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An exploratory longitudinal study of social and language outcomes in children with autism in bilingual home environments

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Abstract

Little is known about outcomes of early intervention for children with autism spectrum disorder (ASD) reared in bilingual homes. There are concerns that social communication deficits among children with ASD may reduce the developmental benefits of early intervention for children with ASD raised in bilingual environments. We conducted an exploratory analysis of cross-sectional and longitudinal data from a larger study to explore associations between home language environment and language ability and social skills in response to early ASD intervention. Participants, aged 12–26 months when recruited, were a subset of a larger two-year, randomized intervention trial (ClinicalTrials.gov identifier: NCT00698997). Children from bilingual homes (BLH, n=13) began intervention with lower gesture use but otherwise demonstrated equal baseline language and social abilities as compared with age and nonverbal IQ-matched children from monolingual homes (MLH, n=24). Significant language growth was exhibited by children from both language groups and there was no moderating effect of home language environment. The BLH group demonstrated increased gesture use over the course of intervention as compared with the MLH group. Preliminary data revealed no basis for concerns regarding negative impact of a bilingual home environment on language or social development in young children with ASD.

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Keywords

autism; bilingualism; language exposure; home language environment; early intervention; Early Start Denver Model (ESDM)

Introduction

Early intervention for autism spectrum disorder (ASD) often occurs in families who speak more than one language, but very little is known about outcomes of early intervention for children reared in bilingual homes. Concerns that children with ASD reared in bilingual environments may demonstrate delayed overall language acquisition compared to children with ASD raised in monolingual home environments have persisted in the professional community, perhaps due to very little published research in this area until very recently. While over 20 percent of children in the United States (U.S.) are raised in homes where languages other than English are spoken (U.S. Census Bureau, 2014) and up to 66% of children worldwide are raised bilingually (Marian and Shook, 2012), there remains a lack of evidence to guide clinical practice for parents of children with ASD regarding language use. Consequently, this topic is often fraught with confusion for healthcare practitioners and families who speak more than one language at home.

The roots of concern about the impact of bilingual homes on developmental outcomes may be traced back almost a century, when studies of typically developing children described detrimental effects of bilingualism on intelligence (Rigg, 1928; Wang, 1926; Graham, 1925; Smith, 1923; Saer, 1923). Although these studies demonstrated fundamental design flaws that largely invalidated these conclusions, the ideas described in these studies continue to exert influence (Peal and Lambert, 1962). Parents of children with ASD living in the U.S. today may be told by healthcare practitioners that they should only speak to their child in English or even to limit interactions with non-English speakers (Wharton et al., 2000; Kremer-Sadlik, 2005; Yu, 2013; Baker, 2013; Kay-Raining Bird et al., 2012; Yu, 2016a; Yu, 2016b; Jegatheesan, 2011; Ijalba, 2016). In some cases, they may even be told their child’s language delays are the result of being raised in a multilingual home environment (Jegatheesan, 2011; Yu, 2016a).

Negative beliefs about rearing children in bilingual homes may deprive children of potential benefits or enhanced developmental outcomes. Parents using their native languages to interact with their child may be more effective in conveying emotions, maintaining child engagement, and expanding on topics of interest (Wharton et al., 2010; Yu, 2016a). Additionally, the quality of parental language input may be related to improved vocabulary skills in typically developing children (Rowe, 2012). Further research is needed to determine whether development in children with ASD is hindered when parents utilize a non-preferred language to communicate during family interactions. Typically developing bilingual and bilingually exposed infants and preschoolers have been shown to be better at perspective taking, a fundamental skill in social communication, than monolingual peers (Fan, et al., 2015; Liberman et al., 2016). Thus, typically developing children from bilingual homes may demonstrate some developmental advantages, however the extent to which these findings extend to children with ASD is not clear.

Evidence regarding the effects of being raised in a multilingual environment for children with ASD is emerging. The majority of studies have investigated language outcomes. One study found that greater secondary language exposure (higher parent-reported secondary language use in the home) was associated with lower expressive and receptive language in 2–5-year-old children with ASD (Chaidez et al., 2012). Other studies report no adverse effects on language skills (Kay-Raining Bird et al., 2012; Hambly and Fombonne, 2012; Ohashi et al., 2012; Reetze et al., 2015; Sen and Geetha, 2011; Hategan and Talas, 2014) and have even shown that children with ASD and intellectual disability can acquire second language vocabulary (Hambly and Fombonne, 2014). Toddlers with ASD from bilingual homes have been observed to coo and use protoimperative gestures more frequently than toddlers with ASD from monolingual homes (Valincenti-McDermott et al., 2012). Bilingually exposed 3–7-year-old children with ASD reportedly have greater total production vocabularies than monolingually exposed peers with ASD (Peterson, et al., 2012). The majority of the evidence suggests children with ASD from bilingual homes have equivalent or greater language outcomes than children with ASD from monolingual homes.

With regard to ASD symptom severity (Valicenti-McDermott et al., 2012; Kay-Raining Bird et al., 2012) and developmental function (Valicenti-McDermott et al., 2012), no group differences between bilingually and monolingually exposed individuals with ASD have been previously reported. Furthermore, bilingually exposed toddlers with ASD demonstrated higher adaptive functioning than monolingually exposed toddlers with ASD (Valincenti-McDermott et al., 2012) and appear to suffer no negative effects in the social domain (Hambly and Fombonne, 2012; Hambly and Fombonne, 2014; Reetze et al., 2015). Children who were bilingually exposed from birth may even demonstrate better parent-reported social interaction skills than children exposed after age 3 years (Hambly and Fombonne, 2012). Bilingually exposed toddlers have also shown advanced skills in some areas of pretend play (Valicenti-McDermott et al., 2012). In a case study, a bilingual, Chinese-English speaking, 5-year-old boy with ASD demonstrated the ability to perform conversational code-switching, a linguistic phenomenon characterized by its pragmatic and social significance (Yu, 2016b). Thus, recent work over the last five years, suggests that children with ASD from bilingual homes demonstrate developmental outcomes equivalent to or better than children with ASD from monolingual homes.

There is little current evidence about how children with ASD in bilingual home environments respond to intervention. In a case study following the progress of a three-year-old bilingual boy with ASD during two years of a Korean-English bilingual speech-language intervention, marked improvements in expressive and receptive language, nonverbal communication, increased eye contact, and decreased challenging behaviors were observed (Elder et al., 2006). Another case study found that a four-year-old girl with ASD from a Spanish-speaking household was more successful at following directions and exhibited fewer challenging behaviors when discrete trial training was administered in Spanish than when it was administered in English (Lang et al., 2011). However, we are aware of no case-control or randomized control studies of children with ASD from bilingual homes.

This study will explore the relationship between home language environment and changes in language and social abilities over time in very young children with ASD, aged 12–26 months, and whether there is preliminary evidence that home language environment may moderate the effects of an early intensive intervention conducted in the home for 2 years on language and social abilities.

Method

Participants

Participating children were drawn from a larger, multi-site, longitudinal, randomized intervention study (described in ClinicalTrials.gov identifier: NCT00698997). The original RCT study sample included ninety-eight participants randomized into two treatment groups (ESDM, n=49; COM, n=49) stratified by age, gender, and Mullen developmental quotient (DQ). The study was conducted across three clinical sites in Sacramento, CA, Seattle, WA, and Ann Arbor, MI. All participants, at baseline, were 12–26 months of age, were diagnosed with ASD by expert clinicians, could crawl or walk, had developmental quotients of 35 or higher, and had English as one of the languages spoken in the home. ASD diagnoses were consistent with DSM-IV-TR criteria based on all available information (standardized developmental testing, family history, direct observations made during research assessments, and medical records) and all children met the cutoff score on the Autism Diagnostic Observation Scale for Toddlers (Luyster et al., 2009). Any participant with current or previous enrollment in 10 or more hours per week of intensive 1:1 autism intervention, serious medical conditions including cerebral palsy, gestational age of less than 35 weeks, DQ less than 35, genetic disorders associated with ASD, or whose parents disclosed any significant mental illness or substance abuse were excluded from the study.

Home language environment data was available for 13 children from bilingual homes (BLH). We matched each BLH participant with one or two participants from monolingual homes (MLH), based on age, and Mullen Scales of Early Learning Nonverbal Developmental Quotient (NVIQ) within 5 points at initial enrollment in the study. Matching was done by the fourth author, who was naïve to other outcome scores during this process. We attempted to match on gender, but were not always able to do so due to lower numbers of girls than boys, which reflects the gender ratio of ASD. When more than two matches for a BLH participant were found, matches were created based on closeness in NVIQ score. Matches were sought within each site to account for potential regional differences. When two in-site matches were not found, matches were sought within the other two sites. For two BLH participants, only one MLH match was found. Since the analysis focused solely on dual language home environment, we excluded one participant who was exposed to three languages in the home. Second languages in our study included English, Spanish, Ukrainian, Portuguese, Japanese, Vietnamese, Chinese, Tigrinya, Romanian, Hindi, and German.

Procedures

Participants were randomized to the Early Start Denver Model (ESDM) or treatment-as-usual in the community (COM) group (ClinicalTrials.gov identifier: NCT00698997). Participants in the ESDM group were offered three months of parent-delivered ESDM intervention followed by two years of intensive in-home therapist-delivered intervention (two 2-hour sessions each day, five days a week), during which semimonthly parent coaching was also offered. The ESDM is a manualized, evidence-based, comprehensive early intensive behavioral intervention for children with autism aged 12–60 months of age. It is a relationship-based, developmental treatment that incorporates teaching practices from applied behavioral analysis, Pivotal Response Treatment, and the Denver Model (Rogers and Dawson, 2010). Each child's treatment plan is individualized and includes developmentally-appropriate communication, joint attention, social interaction, cognitive, personal independence, play, fine motor, gross motor, and behavior skills, which are chosen based on quarterly curriculum assessments. ESDM is child-centered, can be administered in any setting, and creates teaching opportunities within natural activities and play routines. Families in the COM group were given intervention recommendations and community referrals.

Participants were assessed at baseline (age 12–26 months), then randomized and assessed longitudinally at 3 months, 1 year, and 2 years after randomization. For the purposes of the current study only three time points are reported: baseline (T1), 1 year after the start of intervention (T2), and 2 years after the start of intervention (T3). Assessors were blind to intervention group assignment and were licensed clinical psychologists, postdoctoral fellows or graduate students supervised by licensed clinical psychologists.

The study was approved by institutional review boards at each site and all participants signed informed consent forms prior to participation.

Measures

Home language environment—Home language environment was obtained through parent-report of each language used at home at baseline and an estimate of the percentage of time these languages were used. Bilingual home environment (BLH) was defined as exposure to one language other than English 20% or more of the time, consistent with the measurement strategy and percentages used in previous studies (Gutierrez-Clellen et al., 2008; Ohashi et al., 2012; Reetze et al., 2015). Monolingual home environment (MLH) consisted of homes in which English was spoken at least 90% of the time.

Language and social ability

Vineland Adaptive Behavior Scales, Second Edition (VABS-II)—The VABS-II (Sparrow, et al., 2005) is a standardized, norm-referenced parent questionnaire that assesses four areas of adaptive functioning: communication, social, motor, and self-care skills in individuals from birth to 90 years old. Participants' social and language outcomes were assessed using the VABS-II socialization and communication domains and subdomains, respectively. Socialization and communication domain standard scores and v-scale subdomain scores are reported. The VABS-II was administered at all time points.

MacArthur-Bates Communicative Development Inventory: Words and Gestures (MCDI-WG)—The MCDI (Fenson et al., 2007) is a parental self-report of their child's (aged 8 to 30 months) vocabulary and gesture use in the past week. MCDI raw scores for phrases understood (28 total), vocabulary production (396 total), total gestures (63 total), and vocabulary comprehension (396 total) were used as measures of language outcome. The MCDI was administered at all time points.

Mullen Scales of Early Learning (MSEL)—

The MSEL (Mullen, 1995) is an individually-administered, standardized, norm-referenced developmental assessment for infants and children (birth to 68 months). It contains five subscales: fine motor, gross motor, visual reception, expressive language, and receptive language. Age equivalent scores from the expressive and receptive language subscales were used as language outcome measures. The MSEL was administered at all time points.

Data Analysis Approach

T-tests were conducted on continuous variables and Fisher's exact tests were conducted on discrete variables to verify that the two language exposure groups were not statistically different with regard to gender, ethnicity, income, maternal education, treatment group, age, and NVIQ at baseline. T-tests were also conducted to test for significant group differences in social and language outcomes at baseline, 1 year, and 2 years. Finally, multivariate regression with an interaction term, language exposure by treatment assignment, was used to assess whether language exposure moderated treatment effects on social and communication outcomes. Due to the exploratory nature of this project, and the small sample sizes, Bonferroni correction was considered overly stringent, and results were reported both with and without this correction (Bretz et al., 2011). We also utilized Bayesian methods (Kass and Raftery, 1995), which may be more robust for modeling data with a small sample size. The two-sample Bayesian procedure in the BayesFactor package in R (Morey and Rouder, 2011; Rouder et al., 2009) was used to obtain Bayes factors for tests that two independent samples have the same mean.

Results

Frequencies and means are reported for categorical and continuous baseline demographic variables, respectively, in Table 1. Most participating children were white males and roughly two-thirds of mothers had at least a college degree. Language exposure groups were not significantly different in terms of gender, ethnicity, income level, maternal education, treatment assignment, average intervention hours, chronological age, or nonverbal IQ at baseline. Community interventions included autism-specific ABA, speech, occupational, and physical therapy and other non-ABA autism interventions.

When results were adjusted for multiple comparisons using Bonferroni correction, they no longer reached statistical significance. The results below are reported without correction.

At study entry, no significant group differences in socialization and language functioning were found, with the exception of higher MCDI Total Gestures score in the MLH group (BLH: $M=16.42$ ($SD=8.14$), MLH: $M=23.52$ ($SD=11.31$), $t=-2.13$, $p<.05$). (See Table 2)

Group differences in language and socialization outcomes after 1 year and 2 years were also examined, when children were on average roughly 36 and 49 months respectively. Most group differences on language and social functioning were not statistically significant, with the exception of the BLH group showing increased scores on the VABS-II Interpersonal subdomain over the MLH group (BLH: M=12.00 (SD=3.16), MLH: M=9.59 (SD=2.67), $t=2.24$, $p<.05$) after one year of treatment (Table 3). The general pattern of no differences on the VABS-II between the language groups was supported by the Bayesian analyses. The only variable with a significant group difference, the Interpersonal subdomain, had a Bayes Factor, BF_{10}, of 2.59 which provides only anecdotal evidence for the hypothesis that the groups differ (Jeffreys, 1961; Kass and Raftery, 1995). For the language measures (McArthur and Mullen receptive and expressive scales) after one year of treatment, there were no significant differences and all Bayes factors ranged from 0.33 to 0.36. After two years of intervention, all variables had a Bayes factor of .33 to .38, except the MCDI total gestures ($BF_{10} = 0.59$). Thus, all of the 1-yr and 2-yr MCDI and Mullen language variables, save one, and all of the 2-yr VABS-II variables fall on the threshold of Bayes Factor scores (BF_{10} from .33 to .10), that provide “substantial” (Jeffreys, 1961) or “positive” (Kass and Raftery, 1995) evidence for the null hypothesis that the language exposure groups do not differ in their language ability (Table 3).

Multiple regression was used to examine the degree to which child gains in social and language skills (assessed via change scores) over the course of the study may have been moderated by their home language environment (Table 4).

In the regression model, home language environment was coded as follows: BLH = 0, MLH = 1, and treatment group: Community = 0, ESDM = 1. Thus, the intercept of the models reflect the group mean change for BLH in the Community treatment group. Results indicate that both after 1 year and 2 years of treatment there was significant positive change on all language variables (Vineland, MCDI, and Mullen) for BLH children in the community group (all p-values for the intercept terms < .05 or lower). No significant change was seen for the Vineland Socialization domain and its subscores. The Home Language Environment (HLE) term and the HLE by Treatment Group interaction term was not significant. The BLH and MLH groups did not have significantly different rates of change overall or as a function of treatment group with the exception of the MCDI Total Gestures variable. Children in the BLH group showed significantly greater gains than the MLH group in Total Gestures score after 2 years (BLH mean increase of 33.7 (SD=9.9, N=11), MLH mean increase of 20.9 (SD=15.3, N=21), $t=-3.12$, $p < .01$, see Figure 1). However, the interaction term was not significantly different ($t=1.69$, $p > .05$). This model for Total Gestures change after 2 years was also run with maternal education in the model and the HLE factor remained significant ($t=-2.85$, $p < .01$).

Discussion

This exploratory study examined longitudinal data from a small sample of young children with ASD from bilingual homes, age 12–26 months, who participated in a larger randomized clinical trial of early autism intervention. No support was found for the idea that exposure to a second language should be avoided for young children with ASD while in early intervention. We found that bilingually exposed children with ASD made positive language gains over 2 years of intervention and both language exposure groups exhibited comparable overall level of language and social ability and comparable growth in these domains. Children in the bilingual home group showed greater gains than the monolingual home group in their use of gestures after two years of intervention. The following discussion is framed by the caution that this was an exploratory investigation with a small sample, and most findings did not survive correction for multiple comparisons. However, the use of Bayesian analyses, careful characterization of the sample, well matched groups, and longitudinal study design provide strong preliminary evidence that children with ASD make equivalent social and language gains whether they are raised in bilingual or monolingual homes.

This investigation explored development in the youngest sample of bilingually exposed children with ASD of which we are aware. The first and second years of life are a critical period for learning language. Concerns that a more complex language environment may disadvantage young children with ASD in a critical period are understandable but were not supported in this sample. Our finding that bilingually exposed children made greater gains in total gesture use, consistent with previous literature (Valincenti-McDermott et al., 2012), is particularly notable. It may be that parents who interact with their child using their native language are more likely to use language-promoting interaction styles, such as demonstrating increased responsiveness, utilizing varying communicative functions, and being more precise narrators of language, than when speaking in a non-native language (McCabe et al., 2013). Case studies provide preliminary evidence that parents may be more effective in conveying emotions, capturing the child's attention, and expanding on topics of interest when communicating in their native language (Wharton et al., 2010; Kremer-Sadlik, 2005; Yu, 2016a). English children with ASD raised by non-native English speakers are more likely than typically developing siblings of children with ASD and children with ASD raised by native English speakers to adopt the non-English accent of their mothers (Baron-Cohen and Staunton, 1994). Thus, mothers can serve as salient language models for children with ASD and it is possible that mothers communicating with their child in their native language may provide more effective models.

Children in bilingual homes experience a rich social environment while growing up surrounded by different languages (Fan et al., 2015; Liberman et al., 2016). Although this study did not directly investigate parent-child interaction patterns in BLH as compared with MLH groups, previous research suggests that this may be an important mediator of the effects of home language environment and child language outcomes. Previous research has shown that parents with limited English proficiency, who have restricted their interactions with their child to English, may have shorter, more stilted, interactions with their child with ASD, which may promote isolation and social withdrawal of the child during family interactions carried out in the parents' mother tongues (Kremer-Sadlik, 2005; Hudry et al., in press). The social gating hypothesis posits that language learning is facilitated, even dependent upon, social interaction (Kuhl et al., 2003; Kuhl, 2007). Future studies are needed to investigate whether children who are surrounded by family and community members speaking their native languages as opposed to non-native languages experience enhanced language learning.

There are as yet no published studies evaluating changes over time in language or social function in children with ASD from bilingual versus monolingual homes, so it is not possible to compare these results to previous literature. Similarly, reports from clinical trials have not yet evaluated the responses of children with ASD from bilingual home environments as compared with children with ASD from monolingual home environments. Although we did not find language exposure to have a significant effect on treatment outcomes, future studies are needed to examine this further. Research on intervention delivered to bilingual children with language disorders suggests that delivering intervention in the parent's first language may have benefits (Holm and Dodd, 1999; Perozzi and Sanchez, 1992; Thordardottir et al., 2015). Intervention with young children with ASD may be enhanced in children from bilingual homes if delivered in the family's native languages.

This study has a number of important limitations to consider. This study was not designed to evaluate the effects of intervention in a bilingual versus monolingual home environment. The intervention was conducted only in English, which may not have optimized intervention outcomes for children from bilingual homes. Thus, the positive effects on social functioning and communication in the BLH group may underestimate the potential for early intervention to improve outcomes for bilingually exposed toddlers with ASD. Furthermore, our study delivered all assessments in English. If we had been able to use measures administered in languages matched to home language environment, a more accurate estimate of language ability could have been obtained for the bilingual home environment group. When both languages are considered, bilingually exposed children with ASD have been shown to have greater total production vocabularies than monolingually exposed children with ASD (Peterson et al., 2012). Measurement of outcomes revealed significant findings on the VABS-II and MCDI, both of which are parent questionnaires. It could be that bilingual parents interpreted questions in such a way that may have overestimated their child's capabilities. Alternatively, standardized measures may underestimate a child's language ability and functional communication. Using language recording devices to capture language use in the home and community may provide an important window into communication and language development that is missed with standardized or parent-report measures. Our study characterized language exposure at baseline but previous studies have noted that home language environment does not remain static and the addition or reduction of languages in the home may occur (Hambly and Fombonne, 2012; Yu, 2013). In general, it is difficult to quantify bilingual home environment and although the field currently relies heavily on parent-reported estimates, objective measures would be a useful scientific advance. Another caution is that most of the participants included in our analyses were from high-SES families and, due to the fact that this was a secondary analysis of a randomized trial to evaluate treatment efficacy, stringent exclusion criteria were utilized. This means the sample may not have been fully representative of the communities in the Seattle, Sacramento, and Ann Arbor areas. Replication with a community sample of "all comers" is needed to promote generalizability of these findings.

Future studies are needed to directly evaluate whether and how children with ASD acquire multiple languages. This may require longer longitudinal study designs because children with ASD usually acquire language later and some may even remain minimally verbal. Exploring different measures and operational definitions of bilingualism in this population (i.e. dual versus multiple languages, direct versus indirect exposure) is needed. Future research should also consider matching language groups on language of exposure, gender, ethnicity, and autism severity to account for possible confounding variables. Qualitative research, such as parent interviews and observational studies, may provide additional understanding of language development in children with ASD. Furthermore, the relationship between bilingualism and executive functioning in children with ASD is largely unexplored. Individuals with ASD have been shown to struggle with executive functioning, especially in cognitive flexibility and attentional control (Corbett et al, 2009; Pellicano, 2012; Happe, 2006; Ozonoff, 1991), which are areas that the literature has shown bilingual children to excel at when compared to their monolingual counterparts (Bialystok, 1999; Carlson and Meltzoff, 2008; Poulin-Dubois et al., 2011; Bialystok et al., 2004).

Our results, though considered preliminary, suggest children with ASD demonstrate equivalent rates of growth while in early intervention whether they are raised in bilingual or monolingual homes. Some of our data suggests that there may even be social and communicative advantages to growing up in a bilingual home environment. Thus, in combination with previous literature on typically developing children and from case-control studies of children with ASD, this study provides further evidence that professionals should support parents interacting with their children in their preferred language or languages at home. Future studies are needed to investigate whether bilingual intervention would provide a richer and more beneficial environment for developmental growth in bilingually exposed children with ASD. Early intervention studies often exclude participants from bilingual homes to control for home language environment as a confounding factor. However, our results suggest that including children with ASD from bilingual households is warranted and can provide information critical to shaping current intervention practices.

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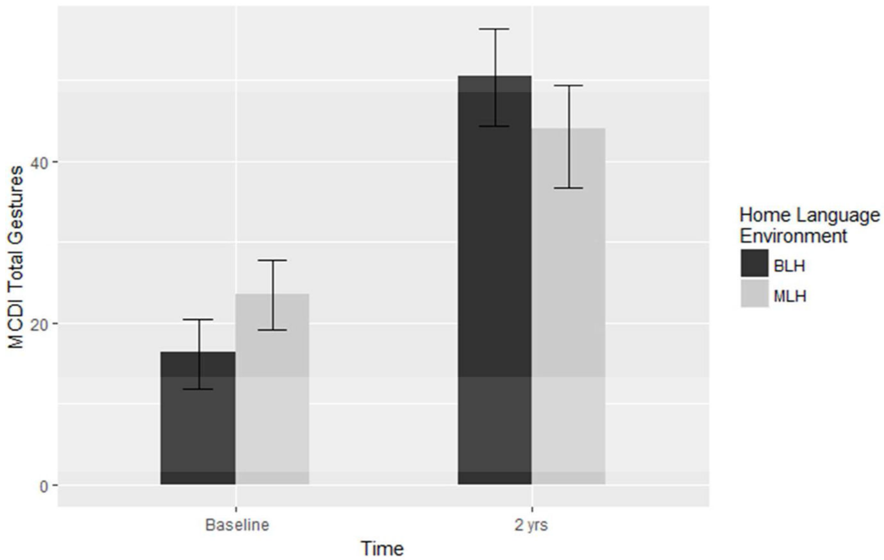
MCDI Total Gestures
40
20
0
Baseline
2 yrs
Time
Home Language Environment
BLH
MLH

Figure 1.

Table 1

Child and family characteristics at baseline.

Variable	BLH (n=13) N	BLH (n=13) %	MLH (n=24) N	MLH (n=24) %	t	p
Male gender	7	53.8	14	58.3		1.00
White ethnicity	9	69.2	18	75.0		0.221
Income						
<50K	5	38.5	5	20.8		0.712
50K~75K	2	15.4	4	16.7		
75K~100K	3	23.1	9	37.5		
>150K	3	23.1	6	25.0		
Maternal education						
High school and below	3	23.1	4	16.7		0.185
Some college	0	0.0	6	25.0		
College degree	6	46.2	11	45.8		
Graduate school[a]	4	30.8	3	12.5		
Treatment						
ESDM	5	38.5	13	54.2		0.495
COM	8	61.5	11	45.8		
	M	(SD)	M	(SD)		
Treatment hours	10.52	7.59	14.45	6.02	−1.61	0.122
Age (months)						
T1	20.8	(3.63)	20.9	(3.19)	−0.09	0.931
T2	36.4	(3.55)	37.1	(3.15)	−0.59	0.558
T3	49.1	(3.50)	48.8	(3.28)	0.21	0.835
Nonverbal IQ	81.77	(15.25)	80.46	(12.42)	0.27	0.793

[a] Includes some graduate school and graduate degree holders

Table 2

Baseline Measures for BLH and MLH Groups.

	BLH			MLH				
Baseline Variable	**M**	**SD**	**N**	**M**	**SD**	**N**	**t**	**p**
VABS-II								
Socialization std score	78.18	8.95	11	78.78	10.46	23	−0.17	0.8641
Interpersonal relationships V-scale	10.18	3.12	11	9.43	2.86	23	0.67	0.5111
Play and leisure time V-scale	10.82	1.83	11	10.65	2.14	23	0.23	0.8175
Coping skills V-scale	12.64	2.29	11	13.96	1.77	23	−1.68	0.1115
Communication std score	67.64	11.75	11	69.74	14.22	23	−0.46	0.6531
Receptive V-scale	19.73	7.13	11	18.70	5.41	23	0.43	0.6766
Expressive V-scale	8.64	2.29	11	9.57	3.20	23	−0.97	0.3424
MCDI								
Phrases Understood	8.92	5.66	12	10.39	7.83	23	−0.64	0.5282
Vocabulary Production	4.00	4.49	12	9.70	11.91	23	−2.03[+]	0.0507
Total Gestures	16.42	8.14	12	23.52	11.31	23	−2.13[*]	0.0413
Vocab Comprehension	54.42	53.68	12	81.96	65.62	23	−1.33	0.1940
MSEL								
Receptive Language age eq.	8.46	5.83	13	9.62	4.55	24	−0.62	0.5394
Expressive Language age eq.	9.54	5.14	13	10.83	3.38	24	−0.82	0.4246

[+] $p < .10$,

[*] $p < .05$

Table 3

Language and socialization outcomes for children with ASD in bilingual vs monolingual homes.

	BLH			MLH					
1-year Outcome Variable	**M**	**SD**	**N**	**M**	**SD**	**N**	**t**	**p**	**Bayes Factor**
VABS-II									
Socialization std score	85.50	15.19	12	78.55	12.20	22	1.36	0.1885	0.75
Interpersonal V-scale	12.00	3.16	12	9.59	2.67	22	2.24*	0.0368	2.59
Play and leisure V-scale	12.58	3.63	12	10.68	2.12	22	1.67	0.1162	1.36
Coping skills V-scale	12.92	2.64	12	13.32	2.64	22	−0.42	0.6762	0.36
Communication std score	89.67	18.55	12	77.86	16.23	22	1.85+	0.0788	1.35
Receptive V-scale	37.17	13.27	12	29.41	8.13	22	1.85+	0.0840	1.78
Expressive V-scale	12.33	3.58	12	11.05	2.87	22	1.07	0.2967	0.56
MCDI									
Phrases Understood	22.31	6.76	13	21.73	7.33	22	0.24	0.8139	0.34
Vocabulary Production	220.15	150.91	13	203.41	143.43	22	0.32	0.7494	0.35
Total Gestures	47.08	13.82	13	45.50	12.97	22	0.33	0.7415	0.35
Vocabulary Comprehension	260.38	124.38	13	255.50	125.30	22	0.11	0.9117	0.34
MSEL									
Mullen Receptive age eq	28.69	10.77	13	27.04	10.38	24	0.45	0.6563	0.36
Mullen Expressive age eq	27.15	9.74	13	26.96	10.58	24	0.06	0.9553	0.33
2-year Outcome Variable	M	SD	N	M	SD	N	t	p	Bayes Factor
VABS-II									
Socialization std score	85.38	21.88	13	83.30	18.43	23	0.29	0.7749	0.34
Interpersonal V-scale	11.62	4.25	13	11.22	3.93	23	0.28	0.7842	0.34
Play and leisure V-scale	11.54	4.25	13	11.09	3.22	23	0.33	0.7429	0.35
Coping skills V-scale	14.15	3.83	13	14.00	3.46	23	0.12	0.9056	0.33
Communication std score	90.46	19.56	13	87.43	18.89	23	0.45	0.6557	0.36
Receptive V-scale	44.00	13.44	13	41.39	12.33	23	0.58	0.5700	0.38
Expressive V-scale	12.08	4.17	13	11.91	4.03	23	0.11	0.9097	0.33
MCDI									

	BLH			MLH					
1-year Outcome Variable	**M**	**SD**	**N**	**M**	**SD**	**N**	**t**	**p**	**Bayes Factor**
Phrases Understood	23.08	7.59	12	23.68	7.88	22	−0.22	0.8302	0.35
Vocabulary Production	280.00	142.77	12	285.36	136.32	22	−0.11	0.9163	0.34
Total Gestures	50.50	11.18	12	43.95	16.70	22	1.36	0.1831	0.59
Vocabulary Comprehension	300.08	141.21	12	311.77	114.29	22	−0.25	0.8082	0.35
MSEL									
Mullen Receptive age eq	40.67	12.71	12	39.55	14.78	22	0.23	0.8185	0.35
Mullen Expressive age eq	35.58	8.92	12	35.41	12.16	22	0.05	0.9623	0.34

+ $p < .10$,

* $p < .05$

Table 4

Moderating effect of home language environment on language and social early intervention outcomes.

	Regression Coefficients				t-statistic				
Outcome Variable	**Intercept**	**HLE[a]**	**TxGrp[b]**	**HLE x TxGrp**	**Intercept**	**HLE[a]**	**Tx Grp[b]**	**HLE x TxGrp**	**Model R^2**
1-year change									
VABS-II									
Socialization std score	4.17	−3.47	−3.67	0.88	0.89	−0.59	−0.50	0.10	0.0415
Interpersonal relationships V-scale	1.00	−0.50	−1.25	0.50	0.80	−0.32	−0.63	0.21	0.0294
Play and leisure time V-scale	2.00	−1.90	−2.50	2.07	1.98	−1.49	−1.57	1.08	0.1274
Coping skills V-scale	−1.00	0.40	2.00	−2.23	−0.85	0.27	1.08	−1.01	0.0488
Communication std score	17.50	−12.10	0.75	3.60	2.45*	−1.34	0.07	0.27	0.0849
Receptive V-scale	14.33	−0.43	2.42	−8.15	3.78***	−0.09	0.40	−1.13	0.1216
Expressive V-scale	3.17	−2.27	−1.92	2.77	2.30*	−1.30	−0.88	1.06	0.0594
MCDI									
Phrases Understood	13.87	−4.28	−2.88	5.28	5.57***	−1.28	−0.67	1.00	0.0538
Vocabulary Production	197.25	−21.75	13.00	20.33	3.86***	−0.32	0.15	0.19	0.0111
Total Gestures	30.13	−9.53	−2.38	4.11	7.04***	−1.66	−0.32	0.45	0.1026
Vocab Comprehension	205.88	−57.68	−33.37	74.84	5.65***	−1.18	−0.53	0.97	0.0500
MSEL									
Expressive Language Age eq.	19.37	0.08	2.23	−5.99	5.37***	0.02	0.38	−0.84	0.0462
Receptive Language Age eq.	17.75	−0.48	−0.35	−1.77	4.98***	−0.10	−0.06	−0.25	0.0135
2-year change									
VABS-II									
Socialization std score	7.71	2.29	−2.46	−9.54	1.37	0.31	−0.26	−0.84	0.1202
Interpersonal relationships V-scale	1.43	1.97	−0.18	−3.22	1.17	1.24	−0.09	−1.31	0.1730
Play and leisure time V-scale	0.71	0.49	−0.46	−1.32	0.63	0.33	−0.25	−0.58	0.0662
Coping skills V-scale	1.71	−1.21	−0.46	−0.62	1.26	−0.68	−0.21	−0.23	0.0658
Communication std score	23.14	−5.74	−6.89	4.08	3.68***	−0.70	−0.66	0.32	0.0396
Receptive V-scale	24.14	0.26	1.11	−5.67	5.43***	0.04	0.15	−0.64	0.0402

Outcome Variable	Regression Coefficients				t-statistic				Model R^2
	Intercept	HLE[a]	TxGrp[b]	HLE x TxGrp	Intercept	HLE[a]	Tx Grp[b]	HLE x TxGrp	
Expressive V-scale	3.43	−1.43	−1.43	1.18	2.29*	−0.73	−0.57	0.39	0.0289
MCDI									
Phrases Understood	13.29	−1.29	1.21	2.24	3.42**	−0.25	0.19	0.29	0.0219
Vocabulary Production	279.57	−8.37	−36.32	36.58	5.23***	−0.12	−0.41	0.34	0.0063
Total Gestures	36.57	−20.67	−7.82	17.38	7.20***	−3.12**	−0.93	1.69	0.2650
Vocab Comprehension	240.00	−23.40	−13.50	40.35	5.34***	−0.40	−0.18	0.44	0.0110
MSEL									
Receptive Language Age eq.	37.38	−6.38	−12.63	10.32	8.38***	−1.04	−1.63	1.09	0.1033
Expressive Language Age eq.	27.62	−2.85	−2.12	1.27	6.67***	−0.50	−0.30	0.14	0.0168

* $p<.05$;

** $p<.01$;

*** $p<.001$

[a] HLE: BLH=0, MLH=1.

[b] TxGrp: COM=0, ESDM=1