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The two-word stage: Motivated by linguistic or cognitive constraints?

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A B S T R A C T

Child development researchers often discuss a "two-word" stage during language acquisition. However, there is still debate over whether the existence of this stage reflects primarily cognitive or linguistic constraints. Analyses of longitudinal data from two Deaf children, Mei and Cal, not exposed to an accessible first language (American Sign Language – ASL) until the age of 6 years, suggest that a linguistic constraint is observed when cognition is relatively spared. These older children acquiring a first language after delayed exposure exhibit aspects of a two-word stage of language development. Results from intelligence assessments, achievement tests, drawing tasks, and qualitative cognitive analyses show that Mei and Cal are at least of average intelligence and ability. However, results from language analyses clearly show differences from both age peers and younger native signers in the early two-word stage, providing new insights into the nature of this phase of language development.

1. Introduction

One of the most robust findings in the study of first language acquisition in children is the existence of a two-word stage at about the age of 2 years. The two-word stage typically occurs within the age range of 19–26 months, and is characterized by a mean length of utterance (MLU) of two morphemes, with a range of 1.75–2.25. For many languages, the utterances of children in this stage include a predominance of nouns, and a lack of grammatical markers (DeVilliers & DeVilliers, 1979); for this

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reason, these aspects have also become part of the linguistic characteristics typically associated with the two-word stage. Over the past five decades other criteria have been added to the definition of the two-word stage, based on what has been described as part of 2-year old language, e.g. the typical semantic relations expressed.

Since the 1970s, some authors have emphasized the ties between linguistic and cognitive development with the two-word stage hypothesized to inextricably link maturation, linguistic, and/or cognitive development (Bloom, Lightbown, & Hood, 1975; Casasola, Bhagwat, & Ferguson, 2006; Clark, 1973; Ervin-Tripp, 1973; Papafragou, Cassidy, & Gleitman, 2007; Piaget, 1980; Schlesinger, 1971, among others). Other authors, however, point out the evidence from linguistically and/or cognitively delayed populations which indicates that dissociations between development of cognitive ability and linguistic ability are possible (Bellugi, Lai, & Wang, 1997; Bellugi, Marks, Bihrle, & Sabo, 1993; Capirici, Sabbadini, & Volterra, 1996; Coggins, 1979; Curtiss, 1982; Landau et al., 2005; Levy, 2004; Mervis, Morris, Bertrand, & Robinson, 1999; Miller, 1988; Oliver & Buckley, 1994; Thomas & Karmiloff-Smith, 2005; Yamada, 1981, 1990, among others). While there is considerable debate over how closely cognitive and linguistic development are linked, one of the current, tempered views is that cognitive and linguistic development can occur at separate paces.

The search for a way to dissociate the development of cognitive and linguistic ability in both the fields of Cognitive Psychology and Linguistics is an on-going goal, and has branched out in several directions. In addition to looking at special medical populations, social populations, and language isolates, various cognitive capacities of typically-developing prelinguistic infants are currently being studied.

Since prelinguistic children, e.g. infants, do not yet use language productively, their knowledge might be considered cognitive or core (Diesendruck, 2003; Gelman & Butterworth, 2005; Spelke, 2011, among others). One of the aims of the above-mentioned line of study is to investigate cognitive development before the convergence of linguistic development. There are many topics of interest in prelingual cognitive development, two of which are children's development of the concept of number, and children's development of categorization.

The concept of number as separate from language is currently under intense debate (Gelman & Butterworth, 2005; Gordon, 2004; Mix, Huttenlocher, & Levine, 2002; Spaepen, Coppola, Spelke, Carey, & Goldin-Meadow, 2011; Wynn, 1992; Zosh & Feigenson, 2009; among others; see Spelke, 2011 for review). Gelman and Butterworth (2005) suggest at least four arguments for a dissociation between numerical cognition and language. One is that children and adults can have problems, due to dementia or brain injury, with language but not with number calculation and vice versa. A second is that neuroimaging studies show different places of activation for numerical processing and for language processing. A third is that speakers of languages such as Munduruku and Pirahã, with limited, and inconsistent use of numbers, are still able to compare sets of up to as many as 80 dots, saying which set has more. Their fourth argument revolves around a study that analyzed the results of an experiment with children ages 5;0–8;6, examining what children think and say when asked about number relationships. From their evidence, Gelman and Butterworth (2005) propose that neural organization separates language from number, as reflected by cognitive development. Further, they suggest that while language most likely has an effect on numerical cognition, it does not cause its development.

Spelke (2011) alternatively suggests that the development of abstract numerical and geometric concepts hinges on the role that acquisition and use of natural language plays in linking information from distinct systems of core knowledge, like natural number and natural geometry. As evidence for the important role of language, she presents a study by Spaepen et al. (2011), of homesigners in Nicaragua. The participants lack a formal education but nonetheless hold jobs, and deal with money. However, despite having a good communication system, when these homesigners try to convey numerical information on their fingers, they do so inaccurately. They also perform non-symbolic matching tasks with number at less than accurate performance, suggesting a special role for language in the use of natural number. As more evidence, Spelke (2011) discusses studies of educated adults with language impairment, who show a dissociation of quantity and number words. Further, she presents evidence from bilingual adults suggesting that learning new number facts in one language elicits a cost when produced in the language opposed to the one the fact was originally learned in. These and other pieces of evidence support Spelke's (2011) assertion that there cannot be a complete dissociation between language and the cognitive concept of number.

It is not just the area of language and numerical concepts that is being debated, but the role of language in the conception of early categories in prelingual children as well. Some researchers argue that naming has a powerful effect on forming cognitive categories (Diesendruck, 2003; Levinson, Kita, Haun, & Rasch, 2002; Waxman & Leddon, 2011, among others), while others argue that the cognitive ability to form categories is more robust than the linguistic patterns of representing them (Li & Gleitman, 2002). Again, the debate over the relationship between cognitive abilities and language is ongoing, indicating the need for additional ways of studying possible dissociations between the two.

Recent research amassed from a number of different language-using populations also indicates the importance placed on finding ways to study a potential dissociation between cognitive ability and language.[1] By reconsidering the putative link between language and cognitive development at the two-word stage, not only can more be learned about language and cognitive development in general, but further research directions can be derived that distinguish between language delays and differences in the path of acquisition for certain populations.

Our study has two goals. The first is to clarify whether cognitive development can precede the development of language in the situation of late first language exposure, i.e. is a dissociation of linguistic and cognitive development possible in the two-word stage of the acquisition of a natural human language? Second, by examining case study data of early stages of language development and the corresponding cognitive development of two Deaf children not exposed to an accessible language (American Sign Language – ASL) until after the age of 5 years, our study aims to further discussion of potential variability in the nature of the two-word stage.

1.1. Theories of the two-word stage in typically developing children

Children's use of two-and three-word utterances, typically occurring around the age of 2 years, has been studied and discussed extensively since the late 1960s. There seem to be four dominant sets of theories of the two-word stage that provide testable hypotheses, as will be presented in Section 2 below. One is a cognitive limitation theory, e.g. Bloom et al. (1975), Clark (1973) and Piaget (1980). The second is a general cognitive processing limitation approach, e.g. Bates and Goodman (1997), Devescovi et al. (2005), Greenfield (1978), Kail (1997), Luna, Garvger, Urban, Lazar, and Sweeney (2004) and Sinclair (1975). The third is a maturational approach, e.g., Radford (1990) and Wexler (1999). The fourth is a linguistic processing limitation theory, e.g., Avrutin (2004), Boster (1997) and Pinker (1984). Each of these theories, while plausibly allowing for some cognitive development in linguistically delayed populations, has a different set of assumptions regarding the relationship between cognitive and linguistic abilities, as detailed below.

Piaget's (1980) cognitive theory suggests that children learn language as a means of representing or coding information that they have already acquired about objects, events, and relations in the world. With this view, language development follows from and depends upon conceptual development in a logical way (Bloom et al., 1975; Clark, 1973; Ervin-Tripp, 1973; Schlesinger, 1971, among others). The relationship between language and cognitive development is reciprocal, as further cognitive development is then dependent on language. According to this view the two-word stage is the linguistic reflection of the child's current cognitive state. As cognitive abilities pass through more advanced cognitive stages, so will language become more complex, and vice-versa. Casasola et al. (2006) hypothesize that as infants comprehend relational terms, they begin to use language to help them achieve a better understanding of specific relational meanings; that language structures infants' discrimination and categorization of motion events; and that the interaction of linguistic and nonlinguistic input allows for a developmental progression. These theories would predict that, for children with delayed language exposure, their cognitive abilities and their linguistic abilities would be similarly delayed because cognition and linguistic development are inextricably tied.

It is also conceivable that one would predict that older children who show normal cognitive test scores would skip over a two-word stage if beginning the language acquisition process at an older than normal age. For example, Tomasello (1992, 2003) proposes that a child's acquisition of language dur-

[1] Parts of this idea have been tentatively suggested by others as well, for specific language populations, e.g. Snedeker, Geren, and Shafto (2007) and Thomas and Karmiloff-Smith (2005).

ing the second year of life and beyond is similar to that of nonlinguistic cognition. Further, it reflects basic cognitive processes and depends on fundamental cognitive processes of symbolization and categorization. With this hypothesis, which views "syntagmatic categories being based on thematic relations", a two-word stage should not be seen in later-learning children who demonstrate normal cognitive development and processes, and more complex thematic relations.

The second theory, a general cognitive processing limitation approach, attributes the two-word stage to growth in children's general cognitive processing abilities. This approach is based on observations that children have limitations in working memory as revealed by limits on the number of elements they can deal with, e.g. digit span, and list attendance (Greenfield, 1978; Sinclair, 1975; and more recently Adams & Gathercole, 2000; Blake, Austin, Cannon, Lisus, & Vaughan, 1994; Cowan, Nugent, Elliott, Ponomarev, & Saults, 1999; Kail, 1997; Luna et al., 2004, among others).

Blake et al. (1994) looked at the relationship between verbal memory (measured by word span) and MLU in groups of children aged 2 through 4 years. For the youngest group of 23 children aged 23–38 months, they found that memory span is a better predictor of spontaneous language than age; furthermore, chronological age did not contribute to the variance beyond its shared variance with memory span, and mental age contributed only marginally. They also found a significant relationship between memory span and MLU in 3-year-olds, but not in 4-year-olds. They conclude that limitations imposed by memory ease as a child's linguistic ability develops.

This early performance limitation leads to a linguistic performance limitation. Therefore in older children, if there is no working memory limitation, as there is in younger children, there should be no cognitive processing limitation, and no constraint on early spontaneous language. Alternatively, the working memory limitation seen in only younger typically developing children might not ease if language development is delayed, and consequently both would be poor. Crucial to this approach, both cognitive and linguistic development should go hand in hand. The two are tied.

There is a second type of general cognitive processing limitation theory. Bates and Goodman (1997), and Devescovi et al. (2005) (see also Anderson & Reilly, 2002) support another type of cognitive theory, that a child's grammatical development is tied to the development of vocabulary. The more words a child knows, the more advanced the child's grammar will be. This can be considered a cognitive processing theory because these researchers attribute the child's vocabulary development in part to the child's growing cognitive ability to represent items and ideas that he/she encounters. Therefore if a child with delayed language input goes through a two-word stage, this theory would expect the child's vocabulary to be limited in a way similar to younger children in the same linguistic stage. Therefore a two-word stage is predictably tied to the number of words in the child's productive vocabulary.

These theories share the hypothesis that children with late language exposure and no cognitive deficit should show similar paths in both language and cognitive abilities. Hence, if there is a two-word stage, both language and cognition should be affected similarly, (e.g. for their chronological age, there should be a smaller vocabulary, simpler concepts, and lower scores on cognitive assessments, or possibly no delay but matched performance in both areas).

In the traditional linguistic maturational approach, the hypothesis has been that, as children get older, certain linguistic abilities become available due to biological maturation, much like the development of secondary sexual characteristics (Radford, 1990; Wexler, 1999). Hence, in this view, a two-word stage reflects the biological state of children at a particular age. Typically, cognitive and linguistic growth occurs together, but the tie between cognitive and linguistic development is not inextricable. Thus, on this approach, children who are older when their exposure to language begins would be expected to skip over the two-word stage, as the biologically-timed maturation allowing more complex structures would have already taken place.

Other linguistic approaches to the two-word stage often attribute it to a set of relatively independent steps of grammatical development which conspire to produce relatively shorter output as an accidental by-product of linguistic hypotheses such as the use of null subjects (e.g., Hyams & Wexler, 1993) or the lack of determiners (see, e.g., Bohnacker, 1997). On such approaches, there is no particular reason to expect linguistic and cognitive development to be tied, but there is also no particular explanation for a two-word stage as such.

There is another theory for why a two-word stage occurs, one which links the child's developing grammar to specifically linguistic processing limitations (e.g., Avrutin, 2004; Boster, 1997; Pinker, 1984). Some researchers argue that there is a specifically linguistic processing mechanism that places limits on the amount of linguistic information processed at early stages of language development (Bloom, 1993; Boster, 1997; Gerken, 1991; Pinker, 1984). Boster (1997) spells out one possible model of such a processing mechanism. On her approach, sentences are generated in a bottom-up fashion (following much recent linguistic theorizing). Each step of lexical look-up and each operation merging components of phrase structure incurs a processing cost (called l and m, respectively). Assuming that children are working under an average processing limitation N, the current processing load P(=sum of l units + m units), will surpass N for certain types of sentence structures. Consequences of this limitation will mean that subjects will be omitted more frequently in transitive sentences and in sentences containing negation, but not in sentences containing a WH-element (since the WH-element in sentence-initial position could not be generated without first succeeding with the structurally-lower subject). These predictions and others are borne out in Boster's study of three children's spontaneous production data.

Similarly, Rizzi (2005) proposes to account for specific aspects of young children's syntax including missing subjects and inflection by appealing to processing limitations. He argues that these limitations may lead children to ‘‘choose'' simpler syntactic options available in some of the world's languages, if not in their target language.

On our view, children initially use limited structural pieces which are compatible with their developing grammar. One way these can be envisioned is along the lines of the treelets of Fodor (1998a,b). On Fodor's proposal, these are bits of precompiled grammatical trees, compatible with particular parameter-settings but not others, and used by the parser to analyze input sentences. On Fodor's model, treelets are part of sentence parsing, and they are also used for learning, since the learner will add to the grammar treelets that are unambiguously required in order to successfully parse incoming sentences. As a child's grammar develops, more and more-developed treelets would be available, allowing for a growing number of utterance types compatible with the adult grammar. At early stages, the child's inventory of treelets is limited, leading to productions which are shorter by virtue of omission of elements used in the adult grammar. Snyder (2007) discusses the conception of the child's grammar in terms of Fodorian treelets, and finds it a promising route to account for his empirical observations about the growth of grammars. In particular, Snyder finds that in spontaneous production, children are grammatically conservative, only using structures that are compatible with the adult grammar and refraining from errors of commission – though errors of omission may be frequent. Fodor's proposal accounts for why children produce only target-compatible utterances, and why they might comprehend structures which they do not yet produce – because the treelets are available for parsing, but not yet integrated into the production grammar.

For some of these models, including our view, cognitive development can occur at some pace even without language. It is the specifically linguistic processing mechanism that develops with language exposure. With delayed exposure, the linguistic processing mechanism is similarly delayed, but independent of more general cognitive processing. Therefore, a two-word stage could be seen in a child with delayed language exposure; but a comparable delay in cognitive development would not necessarily also occur.

In order to assess the relationship between language and cognitive development at the two-word stage, we turn next to see what happens with children who have atypical language exposure.

1.2. Previous studies of language development with atypical exposure to a first language

Characteristics of the two-word stage have been reported in studies with children typically developing a single spoken language (Brown, 1973), children typically developing two spoken languages (Kovacs & Mehler, 2009), typically developing children who use a signed language (Lillo-Martin, 1999; Newport & Ashbrook, 1977), Deaf home signing children (Goldin-Meadow, 2007), children who were adopted early, i.e. before the end of their second year of life (Snedeker et al., 2007), and children who have Williams-Beuren and Down Syndromes (Mervis et al., 1999; Miller, 1988; Musolino, Chunyo, & Landau, 2010; Oliver & Buckley, 1994; Thomas & Karmiloff-Smith, 2005). For the latter groups of children with cognitive impairments, language skills are closer than cognitive ones to age-level, typically-developing peers, though slower to emerge. Debate is ongoing as to whether the children's language is simply delayed in comparison to age-mates (see Musolino et al., 2010), or whether they follow a different language acquisition path as compared to typically developing peers (Karmiloff-Smith et al., 1997; Thomas & Karmiloff-Smith, 2005). For children without cognitive deficits, the debate revolves around whether a two-word stage is based on linguistic input versus the cognitive ability to represent items and ideas. Children who were adopted around the age of 2 years into a new language environment provide insight into the effect of linguistic input and age of acquisition on the development of language, while Deaf home-signer children, who combine gestures despite not having accessible linguistic input, provide insight into whether a two-word stage happens soon after symbols can be represented.

The above-mentioned populations vary in their success at language acquisition, as well as in the amount and type of linguistic exposure they have experienced, and the presence or lack of cognitive deficit. But still the question of whether the two-word stage is due to linguistic or cognitive constraints remains.

A number of previous studies have examined language use by Deaf individuals with delayed linguistic input. However, most of these studies have focused on adults whose childhood experiences included delayed language exposure, and have documented the persisting grammatical and processing differences between their language and that of native signers (Boudreault & Mayberry, 2006; Emmorey, Bellugi, Friederici, & Horn, 1995). Hence they cannot address the question of what characterizes early language acquisition at the time the process is occurring.

An exception to this is the recent report of what the first words are like, when a first language is acquired in adolescence (Ferjan Ramirez, Lieberman, & Mayberry, in press). Using the MacArthur Communicative Developmental Inventory for ASL (CDI-ASL) with three Deaf adolescents exposed to ASL at about the age of 14 years, it was noted that while vocabulary composition is similar for the adolescents and young, native signing children, the adolescents' initial vocabulary growth and development seems to be faster than that of children. Nevertheless, the three adolescents spontaneously produced utterances that averaged between two and three signs per utterance.

Studies of home signers show the development of a communication system, and studies of children adopted at different ages show child language development under delayed input. For child home signers, results suggest that the children go through a two-gesture stage that is similar to other children. Goldin-Meadow and Mylander (1990) report that in their study of 10 Deaf home signing children, two of them began producing two-gesture sentences at ages that are comparable to hearing children learning English, and only slightly behind Deaf children learning ASL. The other children were older, and already producing sentences with combined gestures. Homesign, however, is a communication system that relies on gesture, and does not display all of the properties of a developed human language. Although there are aspects of syntax-like structure that have been reported in the gesture system of home sign including predicate structure based on thematic roles, ordering and production-probability rules, and recursion, much of the lexicon consists of gestures that point to things. Homesign is often replaced, as exposure to a true language begins.

Our longitudinal study examines children with delayed linguistic input, soon after American Sign Language and Deaf culture immersion. We regularly observed the children over a period of 4 years.[2] Thus, our study brings a wealth of data to bear on questions of the effects of delayed language exposure.

2. Present study

Native language learners typically show parallel development in both language and cognition (Clark, 1983). If language level and cognitive level can be measured separately, we can make different predictions about the effects of delayed linguistic exposure given theories of the relationship between language and cognition. We test four alternative hypotheses, listed as A–D below.

[2] The children in this study are different from the home signing children of Goldin-Meadow's studies in that these children went from no accessible language input to being immersed in American Sign Language, with no home sign noted by the parents or school psychologist.

A. Language structures cognitive development, and hence language development and cognitive development are closely tied (Bloom et al., 1975; Casasola et al., 2006; Clark, 1973; Ervin-Tripp, 1973; Piaget, 1980; Schlesinger, 1971). With a delay in language development, cognitive development will also be delayed. If a linguistic two-word stage is seen in older children, the cognitive characteristics of the two-word stage will also be observed.

B. Early length limitations in children's productions that are typical of a linguistic two word stage are due to slowly developing cognitive abilities or specifically linguistic maturation. If language development begins late, when cognitive development has tested as "normal", then language will develop without early length limitations. A two-word stage will be skipped and not be seen at all (Radford, 1990; Tomasello, 1992, 2003; Wexler, 1999).

C. An early length limitation stems not from cognitive, but from vocabulary development (Bates & Goodman, 1997; Devescovi et al., 2005). If the productive vocabulary is larger than that of a typical 2-year old, a two-word stage will not be observable at that time.

D. Early length limitations are due to specifically linguistic processing limitations, and are eased as language develops. Early length limitations will occur regardless of cognitive ability (Avrutin, 2004; Bloom, 1993; Boster, 1997; Gerken, 1991; Pinker, 1984).

2.1. Material and methods

2.1.1. Participants

Mei and Cal offer the opportunity for developmental research that addresses sensitive period effects, without the presence of physical abuse and other confounds. Mei was first immersed in language at the age of 6;0 (years; months), and Cal at age 5;9. We recorded language use by these children from the ages of 6–10 years, relatively soon after their immersion in an accessible first language. The social and medical backgrounds of Mei and Cal are described below (see also Berk, 2003 for more details).

"Mei" and her family live in a very rural part of the country, with no neighbors close by. She was initially misdiagnosed as "low-functioning mentally retarded" at the local medical center in the early 1990s, before newborn hearing screening became mandatory. Between the ages of 3 and 5 years, she attended a Head-Start program 12 h/week. Mei's parents noticed a delay in language, but had been told by the physician that it was expected. Mei's parents were also dealing with health issues of Mei's older brother at the same time, making it easier to put Mei's language issues on the back burner. In response to the parents' concerns, the county's social services provided an associate to work with Mei on language development. Mei's mother reports that the associate made only minimal attempts to engage Mei in linguistic communication. Because the county's associate accepted Mei's original diagnosis, s/he primarily provided Mei with crayons and paper. Soon after the age of 5 years, Mei's independence and higher abilities in areas other than language led the parents and grandmother to raise the question of deafness. They brought her to be tested at a children's hospital in "the big city", where deafness was confirmed and low mental ability was challenged.

Mei completed an intake evaluation at a residential school for Deaf children at age 5;5. At the time of the evaluation, the school psychologist noted in her chart, "Mei's overall performance indicates that she has some well developed nonverbal cognitive abilities". Her vocabulary consisted of 15–20 gestures, not used in combination. They were mostly those required to communicate basic needs, e.g. "food", "eat", "drink", "sleep", etc. Mei began attending the school at age 5;9, but less than 1 month later the school had its summer break and she had no exposure to ASL during that time. We consider Mei's immersion in ASL to have begun on her return to school at the age of 6;0. Although the reported communication policy for the school is Total Communication,[3] ASL was the predominant language Mei was exposed to, including time in the dorms, outside of class, and some class time. At school, two Deaf aides were assigned at different times to work with Mei and Cal at the dorms as Deaf role models and caregivers. The caregivers provided substantial one-on-one and one-on-two input in ASL for Mei and Cal. At home, Mei's parents spoke English, and did not sign. They did not gesture much, if at all, with Mei. Oral training was not attempted with Mei.

[3] Total Communication (TC) has been an approach in deaf education that uses multiple modes of communication, including signs, oral, auditory, written and visual aids.

"Cal" was correctly diagnosed with profound deafness by the age of 18 months. (Similar to Mei, newborn hearing screening was not yet mandatory.) He was exposed to an accessible first language significantly later, however, primarily as a result of his home situation and an ineffective county hospital program. Cal, like Mei, also lived in a very rural part of the country, although nowhere near to Mei. Cal's parents were going through a particularly difficult divorce, and Cal started exhibiting what was thought to be divorce-related behavior problems, e.g. not listening to the parent he was with, out of solidarity for the other, or general anger about the whole situation. Cal participated in the hospital-based program between the ages of 3 and 5 years. The partial day program at a community hospital was targeted at children with behavioral problems and aimed to correct undesirable behaviors. In addition to attending the day program, Cal had a home tutor to teach signed words. According to Cal's mother, the tutor knew approximately 20 signs. Since Cal's mother did not sign, it took her quite a while to realize that the tutor was not a good match for Cal.

Cal completed an intake evaluation at a residential school for Deaf children at age 5;6. At that time, the school psychologist noted in the chart, "Cal's performance on the K-ABC Nonverbal Scale suggests he is functioning within average range of nonverbal intelligence". He was reported to know between 20 and 25 gestures, consisting mostly of communicating basic needs, e.g. "bathroom", "eat", "drink", "sleep", "sit", etc. Cal was first exposed to and immersed in ASL upon starting school at age 5;9. As for Mei, ASL was the predominant language used at school with Cal, including time with the caregiver aide, dorm time with other students and other aides, and some class time.[4]

Data from our observations of the language of these two later learning children are compared with those of two native signing children, i.e. Deaf signing children born to Deaf signing families, Jil, and Sal, whose age reflects language exposure. Data for Jil and Sal were collected separately as part of the Cross-Linguistic Early Syntax Study (CLESS) project at the University of Connecticut (Lillo-Martin & Chen Picher, 2008). Sessions were chosen for comparison when the younger native signers were in the typical two-word stage age range. Therefore they are younger than Mei and Cal at the point when the amount of language exposure is similar. For one analysis, data from Nat, a schoolmate of the same age as Mei and Cal, are also included. Nat is a native-signing age peer for Mei and Cal. For native signers such as Jil, Sal, and Nat, ASL is acquired along a timetable similar to that found for children learning spoken languages (Lillo-Martin, 1999, 2009; Mayberry & Squires, 2006; Newport & Meier, 1985).

2.2. Procedure

Longitudinal spontaneous language production data were collected with Mei and Cal in semi-weekly, 15- to 45-min sessions of naturalistic language production with stories and toys over the course of 4 years. A Deaf signer familiar to the children led one-on-one, individual sessions during which they played with toys that changed weekly, read through books, and/or played with balls and other large motor skill objects. Sessions were videotaped, and so far a subset has been transcribed, reliability checked and coded by either a native Deaf, or a fluent hearing signer. All transcripts were checked by a native Deaf signer. The sessions were chosen to be transcribed based solely on date. All of the first week per month sessions were done, followed by the third week per month sessions, with the eventual goal being to transcribe and check the entire, enormous corpora over time. Similar procedures were followed in collecting data from the native signers, but on differing schedules (once a week to once or twice per month); sessions were generally 45 min to 1 h in length. The native signers interacted with Deaf or hearing fluent signers or their parents during recordings. Longitudinal production data were subjected to five analyses, described below.

Information about the age of participants and the total number of child utterances at each session is given in Table 1. In analyses of Mei's data, sessions within the same month of age are combined, e.g. Mei's session 2 had 75 usable utterances and Mei's session 4 had 60 usable utterances, and since these sessions were within a week of each other, both when she was 6;8, we combine the sessions in the

[4] From the school psychologist's observations and from our conversations with Mei's and Cal's parents, we believe that neither child developed an extensive 'home sign' system as has been reported for other deaf children lacking sign language input (Goldin-Meadow & Mylander, 1984). For the reasons mentioned here, attempts at communication between the children and their parents were minimal, so the children lacked conversation partners necessary for the development of a home sign system.

analyses such that at age 6;8 Mei has 135 utterances. For the native signers, all analyses presented here are based on the first (approximately) 175 child utterances of a session, as indicated in the table, although some sessions have more than that number of utterances.

As described in detail in the next section, the nonlinguistic cognitive ability of the later learners at different ages was coded through independent evaluations by the school psychologist, an informal administration of three to four of the non-verbal subscales of the WISC-R, and two evaluations of the children's drawings. Indices of language and language development included MLU, part-of-speech analysis, and a vocabulary count. Academic achievement was measured from the standardized tests administered at school, and conceptual sophistication was measured by examining semantic relations and use of mental verbs.

2.3. Measures

The measures used, while not exhaustive, provide evidence for linguistic, cognitive, and conceptual stage and hence aid in the evaluation of the hypotheses presented earlier.

2.3.1. Nonlinguistic cognitive development

Kaufman Assessment Battery for Children. The Nonverbal scales of the Kaufman Assessment Battery for Children (K-ABC) version I were administered by the school psychologist as part of the routine intake evaluation. He reports that of the K-ABC Global Scales, the Nonverbal Scales are usually considered to be the best estimate of general intelligence for hearing impaired children.

Human figure drawing. This assessment was conducted following the criteria of Koppitz (1968). The child is asked to draw a child or person. The evaluator compares the components actually drawn to the age-appropriate norms for several categories, including Expected items, Common items, Not Unusual items, and Exceptional items. For Mei and Cal, this assessment was performed by the school psychologist at the intake evaluation.

Spontaneous drawing. During some sessions with Mei and Cal, drawings were spontaneously made that were voluntarily given to the experimenter as a gift. Later, in addition to being enjoyed, these drawings were evaluated for developmental stage following the criteria discussed by Toomela (2003). Toomela (2003) distinguishes four overall stages in the development of drawing: (i) Scribbles and Patterns (children do not produce recognizable drawings; they simply produce scribbles or patterns of lines that do not represent one particular concrete object), (ii) Volume-Prototypes (a shape or a person is represented in a simplified manner, e.g. a cube is drawn as a square, and a person is drawn as a circle with lines extending for legs and arms), (iii) 2-D Exemplars (drawings with some more depth and detail, e.g. a cube will have differentiated parts, albeit not realistically depicted, and a person will also have parts, like a face and hands), (iv) 3-D Exemplars (more specific drawings that show vantage point, specific aspects in both projection and content, with edges and contours represented by lines).

Subscales of WISC-R. Four of the non-verbal subscales of the Wechsler Intelligence Scale for Children—Revised (WISC-R) (Wechsler, 1974), i.e. picture completion, block design, object assembly, and digit coding, were administered to Mei at the age of 9;3. The same subscales were administered to Cal at the age of 9;7. These subscales were given during a regular taping session. Although these subscales were given 3 years after the sessions used in this study of the two-word stage, they are relevant in showing the continuing intellectual development that the children experienced.

2.3.2. Language development

MLU. Mean length of utterance in morphemes was calculated for each session. Full imitations of immediately preceding utterances and self-repetitions without a change in meaning (e.g., emphasis) were excluded. Incomplete utterances or those that could not be fully transcribed were omitted from the MLU analysis. ASL grammatical non-manuals and verbal morphology using space were included as morphemes (similar to Brown's (1973) criteria for spoken languages).

Part-of-speech analysis. Elements in the children's productions were coded as Noun, Verb, Adjective, or Other. Potentially ambiguous items were coded according to their usage in each particular

Table 1
Participant data.

Pseudonym	Age at immersion	Age filming began	Age at conclusion of filming	Age range of current analyses	Range of total # child utterances per session
Mei	6;0	6;7	10;0	6;7–6;10	60–157
Cal	5;9	6;10	10;1	6;10–7;1	78–262
Jil	Birth	1;7	3;7	2;0–2;6	57–178
Sal	Birth	1;7	2;10	2;0–2;2	175–180
Nat	Birth	6;7	10;3	7;11–8;11	227–231

utterance. For the purposes of the analyses in this report, we compare proportion nouns used to proportion verbs used.

Vocabulary count. A tally of word types used was calculated for the first 50 utterances of naturalistic language production in each session. The ASL-CDI (Anderson & Reilly, 2002) was used as the initial basis for our estimate of the children's vocabulary. However, we did not follow the standard method for administering the CDI, namely parental report. Instead, we used the items on the CDI as a checklist, and looked to see which words each participant used in each session. Additional signs not included on the CDI were also tallied. This is clearly an underestimate of the child's full vocabulary at the age of observation, but it provides a rough measure for comparison across sessions and across children.

Each of the transcripts was examined for vocabulary items. Because each session involved different lengths of recording time, we used the first 50 codable utterances from each session as the basis of comparison.

2.3.3. Academic achievement

Stanford Achievement Test. Mei and Cal were administered portions of the 9th Edition of the Stanford Achievement Test as part of their regular academic programs, including the following subscales: work study skills, word reading vocabulary, reading comprehension, problem solving, math, total language, spelling, and environment.

2.3.4. Conceptual sophistication

Semantic relations. Sessions from Mei, Cal, Nat, Jil, and Sal were analyzed according to criteria established by Bloom et al. (1975), and applied to native signers of ASL by Newport and Ashbrook (1977). According to this analysis, children's utterances were classified as expressing one of the following semantic relations (examples given in parentheses).

Early-appearing

Existence: indexes an item and names it (PT(car) CAR[5]).
Action: action performed by an actor (JUMP).
State: transitory state (BOY TIRED).
Locative state: static location of an object (CAT PT(kitchen)).
Locative action: action involving movement (PUT:HERE BOOK).

Mid-appearing

Possession: declaring ownership (MINE DOG).
Attribution: using descriptive characteristics (BALLOON RED).
Negation: making an utterance negative (NOT:WANT BOWL).
WH-question: a question that uses a WH-word (WHAT PT(toy)?).
Notice: referring to the not here and now (HOME I:SEE).

[5] *Notation*: Any word in all capital letters is a gloss for an ASL sign. A hyphen in between two glossed words means that it is signed as one ASL word. If a glossed word is followed by <hn> or <hs>, it means that it is a non-manual head shake or head nod for "yes" and "no". In order to mark word-internal morpheme boundaries, a colon is inserted.

Late-appearing

Instrument: action performed with an instrument (SCISSORS CUT).
Intention: action to be done in the future (WILL LEAVE).
Recurrence: referring to something that happens often (ALWAYS SNEEZE).

2.3.5. Mental verbs

The children's data were examined for their use of mental verbs such as "know", "think" "worry", "feel" and "dream", verbs which are typically not seen in children's language until age 3+ years (Anderson & Reilly, 2002; Naigles, 2000; Papafragou et al., 2007; Shatz, Wellman, & Silber, 1983).

3. Results

3.1. Cognitive Development Indices

A summary of the results of assessing Mei's and Cal's cognitive development at different points in the observation period is given in Table 2. Although there may have been delays in the development of particular abilities (e.g., drawing) at the point of immersion in ASL, it is clear that overall Mei and Cal had age-appropriate non-verbal cognitive development that continued to develop in the non-verbal domain, such that at each point of testing, they were at age level.

K-ABC. The school psychologist administered the Kaufman Assessment Battery for Children during intake evaluations. Both children fell within the average range of intelligence on nonverbal measures. For Mei this is different from her initial diagnosis.

Human figure drawing. The school psychologist's assessment of Mei's and Cal's human figure drawing on the same day as the K-ABC was administered showed skills that were below appropriate for their age. In particular, he noted that their drawings were missing several developmental characteristics. He also noted that these scores were not commensurate with their scores on the K-ABC.

Spontaneous drawings. Two-and-a-half years later, our assessment of Mei's and Cal's spontaneous drawing required a detailed analysis. It was easy to see that the drawings were more advanced than characteristic of the first two stages of Toomela's (2003) scale, but they were not as easily classified into stage (iii) or (iv). Therefore, a further developmental breakdown was assessed, based on Toomela's (2003) definitions of Visual Realism ((a) the drawing represents an exemplar, a particular model rather than a prototype; (b) the drawing is vantage-point specific, only those surfaces and features are depicted that can be seen from a certain point; (c) either linear or parallel projection perspective is used), Symbolism, and Perceptual Distortion (the drawing represents a specific aspect of the figure, but is not drawn to scale correctly). The results using this analysis showed Mei's and Cal's drawings to be age-appropriate, at the stage of visual realism with perceptual distortions. The analysis of a sample of drawings is presented in Table 3.

WISC-R. When tested at age 9;3, Mei's scaled scores on the picture completion (11), block design (12), object assembly (10), and digit coding (8) subtests of the WISC-R were all within one standard

Table 2
Cognitive Development Indices – results summary.

Test	Mei	Cal
Kaufman Assessment Battery for Children (K-ABC) (non-verbal)	5;9 Average range of intelligence	5;9 Average range of intelligence
Human figure drawing	5;9 Below appropriate for age	5;9 Below appropriate for age
Spontaneous drawing	7;11 Age appropriate	8;1 Age appropriate
Subscales of WISC-R (non-verbal)	9;3 Average range of intelligence	9;7 Average range of intelligence

Table 3
Analysis of spontaneous drawings made by Mei and Cal.

Child	Age	Picture type	Notable components	"Stage of drawing"
Mei	7;11	Bride and groom	Profile point of view, under an arch of flowers, white dress, and black tuxedo	Visual realism with perceptual distortions. Age appropriate
	7;11	Redskins mascot	Profile point of view, head only, nose, feather, eyes, mouth depicted, and correct color choice-brick red	Visual realism with perceptual distortions. Age appropriate
Cal	8;2	Bird in cage	Profile point of view, head, eyes, beak, nostrils, legs, feet, body, tail depicted. Bird is clearly on perch, with cage bars drawn over bird	Visual realism with perceptual distortions. Age appropriate
	8;2	Rainbow	Straight-on view, 6 colors drawn, arched lines, one below the other	Symbolic with detail, but not enough context to establish stage

Table 4
Language Development Indices – results summary.

Measure	Mei (6;7–6;10)	Cal (6;10–7;1)
MLU	1.76–2.13	1.70–1.89
Part-of-speech analysis	More nouns than verbs; ratio decreasing	More nouns than verbs; ratio decreasing
Vocabulary count	30–47 types in 50 utterances	33–38 types in 50 utterances
	Jil (2;0–2;6)	Sal (2;0–2;2)
MLU	1.73–1.98	1.67–1.86
Part-of-speech analysis	More nouns than verbs; ratio decreasing	More nouns than verbs; ratio decreasing
Vocabulary count	26 types in 50 utterances	13–24 types in 50 utterances

deviation of the means established for that test (with normally hearing children). When tested at age 9;7, Cal's scaled scores on the picture completion (11), block design (10), object assembly (10), and digit coding (8) subtests of the WISC-R were also all within one standard deviation of the mean. These scores place both children within the normal range of intelligence for their age.

3.2. Language Development Indices

A summary of the results of our language analyses is given in Table 4. According to their MLU counts, Mei and Cal were in a two-word stage at the beginning of our observation period. Their MLU is comparable to that of native signing children in the age range 2;0 to 2;6. Like the native signers, they use nouns more frequently than verbs, and this ratio decreases as MLU increases. Thus, in these senses Mei and Cal look like much younger children beginning the process of language development. However, Mei and Cal do have a larger vocabulary than the younger children. Further differences between Mei and Cal and the younger children in language use are discussed in the following subsection.

MLU. At the beginning of our observation period, the two children with delayed input had MLUs of 1.92, which is comparable to the MLUs of native signers during the period of 2;0–2;6. The mean length of utterance (in morphemes) for each child at monthly age intervals is given in Fig. 1.

Part-of-speech analysis. With the words produced by the children coded as noun, verb, adjective, and other, we were able to code for the percentage of nouns used per language sample, and the percentage of verbs used per language sample. The percentage of nouns versus verbs for each child is given in Fig. 2. All of the children used nouns at least twice as often as verbs.

Given previous observations that the proportion of nouns to verbs decreases as MLU increases in typically developing children, we calculated these proportions, as the ratio of noun to verb, and plotted them against MLU in Fig. 3. Although in both cases, the proportion of nouns to verbs decreases as MLU increases, more data points would be needed to verify this statistically.

Vocabulary count. The results of our vocabulary tally are given in Table 5. (Note: for the multiple sessions of Mei in the same month range, we used the session with the highest total vocabulary.)

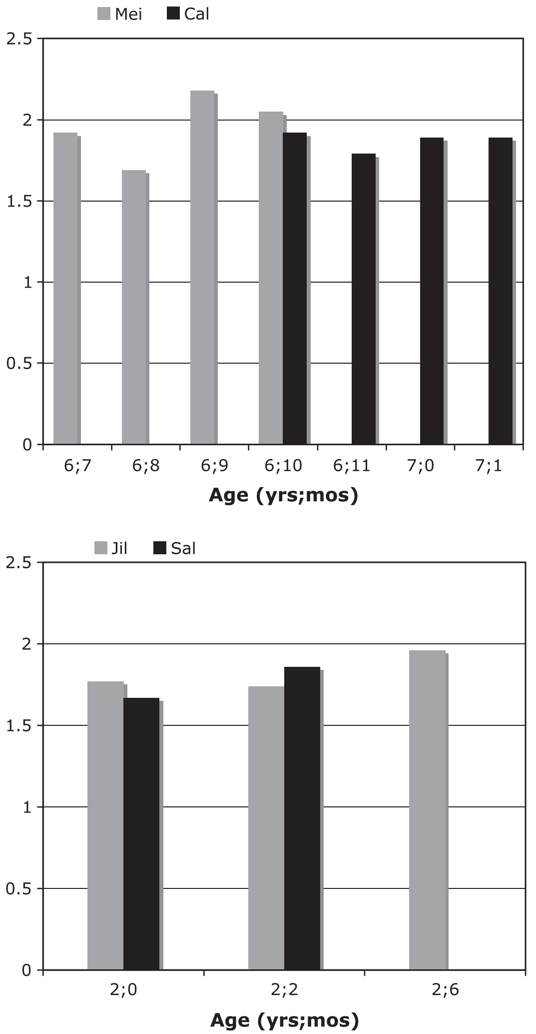

Fig. 1. Early sessions' MLU: signers with delayed input; native signers.

Although the count is clearly an underestimate of the children's total vocabulary, it would appear that Mei and Cal have greater vocabularies than do Jil and Sal; at least, they use a greater variety of words in their utterances than the younger children do.

Another indication of the difference in vocabulary between the older and younger participants can be gleaned by comparing sessions with larger number of utterances. In Table 6, we present the number of word types from sessions selected for similar length for each participant. It is clear that Mei and Cal use a much greater variety of words than do Jil and Sal. The word counts of the later learners approach and even exceed 100 in these samples of 125–200 utterances. In contrast, the word counts of the younger children are at 65 and below in samples of 175 or more utterances.

3.3. *Academic achievement and conceptual sophistication indices*

The results of academic achievement and conceptual sophistication indices are summarized in Table 7. These results extend those of the previous analyses. They indicate that Mei and Cal have

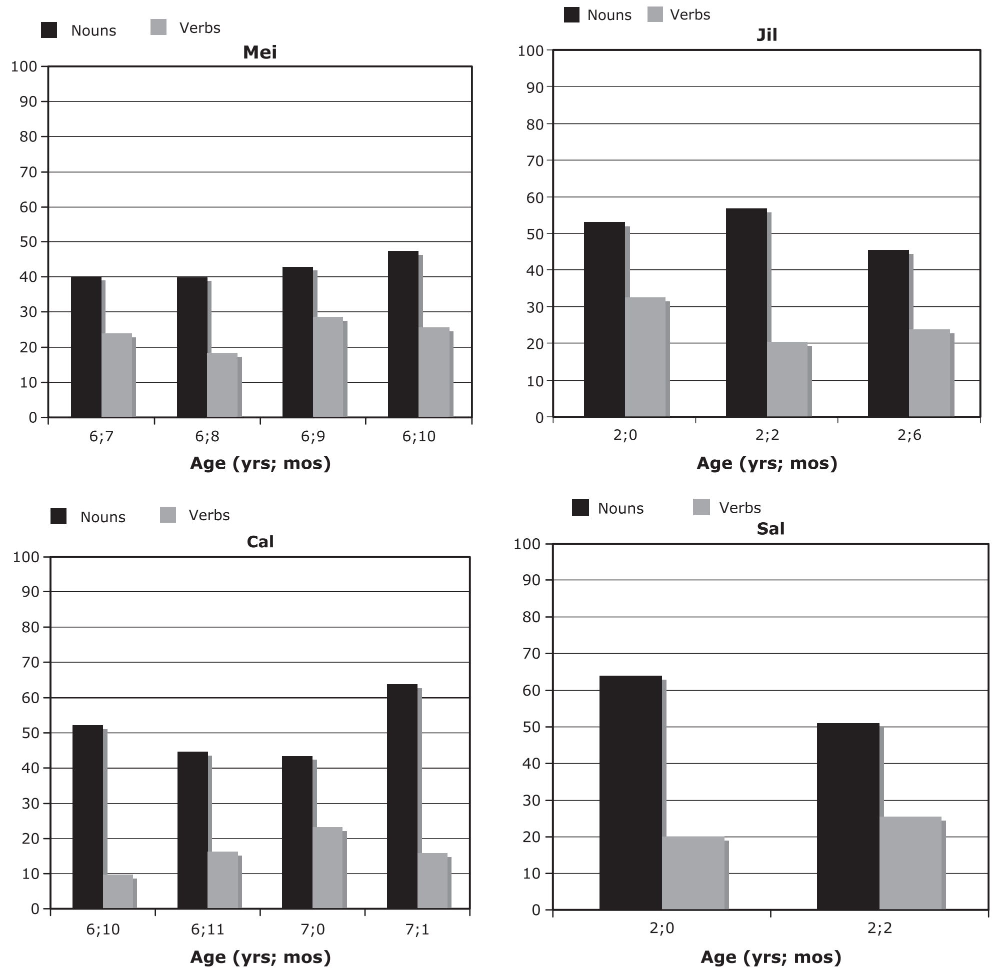

Fig. 2. Use of nouns and verbs in the 2 word stage.

potentially age-appropriate levels of cognitive abilities but are constrained in their use of complex grammatical structures to express all that they know.

Stanford Achievement Test. Near the end of our observation period, Mei and Cal at almost 10 years of age were administered the Stanford Achievement Test. Mei's and Cal's scores on the math portion indicate that both were performing within the range of their age-mates. This adds to the previous results that their non-verbal cognitive development in general is age-appropriate. However, both of them scored well below their peers in the English/reading portion of the test. This is consistent with their overall lower scores on language.

Semantic relations. The results from analyzing semantic relations in two sessions from Mei and Cal, as compared with two sessions for Jil and Sal, are also shown in detail in Table 8. The semantic relations are listed in blocks according to early-, mid-, and late-appearing categories. The total proportions of early-, mid-, and late-appearing relations for each child are displayed in Fig. 4.

Table 9 provides examples of potential intention category items. There is one example from Sal that could be considered to be an item in the intention category, a typically late-appearing relation. Although Sal's utterance is short, it uses emphasis to get the point across. The same category examples from Mei and Cal do not use such a mechanism, as illustrated in the Table. The examples from Mei and Cal convey intention but seem to be missing words, showing a length, but not cognitive limitation.

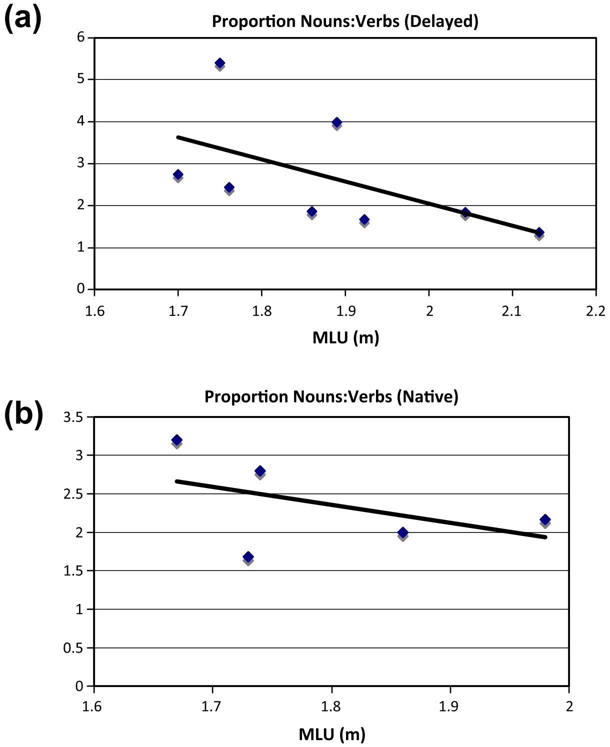

Fig. 3. Proportion nouns: verbs – (a) children with delayed input; (b) native signers.

Table 5
Vocabulary count.

Child	Age	# Vocabulary items (per first 50 utterances)	Child	Age	# Vocabulary items
Mei1	6;7	47	Jil_017	2;0	26
Mei2	6;8	44	Jil_024	2;2	26
Mei5	6;9	47	Jil_039	2;6	26
Mei8	6;10	30	Sal7	2;0	13
Cal1	6;10	38	Sal8	2;2	24
Cal2	6;11	37			
Cal5	7;0	37			
Cal8	7;1	33			

Table 6
Vocabulary in longer sessions.

Child	Age	# Word types	Analyzable utterances
Mei1	6;7	96	133
Mei5	6;9	92	142
Cal1	6;10	76	120
Cal5	7;0	103	183
Jil19	2;2	61	178
Sal7	2;0	65	180
Sal8	2;2	64	175

Table 7
Academic achievement and conceptual sophistication indices – results summary.

Measure	Mei	Cal	Jil	Sal
Stanford Achievement Test	9;7	9;9	N/A	N/A
	Math: At age level (50/69 correct) Eng/Read: Below age level (50/106 correct)	Math: At age level Eng/Read: Below age level (Exact scores N/A)		
Semantic relations	6;6–9;1	6;10–6;11	2;0–2;2	2;0–2;2
	Use of mid- and late-appearing relations comparable to age-mate	Use of mid- and late-appearing relations comparable to age-mate	Primarily early and some mid-appearing relations	Primarily early and some mid-appearing relations
Mental verbs	6;7–6;10 Several examples from the earliest observations	6;10–7;1 Several examples from the earliest observations	2;0–2;2 None	2;0–2;2 None

Table 8
Proportion (number) of different semantic relations in each sample.

Category	Mei (6;7)	Mei (6;8)	Cal (6;10)	Cal (6;11)	Jil (2;0)	Jil (2;2)	Sal (2;0)	Sal (2;2)
Existence	.03 (2)	.03 (1)	.06 (3)	.09 (3)	.09 (3)	.30 (21)	.16 (10)	.18 (7)
Action	.11 (7)	.03 (1)	.06 (3)	.06 (2)	.56 (18)	.17 (12)	.39 (24)	.28 (11)
State	.20 (13)	.11 (4)	.13 (7)	.15 (5)	.19 (6)	.07 (5)	.02 (1)	.08 (3)
Locative state	.06 (4)	.14 (5)	.11 (6)	.09 (3)	... (0)	.06 (4)	.05 (3)	.10 (4)
Locative action	.09 (6)	.05 (2)	.02 (1)	.06 (2)	.03 (1)	.06 (4)	.03 (2)	.18 (7)
Possession	.06 (4)	.11 (4)	.02 (1)	.03 (1)	... (0)	.10 (7)	... (0)	.05 (2)
Attribution	.25 (16)	.32 (12)	.35 (19)	.32 (11)	.03 (1)	.13 (9)	.15 (9)	.08 (3)
Negation	.05 (3)	... (0)	.02 (1)	... (0)	.06 (2)	... (0)	.02 (1)	... (0)
Wh-Quest.	... (0)	.03 (1)	.02 (1)	.06 (2)	.03 (1)	.11 (8)	.09 (6)	.05 (2)
Notice	.02 (1)	.14 (5)	.04 (2)	.03 (1)	... (0)	... (0)	.07 (4)	... (0)
Instrument	... (0)	... (0)	.02 (1)	... (0)	... (0)	... (0)	.02 (1)	... (0)
Intention	.12 (8)	.05 (2)	.06 (3)	.09 (3)	... (0)	... (0)	... (0)	.03 (1)
Recurrence	.02 (1)	... (0)	.11 (6)	.03 (1)	... (0)	... (0)	... (0)	... (0)
Total *N*	65	37	54	34	32	70	61	40

To extend this analysis, we examined a wider age range (i.e. past the two-word stage) for Mei (6;6–9;1) and Jil (2;0–4;6), as well as data from Nat, a native signer age-peer of Mei's. Nat, who was very familiar with the experimenters and with Mei and Cal, was filmed at the age of 7;11 in a spontaneous production session like those of the other children. This comparison provides a developmental perspective on the use of these semantic relations.

All three children use a high percentage of the early appearing semantic relations, throughout the sessions coded. However it is only the last two sessions for Jil that have higher than 10% use of the later-appearing semantic relations. Mei consistently uses 15% or more of the later-appearing semantic relations. 32% of the semantic relations that Nat produced were in the late appearing category.

To see more directly that Mei's use of semantic relations is similar to that of an age peer rather than a language-level peer, Fig. 5 shows Mei at age 7;11 compared to Nat at age 7;11. These plots are compared to that of Jil at age 2;6, at which point Jil and Mei have had approximately the same number of years of exposure. Additionally, the results for Jil at age 4;6 show her development over time.

From the age-appropriate use of semantic relations, and the larger vocabulary, it is hypothesized by some, that Mei and Cal should not exhibit a two-word stage, and yet from the language analyses, they do.

Mental verbs. The number of mental verbs used by each child in each session is presented in Table 10. Mei and Cal use mental verbs even in the very earliest sessions, when they have been immersed in ASL

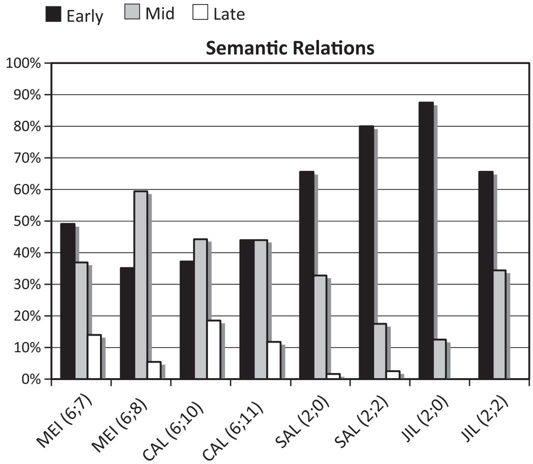

Fig. 4. Semantic relations by category of appearance.

Table 9
Intention category examples.

Sal (2;2)	YOU PT-PICTURE!	I want you to do like the picture
Mei (6;7)	PLAY WATER GROW	I want to play with the thing that grows when you put it in water
	TWO ME OTHER TWO	I want to do another two
	THINK THROW-AT-ME	I thought she would throw it at me
Mei (6;8)	THINK GOLD THINK INSIDE EGG	I think that the thing inside the egg will be gold
	ME DON'T-WANT	I do not want you to throw that spider at me
Cal (6;10)	CAN YES ⟨hn⟩ PT-TOYBAG	We can play more with the toys
	PT-WALL TURN-OFF-SWITCH YOU	I want you to turn off the light
Cal (6;11)	PT-SOMEONE YOURSELF	I want you to do it yourself
	PT-SBB SMELL	I want SBB to smell her

for less than 1 year. However, the younger native signers use no mental verbs during the "two-word" stage.

To summarize, the later learners and the native signing 2-year-olds in this study show evidence of a two-word stage. For both groups, MLU and the proportion of nouns to verbs are indicative of such a stage. However, the later learners are different from the younger native signers in that they display a larger vocabulary count than expected for language users at this stage, use of late-appearing semantic relations, and the use of mental verbs.

4. Discussion

The data presented here converge with those of other studies that suggest that dissociations between language development and cognitive development are possible, but the data also add to our knowledge in showing where the dissociation boundary exists. In aspects of the two-word stage that are primarily linguistic in nature, for example, utterance length, the later-learners are comparable to 2-year-old native signers and behind their age peers, while in aspects that relate to more advanced cognitive development, e.g. semantic relations, the later-learners are more advanced in comparison to 2-year-olds, and similar to age peers.

Mei and Cal experienced relatively normal non-verbal cognitive development during their early years, as indicated by their age-appropriate scores on non-verbal cognitive tests both shortly prior to the beginning of our observations and when tested again some 4 years later. However, due to

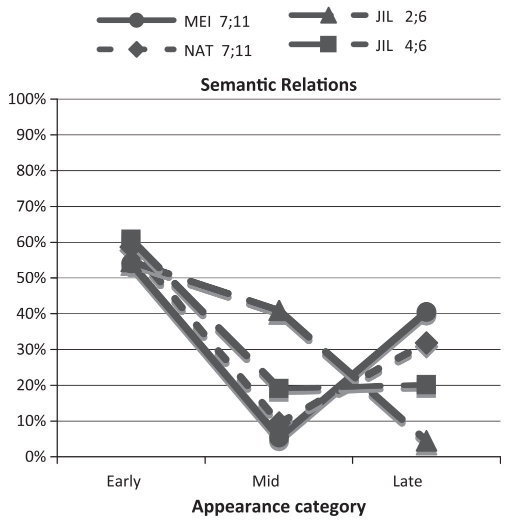

Fig. 5. Semantic relations at selected ages.

Table 10
Use of mental verbs.

Child	Age	# Mental verbs	Child	Age	# Mental verbs
Mei1	6;7	3	Jil17	2;0	0
Mei2	6;8	3	Jil19	2;2	0
Mei4	6;8	0	Sal7	2;0	0
Mei5	6;9	4	Sal8	2;2	0
Mei6	6;9	5			
Mei7	6;9	4			
Mei8	6;10	1			
Cal1	6;10	0			
Cal2	6;11	1			
Cal5	7;0	3			
Cal8	7;1	4			

the lack of accessible linguistic input, they did not start to develop language until around 6 years of age, and about a year after their language immersion they were in a two-word stage, as measured by MLU. The mean length of their utterances reached 2.0–2.15 after 7 (Mei) and even 16 (Cal) months of language exposure; hence there continued to be a growth in utterance length over time.

As with any study that is not an experimental design, with participants randomly assigned to control and test groups, this study has questions that cannot be conclusively answered from the data collected, and more tasks that, in hindsight, it would have been nice to have done. We can conclude from the cognitive indices that we have, that Mei and Cal have "relatively normal non-verbal cognitive development", however our cognitive testing was not exhaustive. Perhaps with more testing, areas of cognitive development that were delayed might have been revealed.

As we analyze this large and valuable data set, it also becomes apparent that it would have been helpful to have results from studies of working memory, and language and cognitive processing. Unfortunately, we do not have much data in these areas, and so we must be very careful in what can now be concluded in these respects. This cautiousness is clearly seen in our evaluation of a linguistic two-word stage and the later-learners.

Revisiting the typically cited characteristics of a two-word stage with data from the two, young, native signing Deaf children whom we studied, we find a fairly typical pattern at the age of

24–26 months: an MLU of ∼2.0, a relatively small vocabulary, a predominance of nouns, the proportion of nouns to verbs decreasing as MLU increases, a lack of mental verbs, and the majority of semantic relations being of the early appearing type. However, the pattern is not the same for the two later learners of ASL we studied. They displayed certain of the characteristics of this stage, including the limited MLU and predominance of nouns, with a decreasing ratio of nouns to verbs. However, Mei and Cal have larger vocabularies than typically-developing children at the two-word stage, mid and late appearing semantic relations, and mental verbs.

Although the two younger, native signers appear to be experiencing a two-word stage, similar to their hearing, spoken language counterparts, the later learners present a specific dissociation. They seem to be in a two-word stage for linguistic computational aspects, but not cognitive aspects. The later learners have a length limitation, a word category difference, and linguistic growth as measured by the change of the proportion of nouns and verbs. They are older than typically developing children at this stage, and they attempt to express more cognitively complex utterances, as seen with their use of mental verbs and later appearing semantic relations.

The results suggest the possibility that the "two-word stage", similar to infants' knowledge of number and categorization, has two components that occur at the same time in typically developing children, i.e. a specific syntactic component and a more general cognitive component. There must be some interaction between the two components, as a complete dissociation would cause other aspects of development to be difficult or impossible, e.g. memory of language events, and lexicon building. However, the data in this study reflect the dissociation of the linguistic aspects of a two-word stage from the general cognitive ones. The results from Mei and Cal further suggest that if even older children with average cognitive abilities experience significant delays in language exposure, they too will still experience an early sentence length limitation that occurs after language exposure begins. The linguistic two-word stage exists as a length limitation on language development, but not a cognitive or semantic limitation.

5. Conclusion

Our study had two goals. The first was to clarify whether cognitive development can precede the development of language in the situation of late first language exposure; i.e., is a dissociation of linguistic and cognitive development possible in the two-word stage of the acquisition of a natural human language? The results suggest that indeed, cognitive development can precede language development, as evidenced by the age-appropriate results of cognitive tests, drawing tasks, semantic relations used, and use of mental verbs – all with a low MLU.

The second goal was to further discussion of how a two-word stage differs in older, cognitively-age appropriate children with delayed first language acquisition. The later learners have a length limitation, a word category difference, and linguistic growth as measured by the change of the proportion of nouns and verbs, but they are older than typically developing children at this stage, and hence they attempt to express more cognitively complex utterances, as seen with their use of mental verbs and later appearing semantic relations. Again, it suggests that there is a specifically linguistic two-word stage that needs further explanation and exploration.

We presented four competing hypotheses to explain why there is a two-word stage in language development. These can now be reevaluated with the data from Mei, Cal, Jil, Sal, and Nat. Overall, our results provide evidence against Hypotheses A and B, repeated below.

A. Language and cognitive development are closely tied. With a delay in language development, cognitive development will also be delayed.

The results from the study of length limitation, word category difference, and linguistic growth as measured by the change of the proportion of nouns and verbs, show a delay for Mei and Cal, as compared to native signing, age peers. However, the cognitive indices do not show a similar delay. This would not have been hypothesized by Piaget (1980), nor likely would it be predicted by Casasola et al. (2006).

B. Early length limitations in children's productions are due to slowly developing cognitive abilities or specifically linguistic maturation. If language development begins when cognitive development is already more advanced, then language will develop without early length limitations.

Again, the results are clear in this regard. Mei and Cal show age appropriate development in their use of semantic relations and mental verbs, indicating more advanced cognitive development than younger, native signers. Tomasello (1992, 2003) or Radford (1990) would predict that Mei and Cal would skip or pass through a two-word stage quickly, but that is not what the results suggest.

Mei and Cal did not show a delay in cognitive development as would be predicted under Hypothesis A; nor did their language development quickly jump to a level commensurate with their cognitive level, as predicted under Hypothesis B. Thus, other explanations of the typical two-word stage need to be considered. Let us reconsider Hypothesis C, repeated below.

C. Grammatical development and vocabulary development are closely linked. Gains in grammatical development are associated with gains in vocabulary.

Bates and Goodman (1997), and Devescovi et al. (2005) argued that for young children, number of vocabulary items is more indicative of grammatical development than age. They show that both English-and Italian-speaking children in the two-word stage have a vocabulary of 51–100 words, as tested by the MacArthur CDI (Fenson et al., 2006), while children with more advanced sentence structures have vocabulary sizes of 101 (Italian) and 200 (English) to above 600 (both languages). If the two-word stage is necessarily related to a more limited total vocabulary, then we would expect Mei and Cal to show a similar vocabulary level to that of the younger Jil and Sal when they are producing utterances of a similar length.

However, our analysis found that Mei and Cal used a larger variety of words in their two-word utterances than did Jil and Sal, both in the narrow view of 50 utterances per session, as well as in the complete transcriptions of longer sessions. Since the number of word types used in a session of less than an hour is surely an underestimate of total vocabulary, we can be confident that Mei and Cal know more than 100 words. Despite this, their production is limited to an average of two words per utterance. This indicates that a greater vocabulary does not necessarily lead to longer utterances; or conversely, that a limitation to two-word utterances is not due solely to limitations in vocabulary.

How does Hypothesis D, repeated below, fare when our data are considered?

D. Early length limitations are due to specifically linguistic limitations, and are eased as language develops. Early length limitations will occur regardless of cognitive ability.

Hypothesis D attributes the two-word stage to development of specifically linguistic limitations. These could include general linguistic processing mechanisms that have been proposed (Pinker, 1984), as well as syntactic processing limitations (Boster, 1997).

Despite large differences in the details of the theories of Pinker, Boster and Avrutin, they all lead to the expectation that even older children with greater cognitive abilities will go through a two-word stage in the development of their native language. Hypothesis D seems to enjoy the greatest support from the findings of our study, but we recognize that further work is required to see if the theories, as they currently stand, can explain the data from this atypical language acquisition situation, with finer scrutiny or whether a new theory needs to be proposed.

Hypothesis D is intended for the two-word stage in children undergoing typical language development as well as for the special circumstances of the children in our study. However it has alternatively been suggested that linguistic processing may proceed in some ways differently for children with later language development in comparison to native language learners.

Emmorey et al. (1995), Mayberry and Eichen (1991), Mayberry and Locke (2003), Morford (2003), Newport (1990), and others have provided evidence that language processing may well be affected by a delay in linguistic input. For example, late first-language learners process language in different ways from native learners even after many years of regular language use. Moreover, early development seems to be needed for efficient phonological processing (see Emmorey, 2002), and less efficient processing seems to be a source of additional difficulties at higher levels (Morford & Mayberry, 2000). It is quite possible that such a delay in linguistic input affects the way that language processing develops, and this might play a role in explaining certain specific areas of language in which Mei and Cal showed continuing differences in comparison to native signers, such as verb agreement (see Berk, 2003, 2004).

While more detailed study of the later stages of language development in Mei and Cal (currently in progress) may help to contribute to the understanding of sensitive period effects on late first language acquisition, the present study clearly details the dissociation of cognitive and linguistic stage, as well as two distinct aspects of the singularly termed "two-word stage". While we would not claim that there is no delay in cognitive ability with a delay in language exposure, it certainly seems from the data we collected, that there is not necessarily a substantial delay. We are currently still working on the details of a linguistic processing mechanism that would predict the constraints on linguistic aspects of a two-word stage. However, our later-learners show that it is possible to have relatively normal cognitive ability, but delays in specific aspects of linguistic ability, within a robust stage of language development, the two-word stage.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.cogpsych.2012.02.002.

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