HIERARCHICAL STRUCTURE IN A SELF-CREATED COMMUNICATION SYSTEM: BUILDING NOMINAL CONSTITUENTS IN HOMESIGN

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Deaf children whose hearing losses are so severe that they cannot acquire spoken language and whose hearing parents have not exposed them to sign language nevertheless use gestures, called HOMESIGNS, to communicate. Homesigners have been shown to refer to entities by pointing at that entity (a demonstrative, *that*). They also use iconic gestures and category points that refer, not to a particular entity, but to its class (a noun, *bird*). We used longitudinal data from a homesigner called David to test the hypothesis that these different types of gestures are combined to form larger, multigesture nominal constituents (*that bird*). We verified this hypothesis by showing that David's multigesture combinations served the same semantic and syntactic functions as demonstrative gestures or noun gestures used on their own. In other words, the larger unit substituted for the smaller units and, in this way, functioned as a nominal constituent. Children are thus able to refer to entities using multigesture units that contain both nouns and demonstratives, even when they do not have a conventional language to provide a model for this type of hierarchical constituent structure.*

Keywords: deaf, homesign, multigesture units, nominal constituents, nouns and demonstratives, hierarchical structure

1. INTRODUCTION. Is constituent structure so essential to language that it will be reinvented by a child who is not exposed to input from a conventional language? Deaf children whose hearing losses prevent them from acquiring the spoken language that surrounds them, and whose hearing parents have not exposed them to sign language, provide a way to address this question. Although they cannot access the spoken linguistic input available to them, deaf children in these circumstances still communicate by creating a gesture system, called HOMESIGN. Homesign has many properties of natural language, including underlying predicate frames (Goldin-Meadow 2003a, 2005), structure at the word level (Goldin-Meadow et al. 1995, Goldin-Meadow et al. 2007) and sentence level (Goldin-Meadow 1982, Goldin-Meadow & Feldman 1977, Goldin-Meadow & Mylander 1998), recursion (Goldin-Meadow 1982), and a distinction between nouns and verbs (Goldin-Meadow et al. 1994). Here we explore whether a homesigner is able to incorporate hierarchical structure into his gesture system by producing a multigesture combination that refers to an entity and functions as a single unit—that is, whether a homesigner can build structure around the noun. In the following sections, we first discuss how spoken and signed languages build noun structures and how those structures are acquired. We then give an overview of homesign gesture systems that motivates the questions we address.

1.1. THE ACQUISITION OF PHRASES BUILT AROUND THE NOUN. Some words in a sentence have a closer relationship to each other than to the other words in the sentence. For example, in the sentence *The dog ran home*, *the* is more closely related to *dog* than to either *ran* or *home*. *The dog* forms a nominal constituent, which combines with *ran home*, a predicate constituent, under a single sentence node to form a hierarchical structure. Linguistic theories differ in approach, but they all attempt to explain the rules that gov-

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ern how words form constituents in sentences. Our focus here is on the constituent that includes the noun and how it is elaborated.

Our goal is to determine whether a child who lacks input from a conventional language will build phrases around the noun. The constituents in which nouns occur are sometimes labeled as noun phrases (NPs) and sometimes as determiner phrases (DPs). A DP consists of a determiner as the functional head, which may be omitted in some cases, and an NP, which has a noun as its head. The noun conveys the category, and the determiner singles out and specifies the particular member of the category, often contrasting one member of the category with another (Lyons 1991:161). Determiners include articles (e.g. *the*, *a*), demonstratives (e.g. *this*, *that*), quantifiers (e.g. *two, some*), and possessive pronouns (e.g. *my*, *his*). Not all languages have articles, but all languages (both spoken (Dryer 2005) and signed (Neidle et al. 2000, Zimmer & Patschke 1990)) appear to have demonstratives (produced either as lexical items or affixes), as well as quantifiers and possessive pronouns (Valian 2009). Demonstratives either indicate location relative to the speaker, or draw the hearer's attention to something in the physical environment. In addition to modifying nouns in a DP, demonstratives can also be used alone as pronominals (Dryer 2005).

Whether all languages have DPs (with determiner as head and NP as complement, as proposed by Abney (1987), to allow nouns to project functional structure as verbs are assumed to do (Chomsky 1986)), or whether some languages have only NPs (Bošković 2004, 2008) is disputed in the literature on both spoken and signed languages (Bahan et al. 1995, Bernath 2009; see review in Snyder 2007). Because it is unlikely that we will have sufficient evidence to determine whether the phrases we identify constitute DPs or NPs in homesign (but see §3), we take a neutral approach to the noun units found in homesign and call them 'nominal constituents'.

Initially, children produce nouns on their own without any dependents: bare nouns (Valian 1986). The omission of elements other than nouns early in development may not be surprising given that additional specifiers are often unnecessary when referring to the here and now, as children typically do. Although bare nouns constitute phrases in adults, who produce nouns not only on their own but also with their dependents when obligatory, it is not at all clear that a bare noun ought to be considered a phrase in a child who has not yet combined a noun with its dependents. When do children give us evidence that phrases built around nouns are part of their language?

Valian (1986) observed six children learning English beginning at age two years, and found that, by this age, all six of the children were producing determiners along with their nouns. Moreover, the children (correctly) used determiners with nouns but not with pronouns, suggesting that they understood the distinction between the two categories. The best evidence, however, that children have phrases built around nouns in their language comes when they produce a noun with its dependents in the same contexts that they produce a pronoun on its own, in other words, when one form can substitute for the other (e.g. using *the big boxes* in the same contexts as *them*). Using this substitution criterion, Valian (1986) found that the six children in her study demonstrated productive use of phrases containing nouns by 2;6 (years;months), around the time that they produced sentences containing three to four words. The children produced these phrases in preverb, postverb, and postpreposition positions, that is, in the same positions that they produced bare nouns.

Why do children begin to produce phrases containing nouns? They may be responding to the communicative need for specificity, particularly as they begin to communicate about objects that are not in the here and now. Alternatively, children may first

introduce articles and demonstratives in response to their own needs rather than the communicative needs of others; in other words, they may be organizing linguistic information to make it meaningful and tangible for themselves (Karmiloff-Smith 1979). And, of course, children are exposed to models of elaborate ways of making reference in the talk that they hear (or see, in the case of sign language) and thus may be responding to their input.

The question we ask here is: what would happen if a child were not exposed to a usable model of a conventional language? Would such a child create phrases containing nouns even without exposure to a model for elaborated phrases of this sort? If so, the presence of phrases built around nouns and embedded in a larger sentence would provide evidence of hierarchical structure—the noun with its dependents (the nominal constituent, in our terms) occupies the same slots as the bare noun and thus is a phrase embedded within a larger structure. Homesign offers a way to address these questions and explore more precisely the role that a language model plays in acquiring hierarchical structure. For example, Perfors, Tenenbaum, and Regier (2011) argue that an ideal learner can recognize the hierarchical phrase structure of language given typical child-directed speech and a set of innate domain-general capacities—in other words, without having the knowledge innately specified as part of a domain-specific language faculty. Homesigners are not exposed to typical child-directed speech. If we find that a homesigner is able to produce sentences containing nominal constituents, it will then be necessary to go back to the Perfors et al. 2011 model to determine whether the minimal input that the homesigner does receive is sufficient (along with the domain-general learning mechanisms Perfors and colleagues posit) to permit the acquisition of hierarchical structure, or whether it will be necessary to add innate structure, perhaps structure that is specific to language learning, to the model.

1.2. HOMESIGN. Hearing children born to hearing parents acquire the spoken language to which they are exposed with little difficulty. Similarly, deaf children born to Deaf parents acquire the sign language to which they are exposed and follow the same developmental trajectory as hearing children learning spoken language (Lillo-Martin 1991, Meier & Newport 1990). However, only 5 to 10% (Hoffmeister & Wilbur 1980) of deaf children are born to Deaf parents. The rest are born to hearing parents, who naturally expose their deaf children to their native spoken language. Although some hearing parents send their deaf children to schools that teach a manual language, such as American Sign Language (ASL) or Manually Coded English (MCE), others prefer the oral method. The oral method of education attempts to teach deaf children spoken language by increasing their sensitivity to sound and teaching them to read lips. Unfortunately, even with rigorous training in the oral method, children with severe to profound hearing losses have great difficulty acquiring spoken language, and are typically quite delayed compared to hearing children learning spoken language and deaf children learning sign language (Lou 1988).

Deaf children in these circumstances do communicate, however, and use gesture to do so. These gestures, called homesign, have many properties of natural language (Goldin-Meadow 2003a), despite the fact that the gestures that serve as input to homesign do not; that is, the gestures that the deaf children's hearing parents produce when they talk to their children are not language-like in form (Goldin-Meadow & Mylander 1983, 1998, Goldin-Meadow et al. 1996, Singleton et al. 1993). We ask here whether a homesigner can add specificity and hierarchical structure to his gesture system in the form of nominal constituents. In other words, are nominal constituents so essential to communication that they will arise even in a language invented de novo by a child?

We address this question by examining the gestures produced by one homesigner whom we call David. We have chosen to focus on this particular child because David's homesigns have been extensively studied and shown to display many properties found in natural languages. For example, David's homesigns have morphologic (Goldin-Meadow et al. 1995, 2007) and syntactic (Feldman et al. 1978, Goldin-Meadow & Feldman 1977, Goldin-Meadow & Mylander 1984) structure, the grammatical categories noun, verb, and adjective (Goldin-Meadow et al. 1994), and nouns that function as generics (Goldin-Meadow et al. 2005). We are thus searching for nominal constituents within a gesture system known to have particular linguistic properties, and can therefore situate our findings within that system—for example, we can examine which linguistic properties are in place before David begins to produce nominal constituents.

David's homesigns also allow the combination of more than one proposition within the bounds of a single sentence. Importantly, the two propositions within these complex sentences are not merely concatenated linearly but are subordinate to a higher sentence node; in other words, the system has hierarchical structure (Goldin-Meadow 1982, 2005). Here we ask whether, in addition to building structure around the verb (by adding propositions and predicates; Goldin-Meadow 1982) and the sentence (by adding negation and question markers; Franklin et al. 2011a,b), David also builds structure around the noun. More specifically, we ask whether David uses multigesture phrases (in addition to single gestures) to refer to an entity. Anecdotal observation has suggested that David does, at times, use more than one gesture to refer to a single entity. These gestures have the potential to serve as a nominal constituent in David's system. The purpose of this article is to determine whether these multigesture noun combinations fulfill this potential.

1.3. STRUCTURE OF THE ARTICLE. We begin by describing in detail the coding system we used to characterize the gestures David produces. We then describe the multigesture combinations David uses to refer to entities, his potential nominal constituents. These combinations contain primarily demonstratives and nouns, although there is evidence for other types of structures within the nominal constituent as well. Demonstratives in David's systems are pointing gestures that indicate physically present entities. These gestures direct attention toward something in the immediate environment and thus meet criteria used to identify demonstratives in natural languages (Dryer 2005).

Next, we test whether the multigesture combinations David produces to refer to an entity function like nominal constituents in his homesign system. We ask whether the gestures within a nominal constituent are contiguous; whether the number of gestures within a nominal constituent has an impact on sentence length; whether nominal constituents have the same privileges of occurrence as single demonstratives and single nouns, both in terms of semantic function and syntactic position; and whether the demonstrative and noun gestures within a nominal-constituent PHRASE (e.g. *that bird*) follow the same word-ordering pattern as demonstrative and noun gestures within a predicate-nominal SENTENCE (e.g. *that's a bird*).

We then search for the roots of David's nominal constituents in his environment. Children acquiring a native language from their parents use the adult language they receive as input to the language they are developing. A profoundly deaf child cannot access the spoken input that his hearing parents produce. Hearing individuals typically gesture when they speak (McNeill 1992), however, and David's mother was no exception (e.g. Goldin-Meadow & Mylander 1984). To examine the impact that the gestures David saw in his environment had on his nominal constituents, we apply the same coding scheme to the gestures David's mother spontaneously produced when she communicated with him. To anticipate our results, we find that, although David's mother did

produce gestures that refer to entities, she never combined those gestures into phrases comparable to the nominal constituents that David produced. Finding no evidence that David sees others produce gestural models for his nominal constituents, we then ask whether David's nominal constituents might be a product of the communication pressure his interlocutors exert. Nominal constituents (e.g. *that bird*) provide more information about a referent than either a single demonstrative (*that*) or noun (*bird*). It is possible that David produces his more elaborated nominal constituents in response to his communication partner's querying looks or requests for additional information, so we explore this possibility.

We end by considering the implications of our findings for the acquisition of two central aspects of language—hierarchical structure and functional categories.

2. METHODS.

2.1. PARTICIPANT. The child in our study is an American homesigner, David. He has a profound hearing loss (≥ 90 decibels) in both ears and was educated in the oral method. At the time of our observations, David had made little progress in acquiring English, occasionally producing single words but never combining those words into sentences. In addition, David had not yet been exposed to a conventional sign language. We verified his lack of exposure to sign by asking a native signer to review the videotapes. She confirmed that David did not use any of the most common ASL signs that young children know. Moreover, when the experimenters informally showed him these signs, he showed no indication that he recognized them.

David was videotaped in his home during interactions with his family members and the experimenters every two or three months between the ages of 2;10 and 5;02. A total of eleven sessions were analyzed. Each session typically lasted about two hours. The experimenters brought to each session the same set of books, toys, and puzzles to elicit communication. Coders who had not been present at the session had access to the toys, books, and puzzles in the lab and could use them to contextualize the child's gestures. In addition, when the experimenters were uncertain about the meaning of David's gesture, they asked his parents to clarify; those conversations were part of the videorecording and thus accessible to the coders.

2.2. CODING GESTURES. Our first step is to isolate gestures from the stream of motor behavior. We used two criteria to identify a gesture: the hand or body movement had to be communicative in intent (i.e. produced when the child had another's attention), but could not be a functional act on an object or person. For example, reaching to pick up a toy communicates the child's desire for a toy, but it does so by directly acting on the world and thus was not considered a gesture. In contrast, an open palm held out flat (a GIVE gesture), produced while making eye contact with the person holding the toy, communicates a request for the toy indirectly and so was considered a gesture.

Once isolated, gestures were coded along the three dimensions used to describe signs in conventional sign language: shape of the hand, location of the hand with respect to the body, and movement of the hand. A change in any one of these dimensions during the stroke of the gesture was taken to signal the end of one gesture and the beginning of another. Motoric criteria were also used to determine the end of a string of gestures and thus sentence boundaries. Two gestures were considered separate sentences if the child paused or relaxed his hands between the gestures. Gestures that were not separated by pause or relaxation of the hands were considered part of the same sentence.

Reliability was determined by having two independent coders transcribe the videotapes. Agreement between coders was 91% for isolating gestures from the stream of

motor behavior, 93% for determining boundaries between signs, and 95% for determining boundaries between sentences (Goldin-Meadow & Mylander 1984). Disagreements between coders were resolved by discussion.

Homesigners produce three different types of gestures: deictic or pointing gestures, iconic gestures, and markers. Markers are typically conventional gestures used to modulate the meanings of other gestures (Franklin et al. 2011a,b): for example, flipping the palms from palm-down to palm-up to question, shaking the head from side to side to negate. As they are not used to refer to entities, markers are not included in the current analyses.

David produced two types of pointing gestures. The first, which is the more frequent of the two, makes reference by literally 'pointing out' the object to which it refers (e.g. pointing at a dog in the room to refer to that dog). The pointing gesture is versatile because it can be used to refer to any present entity, and homesigners use their pointing gestures to refer to the full range of entities that young hearing children refer to with their words, for example, people, inanimate objects, body parts, and places (Feldman et al. 1978). This type of pointing gesture functions like a demonstrative (*this*, *that*), pointing out a particular object but not categorizing it. For example, David produced a pointing gesture at a toy drum followed by a GIVE gesture to request that a particular drum be given to him, *give that (to me)*.

The second type of pointing gesture, which we call a category point, does not refer to the particular object it indicates, but rather to an object of the same type (Butcher et al. 1991). For example, David pointed at an empty bubble jar that was present in the room in order to request a full bubble jar that was in the next room. Although these gestures are points, they appear to function more like nouns than demonstratives because they specify the category to which the object belongs (in this case, the category of *bubble jars*) rather than the particular object (*that jar*). These category points were present in David's repertoire at age 2;10, the earliest session.

Iconic gestures represent an aspect of an object or action through pantomime. For example, David moves two fists as though beating a drum, which is glossed as BEAT if the gesture is functioning as a verb, and as DRUM if the gesture is functioning as a noun (Goldin-Meadow et al. 1994). Note that noun iconic gestures (like category points), when used on their own, do not specify which particular object is under discussion. In this article, we focus on iconic gestures that are functioning as nouns (i.e. that represent objects and serve as the argument in a sentence).

Table 1 presents a tally of all of the pointing and iconic gestures that David produced during our observation sessions, categorized according to type. Nominal gestures (columns A, B, and C) are the focus of our analyses (see §2.3). However, we also include iconic gestures that function as verbs and adjectives (i.e. that represent actions and attributes and serve as predicates in a sentence) in §7 when we examine the syntactic role of the nominal constituents that are the focus of our analysis; these gestures are tallied in column E. In addition, in §8, we include iconic gestures that are nouns but function in a sentence as predicates, that is, predicate nominals (e.g. *bird* in *that's a bird*); these gestures are tallied in column D.

Agreement between coders was 93% for assigning meanings to pointing and iconic gestures (Goldin-Meadow & Mylander 1984) and 94% for deciding whether an iconic gesture served as a noun, verb, or adjective (Goldin-Meadow et al. 1994).

2.3. CODING NOMINALS. David uses two types of gestures to refer to entities: (i) gestures that make reference by indicating a particular entity—demonstrative pointing gestures (e.g. point at a bird used to refer to that particular bird, *that*); and (ii) gestures that

	NOMINALS			PREDICATES	
DAVID'S AGE	SINGLE GESTURES REFERRING TO AN ENTITY		MULTIGESTURE COMBINATIONS REFERRING TO AN ENTITY	NOMINAL PREDICATES	VERBAL PREDICATES (VERBS & ADJECTIVES)
	indicating a particular entity (demonstrative)	indicating the entity's class (noun)			
	A	**B**	**C**	**D**	**E**
2;10	162	3	0	1	73
2;11	178	5	1	4	74
3;00	87	5	0	12	30
3;03	239	10	1	3	65
3;05	497	34	13	41	236
3;08	539	21	5	65	127
3;10	600	41	12	77	232
3;11	313	49	39	84	106
4;06	801	57	28	109	180
4;10	204	25	7	51	123
5;02	346	52	20	44	284
TOTAL	3,966	302	126	491	1,530

TABLE 1. All of the gestures David produced during the observation sessions, categorized according to whether they served a nominal (A, B, C) or predicate (D, E) function. Nominals are divided into single gestures referring to a single entity (A, B) and multigesture combinations referring to a single entity (C). Gestures in column C are those hypothesized to function as nominal constituents in David's homesign system.

make reference by indicating the class of an entity—category pointing gestures (e.g. point at a bird used to refer to some other bird, thereby indicating the referent's class, *bird*), and iconic noun gestures (e.g. flapping hands at the shoulders, which highlights an attribute of the referent's class, *bird*). We ask whether David builds nominal constituents out of these two gesture types.

We pulled out all of the gestures that David used to refer to objects, people, and locations; these gestures are tallied in columns A, B, and C in Table 1. Column A lists the number of times David used a demonstrative pointing gesture on its own to refer to an entity; see example 1a. In established sign languages, points can serve as locatives (Emmorey 2002) as well as demonstratives (Zimmer & Patschke 1990); there were, however, relatively few pointing gestures referring to locations in this data set, and these few instances are included as nominals in Table 1.[1] Column B lists the number of times David used either a category pointing gesture on its own (see example 1b) or an iconic noun gesture on its own (see example 1c) to refer to an entity; 192 of the 302 single gestures referring to an entity by way of its class were iconic gestures, while 110 were category points.

The following conventions are used in these examples and throughout the article (see also the appendix). The first line of each example describes the gestures that David produced. Demonstrative pointing gestures are displayed in lowercase letters in this line (e.g. 'point at bubbles' in 1a); noun iconic gestures are displayed in capital letters (e.g. 'LOLLIPOP' in 1b), as are predicates (e.g. 'GIVE' in 1a and 1b and 'STEER' in 1c);

[1] A point at an object that is present in the room indicates the object (*that*) and implicitly also indicates its location (*there*). We coded a point as denoting a location only when the object under discussion was not in that location—for example, a point at a person's wrist used to indicate that his watch (which was not currently on his wrist) belonged there. As noted in the text, the few pointing gestures that referred to locations (i.e. that could be interpreted as *there*) are included as nominals in Table 1.

noun category point gestures are displayed in italicized lowercase letters (e.g. '*point at toy bus steering wheel*' in 1c). Nominal constituents are enclosed in square brackets in line 1 and also in line 2. The second line provides a gesture-by-gesture translation of the sentence, including a gloss of each demonstrative ('that' in example 1a), iconic noun ('lollipop' in example 1b), and category noun ('bus' in example 1c). The third line in each example is an English gloss of the gestures. The semantic roles that were not explicitly produced but were inferred from context are displayed in parentheses in the third line (see Goldin-Meadow 2003a, 2005:205–8 for evidence that justifies including the semantic elements enclosed in our representations of David's sentences), for example, '(you)' and '(me)' in example 1a. The age at which David produced the example (in years and months) follows each example.

(1) a. point at bubbles GIVE
that give
'(You) give (me) that.' (2;10)

b. LOLLIPOP GIVE
lollipop give
'(You) give (me) lollipop.' (3;05)

c. *point at toy bus steering wheel* STEER
bus steer
'(Grandfather) steers bus.' (2;11)

We found that David not only used single gestures to refer to entities, but he also used combinations of gestures to refer to the same entity (i.e. combinations of demonstrative points, category points, and iconic nouns). We hypothesize that these multigesture combinations are serving as nominal constituents in David's homesign system. We used the following criteria to isolate multigesture combinations that had the potential to be nominal constituents: (i) the gestures must refer to the same entity, (ii) the gestures must be within the same sentence, (iii) the gestures must be contiguous, (iv) the gestures must be of two different types (e.g. we did not count two pointing gestures at the same dog to be a potential nominal constituent, even if they occurred in the same sentence and were adjacent), and (v) the gestures must serve the same semantic role. This last criterion rules out predicate-nominal sentences. For example, when David points at a picture of a bird and then produces the noun gesture BIRD, he is often using the combination to identify the picture as a bird. In this case, the noun gesture is functioning as a predicate rather than as part of a nominal constituent (as we are using the term), and the combination is thus a predicate-nominal sentence. These combinations function like sentences (e.g. *that's a bird*) rather than phrases (e.g. [*that bird*] *pedals a bike*, where *that bird* is a phrase functioning as the subject of the sentence). Predicate-nominal sentences are therefore not included in column C in Table 1, but are tallied instead in column D and are used as a comparative base in the word-order analyses presented in §8. All 126 of the multigesture combinations listed in column C in Table 1 meet these five criteria. Reliability between coders for isolating potential nominal constituents ranged between 92 and 96%.

2.4. CODING GESTURE SENTENCES FOR PROPOSITIONS AND SEMANTIC ELEMENTS. In addition to assigning meanings to individual gestures, we also assigned propositional meanings to gesture sentences and their semantic elements. We considered both the form of the gestures and the context in which the gestures were produced when assigning meanings to sentences (Goldin-Meadow & Mylander 1984). David produced four types of action propositions: transitive acts with a recipient or endpoint (*I put jar on table*), tran-

sitive acts without a recipient (*I open jar*), intransitive acts with a recipient or endpoint (*I go to table*), and intransitive acts without a recipient (*I dance*). He also produced six types of attribute propositions: predicate nominals (*this is a jar*), descriptor relations (*jar is big*), location relations (*jar belongs on shelf*), possessive relations (*jar belongs to me*), similarity relations (*jar 1 resembles jar 2*), and picture identification relations (*picture of jar resembles jar*). Picture identification relations are a type of similarity relation, but unlike similarity relations where there is no way to tell if one entity should be privileged, we can distinguish between the entity and picture; it is therefore possible to analyze picture identification relations for word order (see §7). Each gesture in a sentence was coded according to the semantic role it played in the proposition.

Table 2 presents examples of the gesture sentences David produced, classified according to type of proposition. Gestures that were omitted from the sentence but inferred from context are indicated in parentheses in the gloss column of the table (see Goldin-Meadow 2003a, 2005:205–8 for evidence that these elements are, in fact, part of the predicate structures underlying David's sentences). Agreement between coders was 94% for classifying sentences according to proposition type, and 97% for classifying individual gestures according to semantic role (Goldin-Meadow & Mylander 1984).

TYPE OF PROPOSITION	EXAMPLE (AGE)	SEMANTIC ELEMENTS EXPLICITLY GESTURED[a]	GLOSS[b]
ACTION RELATIONS			
Transitive act with recipient	Bubbles—sister (3;10)	patient—recipient	'(I/David) (give) bubbles (to) sister.'
Transitive act without recipient	Point at playdoh—TURN OVER (3;03)	patient—act	'(You/sister) turn over playdoh can.'
Intransitive act with recipient	Cattle ramp—GO UP (3;05)	recipient—act	'(Cow) goes up cattle ramp.'
Intransitive act without recipient	Point at clown—DANCE (5;02)	intransitive actor—act	'Clown dances.'
ATTRIBUTE RELATIONS			
Nominal predicate	Point at keys—KEY (3;08)	entity—category	'Those (are) keys.'
Descriptor/adjective relation	Point at plane—BROKEN (3;05)	entity—descriptor	'Plane (is) broken.'
Location relation	Point at crown—point at head (2;11)	entity—location	'Crown (belongs on) head.'
Possessive relation	Point at playdoh—point at self (3;03)	entity—possessor	'Playdoh (belongs to) me/David.'
Similarity relation	Point at elephant trunk—point at own nose (2;11)	entity 1—entity 2	'Elephant trunk (is like) my nose.'
Picture identification relation	Point at soldier hat picture—point at soldier hat (3;10)	entity—picture	'Soldier hat picture (is like) soldier hat.'

TABLE 2. Examples and glosses of the different types of propositions David frequently produced in his homesigns, classified according to the semantic elements explicitly gestured.

[a] Acts, categories, and descriptors are predicates rather than arguments and are therefore not included in the NP analyses. Predicate-nominal sentences are discussed in §8, where they are compared to NPs with respect to gesture order.

[b] Although we consider pointing gestures to be demonstratives in David's homesign system, we gloss them using the name of the object to which they refer (e.g. *bubbles*) rather than *this* or *that* in this table to make the gloss of the sentence more transparent.

Table 3 presents a tally of the gestures that David produced during our observation sessions, categorized according to sentence propositions. Each proposition that David conveyed in a sentence is given a separate entry in the table. As is common for young children in the early stages of language acquisition, David's sentences were short. Many include only a single gesture, conveying either one argument (column A) or one predicate (column B). David also produced multigesture sentences, however, tallied in columns C, D, and E. Nominal constituents are counted as single arguments in Table 3 and appear in all columns except for B (predicates alone).

DAVID'S AGE	ARGUMENT ALONE	PREDICATE ALONE	TWO OR MORE ARGUMENTS	ARGUMENT AND PREDICATE	TWO OR MORE ARGUMENTS AND PREDICATE
	A	B	C	D	E
2;10	108	45	10	23	3
2;11	88	39	23	33	4
3;00	63	33	3	6	0
3;03	129	44	40	15	2
3;05	209	141	56	120	10
3;08	210	76	84	88	13
3;10	285	151	60	116	21
3;11	245	115	24	59	5
4;06	313	99	144	151	15
4;10	81	85	27	65	12
5;02	185	195	42	100	14
TOTAL	1,916	1,023	513	776	99

TABLE 3. All of the gesture sentences David produced during the observation sessions, categorized according to the syntactic roles explicitly produced in the sentence propositions: single arguments (A), single predicates (B), or combinations of arguments and predicates (C, D, E). Each nominal constituent was classified as an argument: David produced nominal constituents as arguments alone (A), and in sentences containing two or more arguments (C), an argument and a predicate (D), and two or more arguments and a predicate (E).

3. NOMINAL CONSTITUENTS. Note in column C of Table 1 that David did not consistently produce multigesture combinations referring to the same entity (i.e. potential nominal constituents) until age 3;05, despite the fact that he did produce a number of sentences containing arguments and predicates at his first observation session at age 2;10 (see Table 3, columns C, D, and E). Combining gestures to refer to a single entity thus appears to be a relatively late accomplishment for David.

Most of the potential nominal constituents David produced contained a demonstrative pointing gesture and a noun iconic gesture, as shown in example 2a ($N = 79$). The iconic gesture indicates the category of the referent, *penny*, and the demonstrative point indicates the particular penny David wants, *that*. In this, and in all subsequent examples, the two components of the nominal constituent are enclosed in square brackets in both the gesture description in line 1 (e.g. [PENNY point at penny] in example 2a) and the gesture-by-gesture translation in line 2 ([penny that]). David also produced combinations containing a demonstrative point and a category point ($N = 22$), as shown in example 2b. The point at his own pennies, which he has and therefore cannot be requesting, serves to identify the type of object David wants, a category point indicating 'pennies' (the object indicated by the point is displayed in italicized lowercase letters in line 1, that is, *point at child's pennies*, and the intended category is labeled in line 2, pennies). The demonstrative point at the experimenter's pennies indicates the particular pennies he wants, 'those'. These two types of combinations seem to be functioning like

nominal constituents in David's homesign system, with the demonstrative pointing gesture serving as the determiner and the category pointing gesture or the iconic gesture serving as the noun.

(2) a. [PENNY point at penny] point at self
[penny that] me
'(You) (give) me that penny.' (3;11)

b. [point at experimenter's pennies *point at child's pennies*] point at self
[those pennies] me
'(You) (give) me those pennies.' (3;10)

At times, David used the demonstrative pointing gesture to modify an adjective standing in for a noun ($N = 6$). In example 3a, David produces a demonstrative point at a hand puzzle piece, *that*, and then produces a quantifier, *two*, to request that the experimenter give him two hand puzzle pieces; the quantifier is standing in for the noun, *hand piece*. Similarly, in example 3b, David produces a demonstrative point at a picture of a car, *that*, and then produces an adjective, *broken*, to comment on the fact that the broken car is being towed; the adjective is standing in for the noun, *car*. It is not grammatical in English to omit the noun in this context, but the error does occasionally occur (Valian 1986). Moreover, languages such as Spanish do allow the noun to be omitted and the adjective to stand in its place. Waxman and her colleagues (1997) have shown that children acquiring Spanish assume that adjectives function like nouns in that they have categorical properties that can be used to label and identify novel objects. David appears to be making the same assumption.

(3) a. [point at hand piece TWO] GIVE
[that two] give
'(You) give (me) two (of) that.' (5;02)

b. [point at car BROKEN] TOW point at car
[that broken] tow that
'(Truck) tows that broken (X).' (3;10)

Although most of David's pointing gestures served as demonstratives, David did use pointing gestures to fill other functions served by determiners, such as possessive pronouns ($N = 7$). In 4a, David points at a picture of trains, a category point indicating *trains* (a noun), points at himself (a possessive modifying the noun), and then points downstairs to say 'my trains are there'.

(4) [*point at train picture* point at self] point downstairs
[trains my] there
'My trains (are) there.' (4;06)

David also produced nominal constituents that do not contain a demonstrative. For example, he produces a number of combinations containing a category pointing gesture and a noun iconic gesture (i.e. two nouns) referring to the same entity, one modifying the other, and no demonstrative ($N = 21$), as shown in example 5a. David wants the soldier toy with the cymbals; he points at the soldier toy with the drum, a category point, to convey the class of the object he wants, *soldier*, and then further specifies the object with an iconic gesture, *cymbal*. Similarly, David produces a few combinations ($N = 17$) containing an adjective and a noun, again with no demonstrative. In example 5b, David produces a point at the straight track piece, a category point indicating the class, *track piece*, which he modifies with the adjective, *round*, to ask the experimenter to give him the round track piece.

(5) a. [*point at drum soldier* CYMBAL] flip *point at drum soldier*
[soldier cymbal] where soldier
'Where (is) cymbal soldier?' (3;11)

b. [ROUND *point at straight track piece*] MOVE
[round track piece] move
'(You) move round track piece (here).' (3;05)

Combinations exemplified in 5 seem to be functioning like nominal constituents (and could perhaps be considered determiner phrases with a null determiner). Support for this possibility comes from the fact that David did produce two sentences containing a modifier and a noun that DID contain a determiner: one with a demonstrative point combined with an iconic gesture modifying a category point, *give me* [*that hand-like hand*], in example 6a; and one with a possessive point combined with an iconic gesture modifying a category point, [*my long paddle*] *is downstairs*, in example 6b.

(6) a. [HAND-LIKE *point at hand tab* HAND-LIKE point at hand piece]
[hand-like hand hand-like that]
GIVE
give
'(You) give (me) that hand-like hand.' (5;02)

b. [point at self *point at paddle in room* LONG] point downstairs
[my paddle long] there
'My long paddle is there.' (3;10)

David also produced two sentences that contained a demonstrative point, a possessive point, and a noun. The first of these sentences, example 7a, is best analyzed as a nominal constituent containing a relative clause. David produces a possessive point at the cowboy (*his*), an iconic noun (*straw*), and a demonstrative point at the straw (*that*), in order to request *that straw which is his*. A relative clause is the best gloss for these gestures in English, although there are languages that allow both determiners and possessives to modify a noun, in which case 7a could be glossed as *that his straw*. In the second sentence, example 7b, David produces an iconic noun serving as a possessor (*cowboy's*), a demonstrative point at the cowboy (*that*), and a point at his own head (a category point for the noun, *hat*), to request *a hat which is that cowboy's* (i.e. *that cowboy's hat*—the demonstrative forms a nominal constituent with *cowboy*, and that phrase modifies *hat*). These sentences illustrate the complexity of the nominal constituents that David is able to build.

(7) a. [point at cowboy [STRAW point at straw]] GIVE
[his [straw that]] give
'(You) give (me) that straw (which is) his.' (3;11)

b. [[COWBOY point at cowboy] *point at head*]
[[cowboy that] hat]
'(You) (give) (me) that cowboy's hat.' (3;11)

We have found that David does indeed use multiple, contiguous gestures within the same sentence to refer to a single entity. We now ask whether these combinations function as a single unit and approach this question in several ways. We show that the contiguity criterion used to identify nominal constituents as a unit is valid (§4); that nominal constituents function as a unit with respect to sentence length (§5); that nominal constituents occur in the same semantic (§6) and syntactic (§7) environments as single gestures referring to entities, and can thus substitute for the smaller unit; and that the

ordering pattern within nominal constituents ([*that bird*] *pedals*) is distinct from the ordering pattern that characterizes predicate-nominal sentences (*that's a bird*), adding weight to the hypothesis that nominal constituents are a distinct unit (§8).

4. MUST THE GESTURES IN A NOMINAL CONSTITUENT BE CONTIGUOUS? One of the criteria we used to identify nominal constituents (see §2.3) is that gestures within the constituent must be contiguous and not interrupted by other gestures. Are we justified in using this criterion? Recall that the other criteria for a nominal constituent were that the gestures had to (i) refer to the same entity, (ii) occur within the same sentence, (iii) serve the same semantic role, and (iv) not be repetitions of one another. We reviewed all single demonstrative and noun gestures David produced (columns A and B in Table 1) and pulled out sentences containing gestures that met these four criteria but not the fifth—that is, they were NOT contiguous. We found only nine sentences of this type, compared to 126 sentences that met all five criteria, including contiguity. Thus, 93% (126 out of 135) of the multigesture combinations that met our four criteria for a nominal constituent also met the fifth, contiguity, criterion. Example 8a illustrates a sentence meeting all five criteria for noun constituency, including contiguity ($N = 126$); example 8b illustrates one of the rare sentences meeting all of the criteria except contiguity ($N = 9$); the relevant gestures are bolded in the examples.

(8) a. [**PENNY** **point at penny**] point at self/David
[penny that] me
'(You) (give) that penny (to) me.' (3;11)

b. **point at crown** point at head **CROWN**
that there crown
'(You) (put) [that crown] there.' (2;11)

To determine whether contiguity was a hallmark of nominal constituents, we examined sentences containing repetitions (which we do not consider nominal constituents because they do not contain two different types of gestures). David repeated a gesture for an entity within the same sentence 412 times. Most of these sentences contained two identical pointing gestures ($N = 393$), but a few contained two identical noun iconic gestures ($N = 12$) or two identical category point gestures ($N = 7$). Repeated gestures were contiguous in only 27% (113/412) of these sentences, compared to 93% contiguity for the multigestures referring to the same entity in a nominal constituent, $\chi^2(1) = 179.3$, $p < 0.001$. Example 9a illustrates a sentence in which the two repeated gestures are contiguous ($N = 133$); example 9b illustrates the more common pattern in which the two repeated gestures in a sentence are not contiguous ($N = 299$).

(9) a. **point at gumball machine** **point at gumball machine**
that that
point at experimenter
you
'You (fix) that.' (3;10)

b. **point at puzzle bag** point at puzzle board **point at puzzle bag**
that there that
'(You) (move) that (to) there.' (3;08)

Repetition is frequently found in sign languages, even in adult signers, typically serving to add emphasis to the sentence (Kyle et al. 1985, Lillo-Martin & de Quadros 2008). Signers tend to use the repeated forms to bracket other gestures, as David often did in his noncontiguous repetitions (i.e. example 9b). Whether bracketing forms are used as systematically in David's homesign system as they are in conventional sign languages is a question for future research. The point we stress here is that the contiguity of the

multigesture combinations in nominal constituents is not a general feature of David's system, but is instead a characteristic of this particular construction.

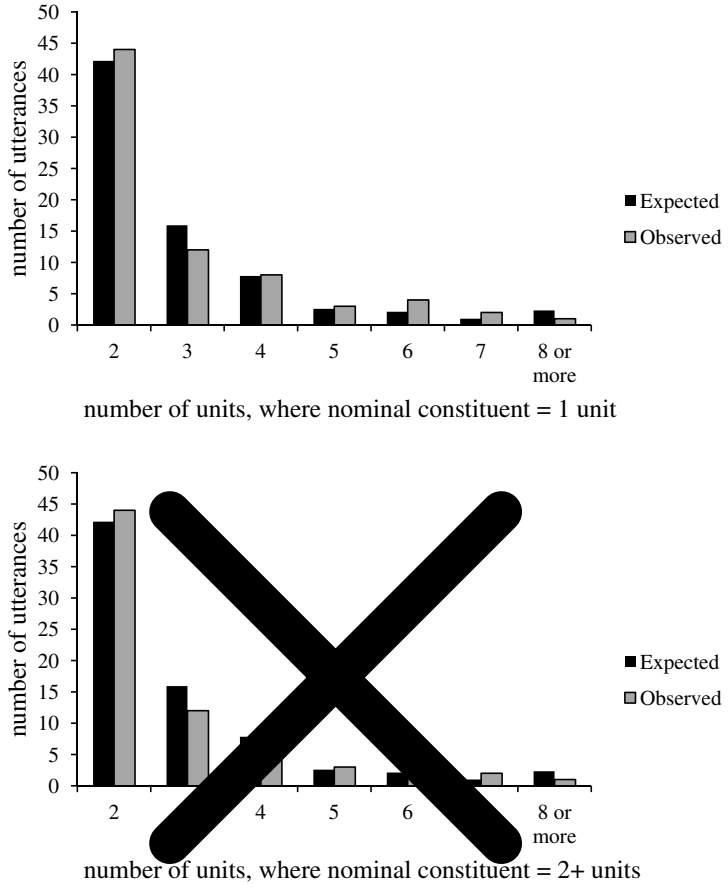
5. THE EFFECT OF NOMINAL CONSTITUENTS ON SENTENCE LENGTH. If the gestures within the nominal constituents we have identified function as a unit, we expect them to behave as a psychological 'chunk' and thus require less effort to process than when they are NOT part of a nominal constituent. This chunking, in turn, has implications for sentence length. Take, for example, the gesture sentence David produced to describe a picture of a bird pedaling a bicycle. He produced a demonstrative point at the bird specifying the particular entity (*that*), an iconic flapping noun gesture identifying the class of the entity (*bird*), and an iconic pedaling verb gesture indicating what the bird was doing in the picture (*pedaling*). If the demonstrative point and noun do NOT form a constituent, each gesture should be considered separately and the sentence should be counted as three units: (i) the demonstrative *that*, (ii) the noun *bird*, and (iii) the verb *pedal*. If, however, the demonstrative point and noun function as a constituent and form a single chunk, the two gestures could contribute only one unit toward sentence length; the sentence should then be counted as two units: (i) the nominal constituent *that bird*, and (ii) the verbal predicate *pedal*.

We can test whether the gestures in a nominal constituent are, as we hypothesize, a unit. We compare David's sentences that, by hypothesis, contain nominal constituents to the rest of his multigesture sentences that do not contain nominal constituents. We use the non-nominal-constituent sentences to determine the distribution of sentence lengths in David's homesign system. We then ask whether David's nominal-constituent sentences fit this distribution better if the nominal constituent is analyzed as a single unit or as individual gestures. The data for this analysis come from columns C, D, and E in Table 3.

We first examined all of David's multigesture sentences, excluding those that contain a nominal constituent, and on the basis of these non-nominal-constituent sentences, calculated how often David produced sentences with two gestures, three gestures, four gestures, and so forth. We found that 0.57 of David's multigesture sentences contained two gestures, 0.22 contained three gestures, 0.11 contained four gestures, 0.04 contained five gestures, 0.03 contained six gestures, 0.01 contained seven gestures, and 0.03 contained eight or more. We then used these probabilities to establish how long we would expect David's sentences that do contain nominal constituents to be.

First, on the assumption that the nominal constituents David produced contributed a single unit to its sentence length, we counted each nominal constituent as one unit no matter how many gestures it contained. Thus, the sentence *that bird pedals* described above would be counted as having two units (*that bird* and *pedals*). We then used the expected probabilities established on the basis of David's non-nominal-constituent sentences to calculate the numbers of multigesture sentences of a given length containing nominal constituents that David would be expected to produce, and compared them to the number he actually produced. Note that, under this hypothesis, a nominal constituent produced on its own contains only one unit. Since we are predicting multiunit sentences in this analysis, we excluded all sentences containing a nominal constituent with no other gestures and focused on sentences that contained at least one gesture in addition to the nominal constituent ($N = 74$). Figure 1a (top graph) presents the data.[2] It

[2] Utterances with single-gesture arguments, either demonstrative or noun, in both simple and complex (multiclause) sentences were used to calculate the expected values in Fig. 1. Sentences containing simple repetitions, such as those described in §4 (e.g. gumball machine—gumball machine—you), were included in the analysis and each repetition of the gesture was counted as contributing one unit to the length of the sentence. If these sentences are excluded from the analysis, the patterns remain the same.



Incorrect graph: see p. 33 for corrected Figure 1

FIGURE 1. The black bars display the number of multiunit, nominal-constituent sentences David would be expected to produce based on the number of multiunit, NON-nominal-constituent sentences he produced (expected), and the gray bars the number actually produced (observed), under these assumptions: 1a (top): the nominal constituent functions as a single unit and contributes one unit to the sentence length count no matter how many gestures it contains; and 1b (bottom): the nominal constituent contributes as many gestures as it contains to the sentence length count. The observed data fit the expected values better in 1a ($\chi^2(6) = 4.5$, n.s.) than 1b ($\chi^2(6) = 55.6$, $p < 0.0001$), suggesting that David's nominal constituents are functioning as a single unit in his sentences.

is clear that the distribution of multigesture sentences containing nominal constituents that David produced (OBSERVED) fits the distribution generated on the basis of his non-nominal-constituent sentences (EXPECTED) quite well. There is no significant difference between the observed and expected distributions, $\chi^2(6) = 4.5$, n.s.

In contrast, on the assumption that the nominal constituents David produced contribute a unit for each gesture they contain to the sentence length count, we counted each nominal constituent according to the actual number of gestures produced. Under this view, the sentence *that bird pedals* would be counted as having three units (*that*, *bird*, and *pedals*). Again we used the expected probabilities established on the basis of David's non-nominal-constituent sentences to calculate the numbers of multigesture sentences containing nominal constituents David would be expected to produce, and compared them to the actual number he did produce. For this comparison, a nominal

constituent contains at least two units; as a result, we could include all the nominal constituents David produced, even those in sentences containing a nominal constituent with no other additional gestures ($N = 123$).[3] Figure 1b shows that the distribution of multigesture sentences in which each gesture is counted individually (observed) is NOT a good fit to the distribution generated on the basis of his non-nominal-constituent sentences (expected), $\chi^2(6) = 55.6$, $p < 0.0001$.[4]

The data thus confirm our hypothesis that the nominal constituent in David's gestures contributes a single unit to the psychological length of a sentence regardless of how many gestures it contains.[5] This finding suggests that nominal constituents have a hierarchical structure, such as [[[*that*] [*bird*]] [*pedals*]], rather than a flat structure, such as [[*that*] [*bird*] [*pedals*]].

6. A SEMANTIC ANALYSIS OF NOMINAL CONSTITUENTS. Our goal in the semantic analysis is to determine whether nominal constituents substitute semantically for single demonstratives and single nouns. Do the multigesture combinations referring to a single entity (i.e. the gestures in column C in Table 1) have the same semantic profile as single gestures referring to a single entity (i.e. columns A and B in Table 1)? If so, we conclude that both types of nominals have the same semantic functions. We conducted two referential analyses and asked whether David's nominal constituents refer to the same types of REFERENTS (§6.1) and play the same types of SEMANTIC ROLES (§6.2) as his single gestures referring to a particular entity (demonstrative pointing gestures) and his single gestures referring to an entity's class (noun iconic gestures and category pointing gestures).

6.1. REFERENTS CONVEYED BY NOMINAL CONSTITUENTS AND SINGLE GESTURES. We categorized all of the entities that David referred to with his single gestures (demonstrative points, noun category points, and noun iconics) and with his multigesture nominal constituents into the following categories: animals, body parts, clothing, food, inanimate objects, people, places, and vehicles. As Table 4 shows, David used his single gestures and his gesture combinations to refer to all eight categories. In addition, we examined each particular entity David referred to with a multigesture nominal constituent and asked whether David also referred to these same entities with a single gesture. David referred to fifty-nine different entities with his various nominal-constituent combinations. All but one item (a restaurant, which is not a common topic for David) was also referred

[3] The total number of sentences in this analysis is 123 rather than 126, the total number of nominal constituents in our data (see column C in Table 1), because David produced three sentences containing two nominal constituents each.

[4] To determine whether David's nominal constituents functioned as a unit in terms of sentence length when he first produced them, we conducted the same analysis but divided his utterances into those produced in the early sessions (2;10–3;08) and those produced in the later sessions (3;10–5;02). We found that, in both early and late sessions, David's observed distribution of multigesture sentences was not significantly different from the expected pattern when the gestures in a nominal constituent were counted as a unit (early sessions: $\chi^2(3) = 0.1$, n.s.; late sessions: $\chi^2(6) = 1.6$, n.s.), but was significantly different when each gesture in a nominal constituent was counted individually (early sessions: $\chi^2(3) = 15.7$, $p < 0.001$; late sessions: $\chi^2(6) = 19.7$, $p < 0.0001$).

[5] In principle, the number of gestures within a constituent should have an effect on sentence length, but because the overwhelming majority of David's nominal constituents contained no more than two gestures, we were able to ignore this factor in our analyses. Similarly, the gestures in the rest of the sentence (i.e. the non-nominal-constituent parts) might contribute in nonstraightforward ways to the length of David's sentences simply because they too could be composed of constituents. Here again, the shortness of David's sentences allows us to make the simplifying (and, for the most part, correct) assumption that the non-nominal-constituent parts of David's sentence did not contain groupings of gestures.

to with single gestures. David thus does not use his nominal constituents to convey a specific kind of referent. Rather, he uses them for precisely the same types of referents that he indicates with his single demonstratives and nouns.

TYPE OF REFERENT	SINGLE GESTURES REFERRING TO AN ENTITY (demonstratives or nouns) $N = 3{,}224$	MULTIGESTURE COMBINATIONS REFERRING TO AN ENTITY (nominal constituents) $N = 126$
Inanimate objects	0.40	0.33
People	0.29	0.17
Animals	0.12	0.12
Vehicles	0.08	0.08
Places	0.08	0.04
Food	0.07	0.05
Body parts	0.06	0.10
Clothing	0.06	0.12

TABLE 4. The proportion of single gestures referring to an entity (demonstrative points, noun category points, or noun iconic gestures) and multigesture combinations referring to an entity (nominal constituents), classified according to type of referent.

6.2. SEMANTIC ROLES CONVEYED BY NOMINAL CONSTITUENTS AND SINGLE GESTURES. We asked the same question about semantic roles that we asked about references. Table 5 presents examples of the eleven different types of semantic roles that David conveyed using single demonstrative pointing gestures, single noun iconic gestures, and combinations of demonstrative pointing gestures and noun iconic gestures referring to an entity (i.e. nominal constituents). Each of the roles that David produced with a single gesture can also be found in a nominal-constituent combination.

David showed a similar pattern with his noun category points. He used noun category points as single gestures for eight of the eleven roles (all but the location of a locative relation, the possessor of a possession relation, and the entity in a similarity relation). He combined noun category points with demonstrative points to convey seven of those eight, omitting only the recipient role. In example 10a, a single noun category point is playing a patient role. David points at his own backside (a noun category point that indicates the part of the experimenter's body he wants moved, *backside*) in order to ask the experimenter to move her backside to where he wanted her to sit. In example 2b, repeated here as 10b, a noun category point is combined with a demonstrative point, and the nominal-constituent unit also plays a patient role. David has a number of pennies in hand but also wants the experimenter's pennies. He points at the experimenter's pennies (a demonstrative point, *those*), then points at his own pennies (a category point that classifies the object he wants, *pennies*), and then points at his chest.

(10) a. ***point at David's backside*** MOVE
backside move
'(You) move backside (to spot).' (3;11)

b. **[point at experimenter's pennies** ***point at David's pennies*****]** point at self
[those pennies] me
'(You) (give) those pennies (to) me.' (3;10)

The fact that multigesture combinations referring to an entity serve the same (and not a subset of) semantic functions as single gestures used on their own suggests that the larger unit can substitute for the smaller unit. In this sense, these multigesture combina-

SEMANTIC ROLE	DEMONSTRATIVE POINTING SINGLE GESTURES	NOUN ICONIC SINGLE GESTURES	DEMONSTRATIVE POINT + NOUN ICONIC GESTURE COMBINATIONS (NOMINAL CONSTITUENTS)
Patient of act with recipient	Point at bubble jar (2;10) *Asking his mom to give him **that (bubble jar)**.*	SOLDIER (3;11) *Asking the experimenter to give him a **toy soldier**.*	COIN—point at coins (3;11) *Asking the experimenter to give him **those coins** to put in a toy bank.*
Patient of act without recipient	Point at shirt (3;11) *Requesting the experimenter take **that (shirt)** off the cowboy doll.*	BUS (3;10) *Requesting the experimenter to push down on a **toy bus** to make it go.*	Point at gun—GUN (3;10) *Describing the action done on **that toy gun** to make a penny fly into a bottle.*
Transitive actor	Point at fox (3;10) *Describing a picture of **that (fox)** driving a jeep.*	SANTA (3;10) *Describing a toy **Santa** swinging on a trapeze.*	BIRD—point at bird (3;05) *Describing a picture of **that bird** eating food.*
Intransitive actor	Point at cat (3;10) *Describing a picture of **that (cat)** jumping to a trampoline.*	BIRD (3;08) *Describing a picture of a **bird** flying.*	Soldier—SOLDIER (4;10) *Describing **that toy soldier** marching.*
Recipient (endpoint)	Point at napkin (2;10) *Requesting that the experimenter put the cookie on **that (napkin)**.*	TRACK (3;05) *Commenting that the block tower fell on a **train track**.*	Point at board—BOARD (3;08) *Requesting that the experimenter put the bag of puzzle pieces on **that board**.*
Entity of location relation	Point at bird puzzle piece (3;10) *Stating that **that (bird puzzle piece)** goes in a particular spot.*	SODA (5;02) *Stating that a **soda** is in the kitchen because he wants to go get one.*	Point at paddle ball—PADDLE BALL (3;10) *Stating that **that paddle ball** toy is downstairs.*
Location of location relation	Point at puzzle spot (3;10) *Stating that the puzzle piece belongs in **that (puzzle spot)**.*	SCHOOL (3;03) *Stating that his brother is at **school**.*	Point at puzzle spot—PUZZLE SPOT (3;10) *Stating that a puzzle piece belongs in **that puzzle spot**.*
Possession of possession relation	Point at crown (2;11) *Stating that **that (crown)** belongs to him.*	HAT (3;08) *Stating that a **hat** belongs to the fireman.*	HAT—point at hat picture (4;06) *Stating that **that hat** in the family photo album picture belongs to him.*
Possessor of possession relation	Point at brother (3;08) *Stating that the mask belongs to **him (his brother)**.*	MONKEY (4;10) *Stating that the banana belongs to a **monkey**.*	Point at cowboy—COWBOY (4;10) *Stating that the hat belongs to **that cowboy**.*
Entity of descriptive relation	Point at kayak (4;06) *Describing **that (kayak)** as little.*	COLLECTION (3;10) *Describing a **collection** of vehicles pictured in a picture book as big.*	Point at cookie—COOKIE (4;06) *Describing **that cookies** they are eating as yummy.*
Entity of similarity relation	Point at television (5;02) *Comment on the similarity between **that (television)** and the toy television.*	SMILE (3;10) *Comment on the similarity between a **smile** on a puzzle piece and his smile.*	Point at lion—LION (4;06) *Comment on the similarity between **that lion** and the mouse wearing a lion mask.*

TABLE 5. Examples of semantic roles conveyed with a single gesture referring to an entity (demonstrative pointing gestures, noun iconic gestures) and multigesture combinations (a demonstrative point + a noun iconic) referring to the same entity (nominal constituent). First line: example and age at which it was produced. Second line: context, with relevant semantic role in bold.

tions function like nominal constituents in David's homesign system, substituting for single demonstratives and single nouns. Further evidence for this claim comes from the fact that David does, at times, produce a series of sentences over which he uses both the larger and smaller units to refer to the same referent. At 3;05, David first uses demonstratives to indicate that he will give a toy car to his sister: point at sister—point at car. He then gestures that his sister should play with the car, but this time he refers to the car using a demonstrative and a noun functioning as a nominal constituent: [point at car—CAR]—point at sister. Finally, he again uses only the demonstrative to refer to the car and gestures that the car is broken: BROKEN—point at car. In this series of gesture sentences, we can see David substitute one form for another.

7. A SYNTACTIC ANALYSIS OF NOMINAL CONSTITUENTS. Previous research has shown that David's gesture sentences display consistent word-order patterns (Goldin-Meadow 2003a, Goldin-Meadow & Mylander 1984). We ask here whether David's nominal constituents occur in the same syntactic environments as his single demonstratives and nouns.

We focused our syntactic analysis on sentence propositions containing two semantic elements (drawn from columns C and D in Table 3). Although David does produce sentence propositions with three or more semantic elements (see column E in Table 3), he does so relatively infrequently; moreover, the diversity of the semantic elements he combines within a single proposition makes it difficult to determine consistent ordering patterns for these longer sentences. We included all sentences conveying two semantic elements in this analysis, with the following exceptions: (i) sentences expressing similarity relations, for example, *elephant nose (is like) my nose* (see Table 2), because there is no way to determine whether one entity should be privileged and therefore no way to determine word order; (ii) sentences that included noncontiguous repetitions, such as the bracketing examples shown in §4, because determining word order is again problematic; (iii) sentences expressing semantic relations that were relatively infrequent, thus not providing enough data to determine a consistent word-order pattern. The analysis is therefore based on 559 sentences in which an argument is conveyed by a single gesture (either a demonstrative or a noun), and thirty-five sentences in which an argument is conveyed by a multigesture nominal constituent.

We categorized David's sentences that did not contain a nominal constituent into those that followed the word orders previously identified in David's gestures and those that violated the orders. As expected, we found that the majority of David's nonconstituent sentences adhered to the dominant orders: 76% ($N = 426$) following the orders vs. 24% ($N = 133$) violating the orders, $\chi^2(1) = 153.58$, $p < 0.001$. We then examined the sentences David produced that contained a nominal constituent to determine whether the nominal-constituent sentences also followed these orders. We found that 75% ($N = 26$) of David's thirty-five nominal-constituent sentences adhered to the orders identified as dominant in his non-nominal-constituent sentences, and 24% ($N = 9$) did not, $\chi^2(1) = 8.26$, $p < 0.01$ (see Figure 2). There were no significant differences between these two distributions, $\chi^2(1) = 0.07$, n.s.

Table 6 gives examples of David's eleven dominant word orders. The word order exemplified is listed in the first column of the table, for example, patient-recipient in the first entry. The second column lists a sentence in which the patient role is conveyed by a demonstrative pointing gesture: point at wand (*that*)—point at self (*me*), 'give *that* (the wand, functioning as a patient) to me'. The third column lists a sentence in which the patient role is conveyed by a nominal constituent, a demonstrative pointing gesture combined with a noun iconic gesture: [iconic gesture (*coin*)—point at coin (*that*)]—

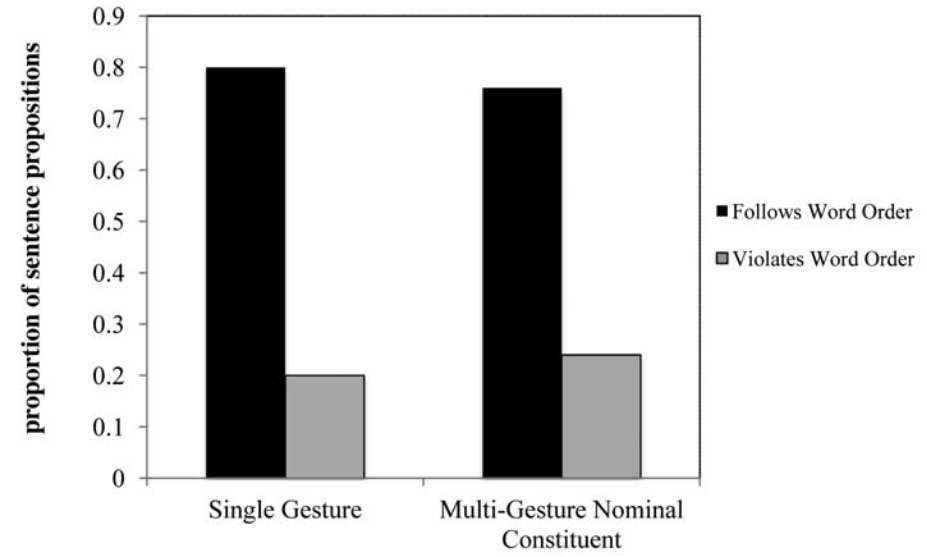


FIGURE 2. The proportion of sentences in which the argument is conveyed by a single gesture ($N = 559$) vs. a multigesture nominal constituent ($N = 35$), categorized according to whether the sentences adhered to (black bars) or violated (gray bars) David's dominant word order.

point at self (*me*), 'give *that coin* (functioning as a patient) to me'. In each example, the argument conveyed by the demonstrative pointing gesture in the second column, as well as the argument conveyed by the nominal constituent in the third column, is bolded. As Table 6 illustrates, nominal constituents can occupy slots for either argument in a two-argument sentence. Take, for example, the two entity-location sentences. In the first, the nominal constituent fills the entity slot, [*those glasses*] *(belong on) eyes*. In the second, the nominal constituent fills the location slot, *puzzle pieces (go on)* [*that board*].

Although not illustrated in Table 6, nominal constituents containing demonstrative points and noun category points also follow David's dominant word orders. In example 10b, presented earlier, David produces a demonstrative point at the experimenter's pennies to identify the pennies he wants (*those*), then produces a noun category point to identify the class of the object he wants (*pennies*), and then points at himself, the intended recipient. The nominal constituent [*those pennies*], the patient, fills the first slot of the sentence, followed by the recipient, that is, [*those pennies*] *me*, conforming to the patient-recipient order found in David's non-nominal-constituent sentences (see the first example in Table 6). In example 11, David produces a demonstrative point at the particular car he wants to press (*that*), then produces a noun category point at a picture of a car to identify the class of the object he wants to act on (*car*), and then produces the verb gesture, *press*. The noun category point again plays the role of patient and again fills the first slot of the sentence, but this time the patient is followed by a verb gesture for the act, that is, [*that car*] *press*, thus following the patient-act order found in David's non-nominal-constituent sentences (see the second example in Table 6).

(11) [point at car *point at car picture*] PRESS
[that car] press
'(I) press that car.' (5;02)

Finally, although our syntactic analyses focused on sentences with only two semantic elements, it is important to point out that David did produce longer sentences containing

ORDER BY ARGUMENTS	ARGUMENTS CONVEYED BY A DEMONSTRATIVE POINTING GESTURE	ARGUMENTS CONVEYED BY A DEMONSTRATIVE POINT + ICONIC NOUN GESTURE COMBINATION
Patient—recipient	**Point at bubble wand**—point at self (2;11) *(You/mom) (give) me that (bubble wand).* While playing with bubbles.	**[COIN—point at coins]**—point at self (3;11) *(You/experimenter) (give) those coins to me.* Request for pennies while playing with a toy bank.
Patient—act	**Point at penny**—PUT DOWN (4;06) *(You/experimenter) put down that (penny) (on bank).* While playing with a bank that shoots pennies into a bottle.	**[TRACK—point at track]**—PUT DOWN (3;05) *(You/experimenter) put down that track (in spot).* While playing with a toy train set.
Patient—act	**Point at playdoh can**—TURN OVER (3;03) *(You/sister) turn over that (playdoh can).* While playing with playdoh with his sister.	**[BUTTON—point at button—BUTTON]**—PRESS (5;02) *(You/experimenter) press that button.* While playing with a toy television.
Patient—transitive actor	**Point at candy**—point at experimenter (5;02) *You/experimenter (eat) that (candy).* While everyone is eating candy.	**[car—CAR—car—CAR—car]**—point at experimenter (3;05) *You/experimenter (act on) that car.* Inviting the experimenter to play with the toy car.
Recipient—act	**Point downstairs**—GO (3;11) *(I/David) go that (place = downstairs).* Stating that he wants to go downstairs to play with a toy.	**[point toward restaurant—point toward restaurant—RESTAURANT]**—GO (3;05) *(We) go to that restaurant.* Comment trying to get everyone to go to Burger King.
Intransitive actor—act	**Point at gumball in machine**—GO ALONG (3;10) *That (gumball) goes along (path in gumball machine).* Comment while playing with a gumball machine.	**[MOTORCYCLE—point at motorcycle picture—MOTORCYLE]**—GO (4;06) *That motorcycle goes (into car carrier).* Comment while looking at a picture book.
Intransitive actor—act	**Point at clown**—DANCE (5;02) *That (clown) dances.* Comment about a clown in a picture book.	**[soldier—SOLDIER]**—MARCH (4;10) *That soldier marches.* Comment about a wind-up toy soldier.
Entity—description	**Point at car**—SMALL (3;05) *That (car) is small.* Comment while playing with toy cars.	**[Point at cookie—COOKIE]**—YUMMY (4;06) *That cookie is yummy.* Comment while eating cookies.
Entity—location	**Point at Christmas lights**—STAIR RAILING (4;10) *Those (Christmas lights) belong on stair railing.* Comment about where Christmas decorations are put in their living room.	**[GLASSES—glasses]**—point at eyes (4;06) *Those glasses belong on eyes.* Comment about where glasses are worn.
Entity—**location**	Point at Mickey Mouse head—**point at Mickey Mouse body** (3;10) *Mickey Mouse head belongs on that (Mickey Mouse body).* While playing with a Mickey Mouse toy.	Puzzle pieces—**[empty puzzle board—BOARD]** (3;10) *Puzzle pieces go on that empty puzzle board.* While playing with puzzles.
Entity—possessor	**Point at knife**—point at sister (3;03) *That (knife) belongs to you/sister.* Comment while playing with playdoh.	**[point at car picture—CAR]**—point at self (3;05) *That car belongs to me.* While playing with toy cars.

TABLE 6. Examples of sentences containing arguments conveyed either by a demonstrative point gesture or a demonstrative point + noun iconic gesture combination, classified according to the two semantic elements explicitly gestured. The argument conveyed by a nominal constituent is bracketed and bolded in the third column; the comparable argument is bolded in the first and second columns. First line in second and third columns: gestures explicitly produced and age at which they were produced. Second italicized line: gloss in English, with semantic elements inferred from context in parentheses. Third line: context.

nominal constituents, as illustrated in example 12. David points at a picture of a bicycle to refer to the patient (*that*), produces a verb gesture (*steer*), and then produces a multi-gesture nominal constituent to refer to the actor (*that bird*). In addition to being a sentence with two arguments (one that follows David's preferred word order for transitive sentences, that is, patient-act-actor; Goldin-Meadow & Mylander 1984:39), this sentence is of interest because it highlights the fact that nominal constituents can occur at the end of David's sentences as well as the beginning.

(12) point at bicycle STEER [point at bird picture BIRD]
that steer [that bird]
'That bird steers that.' (3;08)

8. Comparing structure within a nominal constituent to sentence structure. David used his noun iconic gestures within nominal constituents (e.g. a demonstrative point at a particular bird, followed by a noun iconic gesture for bird to comment on the fact that the bird is pedaling a bike, [*that bird*] *pedals*), but he also used them as predicate nominals (e.g. a demonstrative point at a bird, followed by a noun iconic gesture to identify that particular bird as a bird, *that's a bird*; see column D in Table 1). We used context to help us identify demonstrative point + noun iconic gesture combinations serving a predicate-nominal function. For example, after being shown a picture of a drum, David responded by producing a demonstrative point at the drum picture and producing a noun iconic gesture, DRUM, glossed as *that is a drum*—a predicate-nominal sentence in which the point at the drum fills the argument role and the iconic DRUM gesture fills the predicate role. The surrounding context made it clear that David was labeling the drum rather than requesting or describing it. When there was ambiguity, we erred on the side of coding these combinations as predicate-nominal sentences. If demonstrative point + noun iconic gesture combinations that function as nominal constituents are truly different from demonstrative point + noun iconic gesture combinations that function as predicate-nominal sentences, we might expect the two types of combinations to be structured differently.

To explore this possibility, we examined the order of the demonstrative point gesture and the noun iconic gesture in David's gesture combinations serving as predicate-nominal sentences vs. those serving as nominal constituents. In his predicate-nominal sentences, David produced the point gesture before the iconic gesture 73% of the time (86/118), $\chi^2(1) = 37.9$, $p < 0.001$. In contrast, in nominal constituents, David showed no order preference, producing the point gesture before the iconic gesture 52% of the time (35/67), $\chi^2(1) = 0.15$, n.s. For completeness, we note that David also showed no order preference within his nominal constituents containing noun category points and demonstrative points: he produced the demonstrative point before the category point 56% of the time (10/18), and the category point before the demonstrative point 44% of the time (8/18), $\chi^2(1) = 0.22$, n.s. There was, however, some structure within David's nominal constituents: modifiers in nominal constituents followed the noun 71% of the time (17/24), $\chi^2(1) = 4.16$, $p < 0.05$, and followed the demonstrative point 89% of the time (8/9), $\chi^2(1) = 5.4$, $p \leq 0.02$.

Although it is unusual in the world's languages for nominal constituents to be characterized by free word order, there are natural languages in which the demonstrative can either precede or follow the noun (Dryer 2005). Looking specifically at sign languages, we find that adjectives can appear either before or after the noun in nominal constituents in ASL (Boster 1996), as can determiners—although the position of the determiner does appear to impact meaning (Neidle et al. 2000). It is possible that the order of demonstrative

pointing gestures and noun iconic gestures in David's nominal constituents does capture a difference in meaning (e.g. one of emphasis or focus) that we have been unable to identify with our coding procedures. The point we would like to stress, however, is that finding a difference in word-order patterns between point and iconic gestures used as nominal constituents vs. point and iconic gestures used as predicate-nominal sentences lends weight to the claim that David's nominal constituents are a unique phrase structure, distinct from his sentence structure. This contrastive minimal pair suggests that David's nominal constituents are a structure distinct from predicate-nominal sentences, despite surface similarities in form.

9. GESTURAL INPUT FROM DAVID'S HEARING MOTHER. We have shown that David combines demonstrative points, noun category points, and noun iconic gestures into a unit that functions like a nominal constituent. The question to which we now turn is: what drives the creation of nominal constituents in David's gestures? David does not produce nominal constituents in his earliest sessions and, in this sense, resembles children acquiring conventional languages from input provided by their parents. These children may begin to produce nominal constituents for two reasons. First, they are exposed to a model for nominal constituents and may be copying the input they receive, a hypothesis we explore in this section. Second, as they begin to communicate more about the nonpresent, they may feel communicative pressure to specify objects, people, and places more completely, a hypothesis we explore in §10.

David is not receiving usable input from a conventional language, signed or spoken. He is, however, surrounded by hearing individuals who, like all hearing individuals, gesture when they talk (Goldin-Meadow 2003b). It is possible that the gestures David's parents produce when they interact with him are serving as a model for the nominal constituents he produces. To explore this possibility, we coded the gestures that David's hearing mother produced during her interactions with him, using the same coding system that we used to code David's gestures. We coded the mother's gestures during David's first five observation sessions (up through 3;05), the period before David began reliably producing nominal constituents.

We found that David's mother produced 321 (95%) demonstrative point gestures, twelve (4%) noun iconic gestures, and five (1%) category point gestures in her interactions with David during the sessions when he was between ages 2;10 and 3;05. This distribution resembles the distribution of these three types of gestures in David's productions across all sessions: 3,966 (93%), 192 (4%), 110 (3%), respectively, for David.

But the crucial issue is how David's mother combines these gestures. In fact, David's mother rarely combined any of her gestures with other gestures; rather, she tended to produce one gesture at a time (Goldin-Meadow & Mylander 1983, 1984, 1998). The gestures David's mother used to refer to entities followed this pattern, and combinations of gestures referring to a single entity were also rare. Moreover, when David's mother did use multiple gestures to refer to an entity, she always repeated the same point gesture ($N = 21$). Like David, she was more likely to produce other gestures between her two point repetitions than to produce the repetitions in succession. In other words, she produced more noncontiguous repetitions (62%, 13/21; see example 13a) than contiguous repetitions (38%, 8/21; see example 13b). Recall that the comparable percentages for David were 73% vs. 27% (§4). David's mother may well have provided a gesture model for his point-point repetitions.

(13) a. **point at mouse** point at father **point at mouse**
that him that
'(You/David) (give) that (to) him.' (mother; David's age 2;11)

b. **point at frog's box** **point at frog's box**
that that
'(I) (put) (frog) (in) that.'[6] (mother; David's age 3;03)

The important point, however, is that David's mother never combined different gestures to refer to an entity the way David did. On two occasions she produced a demonstrative point with a noun iconic gesture, but the two gestures clearly referred to different entities (e.g. she produced an iconic CLAY gesture along with a point at David's siblings to indicate that he should give them some clay). In all other instances when David's mother produced a point gesture and an iconic gesture in a single utterance ($N = 22$), the iconic gesture served a predicate verb function (e.g. bird FLY). The picture for noun category point combinations was the same: David's mother did not produce demonstrative points in the same sentence with noun category points during these sessions, and combined a noun category point with an iconic gesture serving a predicate function only once.

Thus, David's mother produced no gesture combinations that could be considered nominal constituents, suggesting that this structure was not available in the gestural input David received. We ask next whether David produced his nominal constituents in response to external pressure from the communicative situation.

10. COMMUNICATIVE PRESSURE. David's nominal-constituent combinations (*that drum*) provide more specificity than either demonstratives (*that*) or nouns (*drum*) produced on their own. It is possible that David produced these combinations only when the communicative situation demanded it, that is, only when a single gesture was not sufficient to convey his intended message to his communication partner. We found some instances of nominal constituents that seemed to be provoked by the interlocutor. For example, David requested that the experimenter give him a Donald Duck toy by pointing at the toy. When the experimenter did not respond to his request, he elaborated on it by producing a nominal constituent—he produced a noun iconic gesture for DUCK (he pursed his lips to represent a duck's bill) followed by a demonstrative point at the toy (*duck that*). Were the majority of the nominal constituents that David produced provoked in this way?

To address this question, we coded how many of David's nominal-constituent combinations appeared to be elaborations of a previously produced single gesture, either a single demonstrative pointing gesture, noun category pointing gesture, or noun iconic gesture. We coded a nominal constituent as an elaboration if David had produced a single gesture for the same referent within the previous ten utterances or within the previous five minutes. This criterion was strictly enforced; thus, we coded a nominal constituent as an elaboration of a referent even if there was no evidence that the interlocutor had not understood David's original gesture for the referent. We found that, although some of David's nominal constituents could be classified as elaborations, the majority could not (67%, 84/126), $\chi^2(1) = 14.0$, $p < 0.001$. In these instances, when David used the nominal constituent to introduce a referent into the discourse, it was the first time the referent had been mentioned. The nominal constituent, then, could not have been motivated by his communication partner's confusion.

David's early nominal constituents could have been produced in response to his communication partner. David may have learned from his interlocutor's responses at a

[6] We have included in parentheses words for semantic elements that David's mother does not express in gesture; unlike David, however, we have no evidence from her gestures that these elements form part of the predicate frames underlying those gestures.

young age that more specificity is, at times, required, which may have led him to produce his first nominal constituents. Table 7 presents the number of nominal constituents David produced, classified according to whether the nominal constituent introduced the referent into the discourse, or whether the nominal constituent elaborated on a previously produced gesture for the referent.

AGE	INTRODUCES REFERENT	ELABORATES ON REFERENT
2;10	–	–
2;11	0	1
3;00	–	–
3;03	1	0
3;05	9	4
3;08	3	2
3;10	11	1
3;11	24	15
4;06	20	8
4;10	4	3
5;02	12	8

TABLE 7. The number of nominal constituents David produced, classified according to whether the nominal constituent introduced the referent into the discourse, or elaborated on a previously produced single gesture for the referent.

The first nominal constituent David produced at age 2;11 was an elaboration. It is clear from the context, however, that David did not produce this particular nominal constituent because his interlocutor was confused about the topic of conversation. David produced the nominal constituent shown in example 14 in the middle of a play session during which David and his mother had been blowing, and gesturing about, bubbles. Indeed, David's mother had been pointing at the bubbles and producing number gestures in gesture sentences before David produced this nominal constituent. It is very unlikely that David produced this combination of gestures to clarify the topic for his mother.

(14) GO DOWN [point at bubbles FIVE]
go down [that five]
'That five (X) go down.' (2;11)

Moreover, the next nominal constituent David produced at age 3;03 was not an elaboration, and only four of the 13 (31%) nominal constituents David produced at age 3;05 were elaborations. It is therefore unlikely that David learned to produce his nominal constituents through trial and error in response to his communication partner's behavior. On some level, David has, as Lyons (1991) puts it, tacitly accepted the responsibility of providing information not given in the context, whether or not his communication partner demands it.

11. CONCLUSION. Early in development, David refers to entities by producing either a single demonstrative gesture (*that*) or a single noun gesture (*penny*). Over time, David develops a new way of referring to entities—he combines demonstrative and noun gestures into a single construction (*that penny*). Once they enter David's homesign system, these combinations play the same semantic and syntactic roles as demonstrative and noun gestures do when produced on their own. In other words, the larger unit (demonstrative combined with noun) shares the same privilege of occurrence as the smaller units (demonstrative or noun). In this sense, the larger unit serves as a nominal constituent in David's homesign system. We explore the implications of our findings for ac-

quisition with respect to two central properties of language: hierarchical structure and functional categories.

11.1. HIERARCHICAL STRUCTURE. Our analyses of David's nominals found that they behaved like constituents. More specifically, in the sentence *press that car* (example 11), if we count the nominal constituent *that car* as contributing one unit to sentence length and the verb *press* as contributing another, we do a better job of approximating the lengths of the nominal-constituent sentences David actually produces than if we count the nominal constituent *that car* as contributing two units. These sentences are thus better described as having constituent structure—([[[*that*] [*car*]] [*press*]])—than flat structure—[[*that*] [*car*] [*press*]]—reflecting the fact that the gestures within a nominal constituent have a closer relationship to each other than they have to other gestures in the sentence. Note that we have included brackets around the entire sentence in these representations, a step that is licensed by previous work showing that sentence-level brackets are needed to account for production probability regularities in David's complex sentences (Goldin-Meadow 1982, 2005).[7] Sentences containing nominal constituents thus contain brackets within brackets and, in this sense, are hierarchical. As a result, these data provide the first evidence of embedded structure in homesign.

Consistent with this pattern, we also found that David ordered his gestures within a nominal constituent (*that drum*) differently from the way he ordered the same gestures when they formed a sentence (*that's a drum*). Word order in David's nominal constituents is unconstrained (the demonstrative point appears before the noun gesture as often as it appears after the noun gesture), but in predicate-nominal sentences it is constrained (the demonstrative point is more likely to appear before the predicate-nominal gesture than after it). The fact that word order is expressed differently within a phrase than within a sentence in David's homesign system lends weight to the claim that the phrase is a unit unto itself with its own patterns of production. Our sentence length data suggest a tighter link between gestures within a phrase than between gestures within a sentence, implying that the phrase is a subordinate unit within the sentence hierarchy. Our findings suggest that a child is able to refer to entities using phrases that embed within them nouns, demonstratives, and modifiers, even when he does not have a conventional language to provide a model for hierarchical structure of this type.

Perfors, Tenenbaum, and Regier (2011) have argued that, in principle, child learners should be able to recognize the hierarchical phrase structure of a language without having this knowledge innately specified. The claim is that human learners are equipped with a domain-general bias toward parsimony, which leads them to search for an optimal trade-off between simplicity and data-fit. Perfors and colleagues (2011) instantiated this idea in a Bayesian model, and showed that learning the hierarchical structure of language can take place without a prior bias favoring the outcome, IF the model is given typical child-directed speech. Our data present a challenge to this theory since the

[7] As described earlier, we use motoric criteria to determine the boundaries of David's gesture sentences; we then determine how many propositions are conveyed within those boundaries, and how often gestures are produced for particular semantic elements in the sentence (production probability; Goldin-Meadow 2005: 205–10). To account for production probability patterns in sentences containing more than one proposition, we need to consider whether a semantic element is found in both propositions, and, if so, whether it plays different roles in the two propositions (and thus contributes one argument slot to the predicate frame underlying the sentence) or the same role in the two propositions (and thus contributes two argument slots). Since both propositions need to be considered, the predicate frame underlying the multiproposition sentence cannot reflect the mere juxtaposition of two predicate frames. David's complex sentences thus result from the unification of two propositions under a higher node, allowing us to insert brackets around the sentence.

minimal input a deaf homesigner receives appears insufficient to permit acquisition of hierarchical structure with the parsimony bias alone.

More generally, usage-based theories of language acquisition also emphasize the essential nature of linguistic input and hold that children acquire language by applying general learning skills to patterns in their linguistic input. For example, according to Tomasello (2005:186), 'children construct from their experience with a particular language some kinds of grammatical categories, based on the function of particular words and phrases in particular utterances—followed by generalizations across these' (see also Bybee & McClelland 2005, Goldberg & Del Giudice 2005). This hypothesis must, of course, be correct at some level—children have to process and glean patterns from the input they receive in order to learn the language of their community. The controversial question is whether children apply biases to their input that influence the generalizations they make.

A strict usage-based account would predict that, in the absence of linguistic input, a child ought not to develop a communication system containing nominal constituents simply because there would be no input from which to glean this particular linguistic pattern. But this prediction fails in our case. David's hearing losses did not allow him to profit from the constituent-structure patterns in the spoken language that surrounded him. Moreover, the gestures that his hearing mother produced along with her talk did not display constituent structure and thus could not have provided a model for the nominal constituents David developed. Our findings thus suggest that children come to language learning biased to develop a structured communication system, including hierarchical structure based on the noun, and ready to interpret the input they receive within the context of those biases.

11.2. FUNCTIONAL CATEGORIES. Most of the multigesture combinations referring to an entity that David produced contained a demonstrative gesture, functioning as a determiner, and a noun gesture (e.g. *give me* [*that drum*]). But, on occasion, David produced other types of determiners, for instance, a possessive pronoun (e.g. [*my trains*] *are downstairs*), and even produced a few sentences containing a determiner, modifier, and noun (e.g. [*my long paddle*] *is downstairs*). Although we do not have conclusive evidence that these combinations are determiner phrases (DPs), the data we have presented are consistent with the hypothesis that they are. The fact that David's phrases built around nouns resemble DPs in natural languages opens the possibility that David has introduced functional categories into his homesign system.

Valian (2009) has suggested that children come to language learning with unspecified lexical (nouns, verbs, etc.) and functional (determiner, tense, etc.) categories. Children then have the task of identifying members of these categories in the language they are learning (Valian 2009). The fact that David produces multigesture combinations referring to an entity that share many characteristics with DPs provides evidence for this claim. Along with the fact that David's system has negation and question markers that serve as functional categories (Franklin et al. 2011a,b), our data thus suggest that children do not require input from a conventional language model to construct a communication system with both lexical and functional categories.

We also explored aspects of the input that David did receive—the gestures that his hearing mother produced when talking to him—to determine whether David's nominal constituents were modeled after these gestures. We found that David's mother never produced a gesture sentence containing a demonstrative gesture and a noun gesture to refer to an entity, whereas David frequently did. Thus David could not have used his mother's gestures as a model for the functional category found in his homesign system.

In addition, although David may have constructed his first combination of functional and lexical categories with an eye toward providing more specific information about the entities he mentioned (indicating the particular entity along with the category to which it belongs), he did not seem to produce these combinations as a result of feedback from his communication partner. The majority of David's nominal constituents were produced to introduce a referent into the discourse, rather than to elaborate on a previously produced (and presumably inadequate) gesture for the referent. Our findings suggest that David has, on some level, developed an intuitive understanding that the intended referent cannot always be recovered from context, and that he can provide greater specificity with his gestures. The particularly interesting aspect of our findings is that the specificity David provides is structured like natural languages—his gestures for the functional and lexical categories within a nominal constituent are adjacent to one another and function as a single unit, and that unit follows the semantic and syntactic patterns that characterize his homesign system.

In sum, we have discovered that, without the benefit of a language model, a deaf child can develop a linguistic system that contains hierarchical structure built around the noun and a functional category serving a determiner role. We do not yet know whether all homesigners are able to create such structure, or whether David is the rare exception. Previous research has established that by age 3;05, when David reliably begins to produce nominal constituents in his gesture sentences, his homesign system already displays an array of linguistic properties (Goldin-Meadow 2003a). Any of these properties may turn out to be critical for building structure around the noun. For example, at age 3;03, David begins to use the same iconic gesture as both noun and verb (e.g. a BEAT gesture used to refer to the act of hitting a drum, a verb, or to refer to the drum itself, a noun) and distinguishes the two uses with morphological and syntactic markers (Goldin-Meadow et al. 1994). It may be essential to establish grammatical categories of this sort before building structure around the noun or, for that matter, the verb. As another example, at age 3;03, David's lexical items show evidence of componential structure for the first time; prior to this point, his gestures can all be described holistically without internal structure (Goldin-Meadow et al. 1995). Perhaps it is essential to introduce structure within the word before building structure around the noun. Finally, at age 3;03, David also begins to use his gestures to refer to displaced objects (Butcher et al. 1991). Although David's nominal constituents frequently refer to present objects, the need to refer to displaced objects may be one motivation for greater specificity in his system.

Thus, although input from a conventional language model is not essential to produce nominal constituents, it may be necessary to have developed a sufficiently complex linguistic system before building structure around the noun. In future work, we will explore this possibility by searching for nominal constituents in the homesigns of other deaf children raised in the United States and Nicaragua. In addition, in Nicaragua, where some deaf individuals continue to use their homesigns into adulthood (Brentari et al. 2012, Coppola & Newport 2005, Coppola & Senghas 2010, Coppola et al. 2010), we can ask whether nominal constituents ever become a required referential form in a self-created gesture system. We may find that all homesigners introduce hierarchically organized nominal constituents into their communication systems, or that this type of structure is rare among homesigners.

Whatever the outcome of these future studies, the data from our study convincingly show that it is possible for a child to build linguistic structure around the noun without a conventional language model to guide him. Although children who are exposed to a conventional language model are clearly responsive to the frequency of forms within

that model, as usage-based theories have suggested (Lieven et al. 1997, Tomasello 2000a,b), our data make it equally clear that frequency need not be the driving force.

Appendix: Notational conventions

Line 1 of each example contains a description of all of the gestures produced in the sentence. Demonstrative pointing gestures are displayed in lowercase letters. Iconic noun gestures are displayed in capital letters. Category noun gestures are displayed in italicized lowercase letters. Nominal constituents are enclosed in square brackets.

Line 2 contains literal glosses of each gesture. Demonstrates are glossed as *that*, if the referent is an object, or as *you* or *me* where appropriate if David is referring to a person. Iconic nouns and category point nouns are glossed as the label for their referents. Nominal constituents are also enclosed in square brackets in this line.

Line 3 is an English gloss of the utterance. Elements that are not explicitly gestured but implied from the context are displayed in parentheses in line 3. The age (in years;months) when David produced the example follows in parentheses in line 3.

The different types of gestures analyzed in this article are notated as follows (and bolded in each example).

(A1) Pointing gestures: Pointing gestures are displayed in lowercase letters in line 1 of each relevant example (‘point at bubbles’) and are glossed as ‘that’ in lines 2 and 3.
point at bubbles GIVE
that give
‘(You) give (me) **that**.’ (2;10)

(A2) Noun iconic gestures: Noun iconic gestures are displayed in capital letters in line 1 of each relevant example (‘LOLLIPOP’); in line 2, each iconic noun gesture is glossed as the label for its referent (lollipop).
LOLLIPOP GIVE
lollipop give
‘(You) give (me) **lollipop**.’ (3;05)

(A3) Noun category pointing gestures: Category points, which are points used to refer to a category of objects rather than a specific object, are displayed in italicized lowercase letters (‘point at David’s backside’) in the first line; in line 2, each category pointing gesture is glossed as the label for its referent (backside).
point at David’s backside MOVE
backside move
‘(You) move **backside** (here).’ (3;11)

(A4) Nominal constituents: The two components of a nominal constituent are enclosed in square brackets in lines 1 and 2.
[PENNY point at penny] point at self
[penny that] me
‘(Give) me **that penny**.’ (3;11)

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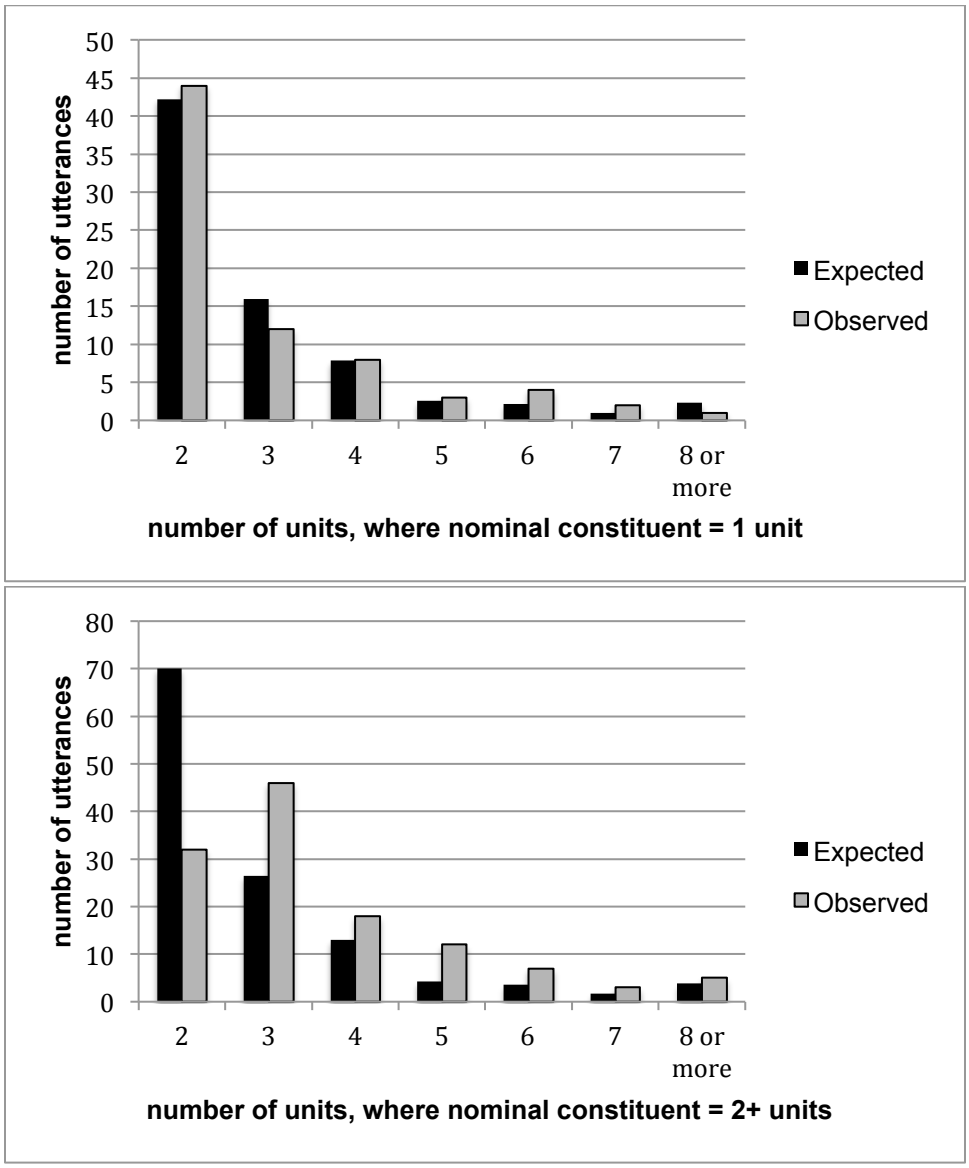

FIGURE 1. The black bars display the number of multiunit, nominal-constituent sentences David would be expected to produce based on the number of multiunit, NON-nominal-constituent sentences he produced (expected), and the gray bars the number actually produced (observed), under these assumptions: 1a (top): the nominal constituent functions as a single unit and contributes one unit to the sentence length count no matter how many gestures it contains; and 1b (bottom): the nominal constituent contributes as many gestures as it contains to the sentence length count. The observed data fit the expected values better in 1a ($2(6) = 4.5, n.s.) than 1b ($2(6) = 55.6, $p < 0.0001$), suggesting that David's nominal constituents are functioning as a single unit in his sentences.