Research Article

Gesture Identification for Nouns and Verbs in Typically Developing Children

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Abstract

The relationship between gesture and verbal language was explored using gesture identification in childrens. A noun-verb distinction is well evidenced across various language systems, and therefore, a set of noun and verb gestures were considered for the gesture identification task. Typically developing children (TDC) of 3^{rd}, 4^{th} and 5^{th} grade with an age range of 8-8.11, 9-9.11 and 10-10.11 years respectively served as participants for the study. The participants were presented 15 noun, and 15 verb gestures and were instructed to name them. The scores were tabulated for both nouns and verbs for the three groups of participants. Kruskal-Wallis test was used to compare the performance of participants across grades. The results revealed no difference in gesture identification scores across the participant groups, thus, showing an absence of a developmental trend in gesture identification in the population considered. Wilcoxon's signed rank test was performed as a within-group analysis, which revealed a significant difference in identifying noun vs. verb gestures in the participant groups. Further, it was inferred that the verb gestures were identified better in comparison to the noun gestures within each group. The results highlight the noun-verb distinction of gesture decoding in TDC.

INTRODUCTION

A gesture is a movement of a body part, especially the hands or the head, used to convey some information. McNeill (1992) regarded gestures as an immediate, visual, and holistic form of communication while speech was considered to be graded, auditory, and systematic. Gesture, speech, and language show tight developmental and neurological associations (Bates & Dick, 2002).

The development of both gesture and speech takes place simultaneously in typically developing children (TDC). Ejiri and Masataka (2001) reported the simultaneous production of canonical babbling and rhythmic hand movements in infants of 6-8 months of age. A child develops deictic gestures (i.e., pointing gestures) for intentional communication at 8-10 months of age (Bates & Snyder, 1987; Bretherton & Bates, 1979), followed by the use of first word. By 18-20 months of age, gesture-word and gesture-gesture combinations for communication are noted (Bretherton & Bates 1979; Caselli, 1990; Volterra, Bates, Benigni, Bretherton, & Camaioni, 1979) while the word combinations are beginning in the verbal language. Children show a preference for spoken language at two years of age, but the gestures continue to scaffold their complex cognitive skills of language processing (Capone & McGregor, 2004). In addition to this, studies carried out in the past have shown shared neural correlates for gesture and speech. Gesture and speech represent a substantial neural overlap in prominent language processing areas such as the inferior frontal cortex and Broadman's Area number 45 (Moll et al., 2000). Further, the premotor cortex plays an essential role in the semantic processing of action language (Aziz-Zadeh, Wilson, Rizzolatti, & Iacoboni, 2006). The left inferior frontal cortex acts as an interface by integrating both gesture and language domains, which is also consistent with the theory of language comprehension (Willems, Ozyurek, & Hagoort, 2007). Thus, gestures are incorporated in various language components and show overlap with some parts of the language system, especially speech.

This link between gesture and speech is explained effectively by the gesture processing models. The Growth Point Theory (McNeill & Duncan, 2000), the Sketch model (De Ruiter, 2000) and the Interface model (Kita & Özyürek, 2003) share a common perspective and consider gesture and speech to be housed in a single integrated system, wherein the processing happen at the pre-lexical level. On the other hand, the Lexical retrieval model (Krauss et al., 2000) postulates that speech and gesture are separate independent systems, and the processing is assumed to operate at the post lexical level. Therefore, the gesture processing models further support the gesture-speech interaction at various levels of language processing.

Further, clinical evidence on language impairment

shows a possibility of a parallel breakdown (gestures and speech are affected equally) of modalities or a trade-off (one mode either facilitates or compensates for the other) between them (Mol, Krahmer, & de Sandt-Koenderman, 2011). Therefore, gestures and speech are thought to share an integrated system through mutual or obligatory interactions (Kelly,Ozyurek, & Maris, 2010).

In general, verbal language would comprise of two major grammatical classes, nouns and verbs. Nouns identify a person, place, idea, or thing, which is an important part of one's utterances and forms content words in communication. Verbs identify actions, processes, state, or relation that forms the major part of the sentence, i.e., the predicate. They aid in understanding the meaning of the sentence and is extensively used in everyday conversation. The neural representation for nouns is localized to the inferior parietal lobule, precuneous and inferior temporal cortex, while that of the verbs is linked to the posterior middle temporal gyrus and inferior frontal gyrus (Elli, Lane, & Bedny, 2019). The noun-verb distinction evident in the functional aspects of the sentence and neural representations is seen even in the brain's lexical-semantic representation. Nouns are usually acquired first during development and also affected first in cases of word finding difficulties in an elderly individual (Marshall, 2003). Further, it is seen that individuals exhibit better speed and accuracy in naming nouns as compared to verbs (Matzig, Druks, Masterson, & Vigliocco, 2009). Thus, difference in the neural organization of grammatical classes of words in the mental lexicon is noticed, which suggests a marked distinction between nouns and verbs in verbal language.

The noun-verb distinction is similarly found in the non-verbal mode, including gestural language and sign language. Both gestures and signs are regarded as manual forms of non-verbal communication; however, there are differences between them. Gestures are mostly simple, unstructured, spontaneous, and imagistic, whereas signs are complex, structured, learned, and categorical (Goldin-Meadow & Brentari, 2017; Kusters & Sahasrabudhe, 2018). The noun-verb distinction of verbal language is well established in sign language (Tkachman & Sandler, 2013). Hunsicker and Golden-Meadow (2013) conducted a single case study on a boy named David for two years. David was a child with hearing impairment, born to normal hearing parents, and learned 'homesigns' (rudimentary signs used by David for communication) during his developmental years. At around 3.5 years of age, David used object signs (represent a physical entity like nouns, similar to iconic gestures) to represent nouns. Later, when David started to combine forms (syntactic units like nouns and verbs) to convey more complex ideas via signs, he used both object and handling signs (similar to pantomime gestures) to represent nouns and verbs, respectively. Similarly, the use of iconic signs to represent nouns is reported in Al-Sayyid Bedouin Sign Language[1] (ABSL; Sandler, Meir, Padden, & Aronoff, 2005). However, it has not been established if they use similar signs to represent verbs. Similar to the ABSL, Z sign language[2] uses describing signs to represent nouns. However, their signs to represent verbs are more pantomime in nature. Thus, a distinction in the form and representation of nouns and verbs is evidenced in sign language.

The noun-verb distinction of gestural language is similar to that of spoken language as well as sign language. Children and adults store nouns and verbs implicitly when encountering an unknown noun or verb (Brown, 1957). Nouns are stored based on their physical attributes, while verbs are stored based on their action properties (Nagy & Getner, 1990). In children with hearing impairment, with no access to a culturally shared linguistic system, gestures to indicate morphological or syntactic markings are represented distinctly and have shown a higher complexity for verbs than nouns (Goldinmeadow, Butcher, Mylander, & Dodge, 1994). Verbs being the major part of action language (signs and gestures), could be represented holistically. Furthermore, researchers have reported that gestures are subjected to semantic processes similar to that evoked by pictures and words (Wu & Coulson, 2005). Hence, the double dissociation between nouns and verbs observed in speech could also be reflected in gestures. Although the difference between noun and verb gestures is noted, specific differences in their encoding and decoding have not been sufficiently explored in the past.

Literature has shown sufficient evidence to demonstrate that gesture and speech integrate at various language processing levels. The majority of evidence has its roots in developmental and neurological domains of language. Nouns and verbs form the pivotal component of any language system. Further, the noun-verb distinction is established in verbal, sign, and gesture language systems in studies concerning children and adults. By and large, the gestural system mimics verbal language system and therefore, double dissociation between nouns and verbs could be looked for. However, evidence pertaining to gesture decoding abilities for nouns vs. verbs is minimal, and there is dearth of literature in child population. Therefore, the current study was planned to explore the gesture decoding abilities in TDC.

The aim of the study was to investigate the gesture identification for nouns and verbs in TDC. The specific objectives were to determine a) the number of correctly recognized noun and verb gestures in TDC of 3^{rd}, 4^{th} and 5^{th} grade with an age range of 8-8.11, 9-9.11 and 10-10.11 years respectively, and b)

[1] ABSL is a sign language that is in its developmental stage, from a prevailing sign language from a community in Bedouin that was found more than 200 years ago, in the Israeli borders.

[2] Z language is a sign language developed by a community of Zinacantán highland Chiapas, Mexico, called the Mayan. This community had no prior exposure to an established sign language.

the number of correctly recognized noun and verb gestures in children within each age group across the three grades.

METHODS

Participants

A total of 59 TDC[3] in the age range of 8-10.11 years (mean age: 9.45 years) recruited from regular school served as participants. They were studying either in 3^{rd}, 4^{th} or 5^{th} grade in a state syllabus school with English as the medium of instruction and were selected based on convenient sampling. All the participants were native speakers of Hindi language.

The participants were subgrouped on the basis of their grade, thereby yielding three subgroups. The subgroup of participants in 3rd grade (mean age: 8.42 years)[4] , 4th grade (mean age: 9.50 years) and 5th grade (mean age: 10.43 years)[4] included 21, 20 and 18 children respectively (See Appendix A for more details). All the participants were selected after seeking parental consent. The participants were free from any sensory, developmental, and neurological issues as per the screening performed using the WHO ten question disability checklist (Singhi, Kumar, Malhi, & Kumar, 2007). Further, the children's teachers and parents were enquired about their overall development and performance at school. Children performing at average and above average level in school and who were free from any developmental problems were considered. Gestures were not used as the primary mode of communication for the participants, and they were not exposed to any formal sign/gestural language in the past.

Materials

A total of 30 gesture videos from two grammatical classes of words (15 nouns and 15 verbs) were used as stimuli for the study. The gesture videos were initially developed for 36 words (18 nouns and 18 verbs). Age specific nouns and verbs were selected from a standardized set of 260 pictures (Snodgrass & Vanderwart, 1980). The nouns and verbs were selected such that they were present even in the Indian version (Ahmed, Murthy, Gargeshwari, & Nikitha, 2013) of the original source. A trained classical dancer with experience of 15 years in the field played the role of the actor in the study. The actor was given the word list and instructed to enact a simple and natural gesture to depict the given noun and the verb. These actions were video recorded using a high definition video camera in a least distractive environment with a white backdrop and artificial lighting. The gesture videos recorded were subjected to an appropriateness check by three judges who included two Speech Language Pathologists and a sign language teacher, each with an experience of 5 to 6 years in the field. The judges were asked to opine if the gestures matched the corresponding word (noun/verb) on a 3-point Likert scale (Very Appropriate, Appropriate, and Not appropriate). The judges opined that 30 stimuli (15 nouns and 15 verbs) out of 36 were appropriate based on which the final list was prepared. (see Appendix B for the final word list of the gesture stimuli).

Procedure

The gesture videos (15 nouns and 15 verbs) were presented one by one using an HP laptop (15.6 inches with 1366 x 768 resolution) kept at a comfortable distance from the participants. The investigator paced the rate of presentation according to the convenience of the participants. The participants were instructed to name the gesture seen in the videos in either Hindi or English (any language of their choice) at the end of the video in one word. The participants were shown the gesture videos for a maximum of 2 times in case of no response. A score of '1' was given for correct response, which included correctly identified noun or verb response, irrespective of the language used and without any self corrections. A score of '0' was given for incorrect response, which included 'no response' (not providing any response), 'semantic error' (a response which is related to the target in terms of its meaning) or 'irrelevant response' (a response which is not related to the target in any terms). The participants were not provided with any cues for retrieval of the words, and the task was not time bound. The maximum possible score for each participant was 30 (15 for nouns and 15 for verbs). The responses were tabulated separately for noun and verb gestures, and appropriate statistical analysis was performed.

Statistical Analyses

The data were subjected to appropriate statistical analysis using SPSS version 20. Mean, median, and standard deviation values were determined through descriptive analysis. Initially, the data was subjected to normality check using Shapiro Wilk's test of normality. The data did not abide by the properties of normal distribution; hence, appropriate non-parametric tests were used based on the objectives.

RESULTS

Identification scores of the 3^{rd}, 4^{th}, and 5^{th} grade TDC for noun and verb gestures were computed. The distribution of the median scores across correctly

[3] Though the study aims at TDC, the study population is recruited from three grades in the age range of 8-8.11, 9-9.11, 10-10.11 and the results are described and discussed accordingly.

[4] There was one child in 3rd grade who was 9.1 years and one child in 5th grade who was 9.11 years as exceptional cases. However, majority of the children satisfied the age split up of the sub-groups. The exceptional cases were considered within the 3rd and 5th grade respectively.

identified noun and verb gestures of the three grades of participants is represented in Table 1 and Figure 1.

Table 1: Median and Interquartile range of correctly identified noun and verb gestures across 3^{rd}, 4^{th} and 5^{th} grades of participants

Groups	Nouns		Verbs	
	Median	IQR	Median	IQR
3^{rd} grade	9	4	12	3
4^{th} grade	11	4	12	2
5^{th} grade	11	3	14	2

Note. IQR=Interquartile range

From Table 1, we can see that median scores are higher for verbs than nouns, and therefore, show that the identification was better for verb gestures compared to noun gestures in all the grades. Further, the interquartile range is higher for nouns as compared to verbs, which indicate that there was more discrepancy in identification of noun gestures than verb gestures. The median scores improved with increasing grades for both noun and verb gestures. This indicates that identification of noun and verb gestures was better in higher grades.

To address the study's first objective, a between-group analysis was performed using the Kruskal Wallis test. Later, a within-group analysis was performed using Wilcoxon's signed rank test, which satisfied the study's second objective.

A between-group analysis was performed to determine the difference in gesture identification across 3rd, 4th and 5th grades. Kruskal Wallis test was used for the purpose and significant differences in number of correctly recognized noun and verb gestures across the three grades were checked. The $\chi 2$ values obtained on comparison and the corresponding p-values are as shown in Table 2.

Table 2: Results of Kruskal Wallis test comparing noun and verb gesture identification scores across grades

Domain	$\chi 2$	*p* value
Noun gestures	1.82	0.272
Verb gestures	0.94	0.934

From Table 2, it is clear that there is no significant difference between the three grades of participants in gesture identification scores for nouns as well as verbs. Therefore, the performance did not vary across the grades and did not show any developmental trend in gesture identification.

A within-group analysis was done using Wilcoxon's signed rank test to compare between the identification scores for noun and verb gestures in children within each grade. Wilcoxon's signed rank test was run thrice (for each grade separately), and Z scores were obtained for all three grades. The Z scores and their corresponding p values are depicted in Table 3.

Table 3: Results of Wilcoxon's sign rank test for three grades of participants for noun and verb gesture identification scores

Groups	Wilcoxon's sign rank test (Z)
3^{rd} grade	3.16
4^{th} grade	2.98
5^{th} grade	2.93

From Table 3, it is evident that there is a significant difference between noun and verb gestures in each of the three grades. As the median scores for verbs were better than nouns across the three grades, it was inferred that identifying verb gestures were easier than identifying noun gestures at all grades.

DISCUSSION

Two objectives were addressed in the present study. The first objective was to determine if there is any difference in gesture identification across the three grades for nouns and verbs. The results showed that the performance did not differ across the grades based on median scores. As seen in verbal language, the developmental trend was not evident here; this could be attributed to the fact that TDC begin to rely more on verbal language by 2 years of age and beyond (Capone & McGregor, 2004). The participants in the current study were TDC, whose ages ranged between 8 and 10.11 years who need not rely on the non-verbal system, unlike children with hearing impairment. Literature has shown that, gestural use in toddlers with hearing impairment is generally on par with normal hearing counterparts. Further, in the case of children with hearing impairment, gestural ability did not depend on their auditory ability unlike the verbal language. Hence, their gestural ability is highly paralleled with the verbal language forms of hearing counterparts (Ambrose, 2016). On the contrary, the gestural language in TDC could be used either as complementary (information about the spoken message) or supplementary (additional information) to verbal language and not as an alternate (replacing) to it.

The second objective was to determine the noun-verb distinction of verbal language in gesture identification in TDC. The results revealed a significant difference in identifying the two grammatical class of words in gestures (noun vs. verb gestures). The verb gestures were identified better than the noun gestures by all the participants. The noun-verb distinction in gestures of children with hearing impairment was noted in TDC (Goldin-Meadow et al., 1994). The better performance on verb gesture identification could be attributed to the verb's direct association to its action, wherein the verbs are stored based on its action properties, unlike the nouns (Nagy & Getner, 1990). Literature has shown that it is easier to produce and understand highly imagery gestural verbs and iconic verbs (Rogers & Oborne, 1987).

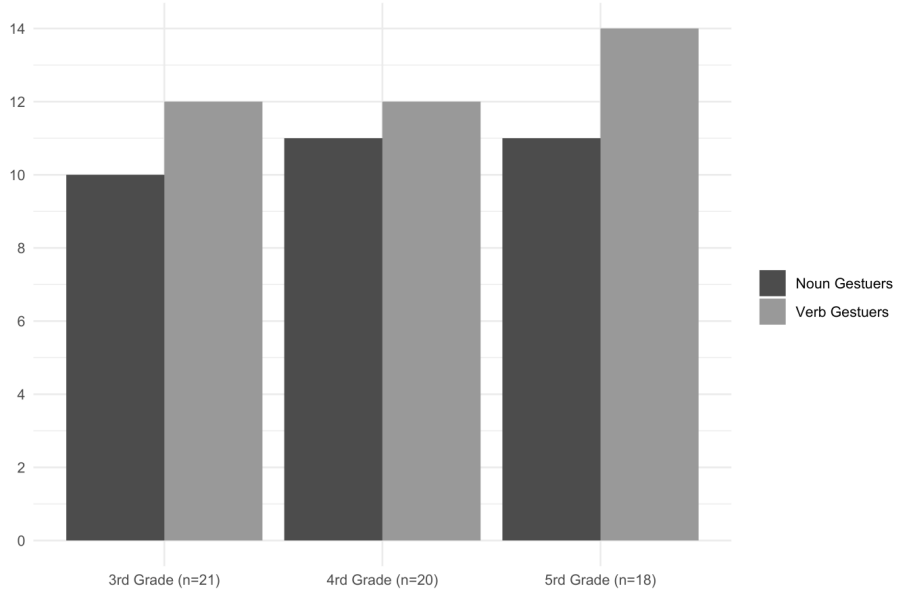

Figure 1: Bar plots representing median scores of correctly identified noun and verb gestures across 3^{rd}, 4^{th} and 5^{th} grade TDC.

Since verbs are direct descriptions of action, state, or occurrence, and the verb gestures used in the current study were majorly iconic in nature. However, nouns are stored based on their physical attributes (Nagy & Getner, 1990) and noun gestures are recognized based on a series of identifying gestures. A noun gesture is determined by a set of semantic features wherein some of the identifying features refer to its function, physical properties, or be abstract in nature (Padden, Hwang, Lepic, & Seegers, 2015). For instance, the gesture for 'basketball' was made by a series of movements of indicating the shape of the ball, bouncing the ball and dropping the ball into the basket. Noun gestures can also be arbitrary in nature, wherein, there is no relationship between the noun gesture and its meaning (Poggi, 2008; Ekman & Friesman, 1969). For instance, the gesture for 'fish' and 'train' are arbitrary in nature i.e., gesture for fish was made by placing the palm of one hand on the back of the other hand and then wiggling the fingers while the gesture for train involved placing the stretched palm close to the mouth with protrusion of lips in rounded position. However, verb gestures were more explicit and iconic, and had a direct association with the meaning or action of the verb. Therefore, the nature of the noun and verb gestures could have resulted in better identification of the verb gestures compared to the noun gestures. Thus, the current study highlighted the dissociation in the identification of noun and verb gestures in TDC.

CONCLUSIONS

The study was carried out to investigate the identification of noun and verb gestures in TDC. The results revealed no difference in gesture identification across the grades; however, verb gestures were identified better than noun gestures. Therefore, a noun-verb distinction in gesture identification was noted and attributed to the very nature of the noun and verb gestures. The study was carried out using less number of participants (59 TDC) and reduced number of stimuli (30 stimuli) from two grammatical classes (nouns and verbs). Further, the study used all or none (0 or 1) scoring pattern which failed to represent the varied responses of the participants. Future studies with greater number of stimuli, stimuli from different grammatical classes, elaborate scoring pattern and with more number of participants would be beneficial.

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Appendix A: *Participant Details*

Sl no.	Age	Class	Gender
1.	8.4	3rd	Male
2	8.7	3rd	Female
3	8.3	3rd	Male
4	8.3	3rd	Male
5	8.7	3rd	Male
6	9.1	3rd	Male
7	8.4	3rd	Male
8	8.4	3rd	Female
9	8.6	3rd	Female
10	8.2	3rd	Female
11	8.4	3rd	Female
12	8.3	3rd	Male
13	8.5	3rd	Female
14	8.5	3rd	Male
15	8.0	3rd	Male
16	8.2	3rd	Female
17	8.8	3rd	Male
18	8.5	3rd	Male
19	8.3	3rd	Female
20	8.2	3rd	Male
21	8.4	3rd	Male
22	9.2	4th	Male
23	9.5	4th	Male
24	9.1	4th	Male
25	9.7	4th	Female
26	9.3	4th	Male
27	9.3	4th	Female
28	9.4	4th	Male
29	9.7	4th	Male
30	9.11	4th	Male
31	9.4	4th	Male
32	9.3	4th	Male
33	9.6	4th	Female
34	9.6	4th	Female
35	9.7	4th	Male
36	9.5	4th	Male
37	9.8	4th	Male
38	9.9	4th	Female
39	9.4	4th	Male
40	9.6	4th	Male
41	9.8	4th	Female
42	10.4	5th	Male
43	10.6	5th	Female
44	10.3	5th	Female
45	10.7	5th	Male
46	10.8	5th	Male
47	10.6	5th	Male
48	10.3	5th	Female
49	10.7	5th	Female
50	10.6	5th	Male
51	10.6	5th	Male
52	10.4	5th	Male
53	10.9	5th	Male
54	10.11	5th	Male
55	10.5	5th	Male
56	10.2	5th	Female
57	10.6	5th	Male
58	9.11	5th	Male
59	10.4	5th	Female

Appendix B: *List of noun and verb gesture stimuli used for the study*

	List of Noun Gestures	**List of Verb Gestures**
1	Baby	Blow
2	Elephant	Cry
3	Hand	Eat
4	Music	Drink
5	Eye	Diving
6	Beard	Call
7	Home	Run
8	Book	See
9	Train	Sit
10	Fish	Smell
11	Ring	Talk
12	Airplane	Think
13	Arrow	Write
14	Bangle	Jump
15	Basketball	Driving