

# Gender differences in early stages of language development. Some evidence and possible explanations

Pasquale Rinaldi<sup>1</sup>  | Patrizio Pasqualetti<sup>1,2</sup>  | Virginia Volterra<sup>1</sup>  |  
Maria Cristina Caselli<sup>1</sup> 

<sup>1</sup>Institute of Cognitive Sciences and Technologies, Italian National Research Council, Rome, Italy

<sup>2</sup>Department of Public Health and Infectious Diseases, Sapienza University of Rome, Rome, Italy

## Correspondence

Pasquale Rinaldi, Institute of Cognitive Sciences and Technologies, Italian National Research Council, Via Nomentana, 56 00161 Roma, Italy.  
Email: pasquale.rinaldi@istc.cnr.it

## Abstract

It is a common feeling that girls speak earlier than boys; however, whether or not there are gender differences in early language acquisition remains controversial. The present paper aims to review the research on gender effects in early language acquisition and development, to determine whether, and from which age, an advantage for girls does eventually emerge. The focus is on the production of actions and communicative gestures, and early lexical comprehension and production, by girls and boys. The data from various studies that were conducted with direct and indirect tools suggest that some gender differences in actions, gesture, and lexical development depend on the interactions of different factors. Studies differ in terms of age ranges, sample sizes, and tools used, and the girl advantage is often slight and/or not evident at all ages considered. Statistical significance for gender differences appears to depend on the greater individual variability among boys, with respect to girls, which results in a greater number of boys classified as children with poor verbal ability. Biological (e.g., different maturational rates), neuropsychological (e.g., different cognitive strategies in solving tasks), and cultural (e.g., differences in the way parents relate socially to boys and girls) factors appear to interact, to create feedback loops of mutual reinforcement.

## KEYWORDS

action–gesture, early language acquisition, gender differences, word comprehension, word production

## 1 | INTRODUCTION

Emergence of language and developmental trajectories of many linguistic skills are characterized by similar developmental stages, regardless of the cultural and linguistic context within which children are born into and grow up in. However, early language acquisition is also characterized by large variability in timing, style, and learning

strategies among infants. What does the variability in this development depend on?

According to the neuro-constructivist approach, language development is intertwined with other cognitive, social, and relational skills, and the construction of meanings is mediated by common domain-general neural systems. Similarities and differences among children in terms of their acquisition processes are linked to the

Edited by Sara Bulgheroni and Cristina Ghiani. Reviewed by Paola Zanchi and Seyda Ozcaliskan.

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dynamic and complex interactions between biological and environmental factors (Bates & Dick, 2002; Karmiloff Smith, 2013).

In trying to explain this variability, several studies have explored the role of gender,<sup>1</sup> and have indicated an advantage for girls with respect to boys for various aspects of language development, and particularly in the early stages of lexical development (e.g., Bornstein et al., 2004; Fenson et al., 2007; Galsworthy et al., 2000). The majority of these studies were conducted using the MacArthur-Bates Communicative Development Inventories (MB-CDIs), as the most frequently used parent questionnaires for early communication and language evaluation in infants and toddlers (Fenson et al., 2007). These include several different forms. The Words and Gestures (WG MB-CDI) form was developed to evaluate infant action-gesture production and vocabulary comprehension and production, from 8 to 24 months (in the Italian version; Caselli et al., 2015). The Word and Sentences (WS MB-CDI) form was developed to evaluate toddler vocabulary production and early morphosyntactic abilities, from 18 to 36 months (in the Italian version; Caselli et al., 2015). Currently these MB-CDIs have been adapted for use in >100 languages, which also allow cross-linguistic comparisons. Moreover, the availability of large samples of longitudinal and cross-sectional data collected using these MB-CDIs provides data for the analysis of developmental trends, variability among children, and gender differences (<https://mb-cdi.stanford.edu/>; <http://wordbank.stanford.edu/>).

However, in the majority of the studies based on parental questionnaires, the analysis of potential gender differences has been addressed mainly to present separate norms for boys and girls, without deepening the possible theoretical explanations of the eventual differences found between the two genders and the factor(s) that might cause such differences.

In the present paper, we review studies on gender effects in early language development (some of which were conducted in our own research laboratory), with the aim to clarify from which age any gender advantage eventually emerges, and until which age it remains evident. In the next section, research on the early production of actions and communicative gestures in girls and boys will be presented and discussed. Then in the following section, we focus on gender differences in early lexical comprehension and production. Finally, in discussing the results from different studies, we will consider three possible conceptual frameworks to explain gender-based variability in language development that consider biological and neuropsychological factors, as well as the role of adult-child interactions, with the suggestion that some gender differences in action, gesture, and lexical development depend on the interactions between these different factors.

## 2 | POTENTIAL GENDER DIFFERENCES IN ACTION-GESTURE PRODUCTION

During the first phases of development, infants engage in several different forms of expression. Along with vocalization, babbling, and their first tentative words, infants produce functional actions

### Significance

There is a growing interest in gender differences in early language acquisition, although whether these differences are significant in terms of differences in the age at which girls and boys reach milestones remains controversial. Here, we provide a mini review of the most important findings and discuss the most recent theories behind this controversy. We consider both the biological and environmental factors that define these potential differences between girls and boys in terms of early action-gesture production and lexical comprehension and production.

in relation to toys and tools, which demonstrate their understanding of the nature of these objects and how they are used (e.g., combing with a comb, drinking from a bottle). They also produce other types of motor behaviors that do not involve objects, but rather only their bodies, hands, and facial expressions (e.g., waving their hand for “ciao,” clapping hands), and these acquire meaning through dyadic child-caregiver interactions. According to our more recent theoretical perspective, gestures as words arise from actions, and they are deeply related to language and cognition; that is, gestures and speech are considered to be part of the same cognitive and communicative system (Iverson, 2010; Volterra et al., 2017, 2018).

Using the WG MB-CDI, several studies have described the acquisition of different types of action-gestures that are performed by infants and toddlers. The WG MB-CDI includes the following categories: First communicative gestures, which include deictic gestures (e.g., pointing) and conventional gestures (e.g., pointing to cheek to indicate that something tastes good); games and routine (e.g., clapping hands); actions with objects (e.g., eating with a spoon or fork); imitating adult actions (e.g., put key in door and lock); and pretending to be a parent (e.g., put a doll to bed).

The majority of normative studies conducted using the WG MB-CDI have reported data on gender differences in action-gesture production, although often such results were not the focus of the studies, and were not further analyzed and discussed. Fenson et al. (1994, 2007) referred an advantage of girls over boys for actions and gestures production, and Butterworth and Morissette (1996) reported that girls point about 1 month before boys, and that the age of pointing onset predicts both the number of gestures produced and the first word comprehension a few months later. These results have been confirmed by other studies conducted with infants exposed to languages and cultures that are not English-American. For example, girl advantages in action-gesture repertoires were reported by Blases et al. (2008) for Danish, and by Eriksson and Berglund (1999) for Swedish. In particular, Eriksson and Berglund (1999) showed that only two subscales yielded significant effects for gender, where girls scored higher than boys for both scales: “First communicative gestures” and “pretending to be a parent.” An interaction of gender with age was also reported for these two scales: the

differences between girls and boys increased in the older age groups (i.e., 16 months).

In a cross-linguistic perspective, Eriksson et al. (2012) merged data from studies on early language skills in boys and girls based on the MB-CDI that were conducted in 10 non-English European language communities, to study the differences between girls and boys as a function of both age and language community. The sample consisted of 13,783 children from the following language communities: Austrian German, Basque, Croatian, Danish, Estonian, French, Galician, Slovene, Spanish, and Swedish. The WG MB-CDI and WS MB-CDI forms were used according to the children's ages. For action-gesture, the girls produced a greater number of gestures than the boys up to 13 months of age. The differences between the girls and boys then decreased from 14 months of age, apparently due to a ceiling effect for girls. Looking at the tails of these distributions, Eriksson and colleagues (2012) reported that in the lower tail, the boys were overrepresented (1.21 boys for each girl), and in the higher tail, they were underrepresented (0.69 boys for each girl).

In the Italian normative study of the WG MB-CDI that was based on a cross-sectional sample of 648 children (45.7% girls), no gender differences emerged in their action-gestures production (Caselli et al., 2015). However, different results were reported by Sansavini and colleagues (2010), who carried out a longitudinal study in typically developing infants for their early development of communicative gestures, object-related actions, and word comprehension and production, including their reciprocal relationships. In this study, 22 monolingual Italian infants were followed monthly from 10 to 17 months using the Italian short form of the WG MB-CDI, which consists of a checklist of 100 lexical items (word comprehension and word production) and of a checklist of 18 actions-gestures. Seven of these were defined as "communicative gestures" (i.e., deictic gestures, first communicative gestures, and games and routine), with the remaining 11 defined as object-related actions (i.e., actions with objects that imitate adult actions, and pretending to be a parent). Considering their results on communicative gestures, at the first age considered (10 months), the mean number of gestures produced by infants corresponded to about half of the gestures listed in the questionnaire, although there was great individual variation, which gradually decreased. The effects of age and gender on the communicative gestures were significant, with the children increasing the number of communicative gestures they produced according to their age, and with girls producing more communicative gestures than boys. No significant interactions between age and gender emerged. The emergence and development of the ability to perform object-related actions occurred later than for communicative gestures. Very few object-related actions were noted at the earliest age assessed, and there were large individual variations. At the final age considered (17 months), object-related actions were being produced by most of the infants, with a decrease in the inter-individual variation. The effects of age and gender on object-related actions were significant, as well as their interaction. At 10 months, boys started to perform object-related actions as well as girls, but from 11 months, the girls developed their action repertoire faster than the boys. In conclusion,

Sansavini et al. (2010) showed an effect of gender on communicative gestures and on object-related actions for the first time, which was seen when these were kept separate from each other.

As indicated above, only a few studies have explicitly focused on gender differences in gestures production. One of the few exceptions was based not on parental questionnaires, but on direct observations of the children (Özçalışkan & Goldin-Meadow, 2010). In this study, 22 girls and 18 boys from 14 to 34 months were observed at home (every 4 months) while interacting with their parents, and as they progressed from one word to multiword speech, with no differences seen in the number or type of gestures that boys and girls produced during the observation sessions. The only difference between girls and boys was in the production of supplementary gesture + speech combinations (e.g., saying the word "eat" while pointing at a cookie). According to various authors (Capirci et al., 1996; Capobianco et al., 2017; Iverson & Goldin-Meadow, 2005) the age at which children first express two ideas in a gesture + speech combination predicts the age at which they produce their first two-word sentence ("eat cookie"). As can be seen from the results reported, the title of the paper by Özçalışkan and Goldin-Meadow (2010), as "Sex differences in language first appear in gesture," is actually misleading, as the only difference between girls and boys was in the production of supplementary gesture + speech combinations and multiword combinations. In both cases, boys are likely to lag behind girls. Taken together, the data reported in this study and as already reported by other studies, showed only that the advantage for girls in early word production might lead to an advantage in the gesture + speech and speech + speech combinations.

### 3 | POTENTIAL GENDER DIFFERENCES IN EARLY LEXICAL COMPREHENSION AND PRODUCTION

For word comprehension and production, the majority of normative studies conducted using the MB-CDIs reported separate norms for boys and girls, as they showed significant differences in lexical development between girls and boys. Fenson et al. (1994, 2007) indicated that mean scores tend to be higher for females than for males of the same age. As a consequence, girls often reach various milestones 1 to 2 months before boys.

A cross-linguistic study conducted by Eriksson and colleagues (2012), as already mentioned above, also explored gender differences in word comprehension and production. For word comprehension, they reported on the main effects of age and language community: older infants understood more words than younger infants, and the number of words children understood varied for different language communities. Although the effect of gender was not statistically significant, boys appeared to be overrepresented in both of the tails of the distribution, with 1.19 and 1.03 boys for each girl in the lower and higher tails, respectively. For word production, in a cross-linguistic study, Eriksson and colleagues (2012) reported on the main effects of gender, age, and language community. Girls

produced more words than boys, and older toddlers used more types of words than younger toddlers. The difference between girls and boys increased with age. The effect of language community indicated that children from different language communities produced different numbers of words, in particular at an earlier age. For the lower tails for the WG MB-CDI and WS MB-CDI forms, there were 1.28 boys for each girl and 1.13 boys for each girl, respectively. For the higher tails for the WG MB-CDI and WS MB-CDI forms, there were 0.70 boys for each girl and 0.65 boys for each girl, respectively. A similar advantage for girls was shown for word combinations, probably because girls had a larger expressive vocabulary size than boys. They interpreted the lack of significant interactions between gender and language community as an indicator of the robustness of the advantage of girls across different language communities (Eriksson et al., 2012).

This study was expanded by Frank et al. (2021). Here, they added other language communities, and collected and re-analyzed the data obtained from different countries, to replicate and extend the results of Eriksson (2012). Through the use of a consistent framework for representing and analyzing data collected using the MB-CDIs, they managed to combine a variety of influential previous analyses of MB-CDI data, and they also assessed the consistency of gender effects on vocabulary size. According to their revision of the literature on cognitive differences due to gender, they were able to predict a modest, but consistent, advantage for girls for early vocabulary. By applying a robust analysis method to avoid detrimental effects from outliers, and especially in small subsets (i.e., generalized linear model), they focused on the age by gender interactions. Their analysis indicated that for word comprehension, despite the small magnitudes of the coefficients, 16 of the 22 languages studied had a female advantage, two languages showed a male advantage, and the remaining four languages did not show any significant age by gender interactions. Frank and colleagues thus concluded that there is some evidence for a modest female advantage in word comprehension.

Turning to word production for the WS MB-CDI form, visual inspection and analysis of the fitted models by Frank and colleagues (2021) showed that 25 of the 26 languages available showed a statistically significant female advantage. In terms of effect size, female advantage was substantially larger than that seen for word comprehension. They also addressed the possible bias of such parent-reporting instruments (as the MB-CDI) toward higher female verbal ability. For this they considered two particular studies, one on gender effects in vocabulary production, as estimated from a naturalistic language (Huttenlocher et al., 2002), and the other on longitudinal data at 20 and 48 months (Bornstein & Putnick, 2012). On the basis of these studies, Frank and colleagues concluded that the gender effect on early vocabulary could not be solely explained by reporting bias, and so it is likely that the female advantage is real.

In the normative study of the Italian version of the MB-CDI that included 1,400 children from 8 to 36 months of age (Caselli et al., 2015), no gender effects were seen for either word comprehension or word production. Then, in the study already reported above by Sansavini and colleagues (2010), no significant differences

between girls and boys up to 14 months of age emerged in lexical skills. Girls then showed an advantage that approached significance for word comprehension, from 14 months of age onwards, but not for word production (Sansavini et al., 2010).

In an ongoing screening program that is aimed at the detection of possible communicative/linguistic delays in 24-month-old to 30-month-old children living in northern Italy (Mantua Province; *Riorganizzazione dello screening del linguaggio nella Provincia di Mantova*), the short form of the Italian WS MB-CDI was used. In this population data set of 8,511 toddlers (3,990 female, 4,521 male) there was a clear gender difference in terms of word production. After adjusting for age effects, the estimated vocabulary size at 28 months for females was 65.3 words (95% CI: 64.4–66.2), and for males, 53.9 words (95% CI: 53.1–54.8), giving a significant difference of 11.4 words (95% CI: 10.2–12.7;  $p < 0.001$ ). It should be noted that this short-form Italian WS MB-CDI includes 100 words, and thus the difference between the means here represents ~10% of the words included in the original checklist. In terms of the standardized effect size (difference/standard deviation), the gender effect was 0.39, as compared to conventional values of 0.20 (small) and 0.50 (medium).

A study on more than 10,000 German children from 3 to 6 years of age reported that at the younger age, girls performed better than boys in all domains examined (i.e., vocabulary, grammar, speech comprehension, pronunciation, processing of sentences, and nonce words). However, the effect sizes were small, and the differences decreased with age and appeared to be lost around school age (Lange et al., 2016). In particular, the advantage for girls was evident in all of the tasks used, as well as for the total score at the younger age, while it remained only for articulation and repetition of nonce words by school age. Furthermore, the variance in language competence was greater among boys than girls. Also taking into account the results from Eriksson et al. (2012), Lange et al. (2016) suggested that boys might simply be overrepresented among children with poor verbal abilities, due to their greater variance and the slightly greater female mean scores.

The significance of a girl advantage was also discussed in an Italian normative study that used a Picture Naming Game with children from 19 to 37 months of age (Bello et al., 2012). This direct assessment included four subtests to evaluate comprehension and production of nouns and predicates. Girls outperformed boys only in the noun production subtest, and this gender gap decreased with age. Although Bello and colleagues did not offer any clear explanation for the lack of gender differences in the other subtests, they speculated that the lower variability in the comprehension subtests (which were easier than the production subtests) might have masked any gender differences. Similarly, the higher variability in the predicate production subtest (the hardest of all) might also have masked any gender differences.

## 4 | DISCUSSION

We have reviewed here studies on the role of gender in the explanation of variability in early communicative and linguistic development,

with the main focus on infant and toddler action–gesture production, and word comprehension and production.

Whether or not there are true gender differences in early language acquisition remains controversial. Indeed, some studies that have used either MB-CDI data or direct measures have reported a small advantage for girls over boys in communicative and linguistic skills, whereas other studies have reported no differences. Some studies have shown that girls outperformed boys in all of the domains assessed (i.e., action–gesture production, and word comprehension and production) (e.g., Eriksson et al., 2012; Fenson et al., 2007), whereas others have reported an advantage for girls in some, but not all, of the domains considered (Bavin et al., 2008; Bello et al., 2012; Lange et al., 2016; Özçalışkan & Goldin-Meadow, 2010; Sansavini et al., 2010). However, these studies have differed in terms of age ranges, sample sizes, and tools used (i.e., indirect vs. direct). See Table 1 for an overview of the studies reviewed.

Despite statistically significant differences in several studies, which are mostly due to large sample sizes, the girl advantage has often remained small, and is not seen at all of the ages considered. The girl advantage is more evident in the early stages of acquisition of a given ability (i.e., when individual variability is greater), and it tends to progressively decrease when the ability is acquired by most children (i.e., when individual variability is reduced). In addition, the statistical significance of the differences between girls and boys appears to depend on greater individual variability among boys than girls, which results in the inclusion of a higher number of boys among children with poor verbal abilities.

Another important factor pertains to the tasks used to assess these linguistic skills, which include, of course, the specific ability involved (e.g., perception, production, judgements of linguistic stimuli). Furthermore, this also depends on their complexity (e.g., syllables, words, sentences) and how they are presented. It is also possible that boys and girls use different, although equally effective, cognitive strategies for some tasks that lead to minor differences in performance, but not in language acquisition itself (Etchell et al., 2018; Hyde, 2016; Zell et al., 2015). Nonetheless, these differences in performance (that researchers and clinicians evaluate) can affect the proportion of males that fall below the cut-off for diagnosis of a language-related neurodevelopmental disorder. Indeed, gender as a categorical variable explains very little of the variance in linguistic proficiency, even if males outnumber females among the lowest scoring percentiles in language tests, and clearly outnumber females in the diagnosis of certain developmental deficits, which include developmental language disorder, dyslexia, stuttering, and autism.

In a recent review on gender and language, Wallentin (2020) reported three different hypotheses to explain putative language differences between genders: (a) strongly innate differences linked to genetic sex; (b) cultural differences linked to environmental asymmetries; and (c) interactions in which other differences influence linguistic skills.

The first hypothesis, is supported by evidence that gender differences in language development depend on gender differences in terms of the timing and composition of the hormonal cascades

during early gestation, and on the evidence that brain development in males is delayed with respect to females. These result in infant gender differences in left hemisphere maturity, and in the lateralization and organization of functions within the brain (Friederici et al., 2008). Nonetheless, several studies have failed to find gender-related differences in brain structure and function that are relevant to language development during childhood, and that might account for differences in language abilities. Conversely, when gender-related differences in brain structure and function are seen, they do not necessarily lead to differences in language test performances (Etchell et al., 2018). In a systematic review, Etchell and colleagues (2018) also reported that gender differences were seen for studies that included tighter age ranges, whereby gender differences appear to be more evident for some developmental stages, while they are negligible for other stages. These differences might depend on the different rates of maturation between girls and boys, possibly leading to different approaches to linguistic processing (Burman et al., 2008).

The second hypothesis, which considers the role of cultural differences linked to environmental asymmetries, is supported by studies that have highlighted that parents speak more to, and talk differently to, daughters than sons (e.g., using more supportive language with daughters), which thus provides daughters with greater exposure to language. There is also evidence of more proximity, conversation, and affiliation of parents with girls than with boys (Eisenberg et al., 1985). In their meta-analysis of studies on mother–child interactions, Campbell et al. (1998) reported that mothers tended to talk more to, and use more supportive speech with, their daughters than with their sons. A more recent study reported that parents follow different play scenarios according to the gender of their child; that is, they are more likely to play with action-oriented toys with boys, whereas symbolic play is more common with girls, which thus affects the quantity and quality of the language used in their interactions (Bleses et al., 2018).

Several studies have consistently demonstrated that the quantity and quality of talking, interacting, and reading with a child in the first 3 years of life are strongly associated with language and cognitive development (for review, see Head Zauche et al., 2016). More input, more supportive communication, and more frequent use of symbolic play in interactions with girls might explain the earlier onset of language and the faster rate of language development, as well as the earlier onset of communicative gestures, in girls than in boys.

The third hypothesis integrates the two previous ones, to suggest that language development in very young girls and boys is affected by an interaction between biological and environmental factors. As an example, Lange and colleagues (2016) hypothesized that the relatively small gender differences in verbal abilities can be explained by sex-different maturational rates. Females appear to mature faster than males, especially at younger ages, and early maturation is correlated with better verbal abilities (Galsworthy et al., 2000; Waber, 1976). However, language-related gender differences appear to also be affected by environmental factors. Indeed, the loss of gender differences at around 6 years of age that were

TABLE 1 Characteristics of the studies reviewed

Study	N	Male/female ratio	Age (months)	Method	Advantage	p value	Effect size	Computed effect size (Cohen's <i>d</i> )	Appearance size or trajectory	Language
<i>Action-gesture production</i>										
Bleses et al. (2008)	2,384	0.96 <sup>c</sup>	8–20	Parental questionnaire (CDI-WG)	Female	<0.0001	Not reported	Not computable	Size	Danish
Caselli et al. (2015)	648	1.19	8–24	Parental questionnaire (CDI-WG)	None	Not reported	Not reported	Not computable	Size	Italian
Ericksson and Berglund (1999)	228 (54 <sup>a</sup> )	0.93 <sup>b</sup>	10–16	Parental questionnaire (CDI-WG)	None	ns	Not reported	Not computable	Size	Swedish
Ericksson et al. (2012)	4,598	0.97	8–16	Parental questionnaire (CDI-WG)	Female	<0.01	Etasq = 0.006	0.21	Size	Multilanguage
Fenson et al. (1994)	659	0.97	8–16	Parental questionnaire (CDI-WG)	Female	<0.00001	Etasq = 0.0125	Not computable	Size	English
Fenson et al. (2007)	1,089	1.00	8–18	Parental questionnaire (CDI-WG)	Female	0.001	Etasq = 0.028	Not computable	Size	English
Özçalışkan and Goldin-Meadow (2010)	40	0.82	14–34	Spontaneous productions in interaction	Female	0.288	Not reported	0.34	Size	English
Sansavini et al. (2010)	22	1.2	10–17	Parental questionnaire (CDI-WG)	Female	0.012	Etasq = 0.28	Not computable	Trajectory	Italian
<i>Word comprehension</i>										
Bello et al. (2012)	388	1.04	19–37	Direct observation (PiNG) noun comprehension	Not reported	0.48	Not reported	Not computable	Size	Italian
Ericksson et al. (2008)	2,398	0.96 <sup>c</sup>	8–20	Parental questionnaire (CDI-WG)	Female	0.0081	Not reported	Not computable	Size	Danish
Bornstein et al. (2004)	26	0.53	24	Parental questionnaire (CDI-WG)	Female	ns	Not reported	0.63	Size	English
	26	0.53	37	Parental questionnaire (RDLS)	Female	<0.01	Etasq = 0.40	1.539947975	Size	English
	184	1.22	20	Parental questionnaire (RDLS)	Female	<0.001	Etasq = 0.09	0.64287675	Size	English
	34	0.79	13	Parental questionnaire (CDI-WG)	Male	ns	Not reported	-0.190508096	Size	English
	34	0.79	20	Parental questionnaire (RDLS)	Female	<0.01	Etasq = 0.20	0.978814696	Size	English
Caselli et al. (2015)	648	1.19	8–24	Parental questionnaire (CDI-WG)	None	Not reported	Not reported	Not computable	Size	Italian
Ericksson and Berglund (1999)	228 (48 <sup>a</sup> )	0.93 <sup>b</sup>	10–16	Parental questionnaire (CDI-WG)	None	ns	Not reported	Not computable	Size	Swedish
Ericksson et al. (2012)	4,635	0.98	8–16	Parental questionnaire (CDI-WG)	Female	0.034	Not reported	0.07	Size	Multilanguage
Fenson et al. (1994)	659	0.97	8–16	Parental questionnaire (CDI-WG)	Female	<0.001	Etasq = 0.0133	Not computable	Size	English
Fenson et al. (2007)	1,089	1.00	8–18	Parental questionnaire (CDI-WG)	Female	0.001	Etasq = 0.017	Not computable	Size	English

(Continues)

**TABLE 1** (Continued)

Study	N	Male/female ratio	Age (months)	Method	Advantage	p value	Effect size (Cohen's d)	Computed effect size (Cohen's d)	Appearance size or trajectory	Language
Frank et al. (2021)	15,807	1.02	8–24 <sup>d</sup>	Parental questionnaire (CDI-WG)	Female	n.a.	Not reported as a unique measure across languages	0.075 <sup>e</sup>	Size	Multilingual
Lange et al. (2016)	6,143	1.03	48–53	Direct observation	Female	<0.01	Cohen's d = 0.09		Size	German
	765	1.3	36–71	Direct observation	Female	<0.05	Cohen's d = 0.13		Size	German
	2,881	1.19	36–71	Direct observation	Female	ns	Cohen's d = 0.06		Size	German
	849	1.08	60–83	Direct observation	Female	0.01	Cohen's d = 0.20		Size	German
Sansavini et al. (2010)	899	1.12	60–83	Direct observation	Female	ns	Cohen's d = 0.10		Size	German
	22	1.2	10–17	Parental questionnaire (CDI-WG)	Female	0.012	Etasq = 0.22	Not computable	Trajectory	Italian

*Word production*

Bello et al. (2012)	388	1.04	19–37	Direct observation (PiNG) noun production	Female	0.008	Not reported	0.240963855	Size	Italian
	388	1.04	19–37	Direct observation (PiNG) predicate production	Not reported	0.56	Not reported	Not computable	Size	Italian
Bleses et al. (2008)	2,398	0.96 <sup>c</sup>	8–20	Parental questionnaire (CDI-WG)	Female	0.00003	Not reported	Not computable	Size	Danish
	3,714	0.96 <sup>c</sup>	16–36	Parental questionnaire (CDI-WS)	Female	<0.00001	Not reported	Not computable	Size	Danish
Bornstein et al. (2004)	26	0.53	24	Parental questionnaire (CDI-WS)	Female	<0.01	Etasq = 0.27	1.314105976	Size	English
	26	0.53	24	Parental questionnaire (RDLS)	Female	<0.05	Etasq = 0.21	1.037247251	Size	English
	26	0.53	37	Parental questionnaire (RDLS)	Female	<0.05	Etasq = 0.16	0.839421089	Size	English
	184	1.22	20	Parental questionnaire (ELI)	Female	<0.001	Etasq = 0.15	0.711202961	Size	English
	184	1.22	20	Parental questionnaire (RDLS)	Female	<0.001	Etasq = 0.15	0.832653061	Size	English
	34	0.79	13	Parental questionnaire (CDI-WG)	Female	ns	Not reported	0.397022333	Size	English
	34	0.79	20	Parental questionnaire (CDI-WS)	Female	<0.01	Etasq = 0.21	1.23712586	Size	English
	34	0.79	20	Parental questionnaire (RDLS)	Female	<0.001	Etasq = 0.27	1.238658777	Size	English
Caselli et al. (2015)	648	1.19	8–24	Parental questionnaire (CDI-WG)	None	Not reported	Not reported	Not computable	Size	Italian
	752	0.99	18–36	Parental questionnaire (CDI-WS)	None	Not reported	Not reported	Not computable	Size	Italian

(Continues)

TABLE 1 (Continued)

Study	N	Male/female ratio	Age (months)	Method	Advantage	p value	Effect size	Computed effect size (Cohen's <i>d</i> )	Appearance size or trajectory	Language
Erickson and Berglund (1999)	228 (55 <sup>a</sup> )	0.93 <sup>b</sup>	10–16	Parental questionnaire (CDI-WG)	None	ns	Not reported	Not computable	Size	Swedish
Erickson et al. (2012)	4,691	0.97	8–16	Parental questionnaire (CDI-WG)	Female	<0.01	Etasq = 0.003	0.17	Size	Multilanguage
Fenson et al. (1994)	9,042	0.95	16–30	Parental questionnaire (CDI-WS)	Female	<0.01	Etasq = 0.014	0.28	Size	Multilanguage
	659	0.97	8–16	Parental questionnaire (CDI-WG)	Female	<0.0001	Etasq = 0.0213	Not computable	Size	English
	1,130	0.98	16–30	Parental questionnaire (CDI-WS)	Female	<0.0001	Etasq = 0.019	Not computable	Size	English
Fenson et al. (2007)	1,461	1.00	16–30	Parental questionnaire (CDI-WS)	Female	<0.0001	Etasq = 0.03	Not computable	Size	English
Frank et al. (2021)	34,402	1	16–36 <sup>d</sup>	Parental questionnaire (CDI-WS)	Female	n.a.	Not reported as a unique measure across languages	0.405 <sup>e</sup>	Size	Multilanguage
Galsworthy et al. (2000)	6,012	0.94	24	Parental questionnaire (CDI-WS)	Female	<0.0001	Not reported	0.34	Size	English
Lange et al. (2016)	6,143	1.03	48–53	Direct observation	Female	<0.001	Cohen's <i>d</i> = 0.09		Size	German
	1,005	1.28	36–71	Direct observation	Female	ns	Cohen's <i>d</i> = 0.07		Size	German
	2,843	1.23	36–71	Direct observation	Female	ns	Cohen's <i>d</i> = 0.07		Size	German
	1,043	1.09	60–83	Direct observation	Female	ns	Cohen's <i>d</i> = 0.07		Size	German
	911	1.13	60–83	Direct observation	Female	ns	Cohen's <i>d</i> = 0.07		Size	German
Lovas (2011)	226	1.26	19	Parental questionnaire (CDI-WS)	Female	ns	Cohen's <i>d</i> = 0.07		Size	English
	114	0.97	24	Parental questionnaire (CDI-WS)	Female	ns	Cohen's <i>d</i> = 0.30		Size	English
Mantua Province Study	9,845	1.13	18–36	Parental questionnaire (CDI-WS)	Female	<0.001	Cohen's <i>d</i> = 0.38		Size	Italian
Sansavini et al. (2010)	22	1.2	10–17	Parental questionnaire (CDI-WG)	Female	ns	Not reported	Not computable	Trajectory	Italian
Two-element combination (gesture–word)										
Caselli et al. (2015)	752	0.99	18–36	Parental questionnaire (CDI-WS)	None	Not reported	Not reported	Not computable	Appearance	Italian

(Continues)



TABLE 1 (Continued)

Study	N	Male/female ratio	Age (months)	Method	Advantage	p value	Effect size	Computed effect size (Cohen's <i>d</i> )	Appearance size or trajectory	Language
Özçalışkan and Goldin-Meadow (2010)	40	0.82	14-34	Spontaneous productions in interaction	Female	<0.01	Not reported	0.87	Appearance	English
<i>Two-element combination (word-word)</i>										
Caselli et al. (2015)	752	0.99	18-36	Parental questionnaire (CDI-WS)	None	Not reported	not reported	Not computable	Appearance	Italian
Ericksson et al. (2012)	9,042	0.95	16-30	Parental questionnaire (CDI-WS)	Female	Not reported	Etasq = 0.083	Not computable	Size	Multilanguage
Fenson et al. (1994)	1,130	0.98	16-30	Parental questionnaire (CDI-WS)	Female	<0.001	Not reported	0.10 <sup>f</sup>	Size	English
Fenson et al. (2007)	1,461	1.00	16-30	Parental questionnaire (CDI-WS)	Female	<0.001	Etasq = 0.009	Not computable	Size	English
Lovas (2011)	226	1.26	19	Parental questionnaire (CDI-WS)	Female	ns	Cohen's <i>d</i> = 0.26		Size	English
Mantua Province Study	114	0.97	24	Parental questionnaire (CDI-WS)	Female	ns	Cohen's <i>d</i> = 0.45		Size	English
Özçalışkan and Goldin-Meadow (2010)	9,845	1.13	18-36	Parental questionnaire (CDI-WS)	Female	<0.001	Cohens' <i>d</i> = 0.20		Size	Italian
	40	0.82	14-34	Spontaneous productions in interaction	Female	<0.002	Not reported	1.04	Appearance	English

Note: Cohen's delta convention: 0.2 "small," 0.5 "medium," 0.8 "large".

Abbreviations: CDI-WG, MacArthur-Bates Communicative Development Inventories-Words and Gestures; CDI-WS, MacArthur-Bates Communicative Development Inventories-Words and Sentences; ELI, early language inventory; PING, picture naming game; RDLS, Reynell developmental language scale.

<sup>a</sup>Number of children involved in analysis on gender differences.

<sup>b</sup>Estimate from Ericksson and Berglund (1999).

<sup>c</sup>Computed from Bleses et al. (2008).

<sup>d</sup>Maximal range.

<sup>e</sup>Computed as the median effect size of the MMAD (difference between medians divided by median absolute deviation) of the different languages.

<sup>f</sup>Phi coefficient derived from reported chi-square.

reported by Lange and colleagues (2016) might still be explained by maturational factors, as well as by specific social and sociolinguistic factors, which include the entry of children to school at this age.

Other studies have underlined the interactions between maturational and environmental factors, and have suggested that parents talk more to girls than to boys because girls are more likely to initiate and respond in verbal interactions (Bornstein et al., 2004; Morisset et al., 1995). Lovas (2011) reported evidence that gender differences in biological aspects and in brain development can produce gender differences in perception and attention, which are believed to mediate children's responses to verbal and non-verbal communication with their parents, and to reinforce gender-differentiated parent interactions with their children, and especially with very young infants. Early gender differences for verbal and joint attention, eye contact, and general neurological maturity will differentially reinforce the verbal behaviors of parents, which will create feedback loops of mutual reinforcement, and thus produce increasingly complex verbal interactions between daughters and their parents (Lovas, 2011; see also Halpern, 2002; Sansavini et al., 2010). According to Miller and Halper (2014), we would suggest that separate consideration of biology and environment as factors that affect gender differences in language and communication is a false dichotomy. Indeed, as they stated, "biological factors such as brain differences can affect how individuals select environments, and these environmental factors can then cause further biological development. Both biology and culture serve as inputs that start this interacting causal loop, which sometimes produces sex differences and sometimes sex similarities" (Miller & Halper, 2014, p. 42).

## DECLARATION OF TRANSPARENCY

The authors, reviewers and editors affirm that in accordance to the policies set by the *Journal of Neuroscience Research*, this manuscript presents an accurate and transparent account of the study being reported and that all critical details describing the methods and results are present.

## CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

## AUTHOR CONTRIBUTIONS

*Conceptualization*, M.C.C. and V.V.; *Writing original draft*, P.R., P.P., V.V. and M.C.C.; *Writing review and editing*, P.R., P.P., V.V. and M.C.C.

## PEER REVIEW

The peer review history for this article is available at <https://publons.com/publon/10.1002/jnr.24914>.

## ORCID

Pasquale Rinaldi  <https://orcid.org/0000-0002-6544-7941>

Patrizio Pasqualetti  <https://orcid.org/0000-0001-5560-1979>

Virginia Volterra  <https://orcid.org/0000-0003-3018-9951>

Maria Cristina Caselli  <https://orcid.org/0000-0003-3460-0170>

## ENDNOTE

<sup>1</sup> According to the APA Dictionary of Psychology (APA, 2015), the term "gender" refers to the psychological, behavioral, social, and cultural aspects of being male and female, while the term "sex" refers to the biological aspects. In many studies of developmental psychology and neuropsychology these terms have been used interchangeably. In the present mini-review, we use the term "gender" (independent of the term used by the authors of the original studies) on the basis that we are primarily interested in psychological, behavioral, social, and cultural differences.

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**How to cite this article:** Rinaldi, P., Pasqualetti, P., Volterra, V., & Caselli, M. C. (2021). Gender differences in early stages of language development. Some evidence and possible explanations. *Journal of Neuroscience Research*, 00, 1–11. <https://doi.org/10.1002/jnr.24914>