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ARTICLE

An investigation into maternal use of telegraphic input to children with Down syndrome

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Abstract

Maternal input influences language development in children with Down syndrome (DS) and typical development (TD). Telegraphic input, or simplified input violating English grammatical rules, is controversial in speech–language pathology, yet no research to date has investigated whether mothers of children with DS use telegraphic input. This study investigated the quality of linguistic input to children with DS compared to age-matched children with TD, and the relationship between maternal input and child language abilities. Mothers of children with DS simplified their input in multiple ways, by using a lower lexical diversity, shorter utterances, and more telegraphic input compared to mothers of children with TD. Telegraphic input was not significantly correlated with other aspects of maternal input or child language abilities. Since children with DS demonstrate specific deficits in grammatical compared to lexical abilities, future work should investigate the long-term influence of maternal telegraphic input on language development in children with DS.

Keywords: maternal input; Down syndrome; parent–child interactions

Introduction

The quality and quantity of maternal input to young children with typical development (TD) and Down syndrome (DS) plays a critical role in communication development (Bornstein *et al.*, 1992; Hart & Risley, 1995; Kay-Raining Bird, Gaskell, Babineau, & MacDonald, 2000; Warren & Brady, 2007). The quality of input can be described in many ways, such as through the function of the input (e.g., commenting, requesting) or the linguistic characteristics (e.g., grammaticality, lexical diversity). When comparing the input of mothers of children with DS and mothers of children with TD, research has found both similarities and differences between groups (Johnson-Glenberg & Chapman, 2004; Kay-Raining Bird & Cleave, 2015; Sterling & Warren, 2014). For example, when children are matched on expressive language ability, mothers of children with DS and TD introduce novel nouns in similar ways, such as by using short utterances and producing the noun in an utterance-final

position (Kay-Raining Bird & Cleave, 2015). In terms of differences, one study found that mothers of children with DS produced utterances with a longer mean length of utterance (MLU), a measure of grammatical complexity, compared to mothers of children with TD matched on expressive language (Johnson-Glenberg & Chapman, 2004). Identifying the relationship between maternal linguistic input and child language abilities can shed light on the ways in which mothers adjust their input, as well as the potential impact these changes may have on child language development, specifically for children with DS. In addition, understanding differences in maternal input based on child diagnosis provides the basis for future research to understand the bi-directional relationship between child language abilities and maternal linguistic input in this clinical population.

Children with DS

DS occurs at a rate of one in every 691 live births and is the most common chromosomal cause of intellectual disability (Parker *et al.*, 2010). Children with DS present with language deficits beginning early in development, in addition to intellectual disabilities (Caselli *et al.*, 1998; Pueschel, 1995; Slonims & McConachie, 2006). While overall language development is affected in DS, some areas of language are impacted more than others (Martin, Klusek, Estigarribia, & Roberts, 2009; Vicari, Caselli, & Tonucci, 2000). Children with DS demonstrate significantly better comprehension than production. In fact, this expressive–receptive gap may be larger than what is observed in children with TD (Martin *et al.*, 2009; Roberts, Price, & Malkin, 2007). In general, expressive vocabulary skills are often below mental age (Caselli, Monaco, Trasciani, & Vicari, 2008), whereas vocabulary comprehension is commensurate with mental age abilities (Chapman, Schwartz, & Kay-Raining Bird, 1991). Individuals with DS also have significant deficits in grammatical skills, in terms of both comprehension and production, scoring below mental age expectations (Caselli *et al.*, 2008; Chapman *et al.*, 1991; Martin *et al.*, 2009). Research has shown that age-equivalent scores in grammatical comprehension fall below age-equivalent scores in vocabulary comprehension in DS (Abbeduto *et al.*, 2003). Abbeduto *et al.* did not find the same discrepancy between grammatical comprehension and vocabulary comprehension in a control group of children with TD. In terms of expressive language, productive language skills in children with DS often remain telegraphic throughout development, lacking many grammatical markings (Caselli *et al.*, 2008; Chapman, 1995). In fact, when matched to children with TD on expressive vocabulary skills, children with DS demonstrate the ability to combine words, but do so less frequently and produce significantly fewer grammatical structures than children with TD (Zampini & D'Odorico, 2011).

Given the known language deficits in individuals with DS, intervention services often begin early in life. Intervening early in life is possible due to the fact that children with DS are often diagnosed prenatally or shortly after birth (Cuckle & Maymon, 2016). During the birth to three time period, intervention services frequently include parent-coached interventions, where speech–language pathologists teach parents and caregivers strategies to support communication development (Bruder & Dunst, 1999). The parent-coaching model is based on the transactional model of development (Sameroff & Chandler, 1975), as well as previous research demonstrating that high quality maternal input significantly and positively impacts language development in children with TD (Landry, Smith, Swank, Assel, & Vellet,

2001) and children with DS (Dimitrova, Özçalışkan, & Adamson, 2016; Yoder & Warren, 2004). The transactional model of development acknowledges the bi-directional nature of early interactions where both caregivers and children influence one another (Sameroff & Chandler, 1975).

Maternal responsivity refers to a warm and nurturing relationship and includes specific behaviors, such as providing positive responses to child communication and following the child's lead during interactions. Highly responsive maternal behaviors positively impact child language development in children with fragile X syndrome (Warren, Brady, Sterling, Fleming, & Marquis, 2010), yet challenging child behaviors adversely impact mothers' capacity to remain responsive to children with developmental delays (Ciciolla, Gerstein, & Crnic, 2014). However, research on mother–child interactions in DS has largely focused on describing maternal behaviors in terms of the function of input (i.e., commenting, directing, requesting) as a way to represent the quality of input, with limited research on the lexical and grammatical quality of maternal input, such as MLU, use of telegraphic input, and lexical diversity as measured in the number of different words (NDW). In children with TD, the linguistic quality of parent input, such as lexical diversity, is predictive of later child language skills (Rowe, 2012). Examining the linguistic quality of maternal input to children with DS is essential given both the impact parent input has on language development and the significant language delays in children with DS.

Telegraphic input is one form of adult input that refers to input that removes function words (e.g., prepositions, articles) or grammatical markings (e.g., past tense –ed) in favor of shorter, simpler phrases (e.g., "Show me truck" instead of "Show me *the* truck"). In contrast to telegraphic input, parents can also simplify their input in a grammatical way, thus including necessary grammatical structures when shortening their utterances (e.g., "Show me *the* truck."). Limited research to date has examined the specific ways in which the linguistic quality of maternal input differs between mothers of children with DS and mothers of children with TD. To our knowledge, no published research has investigated telegraphic input in mothers of children with DS. By identifying whether mothers of children with DS utilize this simplification technique, future research can address whether telegraphic input by parents adversely or positively affects language development in young children with DS. Investigating telegraphic input to young children with DS is particularly imperative due to the significant deficits in grammar production in DS, which often persist into adolescence and adulthood (Chapman, Hesketh, & Kistler, 2002; Finestack, Sterling, & Abbeduto, 2013; Price *et al.*, 2008).

The linguistic quality of parent input

Maternal input to children with TD differs based on the child's developmental abilities, with mothers adjusting their language to be slightly more complex than that of their child, which may scaffold child language development (Bornstein *et al.*, 1992; Johnson-Glenberg & Chapman, 2004; Sokolov, 1993). As their child's language production becomes more complex, parents of children with TD increase both the amount of information in their utterances (Bornstein *et al.*, 1992) and the grammatical complexity (Sokolov, 1993). These findings are consistent with the fine-tuning hypothesis, which states that mothers adjust their input based on the developmental ability of the child (Snow, 1989). Previous literature has described the fine-tuning hypothesis as it relates to children with TD, yet limited research has investigated whether this hypothesis applies to mothers and their children with DS

(Johnson-Glenberg & Chapman, 2004; Kay-Raining Bird & Cleave, 2015). It is not clear if mothers of children with DS consider child factors when adjusting their linguistic complexity, particularly given that children with DS present with relative strengths in receptive language and lexical abilities compared to expressive language and grammatical skills.

To date, three studies have investigated differences between the linguistic quality of maternal input to children with DS compared to children with TD, and one of those studies also examined the relationship between maternal input and child language abilities (Johnson-Glenberg & Chapman, 2004; Kay-Raining Bird & Cleave, 2015; Zampini, Fasolo, & D'Odorico, 2011). Johnson-Glenberg and Chapman (2004) reported that mothers of adolescents and adults with DS used more complex utterances compared to mothers of children with TD matched on expressive language ability. However, mothers of children with DS demonstrated similar linguistic complexity compared to mothers of children with TD matched on non-verbal mental age and mothers of children with TD matched on receptive grammar (Johnson-Glenberg & Chapman, 2004). Johnson-Glenberg and Chapman did not find significant relationships between parent and child MLU or NDW for the dyads with DS. Instead, they found that the parents of the individuals with DS were much more variable in their input (i.e., a wider within-group range of parent NDW). Further analyses revealed a positive relationship between parent and child NDW only for the individuals with DS with lower receptive grammar and non-verbal cognitive abilities. Johnson-Glenberg and Chapman speculated that some parents of individuals with DS may fine-tune their lexical diversity to that of their child's in an attempt to scaffold lexical development. However, it is not clear whether these findings apply to children with DS aged two to five years since the individuals in the study by Johnson-Glenberg and Chapman were adolescents and adults with DS. Understanding these relationships in toddler and preschool-age children with DS is important given that it is a foundational time for language learning. Additionally, children with DS are particularly delayed in transitioning to producing word combinations, so it is vital to understand the grammatical quality of linguistic input during the preverbal and early verbal stages of language development in DS (Iverson, Longobardi, & Caselli, 2003).

In a study by Kay-Raining Bird and Cleave (2015), children with DS aged two to eight years were matched on expressive language ability to children with TD aged one to three years. The mothers of children with DS used shorter utterances than the mothers of children with TD (Kay-Raining Bird & Cleave, 2015), which was opposite of the finding by Johnson-Glenberg and Chapman (2004). Kay-Raining Bird and Cleave (2015) speculated that mothers of children with DS simplified their utterances to compensate for their child's learning and processing difficulties. Zampini *et al.* (2011) examined maternal input to children with DS aged 23 to 26 months compared to both an age-matched group and an expressive vocabulary matched group. They found that maternal MLU did not significantly differ across the three groups. The lack of difference in maternal MLU across the three groups may have been the result of the specific age ranges included in the study or a lack of statistical power given that there were 14 participants in each group. However, other group differences were detected within the sample. For example, for the group with DS, the proportion of maternal subordinate clauses, which was calculated by dividing the number of maternal subordinate clauses by the total number of clauses that contained two or more main verbs, fell between the two groups with TD; that is, the

proportion of maternal subordinate clauses by mothers of children with DS was higher than the vocabulary matched group but lower than the chronological age matched group. They also found that maternal vocabulary in terms of the specific types of words was simpler (i.e., fewer function words and more routine words) when directed to the children with DS compared to maternal vocabulary directed to the other two groups of children. The fact that the mothers of children with DS in the study by Zampini *et al.* sometimes interacted similarly to the mothers in the chronological age matched group suggests that including a chronological age matched group carries value for investigating maternal input.

The differences in findings may be related to the ages of the children with DS in the studies, how the studies selected comparison groups, or the variables used. The Johnson-Glenberg and Chapman (2004) study matched on MLU and included adolescents and adults with DS. The study by Kay-Raining Bird and Cleave (2015) matched on expressive vocabulary size and included children aged two to eight years. Lastly, Zampini *et al.* (2011) included two groups and matched on expressive vocabulary size and chronological age, and included children with DS aged 23–26 months. Thus, it may be the case that maternal input to children with DS differs from that of mothers of children with TD across the lifespan, but differs in unique ways depending on the child's age and stage of language development. The specific aspect of maternal input (e.g., MLU vs. proportion of subordinate clauses) may also matter. The current study continued to investigate differences in the linguistic input of mothers of children with DS in the preverbal and early verbal stages compared to mothers of children with TD, as well as the relationship between maternal linguistic input and child language abilities in DS. Importantly, this study added an investigation into telegraphic input use, which to our knowledge was not previously examined in relation to maternal input to children with DS.

The impact of telegraphic input

Simplified input can be achieved in one of two ways: by using shorter, grammatical phrases, or by using telegraphic input, which includes removing function words and grammatical morphemes in favor of agrammatical phrases that include primarily content words (van Kleeck, Fey, Kaiser, Miller, & Weitzman, 2010). Clinical opinion to date is divided on the potential benefit or detriment of using telegraphic input to children with developmental delays and neurodevelopmental disabilities, and limited work has empirically investigated telegraphic input (Bredin-Oja & Fey, 2014; van Kleeck *et al.*, 2010; Venker *et al.*, 2015; Willer, 1974). One argument for simplified grammatical input is that children learn to imitate just as well if not better from grammatical input while also hearing the correct way to produce utterances (Bredin-Oja & Fey, 2014). From a theoretical perspective, telegraphic input may inhibit the ability to use syntactic bootstrapping, a mechanism for word learning that involves using grammatical structures to learn novel words (Fisher, Gertner, Scott, & Yuan, 2010). Previous research indicates that individuals with DS are able to use syntactic bootstrapping to learn novel nouns and verbs, though they may do so less efficiently than individuals with TD (Cleave, Kay-Raining Bird, Trudeau, & Sutton, 2014). Thus, it may be the case that individuals with DS require more consistent input of grammatical structures to utilize this word learning mechanism. Telegraphic input inherently removes grammatical structures, thereby restricting the ability to use syntactic bootstrapping to make inferences about new words. Children with DS demonstrate deficits relative to mental age-matched peers in expressive grammatical

abilities, including producing fewer correct morphemes (Eadie, Fey, Douglas, & Parsons, 2002). Removing function words and bound morphemes may further hinder the ability to acquire these aspects of language.

Arguments in favor of telegraphic input contend that input containing solely content words may help children understand the relationships between words and focus their attention on learning specific words and word combinations (van Kleeck *et al.*, 2010; Willer, 1974). By limiting the amount of input, children may be able to learn the current language target more easily. An additional argument for telegraphic input is that it may aid young children in comprehension by reducing the input to the most important words (van Kleeck *et al.*, 2010). Lastly, telegraphic input mirrors the point in development where children may start combining words and they themselves use telegraphic language (Brown, 1973); thus, telegraphic input may provide developmentally appropriate language models for children at the single-word level (van Kleeck *et al.*, 2010). It is important to note that there is limited evidence on the best type of input for children with DS, and no published work to date on whether parents of children with DS use telegraphic input.

To our knowledge, there is limited research on the frequency with which parents of children with TD produce telegraphic input. One study transcribed 30 minutes of a parent–child free play interaction including 15 toddlers at 21 months of age, where all of the child participants were not yet producing tense markings (Hadley, Rispoli, Fitzgerald, & Bahnsen, 2011). The study found that parents used an average of 1.81 utterances (range 0–8 utterances) containing telegraphic input during the 30 minutes. Hadley *et al.* also looked more broadly at whether tense was included in utterances (termed 'informative') or not included in utterances (termed 'uninformative'), and found that the frequency of informative utterances positively predicted child morphosyntactic growth and the frequency of uninformative verb forms negatively predicted morphosyntactic growth. This research suggests that, for children with TD, both the number of instances that parents provide complex input and the number of instances that parents exclude verb tenses impact expressive language growth in young children not yet marking verb tense.

Experimental research on young children with TD has also investigated language processing of input with and without determiners (Fernald & Hurtado, 2006; Kedar, Casasola, & Lust, 2006). Removing determiners from sentences and phrases represents one type of telegraphic input. Kedar, Casasola, Lust, and Parmet (2017) specifically tested whether infants and young children were faster and more accurate when the prompt included a matching determiner (e.g., "Can you see *the* ball?") versus a nonsense word (e.g., "Can you see *bo* ball?"), different English word (e.g., "Can you see *by* ball?"), or no determiner (e.g., "Can you see ball?"). Children ages 12 and 18 months were faster and more accurate at following a grammatical rather than agrammatical sentence. Thus, the use of specific types of telegraphic input may hinder processing in TD, although it is unclear how this finding may extend to children with DS.

Two early published intervention studies investigated the impact of telegraphic input on word learning in individuals with intellectual and developmental disabilities, including individuals with DS (Fraser, 1972; Willer, 1974). The study by Willer (1974) randomly assigned participants to two groups of five children aged five to 13 years and the participants were matched on mental age. The study included an intervention targeting specific vocabulary where one group received single-word and telegraphic input during intervention and the other group received grammatical input. Willer found no group differences when testing the comprehension of

language targets but found that the group receiving single-word and telegraphic input demonstrated greater expressive language gains in terms of naming the target objects. The results of Willer must be interpreted with caution due to several important limitations including no pretest of participant knowledge of target vocabulary, a confound between grammaticality and input length, and lack of treatment fidelity. The study by Fraser (1972) included 50 individuals with intellectual and developmental disabilities aged three to 15 years. All participants received an intervention using telegraphic input and an intervention using grammatical input. The interventions targeted specific vocabulary words and the authors found no differences in the comprehension of language targets taught in the telegraphic versus grammatical conditions. In addition, the study by Fraser included 15 individuals with DS and, when analyzed separately from the other participants, there were no differences in language gains when comparing the telegraphic versus the grammatical input interventions.

A more recent intervention study included five children with language delay without intellectual and developmental disabilities aged 30 to 51 months and used an alternating treatment design to test children's ability to imitate telegraphic versus grammatical prompts (Bredin-Oja & Fey, 2014). The study found that three out of five of the children responded the same amount overall regardless of the type of prompt (i.e., telegraphic versus grammatical), but notably the same children produced more grammatical morphemes with grammatical rather than telegraphic prompts. Bredin-Oja and Fey concluded that providing telegraphic prompts over grammatical prompts to children with language delays does not offer any benefits and that, by providing grammatical prompts, children have the opportunity to imitate grammatically correct utterances. Findings from Bredin-Oja and Fey indicate that, when providing grammatical prompts for children to imitate, some children can imitate both the content words and the functions words; however, this work has yet to be completed in children with DS or children with intellectual disability more broadly.

Thus far, only one published study has investigated whether telegraphic input by parents may impact child language development. Venker *et al.* (2015) investigated the impact of a specific type of telegraphic input, namely omitted determiners from noun phrases, on language development in 55 children with autism spectrum disorder (ASD). This longitudinal study examined whether parent telegraphic input predicted child language ability one year later. The child participants were three years of age at the first time-point and four years of age at the second time-point. Utilizing path analyses, Venker *et al.* found that the more often parents omitted determiners (i.e., used telegraphic input) at the first time-point negatively predicted child lexical diversity as measured by NDW at the second time-point. Thus, telegraphic input by parents may negatively impact lexical development in young children with ASD. However, it is not clear if mothers of children with DS also use telegraphic input, and if so, to what extent. If mothers of children with DS use telegraphic input, future work will be necessary to examine what impact telegraphic input may have on children with DS.

Purpose of the present study

Limited work has investigated the linguistic quality of maternal input to children with DS, specifically examining the ways in which mothers of children with DS may simplify

their input (Johnson-Glenberg & Chapman, 2004; Kay-Raining Bird & Cleave, 2015; Zampini *et al.*, 2011). Children with DS have significant language deficits compared to children with TD. It is unclear how mothers of children with DS may adjust the linguistic quality of their input based on the language abilities of children with DS aged two to five years; this is an important area to investigate, particularly since it is such a foundational time in language development for children with DS. Understanding the type of maternal input to children with DS, and how it may differ from maternal input to children with TD, is an essential step toward understanding how differences in maternal linguistic input may impact child language development. Comparing mothers of children with DS to mothers of children with TD matched on chronological age is an important first step to understanding how mothers adjust their input, particularly given the different findings between studies when children were matched on language ability (Johnson-Glenberg & Chapman, 2004; Kay-Raining Bird & Cleave, 2015; Zampini *et al.*, 2011). Moreover, the use of telegraphic input is controversial, yet no published work has identified if mothers of young children with DS use telegraphic input when interacting with their children. Determining how often mothers of children with DS use this input style is important. If mothers of children with DS use telegraphic input, further research will be necessary to determine whether telegraphic input is either advantageous or detrimental to language development in young children with DS. The purpose of this study was to better understand differences in the grammatical and lexical quality of maternal input to children with DS compared to mothers of age-matched children with TD, in addition to what aspects of child language abilities are related to the grammatical and lexical quality of maternal input. Therefore, we asked the following questions:

1. How does the quality of maternal input (i.e., mean length of utterance in morphemes (MLUm), NDW, and telegraphic input) differ between mothers of children with DS and mothers of children with TD matched on chronological age? Are maternal MLUm, NDW, and telegraphic input related to one another?
2. Is maternal input (i.e., MLUm, NDW, and telegraphic input) related to child language abilities (i.e., MLUm, NDW, Mullen Scales of Early Learning (MSEL) expressive and receptive language raw scores) in DS and TD?

For question 1, we hypothesized that the mothers of children with DS would use less complex utterances (i.e., a lower MLUm) and less lexical diversity (i.e., a smaller NDW), based on findings from Kay-Raining Bird and Cleave (2015). We also hypothesized that the mothers of children with DS would produce more telegraphic utterances, given the report in the literature of this behavior among mothers of young children with other neurodevelopmental disorders, such as ASD (Venker *et al.*, 2015). This hypothesis is also based on the fact that children with DS have significant language deficits, so mothers may attempt to simplify their input. Given that our second research question was based on the fine-tuning hypothesis, we expected significant relationships between grammatical and lexical aspects of maternal input and child language abilities. Specifically, we hypothesized that maternal MLUm would be positively correlated with child MLUm and that maternal NDW would be positively correlated with child NDW.

Methods

Participants

The data from this study were drawn from a previous study on mother–child interactions in children with DS compared to children with TD (Sterling & Warren, 2014). The participants included 22 mothers and their children with DS and 22 mothers and their children with TD. Mother–child dyads with DS were recruited from early intervention agencies, support groups, clinics, and the Kansas City Down Syndrome Guild in Kansas and Missouri. The 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 21 and one participant had mosaicism, which is a form of DS resulting from some but not all cells containing an extra copy of chromosome 21. Nineteen children were white, two were African American, and one was Hispanic. Maternal education, defined as the total years of school completed, ranged from 12 to 18 years ($M = 15.57$, $SD = 1.55$) for the mothers of children with DS. The participants with TD were recruited from preschools, daycares, word-of-mouth, and the Infant Cognition Research Laboratory at the University of Kansas. 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. 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 child participants were matched at the group level on chronological age ($t(42) = 0.37$, $p = .715$, $d = 0.11$, variance ratio = 1.20), meeting matching recommendations based on p-values, effect sizes, and variance ratios as specified by Kover and Atwood (2013). The groups were matched on child chronological age for multiple reasons. At a theoretical level, matching on chronological age is consistent with the transactional model of development, which acknowledges the cumulative impact that parent–child interactions have on child development (Sameroff & Chandler, 1975). Matching on chronological age controls for both the child's exposure to language input and the mother's time spent interacting and communicating with the child. It may be the case that mothers change their interaction styles based on chronological age. In fact, Zampini *et al.* (2011) found that mothers of children with DS sometimes used input similar to that of mothers of children with TD matched on chronological age, and at other times provided input similar to mothers of children with TD matched on language ability. Therefore, some aspects of maternal input to children with DS may be based on the child's chronological age. In addition, matching on chronological age is consistent with previous work in parent–child research including children with intellectual and developmental disabilities (Brown *et al.*, 2003; Carvajal & Iglesias, 2000; Slonims & McConachie, 2006; Sterling, Barnum, Skinner, Warren, & Fleming, 2012; Sterling & Warren, 2014; Thiemann-Bourque, Warren, Brady, Gilkerson, & Richards, 2014). Matching in this way allows for an examination of how child age and diagnosis interact and potentially influence maternal input.

As this study was a first look at whether mothers of children with DS use telegraphic input during their interactions, it was also important to establish whether the use of this type of input was similar or different from what would be expected of mothers of children with TD of the same age. Differences would indicate a need to follow up on whether the mothers of children with DS are interacting similarly to mothers of

children with TD matched on language ability or differently than both mothers of children with TD of the same chronological age and mothers of children with TD of the same language age. Furthermore, we would expect MLUm and NDW to be different between groups of children when using a chronological age match, and investigating telegraphic input in this context can shed light on whether the use of telegraphic input is impacted in similar ways. While we would expect that the children with DS would have lower language abilities compared to the children with TD matched on chronological age, we would still expect that the children with DS would be actively communicating in the mother–child interactions.

Lastly, a comparison group matched on expressive language ability for this sample of children with DS would have included children with TD at or below 12 months of age (i.e., some of the expressive language age equivalent scores for the children with DS on the Mullen Scales of Early Learning (MSEL; Mullen, 1995) fell at or below 12 months). In fact, 14 of the children with DS had expressive language age equivalent scores below 24 months. Mother–child interactions for very young children with TD would likely be qualitatively different than those of the preschool-age children that participated in this study, which would make it difficult to interpret findings.

The mothers in this study were similar on maternal education ($t(42) = -0.88$, $p = .383$, $d = 0.31$, variance ratio = 1.33). Including similar levels of maternal education was important since previous findings have demonstrated a relationship between maternal education and interaction style (Hooper, Burchinal, Roberts, Zeisel, & Neebe, 1998; Lowe, Erickson, MacLean, Schrader, & Fuller, 2013; Mervis, Kistler, John, & Morris, 2012).

Procedure

Assessments took place in the participant's home during a one- to two-hour visit. The children completed a play-based, developmental assessment, and each mother–child dyad was recorded while participating in three naturalistic activities: free play, book-reading, and making and eating a snack. A standard set of toys, books, and snacks were provided for the interactions. An examiner read a standard set of instructions to the mothers prior to each activity, instructing the mother to interact as she typically would at home during each activity. We analyzed seven minutes of each interaction, for a total of 21 minutes of mother–child interaction per dyad. Two participants with DS did not eat solid food, so to remain consistent on the total amount of time recorded across participants, free play and book-sharing were extended to two, 10.5-minute segments each, resulting in 21 minutes of interaction for those two dyads.

Developmental assessment

A trained examiner administered the Mullen Scales of Early Learning, a play-based developmental assessment. Each participant completed the four subscales necessary for the overall composite score: Visual Reception, Fine Motor, Expressive Language, and Receptive Language. Raw scores were used to generate an overall composite score with a mean of 100 and standard deviation of 15. Expressive and receptive language raw scores are also reported (see Table 1). Raw scores rather than standard scores are reported and were used to represent the receptive and expressive language variables due to floor effects in the standard scores (i.e., standard score of 20). Eleven of the 22 participants with DS scored at floor on the expressive language subscale, and seven out of 22 participants with DS were at floor on the receptive

Table 1. Descriptive statistics for child variables

	DS $n = 22$ (11 boys)			**TD** $n = 22$ (12 boys)			
Variable	Mean	SD	Range	Mean	SD	Range	Group comparisons[4]
Expressive language raw score[1]	21.32	7.42	11–34	41.48	7.65	27–50	$p < .001$
Expressive language age equivalent[1]	20.25	6.20	11.5–30.5	35.52	5.19	25–41	$p < .001$
Receptive language raw score[1]	26.50	8.19	10–39	39.76	6.43	29–48	$p < .001$
Receptive language age equivalent[1]	25.27	6.22	12–34	34.36	4.03	27.5–39.5	$p < .001$
Early learning composite[1, 2]	56.41	8.86	49–84	115.33	18.41	58–140	$p < .001$
Percent intelligible words[3]	41.51	33.50	0–88.92	96.68	2.91	86.10–99.41	$p < .001$
Total number of analyzed utterances[3]	72.36	82.94	0–316	165.23	39.47	109–427	$p < .001$
MLUm[3]	1.17	0.81	0–1.69	2.57	0.59	1.69–3.73	$p < .001$
NDW[3]	37.23	36.93	0–114	140.41	31.50	78–190	$p < .001$

Notes. [1] As measured by the Mullen Scales of Early Learning (MSEL). [2] The early learning composite consists of the following four subscales: visual reception, fine motor, expressive language, and receptive language. [3] As measured by the Systematic Analysis of Language Transcripts (SALT) software. [4] Independent samples *t*-tests between groups.

language subscale. Utilizing raw scores made it possible to capture the variability in receptive and expressive language abilities present in the children with DS which were not evident with standard scores, and provided a measure of child ability in DS rather than how delayed the children were in comparison to peers with TD. The use of raw rather than standard scores on language measures is consistent with previous research in intellectual and developmental disabilities (Brady, Warren, Fleming, Keller, & Sterling, 2014; Luyster, Kadlec, Carter, & Tager-Flusberg, 2008; McGregor, Rost, Arenas, Farris-Trimble, & Stiles, 2013; Sterling & Abbeduto, 2012).

Mother and child language coding

Maternal and child linguistic input

Trained research assistants transcribed maternal and child linguistic input from the video files using the Systematic Analysis of Language Transcripts (SALT) software conventions (Miller & Iglesias, 2012). After each file was initially transcribed, a second transcriber double-checked the file and indicated any disagreements. The first transcriber then reviewed the identified disagreements. The two transcribers subsequently consensus coded any remaining disagreements and created a final transcript. Using the final transcripts, we obtained values for each mother's MLUm and NDW, and each child's total number of analyzed utterances, MLUm, and NDW. Descriptive information and group comparisons for the child participants are presented in Table 1. To calculate reliability for the SALT transcripts, prior to consensus coding, 20% of the transcripts were chosen at random and transcribed independently by a second transcriber. Reliability was calculated line-by-line separately for mothers and children and included the following five linguistic input variables: utterance segmentation, presence of unintelligible utterances, number of morphemes, number of words, and word identification. For the maternal linguistic variables, overall agreement across the five variables was 91.29% (range 87–99%). Reliability for the child linguistic variables was 85.40% (range 77–93%). It is important to note that transcribers were blind to the child's diagnosis. They only viewed the video-recordings if they needed to clarify an utterance or aspect of the interaction (e.g., such as if the mother was addressing the examiner or the child), which rarely occurred.

Telegraphic input

To identify instances of maternal telegraphic input, a coding scheme modified from Venker *et al.* (2015) was used. Only fully intelligible utterances were coded for telegraphic input. Coders who were blind to the purpose of the study used the SALT transcripts and went line-by-line to identify instances of telegraphic input. Each intelligible parent utterance was coded as either telegraphic or grammatical. Telegraphic input was defined as input that resulted in at least one grammatical error. Errors included an omitted word, including omitted determiner, noun, preposition, or verb (e.g., *Get ball*, *Where the bears*), incorrect verb tense (e.g., *The kitty like you*), and omitted bound morpheme (e.g., *Five monkey in the bed*). It should be noted that omitted determiners in single words (e.g., if a mother labeled a toy and said, "truck") were not counted as telegraphic given the disagreement in the literature as to whether or not this is telegraphic input (van Kleeck *et al.*, 2010; Venker *et al.*, 2015). Prior to coding participant files from the present study, coders reached a training criterion of at least 80% agreement on three different samples. Once criterion was met, both coders independently coded each file. Disagreements

were subsequently identified, and the two coders consensus coded all disagreements for all participants. Cohen's kappa was calculated to measure reliability for identifying telegraphic utterances prior to consensus coding (Hallgren, 2012). The value for the total number of telegraphic utterances was .79, indicating substantial agreement.

Data analysis plan

To compare maternal linguistic quality between groups, we used three separate independent samples *t*-tests with child diagnosis as the independent variable and maternal MLUm, NDW, and total number of telegraphic utterances as the dependent variables. Assumptions for independent samples *t*-tests were checked and all three variables (i.e., maternal MLUm, NDW, and total number of telegraphic utterances) demonstrated a normal distribution based on skewness and kurtosis values as well as homoscedasticity as assessed by visual inspection of spread-level plots of log-transformed studentized residuals versus log-transformed fitted values. We then used correlational analyses to examine the relationships between the different aspects of maternal input separately for the mothers of children with TD and DS. For research question two, we used correlational analyses to examine the relationships between maternal linguistic input and child language measures (i.e., receptive and expressive language raw scores from the MSEL, child MLUm, and child NDW) separately for mother–child dyads with DS and mother–child dyads with TD. Child chronological age was also included in correlational analyses to better understand how child age may be related to maternal input.

Results

Research question 1: comparing maternal input between groups

Our first goal was to investigate differences in the linguistic quality of maternal input to children with DS compared to children with TD, including MLUm, NDW, and the overall quantity of telegraphic input. The average MLUm was 3.53 ($SD = 0.38$) for the mothers of the children with DS and 4.23 ($SD = 0.45$) for the mothers of the children with TD. An independent samples *t*-test indicated a significant difference in MLUm between the two groups ($t(42) = -5.58$, $p < .001$, $\eta_p^2 = .43$). The average NDW for the mothers of the children with DS was 280.18 ($SD = 44.43$) and for the mothers of the children with TD was 313.27 ($SD = 46.96$). An independent samples *t*-test indicated a significant difference in NDW between the two groups ($t(42) = -2.43$, $p = .020$, $\eta_p^2 = .12$). The average total number of telegraphic utterances for the mothers of the children with DS was 10.00 ($SD = 4.34$) and for the mothers of the children with TD was 7.50 ($SD = 3.25$). An independent samples *t*-test indicated a significant difference in the total number of telegraphic utterances between the two groups ($t(42) = 2.16$, $p = .036$, $\eta_p^2 = .10$). See Figure 1 for a visual depiction of group differences. The Holm–Bonferroni method was used to reduce the potential for Type I error (Holm, 1979), and thus the *p*-values were ranked and compared against the new significance values of .050/1 = .05, .050/2 = .025, and .050/3 = .017. Using this correction, there remained a significant difference between mothers of children with DS and mothers of children with TD on all three variables.

Correlational analyses were completed to examine the relationships between maternal input variables. For the mothers of children with DS, maternal MLUm,

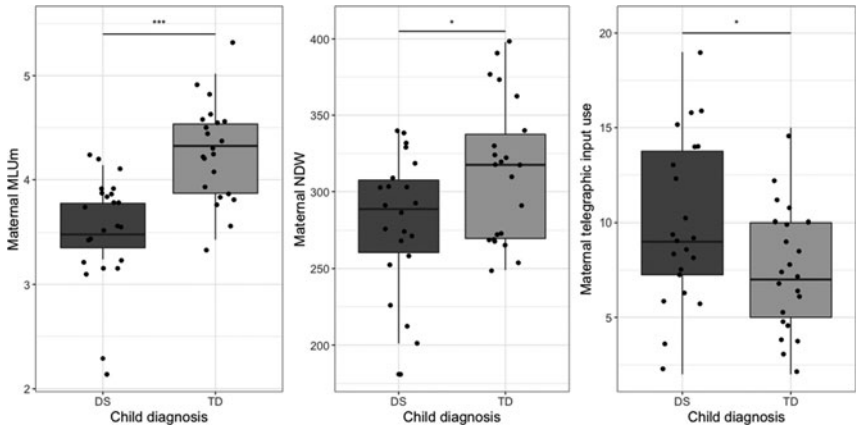

Figure 1. Maternal linguistic input variables by child diagnostic group. Mothers of children with DS used a significantly lower MLUm, a significantly smaller NDW, and significantly more telegraphic input.
Note. Down syndrome = DS; typical development = TD; * $p < .050$, *** $p < .001$.

NDW, and the average total number of telegraphic utterances were not significantly correlated (see Table 2). For the mothers of children with TD, MLUm was significantly positively correlated with NDW, but not with the average total number of telegraphic utterances. Maternal NDW was not significantly correlated with the average total number of telegraphic utterances (see Table 3). In summary, the only significant correlation was between NDW and MLUm in the mothers of children with TD.

Research Question 2: examining relationships between maternal and child variables

Our second goal was to examine the relationship between different aspects of maternal input and child language abilities for children with DS and TD.

Correlations in DS

Correlational analyses were completed to investigate the relationships between maternal input and child language abilities for the mothers and children with DS (see Table 2). Maternal MLUm was not significantly correlated with child receptive language raw score, expressive language raw score, MLUm, NDW, or chronological age. Maternal NDW was significantly positively correlated with child receptive language raw score, but not child expressive language raw score, MLUm, NDW, or chronological age. Maternal use of telegraphic input was not significantly correlated with any of the child language variables.

Correlations in TD

Correlational analyses are presented in Table 3 for the mothers and children with TD. Maternal MLUm was significantly positively correlated with child receptive language raw score, expressive language raw score, and MLUm, but not NDW or chronological age. Maternal NDW was not significantly correlated with child receptive language raw score, expressive language raw score, MLUm, NDW, or

Table 2. Pearson correlations between mother and child variables for children with DS

Variables	1	2	3	4	5	6	7	8
1. Maternal MLUm	–							
2. Maternal NDW	$r = 0.39$ $p = .070$	–						
3. Maternal telegraphic input	$r = 0.15$ $p = .509$	$r = -0.04$ $p = .854$	–					
4. Receptive language raw score	$r = 0.10$ $p = .669$	$r = 0.49^{*}$ $p = .020$	$r = -0.19$ $p = .397$	–				
5. Expressive language raw score	$r = 0.12$ $p = .596$	$r = 0.35$ $p = .110$	$r = 0.05$ $p = .809$	$r = 0.79^{***}$ $p < .001$	–			
6. Child MLUm	$r = -0.08$ $p = .731$	$r = -0.18$ $p = .421$	$r = 0.32$ $p = .141$	$r = -0.07$ $p = .768$	$r = 0.23$ $p = .313$	–		
7. Child NDW	$r = 0.05$ $p = .813$	$r = 0.32$ $p = .147$	$r = 0.16$ $p = .479$	$r = 0.81^{***}$ $p < .001$	$r = 0.95^{***}$ $p < .001$	$r = 0.30$ $p = .171$	–	
8. Child chronological age	$r = 0.17$ $p = .463$	$r = 0.18$ $p = .419$	$r = -0.27$ $p = .228$	$r = 0.80^{***}$ $p < .001$	$r = 0.75^{***}$ $p < .001$	$r = 0.08$ $p = .734$	$r = 0.75^{***}$ $p < .001$	–

Note. * $p < .050$, *** $p < .001$.

Table 3. Pearson correlations between mother and child variables for children with TD

Variables	1	2	3	4	5	6	7	8
1. Maternal MLUm	–							
2. Maternal NDW	$r = 0.58^{**}$ $p = .005$	–						
3. Maternal telegraphic input	$r = 0.04$ $p = .846$	$r = 0.17$ $p = .458$	–					
4. Receptive language raw score	$r = 0.51^{*}$ $p = .019$	$r = 0.23$ $p = .325$	$r = -0.24$ $p = .293$	–				
5. Expressive language raw score	$r = 0.45^{*}$ $p = .041$	$r = 0.11$ $p = .640$	$r = -0.36$ $p = .108$	$r = 0.96^{***}$ $p < .001$	–			
6. Child MLUm	$r = 0.50^{*}$ $p = .019$	$r = -0.04$ $p = .863$	$r = -0.21$ $p = .357$	$r = 0.61^{**}$ $p = .003$	$r = 0.66^{**}$ $p = .001$	–		
7. Child NDW	$r = 0.31$ $p = .158$	$r = 0.35$ $p = .109$	$r = -0.41^{+}$ $p = .058$	$r = 0.49^{*}$ $p = .023$	$r = 0.50^{*}$ $p = .021$	$r = 0.65^{***}$ $p < .001$	–	
8. Child chronological age	$r = 0.32$ $p = .151$	$r = 0.11$ $p = .631$	$r = -0.27$ $p = .225$	$r = 0.77^{***}$ $p < .001$	$r = 0.79^{***}$ $p < .001$	$r = 0.64^{**}$ $p = .001$	$r = 0.65^{**}$ $p = .001$	–

Note. $^{+}$ $p < .060$, * $p < .050$, ** $p < .010$, *** $p < .001$.

chronological age. Maternal use of telegraphic input was not significantly correlated with child receptive language raw score, expressive language raw score, MLUm, NDW, or chronological age. There was a marginal relationship between maternal use of telegraphic input and child NDW ($p = .058$).

Discussion

Research has demonstrated that the quality of maternal input, not just the quantity, plays an important role in child language development, particularly for children with neurodevelopmental disabilities (for a review, see Warren & Brady, 2007; Yoder & Warren, 2004). Children with DS demonstrate significant and pervasive language delays (Caselli *et al.*, 1998; Martin *et al.*, 2009). Therefore, investigating differences in the linguistic input of mothers of children with DS early in life is important for understanding how linguistic changes to input may impact language development in this population, as well as how mothers may adjust their input based on child abilities. The current study aimed to examine the qualitative aspects of maternal language input to children with DS compared to age-matched children with TD, as well as provide a comprehensive look at the relationships between child language abilities and maternal input. Identifying how mothers of children with DS modify the linguistic quality of their input is a necessary first step for developing strategies that teach parents to change the quality of their input in beneficial ways.

Research question 1: comparing maternal input between groups

The current study investigated whether grammatical and lexical qualities of maternal input differed between mothers of children with DS and mothers of children with TD. Mothers of children with DS used less grammatically complex utterances (i.e., a lower MLUm and more telegraphic input) as well as less lexical diversity (i.e., a lower NDW). These differences are consistent with previously identified group differences and further clarify the differing findings by Johnson-Glenberg and Chapman (2004), Kay-Raining Bird and Cleave (2015), and Zampini *et al.* (2011). More specifically, Kay-Raining Bird and Cleave (2015) found that mothers of children with DS used shorter utterances, yet Johnson-Glenberg and Chapman (2004) found that mothers of individuals with DS used longer utterances compared to mothers of children with TD. Zampini *et al.* (2011) found that mothers used a similar MLU as compared to both language and chronological age matched groups. The shorter MLUm noted in mothers of children with DS in this study is similar to the findings in Kay-Raining Bird and Cleave (2015). Kay-Raining Bird and Cleave included children with DS at a similar age to this study (i.e., the children with DS ranged from two to eight years), whereas Johnson-Glenberg and Chapman (2004) looked at maternal input to much older individuals with DS, and Zampini *et al.* (2011) included children specifically ranging from 23 to 26 months, indicating that maternal input may vary based on child chronological age in DS. Our study did not find a significant relationship between child chronological age and maternal language input, but it may be the case that a larger age range is needed to detect a significant relationship between these variables as they may change gradually over several years. Longitudinal studies will be needed to provide further support for this finding.

In terms of maternal lexical complexity, this study found that mothers of children with DS use less lexical diversity, which is in agreement with the findings of less

lexical variability in the study by Zampini *et al.* (2011). However, the study by Johnson-Glenberg and Chapman (2004) found that the parents of individuals with DS used greater lexical diversity. However, Johnson-Glenberg and Chapman found this when the participants were matched on MLU and the individuals with DS were adolescents and adults, whereas this study matched on child chronological age and included children aged 22 to 63 months, which was more similar to the study by Zampini *et al.* (2011) in terms of child age and a chronological age-matched group. Thus, it may be the case that mothers of younger children with DS use less lexical diversity with children with DS compared to same-age children with TD, but greater lexical diversity when the children with DS are adolescents and compared to younger children with TD. However, given the large age difference between the children with DS in this study and the study by Johnson-Glenberg and Chapman (2004), future research will need to clarify these findings across the age range.

This study included a control group where the children were matched on chronological age. While this type of control group is well-situated within the literature (Brown *et al.*, 2003; Carvajal & Iglesias, 2000; Slonims & Mcconachie, 2006; Sterling *et al.*, 2012; Sterling & Warren, 2014; Thiemann-Bourque *et al.*, 2014), it may be the case that telegraphic input does not differ between mothers of children with DS and mothers of children with TD when the children are matched on language ability. Previous research has found that mothers of children with DS may provide input that is sometimes similar to mothers of children with TD matched on chronological age, and at other times resembles maternal input to children with TD matched on language ability. Investigation into the use of telegraphic input to children with DS by mothers was another novel contribution of this study and imperative because describing parent input is the first step toward understanding how different types of input may impact language learning during everyday interactions. It was necessary to match on child chronological age to first understand whether the use of telegraphic input by the mothers of children with DS was similar to what we would expect to see during mother–child interactions for children aged 22 to 63 months.

On average, mothers of children with DS used 10.0 instances of telegraphic input whereas mothers of children with TD used 7.5 instances of telegraphic input. While there was a significant difference in maternal use of telegraphic input, it is unclear what amount of telegraphic input significantly impacts language development. Whether the significant difference is clinically meaningful is unclear without future work to further investigate the cumulative impact of telegraphic input in DS. The interactions reported in this study were only 21 minutes in total. Extrapolating the averages found in this study over ten hours per day for a seven-day week amount to 1500 telegraphic utterances for the group with TD and 2000 telegraphic utterances for the group with DS. Considered in this way, it is apparent that these differences can quickly accumulate over time. The linguistic differences found in this study contribute to previous literature on group differences, which together may have an additive and unique impact on child language development in young children with DS. For example, young children with DS hear fewer words overall compared to age-matched peers (Thiemann-Bourque *et al.*, 2014). More specifically, Thiemann-Bourque *et al.* used Language ENvironment Analysis (LENA) software to record the everyday environment of children with DS aged nine to 54 months compared to chronological age-matched peers with TD, and found that parents spoke more words to the children with TD compared to the children with DS. Thus, it is necessary to continue this line of work and investigate how the combination of

less input overall and more telegraphic input use impacts language development in young children with DS.

The finding that mothers of children with DS use more telegraphic input has preliminary theoretical and clinical implications. Children with DS can use syntactic bootstrapping, albeit less efficiently, than children with TD (Cleave *et al.*, 2014), yet telegraphic input may prevent the use of this word-learning mechanism by removing grammaticality. In addition, children with DS demonstrate specific difficulties with both morphology (Eadie *et al.*, 2002; Finestack *et al.*, 2013), and transitioning from single words to word combinations (Iverson *et al.*, 2003). Future research will need to determine if telegraphic input influences word learning as well as the transition from single words to word combinations in children with DS.

The current study also found considerable variability in the mothers of children with DS, particularly for the total use of telegraphic input. It may be the case that, because the field of speech–language pathology as a whole is not in agreement on the use of telegraphic input (van Kleeck *et al.*, 2010), mothers had received different advice on the ways in which they should simplify their utterances. However, this study did not include parent report of specific strategies or information about the amount or type of speech and language therapy each child was receiving. Nevertheless, the relationships between maternal linguistic variables were examined. MLUm, the total number of telegraphic utterances, and NDW were not significantly correlated for the mothers of children with DS. It was not the case that the mothers of children with DS who used more telegraphic input also used less grammatical and lexical complexity. Therefore, when understanding how mothers of children with DS simplify their input, it is necessary to look at multiple variables independently. These variables may be separable and thus it will be critical to investigate whether mothers may be able to modify specific linguistic aspects of maternal input without changing others.

Research question 2: examining relationships between maternal and child variables

While multiple significant relationships indicative of the fine-tuning hypothesis were found between the mothers and children with TD, only one significant relationship was found between the mothers and children with DS. The lack of significant relationships between many of the child linguistic variables and maternal input variables in DS parallels the overall findings from Johnson-Glenberg and Chapman (2004). However, Johnson-Glenberg and Chapman found a relationship between parent and child NDW for the children with lower language and cognitive abilities. For this study, we did not dichotomize the group with DS based on any variables due to the limited sample size. It is possible that some aspects of maternal fine-tuning were not detected in the dyads with DS due to limited variability in child language abilities (i.e., the majority of the children with DS were at the preverbal or single-word level). However, it is important to note the presence of a significant positive relationship between child receptive language scores and maternal lexical diversity for the mothers and children with DS. Thus, it may be the case that mothers of children with DS increase the lexical diversity of their input as child receptive language ability increases, adapting their input so that their child understands them while also perhaps recognizing that receptive language is a relative strength in children with DS (Martin *et al.*, 2009; Roberts *et al.*, 2007). However, directionality is unclear given the design of this study and the bi-directional relationship of mother and child variables reported in the literature (Slonims & Mcconachie, 2006; Sterling & Warren, 2014).

The children with DS in this study ranged from preverbal to producing early word combinations. However, maternal MLUm, telegraphic input use, and NDW were not correlated with child expressive language ability. It is possible that mothers take into account child gesture and sign language use when providing linguistic input. Studies have demonstrated that mothers of children with DS are able to acknowledge and respond to child signs and gestures (Dimitrova *et al.*, 2016; Lorang, Sterling, & Schroeder, 2018). It may be the case that mothers adjust their language based on their child's gestures or total communication attempts (i.e., the combination of gestures, vocalizations, and verbalizations rather than just verbalizations) when communicating with young children with DS, particularly given that gestures are often the primary means of communication for an extended period of time in children with DS. Future research should explore this potential relationship.

Limitations and future directions

While this study provided much-needed information on the ways in which mothers adjust their input to children with DS compared to age-matched children with TD, the study also had several limitations. The sample size was relatively small, thus restricting our ability to investigate different profiles of young children with DS. Due to the number of correlations and the small sample size, significant correlations must be interpreted with caution, given the potential for Type I error. Corrections were utilized for the independent samples *t*-tests to reduce Type I error but were not applied to the correlations. Correlates of language variables are moderate, on average, thus extensive corrections can result in a failure to detect true relationships and increase the risk of Type II error (Mason-Apps, Stojanovik, Houston-Price, & Buckley, 2018; Yoder & Warren, 2004). Previous studies in parent–child and early language development research in neurodevelopmental disabilities have considered but refrained from using corrections with similar sample sizes due to concerns with Type II error (Beurkens, Hobson, & Hobson, 2013; Mason-Apps *et al.*, 2018; Yoder & Warren, 2004). In addition, a number of studies did not complete corrections for correlations with similar sample sizes in the same age range for children with neurodevelopmental disorders (Flenthrope & Brady, 2010; Johnson-Glenberg & Chapman, 2004; Mastrogiuseppe, Capirci, Cuva, & Venuti, 2015; McDuffie, Yoder, & Stone, 2005; Roach, Barratt, Miller, & Leavitt, 1998). Nevertheless, results from this study should be interpreted as preliminary in nature and future studies should aim for larger sample sizes to reduce concerns regarding Type I error.

Fathers did not participate in this study despite the important role they play in their child's development. Future studies should include fathers to better understand how parents provide similar or different input. The data from this study reflect mother–child interactions at a single point in time. Using the LENA software can make it easier to collect data across time-points and provide additional insight into naturalistic daily interactions. The child participants in this study spanned 22 to 63 months, which represents a relatively large age range in terms of child language development. Future studies should narrow in on specific ages and stages of language development to better understand how parents adjust their input during different developmental stages (e.g., when children are producing single words versus primarily producing two-word combinations). This is particularly important given the large variability in language development in children with DS. In addition, inclusion of groups of children matched on different aspects of language

ability – MLU, receptive vocabulary, and/or expressive vocabulary – will help to shed light on what aspects of child language may influence maternal use of telegraphic input.

Future studies should also use longitudinal designs to better understand how maternal linguistic input and child language abilities change over time, and how parent and child factors may change together. The cascading effects of these group differences are not well understood. Path analysis using longitudinal data similar to that of Venker *et al.* (2015) would be useful in teasing apart the relationships and investigating the impact of telegraphic input on child language development. Future research should also investigate why parents of children with DS use telegraphic input, such as whether they were instructed to use it or do so naturally. Only one significant relationship was found between maternal input and child language abilities for the dyads with DS. However, it is not clear if these relationships depend on child age, language ability, or other factors not measured in this study, such as intellectual functioning. Future research should investigate the relationships between these variables for children with DS at older ages and a wider range of language abilities. Looking across ages is particularly important, given that adolescents and adults with DS are continuing to develop expressive language skills, including grammatical language abilities (Chapman *et al.*, 2002).

This study cannot provide specific clinical recommendations given the single, observational point in time. Intervention studies are necessary to understand how different types of linguistic input impact word learning. Studies similar in design to Bredin-Oja and Fey (2014) will be necessary to determine if children with DS benefit from telegraphic or grammatical interventions, as well as if children with DS are able to imitate some function words, as seen in Bredin-Oja and Fey's work including children with language delays. Eye-tracking may also prove useful as a methodology to experimentally test how children with DS process telegraphic and grammatical input and whether one type of input results in better accuracy and/or processing speed.

Conclusions

Mothers of young children with DS simplify the linguistic complexity of their input compared to mothers of age-matched children with TD. Simplification of maternal utterances may include the use of more telegraphic input. Given the debate regarding telegraphic input, future research is needed to determine the potentially cascading effect of telegraphic input on language development in children with DS, specifically in terms of grammatical development. In addition, the significant relationship between maternal lexical diversity and child receptive language in the dyads with DS at a minimum demonstrates a link between one aspect of maternal input and child language abilities for children with DS ages 22 to 63 months. It is unclear whether this finding may indicate the ability of mothers to fine-tune lexical aspects of their input, but the overall reduced complexity of maternal input compared to the group with TD demonstrates that mothers of children with DS may broadly fine-tune their input by making linguistic modifications based on child diagnosis.

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Declaration of interest. The authors declare that there is no conflict of interest.

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