasari, 1990). Children with AU also have difficulties with the use of conventional gestures, such as waving

goodbye or head nodding (Stone et al., 1997; Wetherby, Prizant, & Hutchinson, 1998). However, for older children with AU who develop narrative abilities, production of iconic gestures shows a relative strength compared to deictic gestures (Capps, Kehres, & Sigman, 1998; de Marchena & Eigsti, 2010).

Although autism may affect a child's production of gestures, the relation that gesture holds to language development remains largely intact. An earlier study (Özçalı kan et al., under review) that examined the relation between early gesture and later vocabulary in children with AU showed that 30-month-old children with AU used similar types of gestures (deictics, emblems, gives, iconics) as TD children in their early communications with their parents, but at significantly lower rates—a difference that was particularly pronounced for deictic gestures (see also Mitchell et al., 2006; Mundy et al., 1986). More importantly, the amount of early deictic gestures children with AU produced were positively related to the size of later receptive (Luyster, Kadlec, Carter, & Tager-Flusberg, 2008; Smith, Mirenda, & Zaidman-Zait, 2007) and expressive vocabularies in speech (Gulsrud, Hellemann, Freeman, & Kasari, 2014; Özçalı kan et al., under review), suggesting a tight positive link between early deictic gestures and later vocabulary in children with AU.

Research thus far suggests that children with AU *do* gesture, albeit at lower rates compared to TD children. The question still remains, however, whether parents of children with AU respond to the gestures their children produce in similar ways as parents of TD children, even though their children gesture at much lower rates; and if so, whether these parental responses have a similar effect on their children's subsequent language development, predicting the acquisition of new words. Most of the earlier work on parents' responsiveness to children with AU focused on parents' responses to a broader range of child communicative behaviors, such as the child's focus of attention and verbal behaviors. Two studies that examined parents' responsiveness to the *focus of attention* of young children with AU showed that parents' verbal responses that followed the child's focus of attention were associated with better language outcomes compared to responses that redirected the child's focus of attention (McDuffie & Yoder, 2010; Siller & Sigman, 2002, 2008). Similar beneficial effects on vocabulary development have been reported for parents' responses to the verbal utterances of children with AU. The number of verbal expansions parents provided in response to the speech of their minimally-verbal 3-year-old children was positively related to children's spoken vocabulary size 6 months later (McDuffie & Yoder, 2010). More recently, Yoder, Watson, and Lambert (2015) examined parental responsiveness to children's attentional and communicative leads during parent-child play, also showing parental responsiveness to be a reliable value-added predictor of both expressive and receptive spoken language growth in preschoolers with AU.

Some intervention studies have examined the effect of combining multiple response strategies in parent-child interactions (e.g., imitations and expansions, turn-taking routines, simplified language) on later vocabulary development of children with AU, showing small to moderate gains in vocabulary development (e.g., Green et al., 2010; Siller, Hutman, & Sigman, 2013). However, several of these studies were either too preliminary (e.g., Wilcox, 1992; Wilcox, Shannon, & Bacon, 1992) or showed no direct effect of parental responsiveness on child expressive vocabulary (e.g., Aldred, Green, & Adams, 2004;

Venker, McDuffie, Weismer, & Abbeduto, 2011), suggesting the need for additional research that focuses on the complex mechanisms with which parental responsiveness might impact vocabulary development of children with AU.

Despite numerous studies that largely examined parents' responsiveness to children's verbal behaviors, there is very little work on parents' responsiveness to the gestures that children with AU produce. The few existing studies (Haebig, McDuffie, & Weismer, 2013; McDuffie & Yoder, 2010) focused on parents' responsiveness to a broader range of nonverbal child communicative behaviors, including not only gestures but also baby signs, non-word vocalizations, and Picture Exchange Communication System (PECS) symbols; none of these studies showed a significant relation between these broad early nonverbal behaviors and later language outcomes. For example, McDuffie and Yoder (2010) found no relationship between parents' responses to their 3-year-old children's nonverbal communicative acts and children's later expressive vocabulary, as measured by the MacArthur-Bates Communicative Development Inventory (MCDI, Fenson et al., 1993). Similarly, Haebig et al. (2013) found no relation between parents' responsiveness to their 2½-year-old children's nonverbal communications and children's language 3 years later, as measured by the Preschool Language Scales (PLS-4, Zimmerman, Steiner, & Pond, 2002; but see Leezenbaum, Campbell, Butler, & Iverson, 2014, for a discussion on the positive impact of parents' responsiveness to the nonverbal communicative acts produced by children at heightened risk for AU). Thus, to date, there is no published work that specifically focuses on parents' responsiveness to gestures of children diagnosed with AU, particularly to gestures that indicate objects, which, as we note above, have been repeatedly shown to play a significant role in later vocabulary development. Gesture signals the child's readiness to take the next step in language learning (Iverson & Goldin-Meadow, 2005; Özçalı kan & Goldin-Meadow, 2005b) in a way that other nonverbal behaviors may not. Thus, targeted parent response to child gesture might prove to be a particularly effective tool in helping children with AU learn labels for referents that they indicate uniquely in gesture—a pattern that has been shown to be true for TD children (Goldin-Meadow et al., 2007).

Child Gesture and Parents' Responsiveness in Down Syndrome

Children with DS show extensive delays in expressive vocabulary development (Beeghly & Cicchetti, 1987; Chapman, 1995; Miller, 1999); consequently they rely heavily on the manual modality to compensate for the difficulties they encounter in spoken language, thus producing gestures and signs at rates comparable to (Iverson, Longobardi, & Caselli, 2003; Zampini, 2008; Zampini & D'Odorico, 2011), or, in some cases, even higher than TD children (Caselli et al., 1998; Franco & Wishart, 1995; Singer Harris, Bellugi, Bates, Jones, & Rossen, 1997; Stefanini, Caselli, & Volterra, 2007). The early gestures children with DS produce also show similarities to the types of gestures that TD children produce, including deictic, emblematic, give, and iconic gestures (Özçalı kan, Adamson, Dimitrova, Bailey, & Schmuck, 2015). In addition to spontaneous gestures, children with DS may also rely heavily on baby signs (i.e., iconic or arbitrary gestures taught deliberately by an adult) to convey information about objects and actions in their immediate environment. Interestingly, the individual variability observed in the production of early baby signs has been found to predict the variability in the size of children's spoken vocabularies one year later (Özçalı kan

et al., 2015; see also Mundy, Kasari, Sigman, & Ruskin, 1995, for a similar relation between early gestures that request objects and later vocabulary in children with DS). Thus, early gestures (as well as baby signs) have been shown to be an important component of the early communicative repertoires of children with DS.

Despite a growing interest in the nonverbal communicative development of children with DS, very little is known about parents' responsiveness to these early gestures. Existing work (Adamson, Bakeman, Deckner, & Nelson, 2012) suggests that parents of children with DS do not differ from parents of TD children in the amount and quality of communicative support that they provide to their children, although there is some indication that they are more likely to highlight words and other symbols during interactions. However, we do not yet know whether parents of children with DS show similarities to parents of TD children in how often they translate their children's gestures into words, and if so, whether these translations influence their children's subsequent vocabulary development.

Current Study

In this study, we focus on gesture as a nonverbal communicative tool that uniquely marks the child's readiness to take the next step in language learning. More specifically, we study the effects of parents' translations of child gesture on the child's subsequent expressive vocabulary, comparing two groups of children with neurodevelopmental disorders (AU, DS). These two groups of children show distinctive patterns of strengths and weaknesses in speech and gesture production, making them an ideal comparison pair to understand whether and how gesture is part of the process of language learning in children with developmental disorders. Even though both groups of children show difficulties in speech development, children with DS show particular strengths in gesture use—producing gestures at rates at least comparable to mental-age matched TD children (Stefanini et al., 2007)—while children with ASD often exhibit difficulties in gesture production, particularly in early pointing gestures (Mundy et al., 1990; Özçalıkan et al., under review).

We first ask whether parents of children with AU or with DS are as likely as parents of TD children to translate their children's gestures into words, regardless of differences in their children's gesture rates. Based on earlier work that shows similar rates of parental responsiveness to children at high- vs. low-risk for autism (Leezenbaum et al., 2014) and to children with DS (Adamson et al., 2012), we predict that parents of children with AU and with DS will be as responsive to their children's gestures as parents of TD children. We next ask whether parents' translations of the gestures that children with AU and children with DS produce have similar effects on their vocabulary development as they do for TD children. More specifically, we ask whether parents' verbal translations of the objects that children with AU and children with DS convey uniquely in gesture but not yet in speech would increase the likelihood of the words for these objects subsequently entering children's spoken vocabularies. Based on earlier work with TD children that showed positive effects of parental translation of child gesture in subsequent vocabulary development (Goldin-Meadow et al., 2007), we predict that children with AU and with DS would show similar beneficial effects of parental translations, namely that the gestures parents translate would be more

likely to enter children's spoken vocabularies than the ones that have not been translated by their parents.

Methods

Participants

The participants in this study were part of a longitudinal project on the development of joint engagement (Adamson, Bakeman, & Deckner, 2004; Adamson, Bakeman, Deckner, & Ronski, 2009). In this study we focus on the parent-child dyads of 23 TD children (18 boys; $M_{\text{age at initial observation}}=18$ months; range=18–18 months), 23 children with AU (20 boys; $M_{\text{age at initial observation}}=31$ months; range=21–37 months), and 23 children with DS (17 boys; $M_{\text{age at initial observation}}=30$ months; range=20–40 months), who were selected so that the three groups were comparable in their expressive vocabulary both for word tokens ($M_{\text{TD}}=168.26$ [SD=125.18] vs. $M_{\text{AU}}=172.91$ [SD=195.88] vs. $M_{\text{DS}}=145.43$, [SD=88.78]; Kruskal-Wallis, $\chi^2(2)=2.42$, $p=.30$), and for word types ($M_{\text{TD}}=28.43$ [SD=26.89] vs. $M_{\text{AU}}=39.65$ [SD=49.07] vs. $M_{\text{DS}}=18.35$, [SD=22.78]; $\chi^2(2)=3.15$, $p=.21$) at the initial observation. Children in each group were predominantly Caucasian (TD: 74%, AU: 83%; DS: 83%), and all were learning English as their native language. The dyads included mother and child with the exception of two father-child dyads. The parents in each group were comparable in age ($M_{\text{TD}}=32.39$ [SD=4.92], $M_{\text{AU}}=33.35$ [SD=3.34], $M_{\text{DS}}=37.65$ [SD=4.74]) and education; the majority of the parents of children with AU (65%), DS (78%) and TD (78%) had at least a college degree at the time of our initial observation. Attrition was relatively low; all of the TD children and children with DS, and the vast majority of the children with AU (19/23) participated in at least four of the five observation sessions.

As part of the inclusion criteria in the original study (Adamson et al., 2004), the children in the autism group were referred by one of the three clinicians associated with the project who had diagnosed the children with autism according to the DSM-IV-TR criteria for autistic disorder (American Psychiatric Association, 2000). Their parents were subsequently administered the Autism Diagnostic Interview-Revised (ADI-R; Lord, Rutter, & LeCouteur 1994), an interview that assesses behavior in three core domains of social interaction, communication, and restricted or repetitive behaviors. ADI-R results were consistent with the clinician referrals in all cases. All of the children scored above cut-off for autism on the social interaction and restricted or repetitive behavior domains; all but one scored above the cut-off on the communication domain, and this child scored just one point below cut-off on the nonverbal version of the communication domain.

Procedure for Data Collection

Parent-child interactions were video-recorded using the Communication Play Protocol (CPP; Adamson et al., 2004) 5 times over approximately a year, from child age 18 to 30 months for TD children, 31 to 43 months for children with AU, and 30 to 45 months for children with DS. CPP consists of a set of scenes aimed at gathering semi-naturalistic observations of parent-child interaction applicable to a diverse group of children. For our purposes, we used 4 five-minute CPP scenes at each observation session: two that encourage *requesting* (help getting toys from a high shelf, help playing with complex toys) and two that encourage

commenting (discussing pictures, discussing novel objects), for a total observation time of approximately 20 minutes per individual child per observation session.

Procedure for Data Coding

Child speech and gesture—We relied on transcripts that were previously transcribed for child's speech (Adamson et Bakeman, 2006) and coded for child's gesture (Özçalı kan et al., 2015, under review). Sounds that referred to entities, properties, or events (e.g., 'doggie', 'open'), along with onomatopoeic (e.g., 'meow'), and conventionalized evaluative sounds (e.g., 'oopsie') were counted as words. We also counted readily translatable word approximations (e.g., 'baba' to refer to bottle) as words but we did not count phonetically consistent forms that were not readily translated into a word. Gesture was defined as a symbolic communicative hand movement that does not involve direct manipulation of objects (e.g., twisting a jar open). The one exception was when the child brought an object to the parent's attention by holding up the object; we considered these show gestures as serving the same function as the pointing gestures and treated them as deictic gestures, following earlier work (Özçalı kan & Goldin-Meadow, 2005a, 2005b). In this study, we focused on two gesture types that conveyed information about objects, namely *deictic gestures* (i.e., gestures that indicate concrete objects or locations; e.g., pointing at or holding up a bottle to refer to the 'bottle') and *give gestures* (i.e., gestures that convey request for an object; e.g., extending empty open palm towards a bottle to convey 'give bottle'). The majority of the gestures were requests for objects for children AU (59%) but not for children with DS (40%), or for TD children (40%). Emblems (e.g., nodding the head to convey 'affirmation', shrugging shoulders to convey 'don't know') were excluded from all analyses because they did not convey information about objects. The very few iconic gestures children produced conveyed primarily action information and were also excluded from all analyses. Given our focus on gestures that were produced spontaneously by children, we excluded all baby signs (i.e., arbitrary or iconic signs taught deliberately by parents) from our analyses as well (see Özçalı kan et al., 2015, under review, for further details on children's use of emblematic and iconic gestures and baby signs in the three groups).

We further classified these deictic and give gestures each child produced in the initial observation session into two types, as either referring to objects already expressed in speech (e.g., child points to bottle and also produces the word 'bottle' within the initial observation session) or as referring to objects *not* yet expressed in speech (e.g., child points to bottle but does not produce the word 'bottle' during the initial observation session). We focused on gestures that referred to objects the child did *not* yet label in speech, creating a 'unique gesture vocabulary' for each individual child. Gestures that indicated objects already expressed in speech at initial observation were excluded from the analysis. We then examined children's speech for the emergence of spoken words for each of these unique gesture vocabulary items in the four subsequent observation sessions and coded whether each unique gesture vocabulary item *did* or *did not enter* the child's spoken vocabulary in the subsequent sessions. For brevity, in the remainder of this paper we use the term 'gesture' to refer only to deictic and give gestures that children produced to either indicate or request objects in the initial observation. We also use the term 'unique gesture' to refer to a

subcategory of such deictic and give gestures that children used to refer to objects not yet labeled in speech.

Parents' translation of child gesture—We relied on transcripts of parental speech (Adamson & Bakeman, 2006) and examined the immediate response each parent produced in reaction to their child's gestures that conveyed unique information not found in speech (e.g., child points to bottle but does not say the word 'bottle') in the initial observation session. We classified each parental reaction to their child's gesture as either providing a verbal response (e.g., 'that is a big bottle') or as not providing a verbal response (e.g., parent hands the child the bottle). We then specifically focused on parental reactions that provided verbal responses; we coded them further as either *translating* the child's unique gesture into words by providing an explicit label (e.g., 'that is a nice bottle') or as *not translating* the child's unique gesture into words (e.g., 'I will get it for you'), following the criteria outlined in Goldin-Meadow et al. (2007).

Reliability—Inter-coder agreement was assessed on a randomly selected 15% of the videotaped sessions by an independent coder, blind to the hypotheses of the study. Agreement between coders was 87% (TD: 91%, AU: 85%, DS: 86%) for identifying gestures, 92% (TD: 93%, AU: 94%, DS: 88%) for identifying gesture gloss, 94% (TD: 95%, AU: 97%, DS: 90%) for classifying gestures into gesture types, 100% (TD: 100%, AU: 100%, DS: 100%) for identifying referents conveyed uniquely in gesture, and 95% (TD: 100%, AU: 100%, DS: 85%) for classifying gestured items as either entering or not entering the child's spoken vocabulary. For each category of coding, the intraclass correlation coefficients were computed using a two-way mixed effects model; absolute agreement was above .98, showing high levels of agreement between coders.

Procedure for Data Analysis

We examined group differences in overall rates of children's gesture production with non-parametric Kruskal-Wallis tests due to the violation of the normality assumption in the distribution of the data. Gesture rates showed large group differences. We therefore converted all raw frequencies for unique gesture vocabulary and parents' translations of these gestures into proportions, and conducted all our statistical analyses on the arcsine-transformed proportions. We examined differences in the proportion of items expressed uniquely in gesture by the child and the translations of these gestures into words by the parent, using one-way ANOVAs—with group (TD, AU, DS) as a between-subjects factor. We also analyzed the effect of parents' translations on the likelihood of gestured vocabulary items entering children's spoken vocabulary with a two-way ANOVA, with *parents' translation* (translated, not translated) as within- and *group* (TD, AU, DS) as between-subjects factors. Three of the children with AU did not convey any referents uniquely in gesture in initial observation; we therefore excluded these 3 children from all analysis of parents' reactions to child gesture.

Results

We first examined whether children with AU or with DS were as likely as TD children to produce deictic and give gestures in order to indicate or request objects in the initial observation and found differences between the three groups, Kruskal-Wallis $\chi^2(2)=15.83$, $p<.001$: TD children gestured significantly more than both children with AU ($M_{TD}=40.70$ [SD=24.17] vs. $M_{AU}=16.04$ [SD=12.95], $\chi^2(1)=14.55$, $p<.001$) and children with DS ($M_{DS}=21.96$ [SD=19.82], $\chi^2(1)=8.42$, $p=.004$), who, in turn, did not differ reliably from each other (DS vs. AU, $\chi^2(1)=.61$, $p=.44$). Importantly, in each group the majority of the gestures were unique, that is, they indicated or requested objects that a child had not yet expressed in speech with words rather than objects that the child already expressed in words as well (TD: 71% vs. 29%, AU: 69% vs. 31%, DS: 94% vs. 6%), although the proportion of production differed by group, $F(2,66)=5.71$, $p=.006$, $\eta^2_p=.14$. Overall, children with DS were significantly more likely to refer to or request objects uniquely in gesture than TD children ($p=.02$) and children with AU ($p=.01$; see Fig.1, Panel A). Taken together, these results show that children with developmental disorders were at least as likely as TD children to identify objects uniquely in gesture before referring to these objects in speech with words.

Turning to *parents' reactions to child gesture*, we next asked whether parents of children with developmental disorders were as likely as parents of TD children to provide verbal responses to their children's gestures. We found that parents in each group provided *verbal responses* to almost all of their children's unique gestures ($M_{TD}=91\%$ [SD=17]; $M_{AU}=93\%$ [SD=15]; $M_{DS}=98\%$ [SD=5]). Importantly, the majority of the verbal responses provided by parents included *translations* of children's unique gestures into words ($M_{TD}=74\%$ [SD=23]; $M_{AU}=77\%$ [SD=28]; $M_{DS}=82\%$ [SD=23]), without any significant differences between the groups, $F(2,63)=.52$, $p=.60$ (see Fig. 1, Panel B).

Finally, turning to the effect of parents' translations of child gesture on children's subsequent vocabularies, we asked whether the words that the parents produced in response to their children's unique gestures were more likely to enter children's spoken vocabularies within the next year than words for the unique gestures that were not translated. For this analysis, we focused on the 23 TD children, 20 children with AU, and 23 children with DS who produced at least one item uniquely in gesture in the initial observation. Significantly greater proportion of unique gestures that were translated by parents entered children's vocabulary as words than unique gestures that were not translated, for TD children (61% vs. 47%), children with AU (47% vs. 30%), and children with DS (24% vs. 10%), showing a main effect of translation, $F(1,63)=5.97$, $p=.02$, $\eta^2_p=.09$. There was also a main effect of group, $F(2,63)=8.01$, $p=.001$, $\eta^2_p=.20$ —with children with DS acquiring lower proportion of the translated items as words compared to TD children (Bonferroni, $p=.001$), but no interaction between group and translation, $F(2,63)=.05$, $p=.95$.

Interestingly, the 16 children with developmental disorders (AU=7, DS=9) who did not have any gestured items entering their vocabulary also expressed fewer items uniquely in gesture at the initial observation ($M_{AU}=1.57$, range=1–3; $M_{DS}=2.89$, range=1–5) compared to their peers who had gestured items entering their vocabulary ($M_{AU}=4.08$, range=1–8, $N=13$; $M_{DS}=6.21$, range=1–14, $N=14$), suggesting that they provided minimal opportunities for

their parents to translate these gestures into words. Moreover, none of the few unique gestures that they did produce—even if the parents translated them—entered the spoken vocabularies one year later, highlighting the individual variability evident in the language acquisition of children with developmental disorders.

We next asked whether the effect of parent translation of child gesture on child vocabulary would be even stronger across the three groups if we focused on the children who acquired at least one of the gestured items that their parents translated into words, thus excluding the 18 children (7 with AU, 9 with DS, and 2 TD) who did not acquire any of the gestured items that their parents translated into words along with the 3 children with AU who did not convey any items uniquely in gesture at initial observation. Our analysis with this subsample of children (13 with AU, 14 with DS, 21 TD) who *did* provide their parents with multiple opportunities to translate unique gestures into words showed the same pattern of results but with a greater effect size for translation, including a main effect of translation ($F(1,45)=6.63$, $p=.013$, $\eta^2_p=.13$), a main effect of group ($F(2,45)=6.54$, $p=.003$, $\eta^2_p=.23$) but no interaction between group and translation ($F(2,45)=.30$, $p=.743$). Significantly greater proportion of unique gestures that were translated by parents entered children's vocabulary as words than unique gestures that were not translated (TD: 67% *vs.* 52%; AU: 73% *vs.* 46%; DS: 40% *vs.* 17%; see Fig.1, Panel C). Children with DS were also significantly less likely than both TD children (Bonferroni, $p=.006$) and children with AU (Bonferroni, $p=.012$) to have translated items entering their vocabularies; no such difference was found between children with AU and TD children ($p=1.00$). Taken together, these results show that parents' translations of gestures children with AU or with DS produce in order to uniquely identify objects were as effective as the translations provided by parents of TD children in increasing the likelihood of these labels entering children's subsequent spoken vocabularies, particularly for children with developmental disorders who convey a substantial number of objects uniquely in gesture.

Discussion

In this study, we asked whether parents of children with AU and parents of children with DS were as likely as parents of TD children to translate into words their children's gestures that uniquely identified objects and whether such parental translations had the same facilitative effect on the vocabulary development of children with AU and with DS as it did for TD children. We found affirmative evidence for both questions. Children in all three groups frequently indicated referents uniquely in gesture before they did so in speech. Importantly, parents in all three groups translated a high percentage of their children's gestures into words, providing spoken labels for those referents. Even more impressive, the referents parents translated into words were significantly more likely to subsequently enter the spoken vocabularies of children in each group than the ones that were not translated. The effect of parental translation on child vocabulary development was also particularly pronounced for children who show evidence of vocabulary growth over time.

Our study showed, for the first time, that children with AU and with DS are as likely as TD children to indicate and/or request objects uniquely in gesture before they do so with words. What might underlie this phenomenon that spans across children with different

developmental disorders who show unique profiles of gesture and speech production? One possible explanation is that gestures are easier to produce than words, not only for TD children but also for children with developmental disorders. Unlike words that involve opaque arbitrary form-to-meaning mappings, gestures involve relatively transparent and contextualized form-to-meaning relations. A child can convey a vast variety of items in gesture by extending an index finger towards the object—a task that might be cognitively less demanding than both remembering the verbal label for an object and articulating that label as a word. There is in fact considerable evidence (see Goldin-Meadow, 2011, 2014, for recent reviews) that suggests that children convey their emerging linguistic and cognitive abilities—from first words to first explanations of various cognitive tasks involving objects—initially in gesture before they can convey them exclusively in speech, using words. As such, gesture could serve as a unique communicative vehicle in sharing information about objects at the early stages of language learning, even for children with developmental disorders.

Even more important, our study showed—also for the first time—that the gestures children with AU and with DS produced to identify objects that they have not expressed in speech with words elicited timely parental verbal input that translated these gestures into words. It is especially noteworthy that parents' responsiveness did not vary across the three groups; parents of children with AU and with DS were as likely as parents of TD children to both verbally respond and provide translations of the unique gestures that their children produced. This result extends existing studies that showed similar rates with which parents respond to gestures produced by children at both low and high risk for autism (Leezenbaum et al., 2014); it also confirms that the child's neurodevelopmental status does not interfere with the propensity of parents to provide immediate contingent and relevant verbal responses to their children's gestures.

Perhaps the most important finding of our study was that parents' translations of the gestures that children with AU, with DS, and TD children produced had similar positive effects on the subsequent vocabulary development of children in all three groups, a pattern shown previously only for TD children (Goldin-Meadow et al., 2007). Why does parents' translation of child gestures play such a powerful role in children's vocabulary development? One possible explanation is that children's gestures provide cues to the parents about their child's readiness to learn a particular concept. As shown in earlier work (Goldin-Meadow et al., 2007; Marcos, 1991; Olson & Masur, 2011), parents can easily glean information from the gestures that their children produce and closely tailor their verbal responses to the communicative interests of the child as indexed by gesture. Such immediate translations, in turn, allow the child to more easily map the verbal label onto the object of interest conveyed in gesture. Results of studies with slightly older children with AU in other communicative contexts, such as situations when parents verbally follow in children's focus of attention as indexed by the child's gaze, suggest that parents' verbal translations may have beneficial effects on language development (McDuffie & Yoder, 2010; Siller & Sigman, 2002, 2008). In other words, with their responses, parents provide the verbal labels for the targets of children's object-directed gestures and scaffold on children's existing communicative abilities in a way that acknowledges the child's current communication. This calibrated verbal response might in turn provide the critical input essential in making the transition

from gesture to word for the language-learning child. Importantly, such positive finding has the potential to inform parent-implemented intervention programs that focus on early language development of children with developmental disorders. At the same time, however, several previous intervention studies have shown that parental responsiveness to children's early communicative acts does not have a direct causal effect on children's spoken language abilities (Aldred et al., 2004; Venker et al., 2011), thereby pointing to the complexity of the factors that might contribute to the effects of parental responsiveness.

Our results also show some differences from what has been shown in earlier work. For example, some of the previous work (Haebig et al., 2013; McDuffie & Yoder, 2010) did not show evidence of an effect of parents' translation of child gesture in the subsequent language development of children with AU. However, this earlier work relied on standardized vocabulary assessments (e.g., MCDI, Fenson et al., 2003; PLS-4, Zimmerman et al., 2002) as the outcome measure rather than focusing on the emergence of individual vocabulary items in children's spontaneous language use in parent-child interactions. Thus, our study, which focused on the emergence of individual vocabulary items unique to each child across the two modalities, has the advantage of capturing a more accurate estimate of the child's burgeoning lexicon in speech, and as such, may serve as a better indicator of the role parents' responsiveness plays in this process.

The facilitative effect of parents' responsiveness to children's gestures on enhancing spoken language development is contingent on the opportunities that children provide for parents to produce such input. Children in all groups were comparable in terms of expressive language but not in terms of gesture production—children with neurodevelopmental disorders gestured at lower rates compared to their TD peers (see Özçalı kan et al., 2015, under review, for more details on children's gesture production), thus limiting the parental opportunities to provide translations for their gestures. This highlights how the transactional process of early language learning may influence and delay language learning in children with neurodevelopmental disorders (Sameroff & Fiese, 2000; Wetherby & Prizant, 2000).

It is also important to note that not all children in our sample seemed to benefit from parents' responsiveness on their subsequent vocabulary development. In fact, 7 (35%) of the children with AU and 9 (39%) of the children with DS in our sample did not have any unique gesture items that entered their vocabulary—even if their parents translated these gestures into words. A closer look at this subset of children who did not benefit from parental translation showed that they differed from their peers who acquired words for the items initially expressed uniquely in gesture: children with AU and DS who did not acquire in speech any item initially expressed uniquely in gesture in fact referred to fewer items uniquely in gesture, thus possibly failing to provide sufficient opportunities for their parents to translate such gestures into words. Moreover, their spoken vocabulary one year later remained limited—with majority of them (75%) producing fewer than 50 words. At the same time, however, children with DS produced a higher proportion of items uniquely in gesture than children with AU, but the relative gains in vocabulary development one year later were comparable in the two groups (in terms of the likelihood of unique gestures becoming words), suggesting that the lower rate of unique gesture production might not be the only factor in explaining variability in vocabulary growth, especially in children with developmental

disorders. Our findings on lower vocabulary gain in DS were also consistent with most of the earlier work that showed reduced spoken language abilities in children with DS, largely due to the phonological difficulties these children show in word production (Beeghly & Cicchetti, 1987; Miller, 1999). It also remains a possibility that different types of parental responsiveness might play optimal facilitative effects for children at different stages of vocabulary development. For example, children with low verbal skills might benefit most from responsiveness to their attentional focus—not gesture per se—as they are just beginning to build joint attention with communicative partners (e.g., Haebig et al., 2013); on the other hand, children with relatively better verbal skills (as in the current study) might attain greater gains from parental responsiveness to their gestures as they have already begun to identify and jointly focus on referents in their immediate environment. Future work examining the possible relations between types of parental responsiveness to children at different levels of verbal development might shed further light onto this question.

In summary, our results show that the targeted parental input to child gesture is important for language development in children with AU and in children with DS. By being finely tuned to children's focus of attention, parents can glean information from children's gestures in order to provide the right information at the right time. Our findings extend previous findings on TD children to children with neurodevelopmental disorders, showing the important role children's gestures play in their own language development—largely through its effects on parents' responsiveness to these gestures

Acknowledgments

We thank the participating families for their dedication to our research efforts. We also thank Lauren Schmuck and Jhonelle Bailey for their help in coding the data, along with the Action Editor and the reviewers for their helpful comments on earlier versions of the manuscript.

This study was approved by an ethics committee and has therefore been performed in accordance with the ethical standards specified in the 1964 Declaration of Helsinki and its later amendments. All parents provided informed consent for their and their child's participation prior to their inclusion in the study.

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Figure.