Research Article

Maternal Responsiveness to Gestures in Children With Down Syndrome

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Purpose: This study compared gesture use in young children with Down syndrome (DS) and typical development (TD) as well as how mothers respond to child gestures based on child age and diagnosis.

Method: Twenty-two mother–child dyads with DS and 22 mother–child dyads with TD participated. The child participants were between 22 and 63 months and were matched on chronological age. We coded child gesture use and whether mothers recoded child gestures (i.e., provided a verbal translation) during naturalistic interactions.

Results: The children with DS used more gestures than peers with TD. After controlling for expressive language ability, the two groups were not significantly different on child gesture use. Regardless of child diagnosis, mothers recoded approximately the same percentage of child gestures. There

was a significant interaction between child diagnosis and child age when predicting the percentage of maternal gesture recodes; mothers of children with DS did not demonstrate differences in the percentage of maternal gesture recodes based on child age, but there was a negative relationship between the percentage of maternal gesture recodes and child age for the children with TD.

Conclusions: Young children with DS gesture more than chronological age–matched children with TD, therefore providing numerous opportunities for caregivers to recode child gestures and support language development. Early intervention should focus on increasing parent responsiveness to child gestures earlier in life in order to provide additional word-learning opportunities for children with DS.

Down syndrome (DS) is the most common chromosomal cause of intellectual disability, occurring at a rate of one in every 691 live births (Parker et al., 2010). Unlike many other disabilities, families of children with DS typically know of the child's diagnosis preceding or shortly after birth; thus, early intervention services often start in the first year of life (Cuckle & Maymon, 2016). Children with DS receive early intervention due to identified language deficits (Martin, Klusek, Estigarribia, & Roberts, 2009), and this intervention generally focuses on supporting communication development during parent–child interactions (Kaiser & Hancock, 2003). Early intervention often includes supporting child gestures and introducing sign language (Wright, Kaiser, Reikowsky, & Roberts, 2013; Yoder & Warren, 2002), given that research shows that children with DS may gesture more than children with typical development (TD; Caselli et al., 1998; Stefanini, Caselli, & Volterra, 2007). In fact, previous research has

referred to this as a “gesture advantage” in children with DS (Caselli et al., 1998), although this argument continues to be a topic of discussion in the literature (Stefanini et al., 2007; Zampini & D’Odorico, 2008). Child gesture use is a particularly important area to study during mother–child interactions because children with DS may be able to learn new words when their mothers acknowledge and verbally translate their gestures (Dimitrova, Özçalışkan, & Adamson, 2016). This parent communication act has been called a recode in the literature (Sterling & Warren, 2014; Warren, Brady, Sterling, Fleming, & Marquis, 2010). Past research on mother–child interactions in DS has largely focused on describing maternal behaviors, with limited research focusing specifically on maternal responsivity to child gesture use and how this may vary depending on a child's age. Thus, this study examined gesture use in children with DS compared to children with TD and the relationship between maternal responsivity to child gestures and child age during mother–child interactions.

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Communicative Abilities in Children With DS

The majority of children with DS have a moderate intellectual disability resulting from a third copy of the 21st chromosome (Pueschel, 1995). Children with DS also

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have language disorders that begin early in life (Caselli et al., 1998; Slonims & McConachie, 2006). Although children with DS have overall language deficits, they present with an uneven profile of communication abilities, with receptive language ability in line with mental age and expressive language ability often below mental age expectations (Martin et al., 2009). Compared to expressive language abilities, children with DS demonstrate relatively better gesture use, a communication modality that also plays an important role in early communication development in children with TD (Caselli, Monaco, Trasciani, & Vicari, 2008; Iverson, Longobardi, & Caselli, 2003; Stefanini et al., 2007).

Gestures are one of the first forms of communication and support language development (Luyster, Kadlec, Carter, & Tager-Flusberg, 2008; McDuffie, Yoder, & Stone, 2005). Within the first year of life, children with TD use gestures to communicate for a variety of purposes, including requesting and initiating social engagement (Shumway & Wetherby, 2009). In 1-year-old children with TD, gesture use is closely related to both receptive and expressive language abilities (Bates, Thal, Whitesell, Fenson, & Oakes, 1989), indicating an intimate relationship between gestures and language during early language development. Gestures also predict language development in children with TD and children with DS (Capone & McGregor, 2004; Rowe, Özçalışkan, & Goldin-Meadow, 2008; Zampini & D'Odorico, 2008). In one study, the quantity of gestures children with TD produced at 14 months predicted their language comprehension scores at 42 months (Rowe et al., 2008). A study on young children with DS found that the total number of gestures produced as well as the total number of different gestures used at 36 months predicted vocabulary production at 42 months (Zampini & D'Odorico, 2008). Although gestures are important for children with TD early in life, children with TD typically transition to producing more language than gestures before 2 years of age (Caselli et al., 1998; Iverson, Capirci, & Caselli, 1994). In children with DS, the transition to spoken language is much slower and qualitatively different. Because children with DS often have decreased speech intelligibility (Martin et al., 2009) and language deficits extending beyond early childhood (Finestack, Sterling, & Abbeduto, 2013), children with DS often rely on gestures far longer than children with TD as a way to augment spoken words as language develops. Fortunately, children with DS demonstrate less difficulty learning and producing gestures as compared to spoken words (Stefanini et al., 2007), which may help children with DS compensate for speech and language deficits.

The increased use of gestures compared to spoken language in children with DS is well documented in the literature (Attwood, 1988; Caselli et al., 1998; Stefanini et al., 2007). Caselli et al. (1998) found that young children with DS produced more gestures than peers with TD matched on word comprehension. Another study found that children with DS used overall more gestures than both their chronologically and developmentally matched peers during a previously designed Italian lexical production task, which was a picture-naming task where the children were asked to

name nouns or predicates (i.e., actions, adverbs, and adjectives) based on a set of pictures (Stefanini et al., 2007). In addition to words, all child gestures were coded during the task, including deictic, iconic, conventional, and beat gestures. The children with DS produced an average of 32.4 gestures throughout the task, whereas the chronologically and developmentally matched groups produced an average of 21.2 and 7.1 gestures, respectively. Approximately 24% of the spoken responses from the children with DS were coded as unintelligible, whereas the two groups of children with TD both had fewer than 1% of unintelligible utterances. Stefanini et al. (2007) reasoned that the increased gesture use described in children with DS is likely the result of a speech disadvantage, because the children with DS were overall less intelligible during the picture-naming task.

Not all studies have found that children with DS gesture more than peers with TD (Iverson et al., 2003; Zampini & D'Odorico, 2008; Zampini, Fasolo, & D'Odorico, 2011). When matched on language ability, one study found that children with DS produced the same amount of gestures during play as the children with TD (Iverson et al., 2003). Zampini and D'Odorico (2008) argued that the disagreement in the literature may be the result of different methodologies given that some studies use parent report whereas others use direct observation and behavioral coding. In addition, different comparison groups and methodologies may contribute to contradictory findings. Expanding on this area of research by comparing age-matched groups and controlling for language ability is an important next step in this line of research given that two studies with contrasting findings have matched on either language ability or chronological age (Iverson et al., 2003; Stefanini et al., 2007). No study to date has simultaneously accounted for both chronological age and language ability. Determining similarities and differences in communication between age-matched children with DS and TD is useful for understanding what support children with DS may need when communicating and interacting with communication partners early in life.

The Transactional Model of Language Development and Maternal Responsivity

Much of the parent-child interaction literature is based on the transactional model of communication (Sameroff & Chandler, 1975). Many studies have adopted this model, which acknowledges the cumulative and substantial impact of early interactions on child communication, social, emotional, and cognitive development (Ciciolla, Gerstein, & Crnic, 2014; Sameroff & Chandler, 1975; Sterling, Warren, Brady, & Fleming, 2013). The transactional model highlights the importance of both communication partners in the success of highly responsive communication exchanges. Maternal responsivity refers to a healthy and positive relationship between a mother and a child; this relationship is characterized by warmth, nurturance, stability, and specific behaviors, such as responses to child initiations and following the child's lead (Warren & Brady, 2007). High levels of maternal responsivity have a significant and cumulative

impact on development in children with TD as well as children with developmental disabilities (Dimitrova et al., 2016; Landry, Smith, Miller-Loncar, & Swank, 1998; Landry, Smith, Swank, Assel, & Vellet, 2001; Warren & Brady, 2007; Warren et al., 2010). However, as the transactional model stipulates, behaviors of both the mother and the child influence the interactional process, and several child factors can make a highly responsive interaction difficult. These child factors include language ability, intelligibility, cognition, chronological age, and child behaviors (Ciciolla et al., 2014; Sterling et al., 2013).

Young children with DS have delayed language, intellectual disability, and decreased speech intelligibility (Martin et al., 2009), which over time may affect maternal responsiveness. However, mothers of children with DS may identify that their child is using more gestures and acknowledge these gestures as a proxy for language development. Recoding, or providing an explicit label for the gesture, may be a way for mothers to teach words. If this is the case, it is possible that mothers of children with DS may increase their responsiveness to child gestures over time, as their children learn more gestures and continue to rely on gestures as an important mode of communication. Conversely, mothers of children with TD may decrease their responsiveness to child gestures as their children talk more and rely less on gestures to communicate. However, this hypothesis remains to be empirically tested. Understanding whether child age affects maternal responsiveness to gestures in DS is an important question because gesture use persists as an important communication modality beyond the first 2 years of life for children with DS, so identifying whether mothers acknowledge and respond to these gestures may be useful for continuing to investigate how mothers may impact expressive language development in children with DS.

Mothers of children with DS interact both similarly and differently with their children as compared to mothers of children with TD (Dimitrova et al., 2016; Johnson-Glenberg & Chapman, 2004; Kay-Raining Bird & Cleave, 2015). Regarding maternal responsiveness to child gestures, one study thus far found that mothers of children with DS recoded child gestures at the same rate as mothers of children with TD when the children were matched on expressive language ability (Dimitrova et al., 2016). Gesture recodes by the mothers facilitated word learning in both groups (Dimitrova et al., 2016). Specifically, the gestures that mothers recoded were more likely to enter the child's vocabulary a year later. Although the children with DS learned fewer of the recoded gestures compared to the children with TD, the children with DS demonstrated greater vocabulary growth for the words mothers recoded as opposed to the gestures referring to objects not recoded. The study by Dimitrova et al. (2016) mirrored a previous study in children with TD, showing that the gestures that the mothers recoded were more likely to enter the child's vocabulary compared to the gestures referencing objects that the mothers did not recode (Goldin-Meadow, Goodrich, Sauer, & Iverson, 2007). Goldin-Meadow et al. (2007) argued that child gestures may provide information to mothers through which they

can adjust their language input to meet their child's interests while also providing language for maximizing word-learning success, which may in turn help children make the transition from gestures to spoken language. Despite the fact that maternal gesture recodes appear useful for expressive language development in children with DS, it may be difficult for mothers of children with DS to remain responsive to these communication attempts as the children get older and the families transition away from parent-coached interventions. Nevertheless, mothers of children with DS and children with TD demonstrate the ability to acknowledge and respond to their child's gestures in meaningful and influential ways, but no research to date has identified if mothers respond differently to child gestures based on the child's age.

Purpose of This Study

This study examined differences between children with DS and children with TD on child gesture use. Given the significant language deficits in the children with DS, analyses also included a group comparison of child gesture use after controlling for expressive language ability. To our knowledge, no studies to date have matched the children on chronological age and controlled for expressive language ability to determine if gesture differences remain significant when taking into account language ability. Understanding gesture use in children with DS between ages 2 and 5 is also important because children with TD quickly depend less on gestures, yet the trajectory is not as clear for children with DS. In addition, limited work to date has investigated how mothers of children with DS recode child gestures in early childhood despite research showing the utility of this parent behavior (Dimitrova et al., 2016). The communicative abilities in children with DS, specifically that gesture use continues to develop and expressive language is a relative weakness, is a clinical feature of this population that does not mirror communicative abilities in children with TD. It is unclear how this uneven profile may differentially influence maternal responsiveness to child gesture use or if mothers of children with DS recognize the increased frequency of gestures and subsequently use these gestures as a means to scaffold language development. Understanding the relationship between child age and maternal gesture recodes is important because children with DS continue to rely on gestures for communication as peers with TD begin depending less on gestures and using more words. Describing the relationship between child age and maternal gesture recodes is an important step toward describing mother-child interactions in children with DS and a necessary precursor to early interventions that takes into account how mothers respond to child communication acts as well as how maternal communication changes based on child age. The purpose of this study was to examine child gesture use in children with DS compared to children with TD controlling for expressive language ability. In addition, this study examined the relationship between child age and maternal responsiveness to child gesture use, and how

this relationship may differ between children with DS and children with TD. The following questions were addressed:

1. Do children with DS gesture more compared to age-matched children with TD? Does the difference in gesture use remain significant when controlling for expressive language ability?
2. How do mothers respond to child gestures in DS and TD? How does maternal responsivity to child gestures differ based on the child's age and diagnosis?

We hypothesized the following: (a) The children with DS would gesture more than the children with TD given that gesture use may be a compensatory strategy in DS and thus provides a modality through which the children can effectively communicate with partners in their environment. (b) The increase in gesture use in the children with DS would remain significant when controlling for expressive language ability. (c) The mothers of children with DS would recode a greater percentage of child gestures compared to mothers of children with TD because young children with DS often use more gestures than words and mothers of children with DS may be more focused on explicitly responding to child communication attempts. (d) Regardless of child age, mothers of children with DS would recode a high percentage of their child's gestures, but this relationship would be different for children with TD; mothers of children with TD would recode a higher percentage of their child's gestures if the child was younger compared to older because the child would be using more words.

Method

Participants

The data analyzed in this study were analyzed retrospectively from a previous study on mother-child interactions in children with DS compared to children with TD (Sterling & Warren, 2014). The participants included two groups of mother-child dyads: 22 mothers and their children with DS and 22 mothers and their children with TD.

Children With DS

The 22 children with DS ranged from 22 to 63 months ($M = 42.8$, $SD = 12$). Eleven participants were male, and 11 participants were female. Per parent report, 21 participants had trisomy, and one participant had mosaicism. Participants were recruited from early intervention agencies, support groups, clinics, and the Kansas City Down Syndrome Guild in Kansas and Missouri. Nineteen children were White, two were African American, and one was Hispanic. Maternal education was defined as the total years of school completed. Maternal education for the mothers of children with DS ranged from 12 to 18 years ($M = 15.57$, $SD = 1.55$).

Children With TD

The 22 children with TD ranged from 26 to 63 months ($M = 44$, $SD = 10.4$). Twelve participants were male, and

10 participants were female. Participants were recruited from preschools, day cares, word-of-mouth, and the Infant Cognition Research Laboratory at the University of Kansas. All of the children with TD were White. Maternal education for the mothers of children with TD ranged from 11 to 18 years ($M = 16.14$, $SD = 2.06$).

Group Matching

The children were matched at the group level on chronological age, $t(42) = 0.37$, $p = .715$, $d = 0.11$, variance ratio = 1.20, meeting the recommendations set forth by Kover and Atwood (2013). At the group level, the mothers were similar on maternal education, $t(42) = -0.88$, $p = .383$, $d = 0.31$, variance ratio = 1.33. Matching on chronological age allows for investigation into how child age and diagnosis interact and impact maternal behaviors. In addition, we matched on chronological age because of the known influence mother-child interactions have on communication development and the fact that mothers may develop their interaction styles as the child ages. This rationale is consistent with the transactional model of communication (Sameroff & Chandler, 1975), which acknowledges the cumulative impact of parent-child interactions on child development. Matching on chronological age is also consistent with previous work in parent-child research (Sterling, Barnum, Skinner, Warren, & Fleming, 2012; Sterling & Warren, 2014). Given findings demonstrating a link between maternal education and parent interaction style (Hooper, Burchinal, Roberts, Zeisel, & Neebe, 1998; Lowe, Erickson, MacLean, Schrader, & Fuller, 2013; Mervis, Kistler, John, & Morris, 2012), we included groups that were similar based on maternal education.

Procedure

Assessments took place in the participant's home during a single 1- to 2-hr visit. The children completed a developmental assessment, and each mother-child dyad participated in three semistructured activities, including free-play, book reading, and making and eating a snack. A standard set of toys, books, and snacks were used for the interactions. An examiner read a standard set of instructions to the mothers prior to each activity. The three interactions were video-recorded for later analysis. Using the video clips of the three activities, the videos were edited to three 7-min segments, resulting in a total of 21 min of coded mother-child interaction per dyad. Each video was edited to a 7-min segment by starting immediately after the instructions until 7 min of interaction were completed. Two of the participants with DS did not eat solid food, so to ensure consistency in video length across all participants, free-play and book sharing were extended for only these two dyads and edited in the same way as previously described, by starting immediately after the instructions, but now including 10.5 min of interaction per activity, which resulted in a total of 21 min per dyad (i.e., 10.5 min of play and 10.5 min of book sharing for each of the two dyads).

Interaction Language Sample

Research assistants transcribed all of the mother–child interactions using standard conventions of the Systematic Analysis of Language Transcript (SALT) software (Miller & Iglesias, 2012). The percentage of intelligible words for each child participant was calculated. The children with TD were overall more intelligible than the group with DS, $t(42) = -7.70$, $p = .000$ (see Table 1). To calculate reliability, approximately 20% of the interactions were chosen at random and transcribed by a second, independent transcriber. Reliability was calculated line-by-line for the presence of unintelligible utterances. Overall agreement between transcribers was 87.63%.

Developmental Assessment

Each child completed a play-based developmental assessment, the Mullen Scales of Early Learning (MSEL; Mullen, 1995), which was administered by a trained examiner. The MSEL is a standardized developmental assessment composed of five subscales, including Gross Motor, Visual Reception, Fine Motor, Expressive Language, and Receptive Language. The Gross Motor subscale is not factored into the overall composite score and thus was not completed. All other subscales were completed and used to generate an overall early learning composite score with a mean of 100 and a standard deviation of 15. See Table 1 for descriptive statistics on expressive and receptive language subscales.

Coding

Child Gesture Coding

We obtained a quantitative measure of child gesture use by coding the videos of the mother–child interactions using ProCoder for Digital Video (Tapp, 2003). Two trained coders identified all instances of child gesture use. We defined a gesture as any intentional hand or head movement that did not include object manipulation and was used to express an idea or communicate information (Dimitrova et al., 2016; Iverson et al., 2003). All child gestures had to be paired with a joint referent or adult attention. Therefore, coders identified all symbolic, deictic, emphatic, and descriptive gestures. Signs, points, head nods, shows, and gives are a few examples

of child behaviors coded as gestures, although additional types of gestures were coded. Eye gaze and facial expressions were not coded. If a child used sign language, including baby sign, these communication acts were coded as signs but were also included in the total number of gestures produced. Therefore, we obtained a measure of the total number of gestures, including signs as well as the total number of signs produced during the 21 minutes of dyadic interactions.

Maternal Coding

The second step was to identify if a maternal gesture recode followed the child gesture. Therefore, every child gesture code was followed with either a code of maternal gesture recode or no maternal gesture recode. We defined a maternal gesture recode as a direct spoken translation of the child's gesture either with or without a maternal gesture. It is important to note that this study did not distinguish between the presence or absence of a maternal gesture as part of the recode, but only whether or not the mother verbally recoded the child gesture. Each maternal gesture recode had to include a specific label. When the mother did not verbally recode the child gesture, the child gesture received a code of no maternal gesture recode. If the mother recoded the child gesture by verbally recoding the gesture or both verbally recoding the gesture and copying the child's gesture, the gesture received a code of maternal gesture recode. For example, a child gesture would receive maternal gesture recode if a child pointed to a picture of a dog and the parent said, "dog," or if the child signed "more" to get more snack and the mother said, "You want more snack." If the child pointed to a toy and the mother said, "Here you go," while handing the child the toy or if the child nodded to obtain a toy and the mother handed the child the toy without speaking, the gesture would be coded as no maternal gesture recode.

Because the number of child gestures varied across children, we calculated the percentage of total child gestures receiving a code of maternal gesture recode or no maternal gesture recode. To calculate the percentage of maternal gesture recodes, the number of child gestures recoded was divided by the total number of child gestures produced and multiplied by 100. Similarly, we divided the

Table 1. Descriptive statistics for child variables.

Variable	Down syndrome		Typically developing		Group comparisons ^a
	<i>n</i> = 22 (11 boys, 11 girls)		<i>n</i> = 22 (12 boys, 10 girls)		
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Expressive language raw score ^b	21.32	7.42	41.48	7.65	<i>p</i> < .001
Receptive language raw score ^b	26.50	8.19	39.76	6.43	<i>p</i> < .001
Early learning composite ^b	56.41	8.86	115.33	18.41	<i>p</i> < .001
Percent intelligible words ^c	96.68	2.90	41.51	33.50	<i>p</i> < .001

^aIndependent samples *t* tests between groups. ^bAs measured by the Mullen Scales of Early Learning. ^cAs measured by the Systematic Analysis of Language Transcripts.

number of child gestures not recoded by the total number of child gestures and multiplied by 100 to compute the percentage of child gestures not recoded. Percentages of maternal gesture recodes, rather than rates, were used because child gesture use varied and percentages captured how often mothers recoded child gestures when provided the opportunity regardless of how often the child gestured. Thus, mothers were not at an advantage nor were penalized based on the amount of child gesture use. In addition, utilizing percentages for analyses is consistent with past work on maternal gesture recodes in DS and TD (Dimitrova et al., 2016).

Child Gesture and Maternal Coding Reliability

Prior to coding participant files from this study, coders reached a training criterion of at least 80% agreement across all child and mother codes on three samples independent of the files used in this study. Once criterion was met, the two coders independently coded each file included in this study. We then compared the files, and disagreements were consensus coded for all video files. For child gesture use, reliability was measured by calculating intraclass correlation coefficients (ICCs) between the primary and reliability codes, using the absolute agreement and single measure values (Shrout & Fleiss, 1979). Given the ratio nature of the child data, ICCs are the recommended measure of reliability (Hallgren, 2012). ICC values at or above .75 are considered excellent (Hallgren, 2012). The ICC for the total number of child gestures was .96. Reliability for the maternal gesture recode codes was measured by calculating Cohen's kappas given the nominal nature of the coding scheme (Hallgren, 2012). Cohen's kappas for the gestures coded as no maternal gesture recode and maternal gesture recode were .84 and .92, respectively. Kappa values at or above .81 indicate near perfect agreement (Hallgren, 2012).

Data Analysis Plan

First, we compared child gesture use between groups using an independent samples *t* test with child gesture use as the dependent variable and diagnostic group as the independent variable. To determine the role of expressive language ability, we used multiple regression with child gesture use as the dependent variable and group diagnosis and expressive language ability as the independent variables. The variables were entered simultaneously to better understand which variable better predicted child gesture use. The multiple regression included raw scores of the expressive language subscale of the MSEL as the measurement of expressive language given the floor effects on standard scores observed for the group with DS. More specifically, 11 of the 22 participants with DS in this study received a standard score of 20 on the MSEL, which is the lowest possible score. By using raw scores, we were able to capture the variability in expressive language abilities in the participants with DS, which were masked by standard scores. Other studies including participants with intellectual and developmental disabilities also used raw scores (Brady, Warren, Fleming,

Keller, & Sterling, 2014; Luyster et al., 2008; Sterling & Abbeduto, 2012). Post hoc analyses to better understand child gesture use included simple linear regression to determine if child chronological age predicted gesture use in either group and if child chronological age predicted sign language use in the group with DS.

To address Research Question 2, we used an independent samples *t* test to investigate group differences in maternal gesture recodes. To address the second part of Research Question 2 and explore maternal gesture recode differences between groups as a function of child age, we used a between-subjects univariate analysis of variance with diagnosis (i.e., DS or TD) as a fixed factor and child chronological age as a continuous variable. We planned to follow up any significant findings with post hoc analyses separating the groups and using correlations between child chronological age and percentage of maternal gesture recodes to investigate relationships between the variables within each group.

Results

Research Question 1

The children with DS averaged 82.59 ($SD = 41.70$) gestures during the 21 min of interaction, and the children with TD averaged 51.18 ($SD = 17.62$) gestures (see Figure 1). An independent samples *t* test indicated a significant difference between the two groups, $t(42) = 3.21$, $p = .003$, $\eta_p^2 = .20$. The result of the multiple regression indicated that expressive language ability and child diagnosis together significantly explained 19.20% of the total variance in child gesture

Figure 1. Child gesture use in Down syndrome (DS) and typical development (TD). ** $p < .010$.

use, $F(2, 40) = 4.77, p = .014$. Neither child diagnosis nor expressive language ability individually predicted child gesture use in the overall model (see Table 2 for the individual predictors).

To further understand child gesture use in each group, we conducted post hoc analyses using two simple regression models to investigate if child chronological age predicted child gesture use. Child chronological age did not predict child gesture use for the children with DS, $t(20) = -0.87, p = .397, \eta_p^2 = .04$, nor the children with TD, $t(20) = 0.19, p = .848, \eta_p^2 = .00$. We also looked at if child chronological age predicted the use of sign language for the group with DS. The children with DS averaged 6.09 signs ($SD = 8.08$) during the 21 min of interaction, and the children with TD averaged 0.09 signs ($SD = 0.29$). Child chronological age did not predict child sign language use for the children with DS, $t(20) = -0.07, p = .648, \eta_p^2 = .01$. We did not look at the relationship between child chronological age and sign language use in the children with TD given the relatively minimal use of sign language in the group with TD.

Research Question 2

The average percentages of gestures with no maternal gesture recode were 58% ($SD = 13\%$, range = 18%–81%) in the group with DS and 59% ($SD = 12\%$, range = 32%–81%) in the group with TD. The average percentages of maternal gesture recodes were 42% ($SD = 13\%$, range = 19%–72%) in the group with DS and 41% ($SD = 12\%$, range = 19%–68%) in the group with TD. Using an independent samples t test, we did not find a significant difference in the percentage of maternal gesture recodes, $t(42) = 0.30, p = .767, \eta_p^2 = .00$. The between-subjects univariate analysis of variance investigating maternal gesture recodes based on child chronological age and diagnosis yielded a significant interaction: $F(1, 40) = 3.18, p = .003, \eta_p^2 = .20$. Figure 2 illustrates the interaction between diagnosis and child chronological age in predicting maternal gesture recodes. Based on the significant interaction, we conducted post hoc analyses to determine if child chronological age was correlated with the percentage of maternal gesture recodes within each group. For the group with DS, child chronological age was not significantly correlated with the percentage of maternal gesture recodes, $r = .40, p = .069$.

Table 2. Summary of the multiple regression analyses predicting child gesture use.

Variable	<i>B</i>	<i>SE_B</i>	β	<i>p</i>	η_p^2
Intercept	113.18	15.60		.000	
Group diagnosis	22.80	16.83	.33	.183	.04
Expressive language raw score ^a	-0.37	0.68	-.13	.591	.01

Note. *B* = unstandardized regression coefficient; *SE_B* = standard error of the coefficient; β = standardized coefficient; η_p^2 = partial eta squared.

^aAs measured by the Mullen Scales of Early Learning.

Figure 2. Relationship between gesture recodes and child age in Down syndrome (DS) and typical development (TD).

For the group with TD, child chronological age was significantly correlated with the percentage of maternal gesture recodes, $r = -.51, p = .016$.

Discussion

This study sought to better understand gesture use in young children with DS as well as how mothers of children with DS respond to this aspect of communication compared to mothers of children with TD. We found that young children with DS gestured more than chronological age-matched children with TD. This difference did not remain significant when including expressive language ability in the regression model as a covariate. Despite the fact that the children with DS gestured more often, the mothers in both groups recoded the same percentage of child gestures. However, the mothers of children with DS recoded child gestures similarly regardless of age. There was a significant negative relationship between maternal gesture recodes and child age for the children with TD. The differences between the children with DS and the children with TD as well as the similarities and differences between the mothers of these two groups suggest important clinical implications as well as future directions for continued research in this area.

Research Question 1: Gesture Comparison Between Groups

We examined whether children with DS gestured more than age-matched children with TD and whether this difference remained when taking into account expressive

language ability. Our findings support our hypothesis that children with DS gesture more than peers with TD. However, our findings do not support our second hypothesis that child diagnosis would remain a significant predictor of child gesture use after accounting for language ability. The omnibus *F* test in the multiple regression was significant, whereas neither expressive language ability nor child diagnosis were individually significant, indicating that expressive language ability and child diagnosis overlap in terms of the variance they explain in child gesture use. Thus, both expressive language ability and child diagnosis appear to simultaneously contribute to gesture use. Therefore, children with DS seem to be using gestures as a compensatory strategy to overcome communication deficits in DS.

Our results complement previous studies comparing gesture use in children with DS and children with TD (Iverson et al., 2003; Zampini & D'Odorico, 2008) and perhaps shed light on what statistical design and child factors may influence previous contradictory findings on gesture use in children with DS compared to children with TD. As children with DS progress through their early years, they often struggle to develop expressive language skills. However, given the increased use of gestures for children with DS in this study, it may be the case that these children continue to develop better communication skills through gestures while gradually increasing their ability to use spoken words. Because the transition to primarily using spoken words typically happens by 2 years of age in children with TD (Caselli et al., 1998; Iverson et al., 1994), many of the children with TD in our study had likely moved beyond relying on gestures to communicate; this explains the finding that the children with DS used more gestures than the children with TD and can also explain the finding that, when controlling for expressive language ability, the two groups were no longer different in terms of child gesture use. Gesture use is seemingly a compensatory communicative strategy for children with DS.

Because children with DS have less intelligible speech in conjunction with significant language delays, some researchers argue that the fact that children with DS use more gestures than children with TD is actually a reflection of a speech disadvantage in DS (Caselli et al., 1998; Slonims & McConachie, 2006; Stefanini et al., 2007). We did not control for speech intelligibility, yet child diagnosis was no longer a significant predictor of child gesture use when controlling for expressive language ability, indicating that expressive language deficits in DS do play an important role in the increase in child gestures observed. Although this study did not investigate the additive impact of expressive language ability and speech intelligibility, it may be that speech intelligibility and expressive language ability in combination limit verbal communication success and result in the need for children with DS to utilize more gestures, although this remains to be tested. However, it is important to note that this study investigated young and, in some cases, preverbal children with DS, and when the children with DS were verbal, they were less intelligible than the group with TD. Nevertheless, the increased gesture use in

the group with DS may also stem from the strength that children with DS demonstrate in visuospatial skills over expressive language skills (Fidler, 2005; Jarrold, Baddeley, & Hewes, 1999). Specifically, children with DS demonstrate a strength in visual imitation (Fidler, 2005; Heimann, Ullstadius, & Swerlander, 1998), which may potentially contribute to more gesture use. In addition, children with DS demonstrate a relative ease with which they learn gestures over spoken words (Stefanini et al., 2007). The combination of language deficits in addition to both the identified strength in visual processing and the fact that children with DS acquire gestures as a form of communication more easily than spoken language may explain the increased use of gestures in the children with DS.

Research Question 2: Maternal Responsivity to Child Gestures

We investigated whether mothers of children with DS recode a greater percentage of their child's gestures compared to mothers of children with TD. We hypothesized that the mothers of children with DS would recode a greater percentage of child gestures because the mothers of the children with DS would likely have more experience recognizing child gestures as communication attempts. However, the two groups of mothers did not differ on the percentages of maternal gesture recodes. All of the mothers in the current study recognized and recoded child gestures. The mothers of children with DS did not recode a greater percentage of child gestures compared to the mothers of children with TD despite the expressive language deficits present in the children with DS. This finding is consistent with previous work, which found that mothers of children with DS and mothers of children with TD are equally responsive to child gestures (Dimitrova et al., 2016). In both groups, the mothers recoded approximately 40% of the child's nonverbal communication attempts. The lack of differences shows that, regardless of diagnosis, mothers are responding similarly to child gestures. In addition, the similarities between groups may indicate that, without instruction, mothers still recode child gestures because the mothers and children with TD likely did not receive any early intervention, and therefore, the mothers would have never received any guidance on using gesture recodes.

This study also investigated how maternal gesture recodes by mothers differed based on the child's age and diagnosis. We hypothesized that, regardless of child age, mothers of children with DS would recode a high percentage of their child's gestures. We also hypothesized that the mothers of children with TD would recode a higher percentage of their child's gestures if the child was younger and a lower percentage of their child's gestures if the child was older because the child would be using more words and rely less on gestures. We found a significant interaction between child diagnosis and chronological age in predicting maternal gesture recodes. As hypothesized, there was a negative relationship between maternal gesture recodes and child chronological age in the children with TD. This

finding makes sense, given that as children with TD get older, they also have better language skills and likely require fewer adult prompts and models when communicating. For the group with DS, there was not a decrease in maternal gesture recoding by child age, but rather mothers recoded a similar percentage of child gestures regardless of age. Children with DS do not seamlessly transition from gesture use to spoken language like we see in children with TD so mothers may continue recoding child gestures. Given the expressive language deficits in children with DS, mothers of children with DS may need to recode more child gestures overall. Children with DS gesture more than same-age peers, which provides opportunities for parents to recode these communication attempts to promote language development.

Clinical Implications

The young children with DS from this study gestured more often than the children with TD, yet this difference did not remain when controlling for expressive language. There were no significant relationships between child chronological age and overall gesture or sign language use in the group with DS. Our findings build on work demonstrating that children with DS have a propensity for using gestures to compensate for language delays. However, these gestures may not necessarily increase between 2 and 5 years of age. Children with DS make communicative gains in interventions that focus on gestures and sign language (Wright et al., 2013; Yoder & Warren, 2002), although it is important to note that teaching sign language rather than promoting all gestures may be more appropriate for supporting language development and communication independence. Because research shows that intelligibility and expressive language deficits present in children with DS beyond the early years (Finestack et al., 2013; Martin et al., 2009; Roberts et al., 2005), gesture use is a meaningful modality through which individuals with DS augment their spoken language abilities beyond early childhood. Helping caregivers recognize this modality of communication is important for successful interactions. In addition, the increased use of gestures compared to age-matched peers with TD subsequently provides more opportunities for language learning when caregivers recognize and recode these gestures.

Previous research has demonstrated the benefit that maternal gesture recoding of child gestures has on both children with TD and children with DS, indicating that children with DS were more likely to learn the vocabulary that their mother recoded compared to the gestures not recoded, albeit at a slower rate than children with TD (Dimitrova et al., 2016). The children with DS learned 24% of the words that the mothers recoded, whereas the children with TD learned 61% of the words recoded by their mothers (Dimitrova et al., 2016). This slower trajectory of learning in children with DS is not surprising, given the intellectual disability and language-learning difficulties present in the children with DS. However, the lower rate of learning may indicate that mothers of children with DS

need to capitalize on learning opportunities and recode even more of their child's gestures to further expand their child's vocabulary by creating an optimal learning environment. In our study, the mothers of children with DS and mothers of children with TD were recoding child gestures at the same rate, demonstrating that the mothers of children with DS were equally responsive to child gestures compared to mothers of children with TD. Although the mothers of children with DS were responsive to child gestures, indicating that mothers may recognize child gestures as opportunities to support language development, nearly 60% of child gestures on average were not recoded. The large percentage of gestures not recoded indicates that mothers of children with DS have many additional opportunities to promote word learning during naturalistic interactions. Specifically teaching mothers to identify and recode child gestures may result in fewer missed opportunities for language learning.

Limitations and Future Directions

This study added to our understanding of gesture use in children with DS and maternal recodes to child gestures based on child age. However, this study did have multiple limitations. The sample size was relatively small, therefore restricting power and constraining analyses. This study did not separate the impact of expressive language and speech intelligibility, both of which may play a unique role in the quantity of gestures children with DS produce. We also did not have information on motor speech abilities, which are impaired in children with DS (Rupela, Velleman, & Andrianopoulos, 2016). Future studies should aim to disentangle the influence of speech intelligibility, expressive language, and motor speech abilities on communication success and how deficits in these areas may result in compensatory strategies, such as an increase in gesture use, in DS compared to TD. In addition, fathers did not participate in this study, and the role of fathers in parent-child interactions for children with DS is a historically understudied area. Therefore, the inclusion of fathers and other caregivers represents an important future direction to better understand if the same patterns hold across caregivers or if different caregivers interact differently. Including fathers is particularly important given the increasing role fathers play in caregiving compared to previous decades (Riblett Wilkie, 1993).

The cross-sectional nature of this study does not allow for conclusions regarding how maternal responsiveness to child gestures changes over time and the affect of maternal responsiveness to child gestures on child language development. Furthermore, the single-instance, 21-minute interaction sample may not fully represent mother-child interactions. Mother-child interactions may change throughout the day based on intrinsic and extrinsic factors, such as the activity, environment, parent stress levels, and mood. Therefore, the 21 minutes may not capture daily fluctuations in interactions based on all of these factors among others. However, the home-based data collection does attempt to more

naturalistically study mother–child interactions. Future studies should utilize a longitudinal design to better understand how parents respond to child communication attempts over time and how responsiveness to child gesture use impacts child communication later in development. This study included a relatively wide range in child age (i.e., 22–63 months). Future studies should narrow in on specific ages to better understand maternal and child behaviors at specific points in development. Also including children with DS older than 5 years old in future studies is an important future direction to better understand both gesture development in DS as well as how maternal responsiveness to child gestures changes beyond the preschool years.

The current study found that mothers of children with DS did not recode child gestures differently based on child age. The study by Dimitrova et al. (2016) found that children with DS can learn new vocabulary from maternal recodes of child gestures. The children with DS in the study by Dimitrova et al. (2016) were using single words and gestures to communicate. Therefore, conclusions may only apply to children at a specific stage in language development. Next steps should examine how children with DS learn from gesture recodes at different ages and language abilities. In addition, future research is needed to determine if increasing gesture recodes through interventions such as parent coaching enhances language learning and results in larger expressive language gains over time. Future studies targeting gesture recodes during parent coaching should include parent implementation of strategies and address caregiver perspectives on implementation. Future research should investigate the role of maternal gesture use on child communication in children with DS. Specifically, research should identify if a relationship exists between parent and child gesture use as well as if maternal gestures affect child communicative abilities. Given the important role that language input has on child language ability and the common use of gestures in DS, the quantity and quality of maternal gestures may potentially play a role in the communication skills of children with DS, although this remains to be studied. In addition to the much-needed future research on gestures, studies are needed to examine how parents respond to other modalities and ways in which young children with DS may communicate, such as through eye gaze, facial expressions, and augmented communication. It is useful to understand whether maternal acknowledgment or recodes of these aspects of child communication result in child language gains.

Conclusions

Based on this study, young children with DS gesture more than age-matched peers with TD, but this difference does not remain significant after accounting for expressive language ability. Mothers of children with TD respond differently to child gestures based on the child's age, but this is not the case for the mothers of children with DS. As we continue to unpack how children with DS use gestures to compensate for language delays and the important role

parents play supporting both this communication modality as well as language development as a whole, intervention studies will be necessary to determine what level of maternal responsiveness to child gestures optimizes language learning for children with DS. Continuing to investigate parent–child interactions and child communication based on child chronological age will help us to better understand the trajectory of parenting and language learning in children with DS.

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