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# Remote Natural Language Sampling of Parents and Children With Autism Spectrum Disorder: Role of Activity and Language Level

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Natural language sampling (NLS) is a common methodology in research and clinical practice used to evaluate a child's spontaneous spoken language in a naturalistic context. Autism spectrum disorder (ASD) is a complex neurodevelopmental condition that results in heterogeneous language profiles. NLS has emerged as a useful method for better understanding language use and development in this population. Prior work has examined the effects that contexts (e.g., home, lab) and conversational partners (e.g., examiner, parent) have on childrens language production, but less is known about remote collection of interactions between parents and children with ASD at home. Increasing our understanding of in-home remote NLS with children with ASD will improve naturalistic approaches to language assessment in children with ASD. We analyzed natural language samples of 90 dyads of parents and four- to seven-year old children with ASD collected remotely in the home using items and activities from the family's own home. The 15-min parent-child interactions were transcribed and analyzed for the child's language level measured by the number of different words. We examined the range of activities and the relationship between activities and the child's language level. We found that in-home parent-child activities fell into 13 descriptive categories, but we found no significant difference in child's language level (measured by the mean number of different words) across activities. We found that dyads involving children with higher language levels engaged in significantly fewer different activities compared to children with lower language levels. We found no difference in the number of different words elicited in the five most frequent activities in our sample. These results support the feasibility of remote in-home language sampling. While the types of activities that parent-child dyads engaged in did not affect the richness of language elicited, the number of different activities was associated with the child's language level. Allowing parents to steer children with lower language levels toward more different activities may allow children with lower language to more fully demonstrate their spoken language abilities.

**Keywords: autism spectrum disorder, natural language sampling, remote assessment, language, parent-child activities**

## 1. INTRODUCTION

Natural language sampling (NLS) is a common methodology in research and clinical practice used to evaluate a child's spontaneous spoken language in a naturalistic context. It provides a more naturalistic and representative sample of a child's language use than standardized assessments (see e.g., Evans and Craig, 1992; Costanza-Smith, 2010; Sanchez et al., 2020). NLS was traditionally carried out in the research lab or clinic, but with 86.6% of families in the U.S. having smartphones or devices with internet access in the home (American Communities Survey, 2019), remote in-home NLS is feasible. With the COVID-19 pandemic, remote NLS in research and clinical practice has become a necessary tool.

For children with autism spectrum disorder (ASD), NLS has emerged as a particularly useful method of language assessment with children with ASD (Tager-Flusberg et al., 2009; Barokova and Tager-Flusberg, 2018). While some children with ASD show standardized assessment scores within one standard deviation of the mean, 30% of children with ASD are minimally or low verbal (MLV) and remain so past the age of five despite access to early and quality interventions (Tager-Flusberg and Kasari, 2013). Other children with ASD fall between verbally fluent and minimally verbal. NLS can be analyzed for a range of different language features (Miller, 1981) to assess within language heterogeneity, a salient characteristic of ASD (Barokova and Tager-Flusberg, 2018).

Previous studies suggest that children with ASD, especially those who are MLV, demonstrate their best abilities in naturalistic contexts (Tager-Flusberg and Kasari, 2013). Given that naturalistic assessment is a more optimal approach for MLV individuals with ASD, researchers have encouraged parents of children with ASD to collect NLS at home. Barokova et al. (2020)'s study included parents of MLV children with ASD who used NLS in the home using a semi-structured protocol. The researchers then compared NLS collected by researchers in the lab to those collected by parents in the home using the same protocol. They found that MLV children produced an average of seven more utterances, took two more conversational turns, and produced around 1.5 more different words during a 20-min NLS with parents compared to with an examiner. Similarly, Kover et al. (2014) found that young children with ASD produced more utterances and showed better structural and pragmatic language skills in a play-based context with a parent compared to the Autism Diagnostic Observation Schedule (ADOS) (Lord et al., 2012), a semi-structured diagnostic autism assessment administered by an examiner which is commonly used as a language sampling context. Other studies have also reported on the quality and quantity of language elicited in naturalistic and home environments (see e.g., Burgess et al., 2013; Gladfelter and Van Zuiden, 2020; Hilvert et al., 2020). These findings support the influential role parents play at eliciting language from their children that is representative of their child's actual expressive language abilities and highlights the potential of remote collection of a NLS by parents at home. Given the shift toward naturalistic parent-mediated interventions for young children with ASD, remote in-home assessment using materials and everyday in-home activities will increase the proximity of individualized assessment and intervention that generalizes across people and contexts (see e.g., Schreibman et al., 2015; Bentenuto et al., 2016).

Given the COVID-19 pandemic, remote data collection has allowed researchers to continue their work when in-person collection of NLS is not feasible. Recent work supports the feasibility of remote methods for examining childrens language production. Manning et al. (2020) compared language samples from neurotypical children during parent-child play collected in the laboratory to parent-child play collected via video chat in the home. They found in-person samples and remote samples did not differ significantly in the number of usable samples or in the percent of intelligible utterances. Similarly, they found no significant differences in child speech and language characteristics (including mean length of utterance, type-token ratio, number of different words, grammatical errors/omissions, and child speech intelligibility) between in-person and remote samples. Furthermore, they investigated transcription reliability through a blinded comparison of 25% of the remote and in lab samples by dividing the number of matching words, morphemes, and codes between the two transcripts by the total words/morphemes/codes, and did not differ significantly for samples collected in-person vs. remotely. They reported high transcription reliability between in-lab and at-home language samples ($M$ = 88.59%; Range = 82–98%).

Although prior work has examined the effects of different language sampling contexts (e.g., home, lab) and conversational partners (e.g., examiner, parent) on childrens language production, less is known about remote collection of interactions between parents and children with ASD at home, particularly when parents are given open-ended elicitation instructions and use items and materials they have in the home. Our goal is to understand open-ended NLS with parents and items in the child's own home, including the type and number of activities and the relationship to the child's language level. Exploring specific activities during parent-child interactions in the home can allow for a richer and ecologically valid assessment of childrens spoken language abilities compared to standardized assessments with unfamiliar adults in a lab or clinic setting (see e.g., Costanza-Smith, 2010). Such work can provide insights into the role of in-home NLS in the assessment of language for children with ASD and inform individualized parent-mediated interventions.

Autism assessment practices have evolved significantly over the past three decades (Rosen et al., 2021). Due to the COVID-19 pandemic, the Autism Science Foundation convened a panel of senior clinicians, researchers and a professional parent-leader to re-envision the autism assessment process in light of pandemic-related experiences. The COVID-19 pandemic presents a unique opportunity to step back and review ASD assessment with the goal of developing accessible, flexible and sustainable practices (Zwaigenbaum et al., 2021). The development and adaptation of remote assessment tools can meet the demands of the pandemic and also provide an opportunity to refine assessment methods so that they are more equitable across demographic characteristics (e.g., race, ethnicity, sex, gender), as well as feasible across cultures (Franz et al., 2017; Dash et al., 2021).

## 1.1. Goals of the Current Study

The overall goal of this study is to understand NLS via naturalistic interactions between parents and children with ASD collected remotely in the home using items, materials and activities from the family's own home. It is essential to understand naturalistic, open-ended remote language sampling because it can open the window to accessible and equitable practices for language assessment, particularly for children with ASD who are MLV.

The current study seeks to answer the following specific questions:

1. What activities do parents choose to promote spoken language with their children in a remote context?
2. Does type of activity or number of activities depend on child language level (measured by number of different words)?
3. Do different activity types elicit more language from children (measured by number of different words)?

# 2. METHODS

Study data were collected and managed using REDCap (Research Electronic Data Capture) electronic data capture tools (Harris et al., 2009, 2019) hosted at Boston University. REDCap is a secure, HIPAA compliant, web-based software platform for research studies, providing an interface for validated data capture and data manipulation and export.

## 2.1. Participants

We enrolled a total of 105 families, of which 13 were recruited from social media advertising and 92 were recruited through the Simons Foundation Powering Autism Research for Knowledge (SPARK) research match registry (Feliciano et al., 2018). SPARK is a national ASD genotyping project that recruits families from 31 U.S. academic medical centers with over 70,000 families enrolled. Once families enroll, they are offered the opportunity to continue hearing about and engaging in prospective research opportunities through their online research registry. SPARK has been shown to have high validity for autism diagnosis. Based on two different methods of confirming ASD diagnosis using electronic medical records, Fombonne et al. (2021) found 98.8% agreement with SPARK cohort data. SPARK participants are required to have personal access to internet-connected devices to complete studies and surveys online. Written informed consent from and assent was obtained from all participants prior to enrollment.

Of the 105 families that enrolled, 13 did not complete the study, and two had low audio quality such that less than 80% of the adult's speech was intelligible to two trained transcribers. After removing these 15 participants, our sample consisted of 90 parent-child dyads that completed the study between December of 2020 and November of 2021. The 90 child participants (20 female) were between the ages of 4 and 7 years (age in months ($M$=74.96, $SD$=12.85, $Range$ = 49–95). **Table 1** shows the racial and ethnic characteristics of the participants and the highest educational degree attained by the child's primary caregiver.

**TABLE 1** | Participant demographics.

| **Characteristic** | **Number (%)** | | | |
|---|---|---|---|---|
| **Race and Ethnicity** | **Not hispanic or latino** | **Hispanic or latino** | **Not reported** | **Total** |
| American Indian/Alaska Native | 1 (1.1%) | 0 | 0 | 1 (1.1%) |
| Asian | 4 (4.4%) | 0 | 0 | 4 (4.4%) |
| Native Hawaiian or Other Pacific Islander | 0 | 0 | 0 | 0 |
| Black or African American | 5 (5.6%) | 1 (1.1%) | 0 | 6 (6.7%) |
| White | 58 (64.4%) | 8 (9%) | 0 | 66 (73.3%) |
| More than one race | 5 (5.6%) | 2 (2.2%) | 1 (1.1%) | 8 (9%) |
| Other | 1 (1.1%) | 2 (2.2%) | 0 | 3 (3.3%) |
| Not reported | 1 (1.1%) | 0 | 1 (1.1%) | 2 (2.2%) |
| Total | 75 (83.3%) | 13 (14.5%) | 2 (2.2%) | 90 (100%) |
| **Primary Caregiver Highest Degree** | | | | |
| High school graduate or GED | | | | 6 (6.7%) |
| Special training after high school (vocational or trade degree) | | | | 3 (3.3%) |
| Some college | | | | 18 (20%) |
| College degree | | | | 32 (35.6%) |
| Graduate or professional degree | | | | 29 (32.2%) |
| No answer | | | | 2 (2.2%) |
| Total | | | | 90 (100%) |

## 2.2. Procedure

The Parent-Child Interaction (PCI) consisted of a 15-min, naturalistic interaction between the child and a parent. This interaction was recorded by an examiner over Zoom. Parents were instructed before the interaction to prepare two to four activities that they thought would hold their child's attention for this duration of the interaction and elicit communication. Parents were provided with instructions that included a list of possible activities. Parents were given an opportunity prior to the interaction to brainstorm possible activities with the examiner if they were unsure what would work well with Zoom video. Parents were instructed, if possible, to avoid activities that featured electronic devices and/or toys that made a lot of sounds as these could both discourage active engagement and make existing communication inaudible. They were also instructed to, when possible, interact at a table in a room with minimal distractions and no other people present (see **Supplementary Materials I** for the written instructions that were provided to parents).

Once activities were determined, parents positioned themselves so that both they and their child were visible on screen. The examiner recording the interaction turned off their video so as to not be a distraction, but remained on the call. This allowed the examiner to pause the recording whenever the child needed a break, if there were technical issues with the video call, or to request that the parent and or child reposition themselves remain visible onscreen. Once 15 min of interaction were recorded, the examiner turned their video back on and informed the caregivers that the interaction was finished.

Parents were provided with detailed step-by-step instructions for downloading and using Zoom, though most families were already familiar with using Zoom. Parents were also provided with detailed instructions for recording high quality audio in wav format using the Lexis audio editor app on a home device and uploading the files to a secure shared folder. Once the parent uploaded the .wav audio file, the research technician moved it to a secure password protected lab server and deleted the file from the shared folder. Recording via the Lexis app on an in-home local device, in addition to Zoom, ensured a second back-up audio file of higher quality, as it did not rely on variable internet connectivity.

We selected a 15-min interaction as previous NLS research has shown that language samples of 10–20 min in length are sufficient to extract reliable language measures from children with autism (Tager-Flusberg et al., 2009; Kover and Abbeduto, 2010). Our piloting showed that a 15-min parent-child interaction was well-tolerated by children with ASD and their parents, who were tasked with keeping the children visible on screen. We chose to prioritize video data, over audio-only, so that we could code video for non-verbal communication, joint attention and engagement for subsequent studies with these data. While manual transcription and coding of these data are labor-intensive, they result in a rich data set. Moreover, reliable automated methods for the analysis of speech in children with ASD over the age of 5 have not yet been developed. A recent test of the reliability of LENA (Language Environment Analysis; Gray et al., 2007), a portable, digital language processor validated for use with the typically developing 0-4 age group, found this method was unreliable for children with autism over the age of 5 (Jones et al., 2019).

Parents also completed the *Vineland Adaptive Behavior Scales-Third Edition* (VABS) (Sparrow et al., 2016) semi-structured interview, an individually administered measure of adaptive functioning used in the diagnosis of intellectual and developmental disabilities. The VABS interview was administered remotely using Zoom by research-reliable technicians. Core domain standard scores represent an examinees overall adaptive functioning across four broad domains: communication, daily living skills, motor skills and socialization. The overall level of adaptive functioning is based on the Adaptive Behavioral Composite (*M* = 100; *SD* = 15). Adaptive raw scores were computed at the subdomain level and converted to v-scale scores (*M*=15; *SD*=3). **Table 2** shows the children's scores overall and in the four domains assessed.

**TABLE 2** | Characteristics of child participants.

| Characteristic | *M* | *SD* | Range |
|---|---|---|---|
| Age in months | 74.96 | 12.85 | 49-95 |
| VABS Standard Score | 58.3 | 13.79 | 31-84 |
| VABS Communication Domain | 53.1 | 21.49 | 20-94 |
| VABS Living Domain | 63.18 | 12.76 | 31-102 |
| VABS Social Domain | 57.82 | 14.12 | 32-90 |
| VABS Motor Domain | 70.14 | 13.47 | 20-100 |

## 2.3. Transcription

The parent-child interactions were transcribed using the Systematic Analysis for Language Transcripts (SALT; Miller and Iglesias, 2012) procedures. In accordance with SALT procedures, utterances were segmented into communication units defined as an independent clause with its modifiers. A word was defined as a set of characters bound by spaces. Common phrases with co-occurring words that were spoken without pauses between them (e.g., "alldone," "nothankyou," "allgone," "cleanup," "gimme," and "kinda") were transcribed as one word following transcription standards for children with ASD (Tager-Flusberg and Anderson, 1991; Tager-Flusberg et al., 2009; La Valle et al., 2020). Words were transcribed using standard orthography to avoid increasing the number of different words used within and across transcripts. One researcher transcribed all utterances and marked bound morphemes according to SALT conventions. A second researcher then reviewed the file to proof the transcription. Transcription proofing involved reviewing the initial transcript while viewing the video of the parent-child interaction. Discrepancies were settled by the two researchers reaching a consensus in accordance with SALT conventions (Miller and Iglesias, 2012). In the rare case that a consensus could not be reached, the word or utterance in question was marked as unintelligible to avoid inflating the number of intelligible words produced.

All intelligible verbal utterances were included (including utterances that were interrupted or abandoned), since our focus was on number of different words rather than utterances at the conversational level. Unintelligible and nonverbal utterances were excluded. Following conventions for NLS with individuals with ASD (see e.g., Tager-Flusberg and Anderson, 1991; La Valle et al., 2020), we did not include stereotyped language (e.g., echolalia, scripted recitation and idiosyncratic language), sign language or alternative and augmentative communication (AAC) (e.g., speech generating devices). While AAC and manual sign are valid forms of communication, it is unclear how to treat the use of AAC and manual sign, as NLS was developed to analyze spoken language. Similarly, stereotyped language is common in those with ASD, particularly those with lower language levels (La Valle et al., 2020) and serves communicative functions (Stiegler, 2015). Additional studies are needed to understand the role of stereotyped language in language production in children with ASD. Future studies are needed to understand non-spoken communication modalities and stereotyped language use in the context of NLS.

### 2.3.1. Number of Different Words (NDW)

Number of different words is a well-established measure of lexical diversity (vocabulary development) that can be reliably obtained from a 10 to 15 min language sample for the purpose of screening and/or diagnosis (Miller et al., 2011; Paul et al., 2018). NDW is an optimal measure of language for children with ASD, particularly those who are MLV and have little spoken language (Barokova et al., 2020). We used the SALT

**TABLE 3 |** Characteristics of child spoken language.

| Characteristic | *M* | *SD* | Range |
|---|---|---|---|
| Utterances per minute | 2.56 | 3.09 | 0–13.27 |
| Percent intelligible utterances | 53.74 | 30.07 | 0–100 |
| Number of different words | 38.81 | 49.91 | 0–233 |
| Mean length of utterance in morphemes | 1.67 | 1.24 | 1–5.94 |
| Time of interaction | 14.98 | 0.13 | 13.87–15 |

software (Miller and Iglesias, 2012) to obtain the measure of number of different words. We included only utterances that were complete, intelligible and spontaneous. While stereotyped language is common in children with ASD (Stiegler, 2015), it is typically excluded from NLS measures of spontaneous language ability (see e.g., Tager-Flusberg and Calkins, 1990; Tager-Flusberg and Anderson, 1991). Stereotyped utterances were defined as repetitions, scripted recitations, neologisms and idiosyncratic speech. Repetitions were further defined as that was a complete or partial repetitions of a previous utterance within the past five utterances spoken by either the child or the parent (Tager-Flusberg and Anderson, 1991; La Valle et al., 2020). Singing, reading, counting and other forms of language recitation are typically not considered spontaneous spoken language. While we included those activities in our analyses, we did not include the child's utterances that involved singing, reading, counting or reciting in the spontaneous spoken language measures. In **Table 3**, we outlined a range of spoken language measures for our sample, including talkativeness (number of utterances per minute), speech sound production (percent intelligible utterances), mean length of utterance in morphemes (MLUm) (syntax), and our main measure of vocabulary–number of different word roots (NDW). We also show the time of the interaction because four of the parent-child interactions were under 15 min in length because the child would no longer remain on the video call.

## 2.4. Coding

### 2.4.1. Activities

We descriptively categorized the activities in all parent-child interactions based on the materials used and the primary purpose of the activity. Two research assistants categorized all activities for each parent-child dyad. Since the coding of activity categories was primarily descriptive, the activity categorization was then reviewed by the first author, and questions and discrepancies were settled by consensus. The activities were placed into one and only one category based on the following descriptions (with examples):

1. *Conversation only*: No activity or items are presented. The caregiver and child have conversation about themselves or things in their immediate environment.
   Example 1: The child sits on his father's lap at the kitchen table. The child plays with the father's wrist watch, and they talk about it.
   Example 2: The mother asks the child questions about the child's day at school.

2. *Cooking, baking*: Making real food using kitchen items.
   Example 1: The mother gives the boy a cup of whipped cream. The child adds food coloring and stirs. The mother instructs the child to spread the whipped cream on cookies then put sprinkles on them.
   Example 2: The mother and the child make brownies together.

3. *Coloring, art*: Using crayons, markers, paint or other supplies to make a drawing, painting or other craft.
   Example 1: The mother and child draw pictures with markers.
   Example 2: The child colors on her arms and legs with washable markers while the mother comments.

4. *Educational activities*: Activities (including paper/workbooks, flashcards, apps and games) that are explicitly designed to promote literacy or math.
   Example 1: The mother tells the child words to write on a small dry-erase board.
   Example 2: The mother and the child work on math homework sent home by the child's classroom teacher.

5. *Figure play*: Play with action figures, stuffed animals or other toys that can be animated.
   Example 1: The mother and child play with superhero figures making them fly and talk.
   Example 2: The mother and the child play with stuffed animals, putting clothing on them and discussing it.

6. *Games, puzzles*: Turn-taking games and puzzles.
   Example 1: The mother and child put together a puzzle.
   Example 2: The mother and child play the card game Uno.

7. *Manipulatives*: Play with toys that are designed to be manipulated with the hands.
   Example 1: The mother and the child build a tower with blocks.
   Example 2: The father and the child play with lego bricks making enclosures for lego animals

8. *Motor*: Activities that primarily involve gross or fine body movements.
   Example 1: The mother sits on the floor with the child on the couch. The mother reaches for the child's feet and the child pulls them up so the mother can't get them.
   Example 2: The mother and the child throw a ball back and forth.

9. *Screentime*: The child is using a tablet or phone (not used as a communication device or an educational app).
   Example 1: The child is playing with an app on the tablet (not educational or communicative)
   Example 2: The child watches a video on his mother's phone.

10. *Sensory*: Activities that involve the senses, e.g., touch, sight, hearing, taste, smell.

Example 1: The mother sprays different scented spray bottles and the child smells them.
Example 2: The mother and the child play with kinetic sand, forming it into mounds and pushing their fingers into it.

11. *Shared book reading*: The caregiver and child read, look at, comment on, turn the pages of a book together.
Example 1: The mother reads the book and the child comments and turns the pages.
Example 2: The father and the child take turns reading a book together.

12. *Singing, reciting*: Verbal social routines that include songs, counting, reciting the alphabet, reciting poems or riddles.
Example 1: The mother and the child sing *Baby Shark* together.
Example 2: The father helps the child count money the child got for a birthday.

13. *Snack*: Eating a snack is the primary activity.
Example 1: The father gets fruit snacks, giving them to the child one-by-one and prompting the child to ask for more.
Example 2: The mother gives the child fruit snacks one-by-one asking what color the child wants.

#### 2.4.2. Activity Time Range

In order to understand differences between activities, we noted the time range that each parent-child dyad spent engaged in a particular activity. Two research assistants annotated the start time and end time of the activity based on when the parent presented the activity materials (start time) and when the materials were put away or put aside (end time). If a child rejected the activity, it was not counted. Only activity durations longer than 20 s were included, as many activities shorter than 20 s did not engage the child, an alternative activity was presented.

#### 2.4.3. Number of Different Words (NDW per Minute by Activity Type)

Transcriptions were marked with the start and end time of the activity. Using SALT, we extracted NDW for the duration of the activity by specifying the start time and end time in the SALT settings. Then, we calculated NDW per minute by dividing NDW by the duration of the activity to standardize the measure across activities with varying durations.

## 3. ANALYSIS

### 3.1. What Activities Do Parents Choose to Promote Spoken Language With Their Children in a Remote Context?

Our first aim was to understand the range of activities that parents selected to promote communication in the home with their child with ASD. **Table 4** shows the percentage of parent-child dyads that engaged in each type of activity. The most frequent activities were: sensory activities, play with manipulative toys, conversation only, games or puzzles, coloring or other art activities, snack, play with toy figures and shared book reading. Less frequent activities include educational (math or literacy) activities, motor activities, screentime, singing or reciting and cooking or baking.

**TABLE 4** | Percentage of parent-child dyads engaged in different activity types.

| Activity type | Number | Percentage |
|---|---|---|
| Manipulatives | 27 | 30 |
| Games and puzzles | 23 | 25.6 |
| Sensory | 21 | 23.3 |
| Shared book reading | 18 | 20 |
| Coloring and art | 16 | 17.8 |
| Figure play | 16 | 17.8 |
| Conversation only | 15 | 16.7 |
| Motor | 14 | 15.6 |
| Educational | 10 | 11.1 |
| Snack | 10 | 11.1 |
| Singing and reciting | 9 | 10.4 |
| Screen time | 6 | 6.7 |
| Cooking and baking | 3 | 3.3 |

### 3.2. Does the Type of Activity or Number of Activities Depend on Child Language Level?

**Figure 1** shows the child's NDW by activity type. We conducted a Chi-square test to evaluate if there was a significant difference in the mean NDW between the different activity types, however the difference was not significant [$\chi^2(540) = 484.48, p = 0.96$]. Children with lower language, those who had fewer than 20 different spoken words during the parent-child interaction, engaged in all types of activities. While there was not a significant difference across activities, **Figure 1** shows that dyads with children whose NDW levels were higher than 80 different words in 15 min did not engage in coloring and art, cooking and baking, motor activities, screentime, singing and reciting or snack activities.

**Figure 2** shows the child's NDW and the number of activities in which the parent-child dyad engaged. A simple linear regression model showed that the child's NDW was a significant predictor of the number of activities ($\beta = -0.01, t = -3.52, p < 0.001$). Parent-child dyads whose children had higher language ability tended to engage in a smaller number of activity types, while parent-child dyads whose children had lower language ability engaged in a range of one to five different activity types.

### 3.3. Does Type of Activity Elicit More Vocabulary From Children?

Our third aim was to examine if different types of activities elicit more language from children. We found no significant difference in the number of different words per minute elicited during the five most common activities: coloring/art, games/puzzles, play with manipulatives, sensory activities and shared book reading [$\chi^2(264) = 270.55, p = 0.38$] (see **Figure 3**).

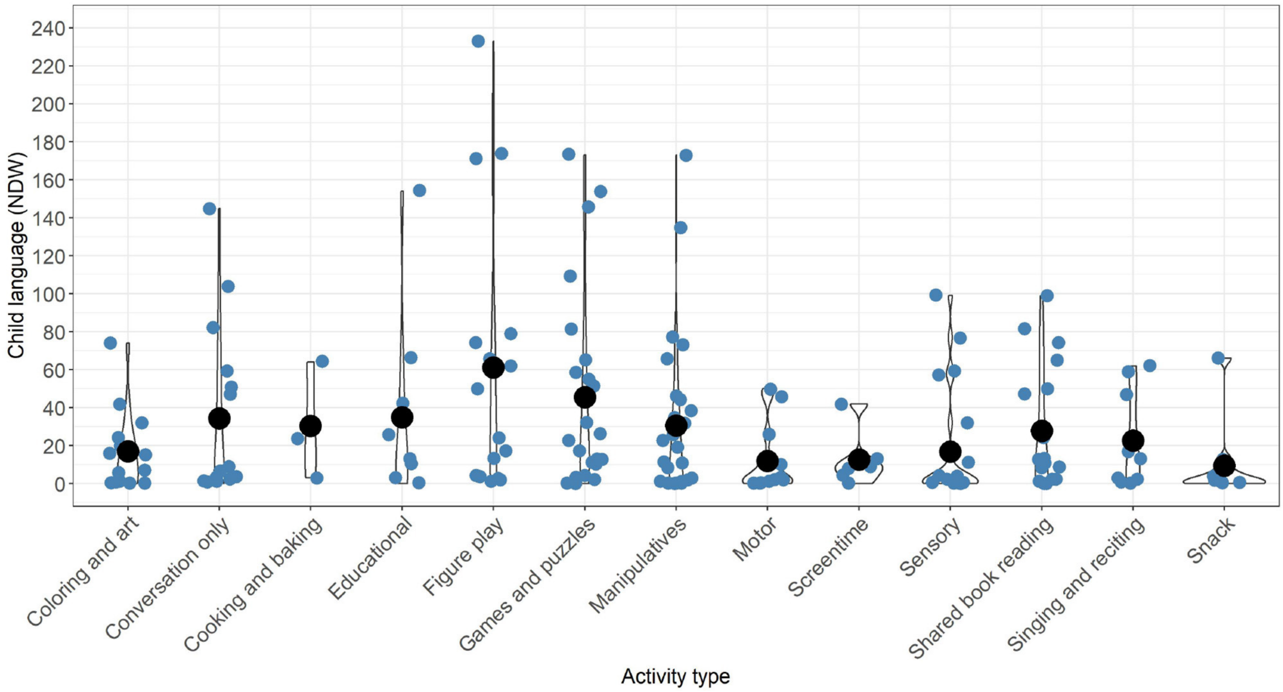


**FIGURE 1 |** Activity types and child spoken language level.

## 4. DISCUSSION

### 4.1. Range of Parent-Selected Activities

The focus of this study was on remote assessment of child language using open ended-parent-child interactions in the home. Parents were not provided with a set of specific activities and materials but were allowed to use the materials in the home and the activities that their children preferred. We found that parents chose activities that fell into 13 different descriptive categories, including some activities that are not typically included in lab-based semi-structured language assessments, such as cooking and baking. We found that all categories of activity were used with children who had low language levels. For dyads with children whose language level was higher (e.g., NDW above 80), they did not engage in coloring and art, cooking and baking, motor activities, screentime, singing and reciting or snack activities. They did engage in conversation only, educational activities, figure play, games and puzzles, manipulatives, sensory activities and shared book reading. Understanding the range of activities that parents select to engage children with ASD in the home with in-home materials and activities is essential to increasing the accessibility and equity of language assessment during pandemic stay-at-home times and beyond.

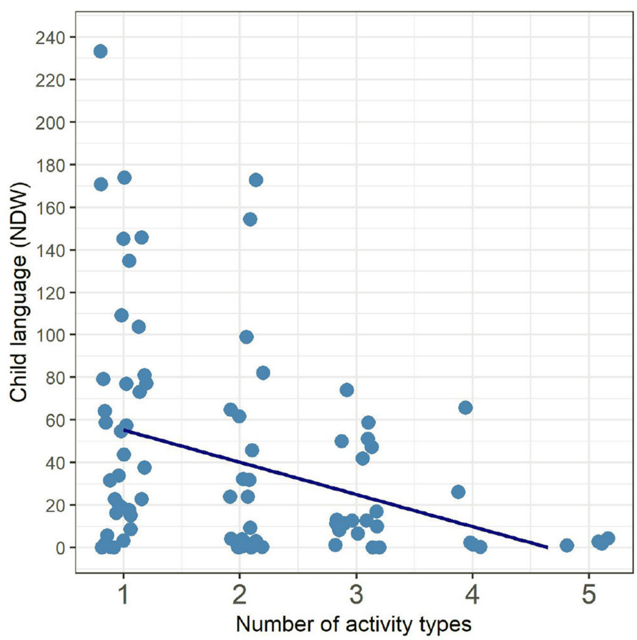


**FIGURE 2 |** Number of different activity types and child spoken language level.

### 4.2. Type and Number of Activities

We then aimed to discover the relationship between the child's language level and the type and number of activities. Not only are parents of lower verbal children with ASD engaging in all types of activities, but we also found that there was no significant difference in child language level across activities. Parents of nonverbal and minimally verbal children did not engage in different activities from those whose children had

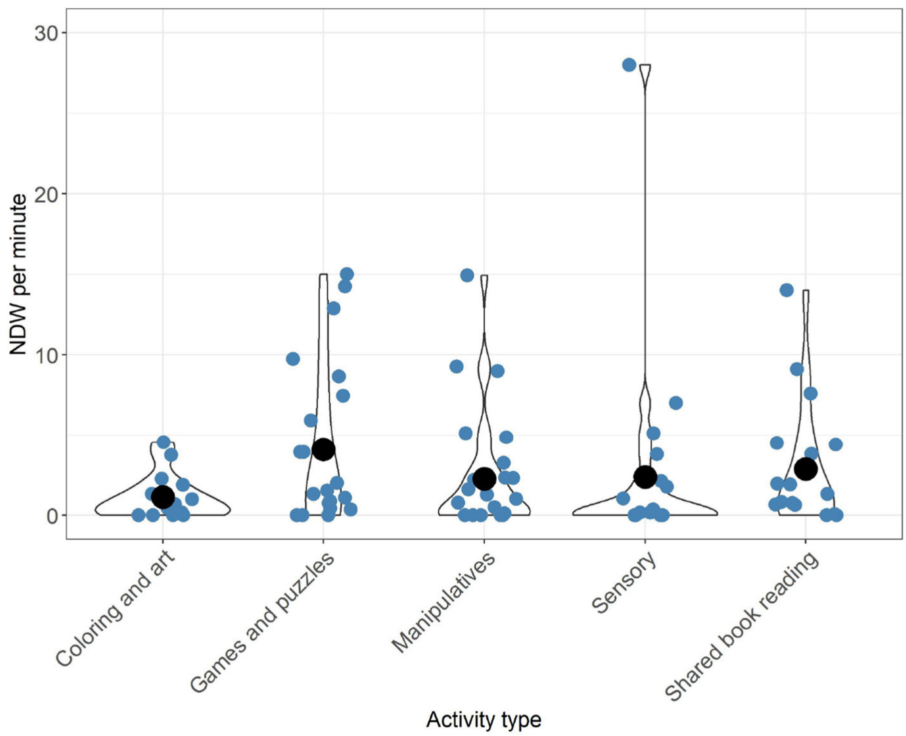


**FIGURE 3 |** Number of different words (NDW) per minute by activity type.

higher language levels. We did find a significant relationship between the child's language level and the number of different activity types. Parents of children with low language levels tended to engage in a greater number of different activities (up to five in the 15-min interaction). In a recent study using NLS for language assessment with children with ASD, Barokova and colleagues (Barokova et al., 2020) developed a novel protocol for eliciting natural language samples with minimally and low verbal children with ASD. Their protocol involved eight different activities designed to be elicited in a 20-min timeframe. This approach aligns with our findings that parent-child dyads with children who had lower language levels engaged in a higher number of different activity types.

Some, but not all, parent-child dyads in which the child had a smaller number of different words, engaged in a larger number of different types of activities. It is well-known that children with autism have significant social-communication delays in symbolic play and joint attention that differentiate them from typically developing children and children with intellectual disability without autism (Mundy et al., 1986). Both symbolic play and joint attention are significantly associated with social (Sigman et al., 1999), cognitive (Mundy et al., 2010) and communication development (Kasari et al., 2008) as well as expressive langauge in particular (Adamson et al., 2019). Therefore, the level of the child's skills in symbolic play and joint attention may have played a role mediating the relationship between the number of different activities and the language level of the child.

Other factors may have contributed to the association between number of activities and number of different words. The environmental setup of certain activities may not have been feasible within the camera frame for some families. The families may not have had access to all the necessary activity materials during the PCI, since they were asked to do the activity at a tabletop in a quiet room. Finally, while some parents may have added different types of activities to keep their children with lower language engaged, we observed a broader range of engagement strategies that parents used. Along similar lines, parents are in tune to their child's play skills and abilities, which plays a role in the child's response to the interaction (Barokova et al., 2020). These factors should be considered in future research on approaches to analyzing naturalistic parent-child interactions.

## 4.3. Do Different Activity Types Elicit More Language?

Our third question was whether different activities elicit more language (measured by number of different words per minute) from children with ASD. We found that there was not a significant difference in NDW per minute in the five more common activities: coloring/art, games/puzzles, play with manipulatives, sensory activities and shared book reading. Similar to our findings that type of activity did not elicit significantly more language, Barokova et al. (2020) found no significant difference in spoken language production (measured by frequency of utterances per minute) between activities (with the exception of watching a short animated movie designed to elicit a narrative or naming of the movie characters). Both our study and the Barokova study reported no difference in spoken language production between activities in their protocol, with the possible exception of screentime. Taken together, these results suggest that a wide range of items, materials and activities, including those already in the home for remote NLS, do not significantly affect the quality or quantity of language elicited from the child.

Rather than play activities being determined by the child's language level, it is possible that play activities are more highly influenced by the child's level of symbolic play. As previously discussed, delays in symbolic play in children with autism are associated with social, cognitive and communication development (Sigman et al., 1999; Kasari et al., 2008; Mundy et al., 2010). Symbolic play allows children to progress developmentally from playing with toys functionally, such as in constructive and manipulative play, to playing with toys symbolically, such as in figurative play (Lifter et al., 1993). Compared to typically developing children matched on mental age, children with autism have significant delays in the development of symbolic play (Baron-Cohen, 1987; Jarrold et al., 1993). Children with autism show less spontaneous, creative symbolic play (Jarrold et al., 1993; Libby et al., 1998) and more manipulation of objects in a rigid or stereotyped manner (Atlas, 1990). Beyond these delays in play skills, children with autism show more focus on objects with less frequent engagement of others into their play activities (Kasari et al., 2010). It is likely that symbolic play skills in children is more predictive of choice of activity than language level, and future work should examine the role of joint attention and symbolic play in remote, open ended-parent-child interactions in the home.

## 5. LIMITATIONS AND FUTURE DIRECTIONS

Following NLS conventions for individuals with ASD (see e.g., Tager-Flusberg and Anderson, 1991; La Valle et al., 2020), our analyses did not include stereotyped language (e.g., echolalia, scripted recitation, and idiosyncratic language), sign language or alternative and augmentative communication (AAC) (e.g., speech generating devices). While AAC and sign language are valid forms of communication, and some children in the sample appeared to use AAC spontaneously, it is unclear how to treat the use of AAC and sign, as NLS was developed to analyze spoken language. Similarly, stereotyped language is common in those with ASD, particularly those with lower language levels (La Valle et al., 2020) and serves communicative functions (see e.g., Stiegler, 2015). Future studies are needed to understand the use of AAC, sign language and stereotyped language. It is important to understand how to analyze use of AAC, sign language and stereotyped language using NLS and to examine how these influence the development of language in children with ASD.

Another limitation and potential future direction involves the categorization of activity types. Effects may have been different if activity types were grouped differently. For example, there are clear similarities between some activities categorized as sensory, motor, manipulatives and figure play. While playing with blocks and legos was categorized as manipulatives, playing with playdoh or kinetic sand was considered sensory play. However, if the parent-child dyad was playing with playdoh and figures and the primary purpose of the play involved interactions between the figures, then the activity was categorized as figure play. Similarly, for a child whose parent gave him or her small marshmallow rings to string on a straw, this activity was categorized as motor due to the fine motor focus of the activity, but it could have been considered a manipulative activity. In addition, some activity categories overlapped, such as the previous example of play that involved playdoh and toy figures. We restricted our activity coding to a single activity, but a deeper understanding of simultaneous activities would improve our understanding of naturalistic parent-child interactions for the purpose of remote language assessment. Along similar lines, understanding the complexity of play skills (see e.g., Bornstein and O'Reilly, 1993; Freeman and Kasari, 2013; Bentenuto et al., 2016) and parent strategies for responding to and engaging their child (see e.g., Adamson et al., 2012, 2019) was beyond the scope of this paper, but will improve our understanding of methods for remote naturalistic language sampling for children with ASD.

## 6. CONCLUSIONS

In this study, we analyzed natural language samples of naturalistic interactions between parents and children with ASD collected remotely in the home. We gave parents few parameters to allow for naturalistic play-based interactions in the home with items, materials and activities in the family's own home. It is important to understand naturalistic, open-ended remote NLS because they open the window to accessible and equitable methods for language assessment, particularly for children with ASD who are nonverbal and minimally verbal, for whom current standardized language assessments are not feasible or valid. While parent-child dyads engaged in a wide range of different activity types with their children in the home, we found no significant difference between activity type and the child's language level measured by NDW. Parents of children who were nonverbal and minimally verbal engaged in all types of activities, and they engaged in the same activities as did parents of children with higher language levels. We did find, however, a significant relationship between language level and the number of different activity types. Parents of children with lower language levels tended to engage in a higher number of different activity types. Different activities did not elicit significantly more language. These results suggest that remote, in-home NLS with items, materials and activities selected by parents are an appropriate method to assess language remotely in children with ASD, so long as a sufficient number of activity types are presented to children who have lower language levels. Finally, our results support the feasibility of remote in-home natural language sampling using the family's own items, materials and activities.

## DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: National Database for Autism Research (NDAR).

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Boston University Institutional Review Board. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

## AUTHOR CONTRIBUTIONS

LB contributions include transcription, coding, conceptualization, analysis, writing, and editing. CLa contributed conceptualization, transcription, and editing. SS contributed conceptualization, data acquisition, and editing. JP contributed data acquisition and writing. CLi contributed transcription and coding. NP and LS contributed transcription. HT-F contributed funding acquisition, lab resources, conceptualization, and editing. All authors contributed to the article and approved the submitted version.

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## SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcomm.2022.820564/full#supplementary-material

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