Portrayal of Higher Order Semantics in Subcortical Lesion

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ABSTRACT

Higher order semantics pertains to a person's ability to develop an advanced vocabulary, understand word relationships, paraphrasing, reasoning, and developing the ability to look at things from another individual's perspective. It has been proposed for some time that subcortical structures, including basal ganglia, thalamus, caudate nucleus, play an important role in the higher order semantic functions. Our study aimed at analyzing how higher order semantics are influenced by subcortical lesion. For this purpose, five semantic domains namely polar questions, semantic anomaly, syntagmatic relation, homonymy and figurative language were selected and assessed using a newly developed evaluation tool. This tool was administered on 30 participants with subcortical lesion without any aphasic component. Our results revealed that individual's with subcortical lesion performed subpar in all the domains suggesting that pathologies of subcortex can inhibit the activation of semantic skills. Further, within the higher order semantic skills, we identified that homonym and figurative language was significantly impaired followed by syntagmatic relation, semantic anomaly and polar questions. From this we can substantiate that along with cortical structures subcortex also have an inevitable role in semantic processing.

Keywords: *Higher order semantics, cognition, subcortical lesion, Basal ganglia, Homonym, Figurative language.*

INTRODUCTION

Metalinguistic awareness is defined as the ability to distance oneself from the content of speech in order to reflect upon and manipulate the structure of language (Chen, Ramirez, Luo, Geva & Ku 2012). Higher order semantics which refers to a person's conscious ability to recognize the meaning of words within the context of interaction (Gombert, 1992), is considered as one of the major metalinguistic ability. This ability reflects on the meaning of words (Graves & Watts -Taffe, 2008; Scott & Naggy, 2004). Higher order semantic (Metasemantics) processing is important to determine the right sense or meaning of words in the context of a sentence. These skills are essential to resolve the ambiguity like in case of ambiguous words that have the same form but more than one meaning. Tasks like semantic anomaly, figurative language, homonyms etc. can elicit metasemantic abilities. Figurative language includes sentences or phrases that do not have a literal meaning. Figurative language of one or the other type is used in everyday conversation thereby playing an important role in efficient communication. Figurative language forms are metaphor, idiom, simile, alliteration, personification, hyperbole, clichés and onomatopoeia. These language forms are not interpreted literally but rather involve symbolism that goes beyond the literal meaning of their constituent words (Papagno, 2001). Gibbs (1992) described idioms as strings of words whose meaning

cannot be derived from the analysis of the words' typical meaning and claims that idioms have complex figurative interpretations that are not arbitrarily determined. Similarly the comprehension of metaphor requires non-literal interpretation that extends beyond first-order lexical processing. Subcortex plays a vital role in the higher language processing, as it function as one of the primary cognitive centers. Higher order processing requires active participation of various cognitive faculties like attention, working memory, executive functions etc. Hence, it can be theorized that these areas could be held responsible for modulating the higher order language processing which includes the metasemantics as well. Recently studies are being conducted to prove this theory. Ketteler, Kastrau, Vohn and Huber (2008) studied neurofunctional representations of ambiguity processing by using functional magnetic resonance imaging (fMRI) in twelve right-handed, healthy adults aged between 21 and 29 years. An ambiguity resolution task with 4 different conditions (dominant vs. nondominant; dominant vs. distractor; non-dominant vs. distractor; distractor vs. distractor) was given. He identified significant activation especially in the thalamus and some parts of the basal ganglia(caudate nucleus,putamen).Hence the findings implicated the participation of the thalamus and other basal ganglia circuits in high level linguistic functions. Wahl, Marzinzik, Friederici, Hahne, Kupsch, et.al (2008) in his study insisted that the human thalamus systematically reacts to syntactic and semantic parameters of auditorily presented language in a temporally interleaved manner in coordination with cortical regions using simultaneous EEG recordings directly from deep brain structures and the scalp. With this he postulated that syntactic and semantic language analysis is primarily realized within cortico-thalamic networks. Ketteler (2014) observed that patients with disturbed basal ganglia function such as Parkinson′s disease showed development of discourse

comprehension deficits evoked by lexical ambiguity.

Functional Magnetic Resonance Imaging was done to investigate the participation of cortico-subcortical networks during ambiguity resolution. Participants were asked to relate meanings to a lexically ambiguous target (homonym). Less activity was observed in the left caudate which was associated with semantic integration deficits in Parkinson's disease. The results henceforth implied a relationship between subtle language deficits and early stages of basal ganglia dysfunction. Uchiyama, Saito, Tanabe, Harada and Seki et. al (2012) also substantiated that head of caudate was activated during the processing of metaphor whereas sarcasm activated amygdala.

Aim

To analyze the higher order semantics in individuals with subcortical lesion.

METHOD
Participants

30 native right handed Malayalam speaking non-aphasic individuals with subcortical lesion without any premorbid history of brain injury or/and psychological issues, education level of minimum 10th standard, and with normal/corrected vision and hearing were selected for the study. The participants were confirmed for the absence of any cortical lesion and/ or atrophic changes based on neuroimaging findings. WAB (Philip, 1992) was administered to confirm the absence of aphasia in the selected participants.

Procedure

The study was carried out in two phase:
Phase 1-development of assessment material
Phase 2-test administration

Development of assessment material

The primary aim was to develop a material in Malayalam to assess the Metasemantic abilities in adults. This was based on the detailed review of literature, information from Clinical Evaluation of Language Fundamentals (Semel, Wiig & Secord, 1995), semantic section of Linguistic Profile Test in Malayalam

(Asha,1997) and The Right Hemisphere Language Battery For Adult In Malayalam (Ahamed, 1998). Developed material contained 5 domains namely polar question, semantic anomaly, syntagmatic relation, homonym and figurative language. Under figurative language there were 3 subtests - hyperbole, idioms, and metaphor. The developed material was given to three Malayalam high school teachers and 10 speech pathologists to evaluate its appropriateness. A three point rating scale was used- "inappropriate, appropriate and highly appropriate". 10 items marked as "highly appropriate" were selected under polar question, semantic anomaly, syntagmatic relation and 5 items under homonymy and 5 items each under figurative speech. A pilot study was carried out on ten neurotypical adults from each age group to check the appropriateness of the material. It was found that selected items could elicit the metasemantic skills. Following are the domains selected for the study. Full test is available as Appendix I

Domain 1: Polar Questions
Polar question is a question whose expected answer is either "yes" or "no". This section consists of 10 such questions.
Scoring: one mark was given to each correct answer.

Domain 2: Semantic anomaly
This domain consists of sentences that violate semantic rules to create meaningless sentences along with meaningful sentences. There are 5 semantic anomalous sentence and 5 meaningful sentences. Instruction: participant has to say yes for semantically correct sentences and no for semantically incorrect sentences
Scoring: one mark was given to each correct answer.

Domain 3: Syntagmatic relation
Syntagmatic relation refers to a type of semantic relation between words that co-occur in the same sentence or text. This section consists of 10 items with two options (one correct and one incorrect) to choose for each item. Instruction: The individual can either point to or say the correct answer from the options provided.
Scoring: One mark was given to each correct answer and zero for incorrect answer.

Domain 4: homonyms
Homonyms are two or more words having same spelling or pronunciation but with different meanings. This section consists of 5 items with three options to choose for each item. Instructions: The individual can either point to or say the correct answer from the options provided.
Scoring: One mark was given to each correct answer and zero for incorrect answer.

Domain 5: Figurative language
A figurative language uses a word or phrase that does not have its normal every day, literal meaning Under this domain, there were 3 subtests-hyperboles, idioms, metaphor comprehension. Hyperboles are exaggerated statements that are not meant to be taken literally. Idioms are group of words in a fixed order that have a particular meaning which is different from meanings of each word on its own. Metaphors are phrases that are applied to an object or action to which it is not literally applicable. Each subtest contains five questions with three options for each.
Scoring: One mark was given to each correct answer and zero for incorrect answer.

Procedure: The participants were informed about the purpose and nature of the assessment prior to testing. The participants were seated in a quiet and comfortable room. The clinician initially made rapport and appropriately instructed the participant before the administration of the test.
SCORING: A two point rating scale was used with a score of one for correct response and a score of zero for incorrect response.

RESULTS
Table 1 records the mean and standard deviation of individuals with subcortical lesion for each domain

Table 1 *Mean and standard deviation of different metasemantic domains in individuals with subcortical lesion*

DOMAIN	N	Mean	SD
1	30	8.7667	1.25075
2	30	8.5333	1.07425
3	30	6.9333	1.63861
4	30	1.5000	1.16708
5	30	1.6556	0. .97668

From the above table 1, it is evident that the least affected domain being the polar question and semantic anomaly. The most affected domains are homonymy and figurative language. The poorer performance on all the domains can be linked with the pathological conditions of subcortical structures which are integral part of complex neural processing of higher semantic skills.

DISCUSSION

Domain 4 i.e. homonym required the participants to choose the two most appropriate meaning of the target word from a choice of two related and one unrelated word. Ambiguity of homonyms required extra cognitive demands. Participants with subcortical lesions were able to choose only one correct meaning instead of two from the choice of three which evidenced their inefficiency in manipulating semantic concepts. This can be attributed to the fact that basal ganglia, thalamus and internal capsule are involved in retrieving words from pre-existing lexical store which is essential for performing high level linguistic task like homonym. So any disruption in the functioning of this system can hamper their performance. Furthermore to carry out this task accurately, semantic memory, controlled semantic retrieval, semantic association judgment, semantic maintenance and executive function are essential. Neurological underpinnings sub serving these abilities are anterior ventrolateral prefrontal cortex and left inferior prefrontal cortex, left middle temporal gyrus and bilateral inferior frontal gyrus. Subcortical structures like basal ganglia and thalamus have strong reciprocal connections to these regions. Hence any disruptions to these structures will have adverse effect on performance. Participants in the study had lesion in capsulo-ganglionic region, basal ganglia structures and thalamus. Above findings gain support from the study of Ketteler, Kastraub, Vohnc, and Huberd (2007).

The domain figurative language had three sub domains that include idioms, hyperbole, and metaphors. Comparatively better performance was observed in the subdomain-hyperbole which are often used in everyday conversation and takes the advantage of familiarity Poorer score in other figurative language subdomains can be explained on the grounds that figurative language operates not only on the level of language as a framing device but also at the conceptual level as reasoning device. It is characterized by the ability to process language beyond the literal interpretation of individual words. The competency for interpretation relies both on inferencing skills and on the ability to integrate contextual information from both verbal and nonverbal sources. Metaphor analysis is a property of language centers of brain and involves the manipulation of mental imagery in order to allow a concrete mental representation to stand for more abstract representations. It puts heavier demands on cognitive linguistic processing and requires additional effort for alignment and inference.

Inferential skills play a significant role in accessing the appropriate intended meaning and involves mapping between elements in a distantly related mental domains. It also requires retrieving information from memory and high abstract thinking.

The metasemantic domain, idioms are stored as lexical items in the brain .To interpret the meaning of idioms, two process are involved, retrieval process and literal composition computation process. Processing and understanding idioms cannot be reduced to lexical access or lexical retrieval only. The initial stage of idiom processing includes accessing the literal meaning and then selecting the relevant

properties of presented sentences and further inhibiting aspects which are not relevant through a process of constant updating. Reason for obtaining lower scores in this domain can be accredited to the participant's inability to inhibit the literal meaning and interpreting the non literal meaning and the inability to revise the concept of literal meaning which is the major impact of subcortical lesion. Besides language, cognition plays a crucial role in processing and interpretation of figurative language. Left inferior frontal gyrus in conjunction with subcortical structures governs figurative language function. Hence it can be concluded that any disturbance in these connections can result in poor performance. The results of the present study confirm with the findings of Copland (2003) investigated the impact of basal ganglia dysfunction on semantic processing and reported that circumscribed deficit in the selective attentional engagement of the semantic network on the basis of meaning frequency, possibly implicating a disturbance of frontal–subcortical systems influencing inhibitory semantic mechanism.

CONCLUSION

The analysis of effect of subcortical lesion on each metasemantic domains disclosed that the poorer performance on the domains homonym and figurative language whereas better performance in polar questions and semantic anomaly, can be linked with the pathological condition of subcortical structures which are integral part of complex neural processing of higher semantic skills. Subcortical structures like basal ganglia, thalamus and internal capsule are involved in retrieving words from pre-existing lexical store, semantic verification and , executive function which are essential for performing high level linguistic task like homonym. So any disruption in the functioning of this system can hamper the performance. Besides language, cognition plays a crucial role in processing and interpretation of figurative language. Left inferior frontal gyrus in conjunction with

subcortical structures governs figurative language function. Hence it can be concluded that any disturbance in these connections can result in poor performance.

To perform syntagmatic relation, one should have adequate semantic knowledge of words, familiarity of words, lexical restructuring and salient skill being free word association. It encompasses the direct incorporation of word association into semantic network which involves the active participation of cortical structures along with subcortical structures. Limited functioning of these structures resulting from pathological condition could be the reason for reduced performance. Person should be able to process individual words and integrates its meaning by making association with its attributes in the semantic anomaly domain. The reduced scores in this domain can be ascribed to the affected semantic memory and executive functions for making judgment of relation between word and referent and integration to semantic system. Significantly better performance was obtained for polar questions which can be attributed to the fact that this task put less taxing for cognitive system.

Conflict of interest
There are no conflicts of interest for the study.

Ethical consideration
The study has followed all the ethical standards of the research. Informed consent was obtained from all the participants while ensuring their confidentiality and anonymity. The research was conducted independently and impartially with approval of ethical committee of Kerala University of health sciences.

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