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Gesture Identification Abilities for Nouns and Verbs in Typically Developing Children

Abstract

The relationship between gesture and verbal language was explored in terms of gesture identification. A noun-verb distinction is well evidenced across various language systems and therefore a set of noun and verb gestures were considered for gesture identification task. Typical developing children (TDC) of 3rd, 4th and 5th grade with an age range of 7-13 years served as participants for the study. The participants were presented with 15 noun and 15 verb gestures and were instructed to name them. The scores were tabulated across nouns and verbs for the three groups of participants. A between group analyses was performed using Kruskal Wallis test for noun and for verb gestures; which revealed no difference in gesture identification scores across the groups. Therefore, did not show a developmental trend in gesture identification ability in the population considered. Wilcoxon's signed rank test was performed as within group analysis; this revealed a significant difference in identification of noun vs. verb gestures in the groups. Further, it was inferred that the verb gestures were identified better in comparison to the noun gestures within each group based on the scores. Therefore, the results highlight the noun-verb distinction of gesture decoding in TDC.

Keywords:Non-verbal communication, Decoding, Grammatical class

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 immediate, visual, holistic form of communication while speech to be graded, auditory, systematicin nature.Gesture, speech and language show tight developmental and neurologicalassociation (Bates & Dick, 2002).

Development of both, gesture and speech takes place simultaneously in typically developing children (TDC). Ejiri and Masataka (2001) reported simultaneous production of canonical babbling with rhythmic hand movements in infants of 6 to 8 months of age. A child develops deictic gestures for intentional communication at 8-10 months of age (Bates & Snyder, 1987; Bretherton &Bates 1979) which is followed by use of his first word. By 18-20 months of age, gesture-word and gesture-gesture combinations for communication are noted (Bretherton & Bates 1979; Caselli, 1990; Volterra et al., 1979) while the word combinations are beginning in the verbal language. At 2 years of age, children show preference for verbal language but the gestures still continue to scaffold theircomplex 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 strong neural overlap in prominent language processing areas such as inferior frontal cortex and Broadman's Area number 45 (Moll et al., 2000). Further, premotor cortex plays an important role in semantic processing of action language (Aziz-Zadeh et al., 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 et al., 2007).Thus, gestures are incorporated in various components of language and show overlap with some parts of language system especially with speech.

Thislink between gesture and speech is explained effectively by the gestural 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 considers gesture and speech to be housed in a single integrated system,wherein the processing happen at the pre-lexical level. The Lexical retrieval model on the other hand (Krauss et al., 2000)postulates that speech and gesture are a part of separate independent systems and the processing is assumed to operate at the post lexical level.

Therefore, the gesture processing modelsfurther support the gesture-speech interaction at various levels of language processing.

Further,clinical evidences 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 et al., 2011). Therefore, gestures and speech are thought to share an integrated system either through mutual or obligatory interactions (Kelly et al., 2010).

A language in general would comprise of two major word classes: Nouns and Verbs. Nouns identify a person, place, idea or thing which is an important part of one's utterances and form the content words in communication. Verbs identify actions, processes, state or a relation which form the major part of the sentence, i.e. the predicate, and help in understanding the meaning of the sentence and is extensively used in everyday conversation.The neural representation of nouns are localised 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 et al., 2019). The noun-verb distinction as evidenced in the functional aspects of the sentence and neural correlate is also seen in terms of their lexical semantic representation of the brain.Nouns are usually acquired first during development and also affected first in case word finding difficulties in an individual (Marshall, 2003). Further it is seen that iindividuals exhibit better speed and accuracy in naming nouns as compared to verbs (Matzig et al., 2009). Thus, thedifference in the neural organization of word classes in the mental lexicon is noticed.This further suggests a marked distinction in nouns and verbs is established in verbal language.

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, over a period of two years. The child being hearing impaired, born to normal hearing parentslearned homesignsduring his developmental years. Around 3.5 years of age, David used *object*gestures (that are similar to iconic gestures) to represent nouns.Later when David started to combine forms to convey more complex ideas via gestures, he used both *object* and *handling* gestures (that are similar to pantomime gestures) to represent nouns and verbs respectively. Similarly, use of iconic gestures to represent nouns is reported in [1]Al-Sayyid Bedouin Sign Language (ABSL; Sandler et al., 2005). However, it has not been established if they use similar gestures to represent verbs. Similar to the ABSL, [2]Z sign language uses describing gestures to represent nouns. However, their gestures to represent verbs are more pantomime in nature. Thus a distinction in the form and representation of nouns and verbs are evidenced in sign language.

The noun-verb distinction is also found in gestural language similar to that of spoken language as well as sign language. Children and adults store nouns and verbs in an implicit way when they encounter an unfamiliar noun or verb (Brown, 1957). Nouns are stored based on its physical attributes while verbs are stored based onits action properties (Nagy & Getner, 1990).In deaf children with no access to culturally shared linguistic system, gestures to indicate morphological or syntactic markings are represented distinctly and have shown a higher complexity of gestures for verbs than nouns (Goldinmeadow et al., 1994). Verbs being the major part of action language (signs and gestures) could be represented holistically. Furthermore, authors have reported that gestures are subjected to similar semantic process as 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. Though, difference in the gestures for nouns and verbs has been observed, specific differences in encoding and decoding of gestures for nouns and verbs have not been sufficiently explored in the past.

Need for the study: Literature has shown redundant evidence to demonstrate that gesture and speech integrate at various levels of language processing. The majority of evidence has its roots from developmental and neurological domains of language. Nouns and verbs form the pivotal component of any language system. However, noun-verb distinction is established in verbal, sign and gesture language systems in studies with respect to children and adults. By large the gestural system mimics verbal language system and the double dissociation between the 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 children specifically. Therefore, the current studywas planned to explore the gesture decoding abilities in children with normal language development.

Aim of the study: To investigate the gesture identification abilities for nouns and verbs in typically developing children (TDC).

Objectives

To compare the number of correctly recognized noun and verb gesturesin children across 3rd, 4th and 5th grade.

To compare the number of correctly recognized between noun and verb gestures in children within each group.

Method

Participant details

A total of 59 Typically Developing Children (TDC)served as participants. The participants wereselected based on convenient sampling. The participants were studying either in 3rd, 4thor 5thgrade in a state syllabus school with native language as Hindi. The age of the participants ranged from 7 to 13 years with mean age of 10.3 years. Children above 6

years were selected with the intent that the language development would have been complete by then.

The sub-grouping of participants wasmade based on their grade which yielded three groups. The sub-groups had 21 children in 3rd grade, 20 children in 4th grade and 18 children in 5th grade. Gesture naming task was administered on the participants after screening for any sensory, developmental and neurological issues. All the participants were selectedafter seeking parental consent. The participants were free of any of the sensory, developmental and neurological issues.

Materials

A total of 30 gesture videos (15 nouns and 15 verbs) were used as stimuli for the study. The gesture videos were initially developed for 37 words (18 nouns and 18 verbs). Age specific nouns and verbs were selected from a standardized set of 260 picture (Snodgrass & Vanderwart, 1980)source. The nouns and verbs were given to a trained classical dancer with an experience of 15 years in the field and the actor was instructed to enact a simple and natural gesture for them. These actions were video recorded using a high definition video camera in a least distractive environment in a white backdrop with artificial lighting. The gesture videos recorded were subjected to a validity check by 3 judges who included 2 SLP's and sign language teacher each with an experience of 5 to 6 years in the field. The judges were asked to opineif the gestures matched the given word on a 3-point likert's scale (Very Appropriate, Appropriate and Not appropriate). The judges opined that 30 stimuli (15 nouns and 15 verbs) out of 37stimuliwere appropriate and thefinal list was prepared by using them (see *Appendix A* for the final word list and *Appendix B* for an example each of a noun and verb gestures)

Procedure

The gesture videos (15 nouns and 15 verbs) were presented one by one using a HP laptop (15.6 inches with 1366 x 768 resolution) kept at a comfortable distance. The rate and order of presentation of the gesture videos were controlled and counterbalanced between the participants. The participants were instructed to name the noun and verb gesture videosat the end of the each video completion in one word. The participants were shown the gesture videos for a maximum of 2 times in case of no response. A scoring of either 1 or 0 was given for correct and incorrect response (including no response, irrelevant response) respectively, yielding a maximum score of 30 (15 for nouns and 15 for verbs).The participants were not provided with any cues for retrieval of the words. The task was not time bound and the responses were tabulated separately for noun and verb gestures. Appropriate statistical analysis was performed to reach at the results.

Results

The scores for the 3rd, 4th and 5th grade TDC across nounand verb gestures were computed. The noun gestures elicitedamean scores 9.91, 11 and 11.17 respectively for the three groups of participants. The mean scores for verb gestures were 11.91, 12.25 and 14 mean scores respectivelyfor the three groups of participants. Figure 1 represents the distribution of the mean scores across of correctly identified noun and verb gestures of the three grades of participants considered. From the distribution of the responses one can infer that the gesture identification abilities were better for verb gestures in comparison to noun gestures in all the groups and the performance improved with age.

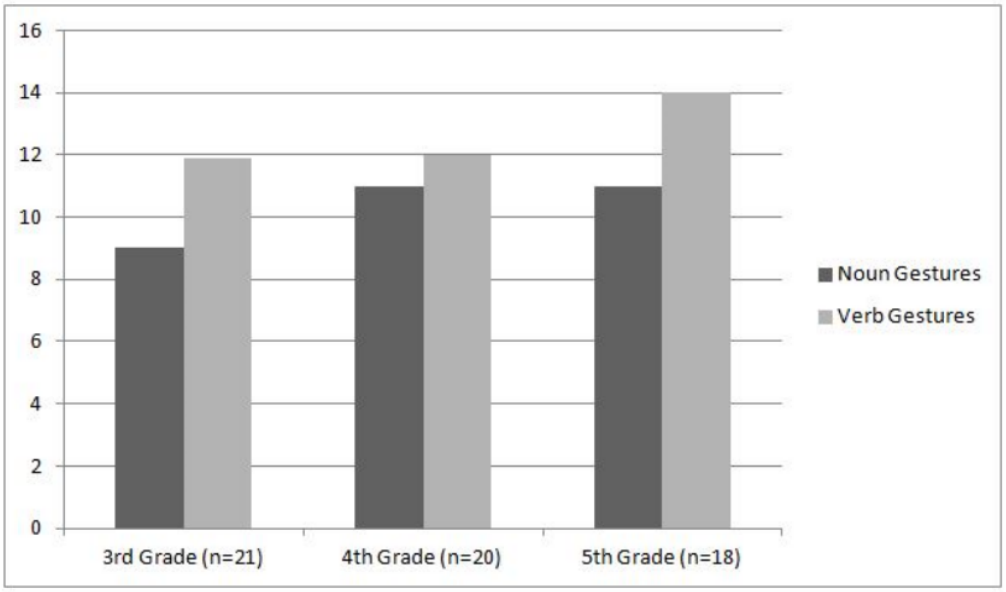

Figure 1: Bar plots representing median scores of correctly identified noun and verb gestures across 3rd, 4th and 5th grade TDC.

Themedian scores were also computed for nouns and verbs. For the noun gestures median scores of 9, 11 and 11 was obtained while the median scores for verbs were 12, 12 and 14 across the groups. The median scores also followed the same direction as that of the mean values. Further statistical analysis was carried to verify if there was any significant difference between the three groups. The data was subjected to the test of normality using Shapiro Wilk's test and the results suggested that the data was non-normal ($p<0.05$). Kruskal Wallis test was chosen as there were three groups. The $\chi 2$ obtained on comparison was 1.82 and 0.94 for noun and for verb gestures respectively. The corresponding p value showed no significant difference between the groups; therefore the performance on gesture identification did not vary across the three groups of participants considered.

Further, to verify if there was any significant difference across noun and verb gesture identification, Wilcoxon's signed rank was performed as the data followed non-normal

distribution. Wilcoxon's signed rank test was run thrice (for each grades separately) and Z scores of 3.16, 2.98 and 2.93($p<0.05$ $r=0.64$, $r=0.56$ and $r= 0.55$) showed significant difference across noun and verb gestures for all three groups.As the median scores for verbs were better than nouns for all the three groups, it was inferred that the decoding of verb gestures wereeasier than decoding noun gestures.Additionally, qualitative analysis was carried out on the errors revealed few findings. Semantically related errors were more for both noun and verb gestures majority of the time. The participants gave different labels for the same target stimuli in case of noun gestures; therefore showing discrepancy in markers for identification of nouns gestures. The item 'elephant' was difficult for most of the participants followed by the item 'arrow', the item arrow was infrequent while elephant was frequent. This showed that the frequency of the items did not have a direct implication on performance. The frequency of usage had significance for verb gestures. The frequent items were identified and named easily. However, the error analysis for the verb gestures showed that the participants erred on one particular item 'diving' most of the time. And also there was confusion between few items like yawning and sleeping but items like cry,eat, jump were recognised easily by all participants. There were also occasions wherein the participants named nouns instead of verbs resulting in reduced scores. It was also noticed that the time taken to identify noun gestures were more compared to verb gestures, despite any specific measurements made.

Discussion

Two objectives were addressed in the present study. The first objective was to determine if there exists any difference in gesture identification abilities across the three groups of participants. The results showed that the performance did not differ across the participant groups significantly though the groups differed in their age. The developmental trend as seen in verbal language was not evidenced 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 age ranged between 7-13 years who need not rely on non-verbal system unlike hearing impaired counterparts. Gestural use in toddlers with hearing impairment has been in par normal hearing counterparts. Further, gestural language in TDC could be used either as complimentary (information about the spoken message) or supplementary (additional information) to verbal language and not as an alternate (replacing) to it. However, in case of children with hearing impairment, gestural ability did not depend on their auditory ability like the verbal language did. Hence, their gestural ability highly paralleled with the verbal language forms of the hearing counterparts (Ambrose, 2016). Therefore we could infer that TDC use gestural input to enhance cognitive skills rather than a direct profit to verbal language decoding with increasing age, though this is too immature to speculate with this study and with no direct studies in the past with such an objective to the best of the knowledge of the authors.

The second objective was to determine the noun-verb distinction of verbal language in case of gesture identification in TDC. The results revealed a significantly difference in identification of nouns vs. Verbs. All the participants better identified verb gestures in comparison to the noun gestures. The noun-verb distinction evidenced in the major word classes (i.e., nouns and verbs) of hearing impaired children (Goldin-Meadow et al., 1994) was noted in TDC.The better performance on verb gesture identification could be attributed to the fact that direct associate of verb to its action; wherein the verbs are stored based on its action properties unlike the nouns (Nagy & Getner, 1990).It is noted that it is easier to produce and understand highly imagery verbs and iconic verbs (Rogers & Oborne, 1987). And it is true since verbs are direct description of action, state or occurrence and also the verb gestures used in the current study was majorly iconic in nature. However, the nouns are stored based on their physical attributes (Nagy & Getner, 1990) and are recognized based on a series of

identifying gestures. Further, a noun is multi-dimensional in nature and the gesture for a noun could be dynamic in nature (Sassure, 1916). However, a noun in verbal language language is unidirectional in nature and identifies the referent in a sentence (Antinucci &Parisi, 1973). A noun gesture is identified by a set of semantic features wherein some of the identifying features could be either refer to its function, physical properties or could also be abstract in nature (Padden et al., 2015). Few noun gestures were arbitrary in nature wherein there was no relationship between the noun gesture and its meaning(Poggi, 2008; Ekman & Friesman, 1969). The gesture for few nouns such as *fish* and *train* were arbitrary in nature i.e., gesture for fish was done by placing the palm of onehand 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. Arbitrary gestures are also typical ofculture and its learning is achieved by associating the form to itsshared meaning (Ekman, 2004; Ekman & Friesen, 1969; Gullberg, 2006; Haviland,2005). Therefore, arbitrary gestures areprone to cultural influence and can take different meanings in different cultures (Agostini et al., 2018). However, verb gestures were more explicit and iconic in nature which had a direct associate to the meaning or action of the verb. Therefore could have resulted in better identification of the verb gestures in comparison to the noun gestures. Thus the current study highlighted the noun-verb distinction in gesture identification in TDC.

Conclusions

The study was carried out with the aim to investigate the gesture identification abilities of noun and verb gestures in TDC. Children studying in 3rd, 4th and 5th grade with ages ranging between 7-13 years served as participants with mean age of the being 10.3 years. Gesture naming task was administered on the participants comprising of 15 noun and 15 verb gestures as stimuli. A between group analysis was performed to compare the number of correctly recognized noun and verb gestures in children across 3rd, 4th and 5th grade. This

revealed no significant difference across the groups in gesture identification. Further, a within group analysis was performed to compare the number of correctly recognized across the grammatical class of gesture stimuli. This revealed a significant difference in identification of noun and verb gestures in each of the groups. All the participants could name the verb gestures better than the noun gestures. Thus, a noun-verb distinction in gesture identification was evidenced in the current study.

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Author Contributions

Mehulla Jain, Ankit Anand and Deepshikha Kujur were responsible for data collection and drafting the manuscript. Nikitha M guided throughout the development of the study and the manuscript and also contributed towards the discussion and editing of the manuscript.Abhishek B P guided and supervised the entire process and also was responsible for editing and proof reading of the manuscript.

Conflicting of Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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Appendix A

List of noun and verb gesture stimulus used for the study

Sl. no	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

Appendix B

Example screenshots of noun and verb gesture video stimuli

Figure 2: Screenshot of noun gesture video depicting 'baby'

Figure 3: Screenshot of verb gesture video depicting 'cry'

Footnotes (To be inserted in page no. 4)

[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.

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