

MEASUREMENT OF REACTION TIME FOR PROCESSING OF CONCRETE AND ABSTRACT WORDS

¹Sampath Kumar Lagishetti, & ²Goswami S. P.

Abstract

Concreteness is a phenomenon which refers to the linguistic stimuli to indicate concrete concepts generally show an advantage over abstract concepts. Dual-coding theory is a classical explanation for concreteness effect (Paivio, 1971, 1986). The aim of the study was to measure the reaction time (Judgment task) in processing abstract and concrete words and to find out the gender differences if any. Twenty young adults within the age range of 18-25 years (10 males and 10 females) were considered in this study. Stimuli used were abstract and concrete words and total of 100 words were taken from various resources and was given for rating to twenty speech language pathologist and asked them to rate on 3 point rating scale. Out of which 50 words in each category were considered for experiment. Stimuli were audio recorded by a native Kannada adult female speaker and the recorded stimuli were normalized. Separate program was done loaded in DMDX and the stimulus was presented through Headphones and all the participants were asked to judge the type of word. Mixed analysis of variance repeated measures analysis of variance was done for comparison between abstract and concrete words and gender differences. The results of the present study revealed that there were faster reaction times for concrete words compared to abstract words and no gender differences were observed. Conclusion of the study explains that concreteness is an important variable in differentiating the processing abstract and concrete words.

Key words: Dual coding theory, Neuro typical, Stimuli, Behavior, Response

Concreteness effect is a phenomenon that has been broadly reported in the memory and verbal learning literature. It refers to the ability of the linguistic stimuli to indicate concrete concepts which e.g., “book” generally show a performance advantage over abstract concepts e.g., “sad” (Tolentino, & Tokowicz, 2009). This finding has been demonstrated in a variety of tasks including lexical decision (James, 1975; Schwanenflugel, & Shoben, 1983). The term concreteness effect refers to the observation that concrete nouns are processed faster and more accurately than abstract nouns in a variety of cognitive tasks (Jessen, Heun, Erb, Granath, Klose, Papassotiropoulos, & Grodd, 2000).

The classical explanation for the concreteness effect comes from Paivio's (1971 & 1986) dual coding theory which states that there are systems for functionally and structurally distinct representational systems, an imagery system specific for the depiction and processing of nonverbal stimuli, and verbal system specific for the handling of linguistic stimuli. According to this theory, a variant of the several semantic-systems views- verbal “linguistic” semantic system and a nonverbal “imagistic” semantic system were associated and responsible in processing of concrete words, whereas the linguistic system is responsible for abstract words. Concrete words

have advantages over abstract words as they are linked with information stored in both systems. For example, participants are able to recognize “book” faster compared to “sad” in a lexical decision task because “book” is processed and represented in both linguistic and imagistic systems while “sad” is processed and represented only in the linguistic system.

Processing of concrete and abstract words is yet unaddressed issue in the current literature in both Neuro typical adults and adult language disorders. In treatment of persons with aphasia, concrete words have more effect on treatment as concrete words have both imagery and verbal systems information where as abstract words have only verbal system. Persons with aphasia were hypothesized to utilize the right hemisphere for semantic processing instead of the damaged left hemisphere (Kiran, & Tuchtenhagen, 2005). If concrete words are processed bilaterally, then persons with aphasia will show preference for concrete words, which will be shown in a treatment study using abstract and concrete concepts. This processing of abstract and concrete words were mainly studied using two kinds of methods those are behavioral measurements and electrophysiological measurements.

¹Junior Research Fellow, All India Institute of Speech and Hearing (AIISH), Mysore-06, Email: lagishettisk@gmail.com & ²Professor in Speech Pathology, AIISH, Mysore-06, Email: goswami16@yahoo.com

Behavioral measurements

Behavioural testing is based on a participant's response, in which participants have to respond to stimuli either verbally or through other means of responding like pressing the button. In this behavioural measurement participants cooperation, interest and attention towards the stimuli can affect the response pattern.

James (1975) carried out four different experiments on 48 undergraduates, where they were asked to judge the presented letter strings were either words or non-words. Results of the study revealed that faster reaction time for concrete words than for low frequency abstract words when nonword distracters were pronounceable. However there was no effect of concreteness on for high-frequency nouns. These results indicate that lexical decision involves repossession of semantic information in certain conditions.

Three experiments done by Kroll, Judith, Merves, and Jill (1986) on 48 undergraduates in which they compared the speed and accuracy of lexical decisions for concrete and abstract nouns. In one of their experiment they found that concrete nouns had small speed advantage in lexical decision than abstract words. Other studies show that more active consistent representations for concrete words than abstract words (Van Hell & De Groot, 1988a, and 1998b). Behavioral performance from another study confirms the previously established finding that concrete words are recognized more quickly and accurately than abstract words (Kiehl, Liddle, Smith, Mendrek, Forster & Hare, 1999). Schwanenflugel and Stowe (1989) studied the influence of a sentence context on the processing of abstract and concrete words on 38 native English speaking students and the results supported a context availability view that abstract words were comprehended more slowly than concrete words.

Neural basis for concreteness effect was studied basically using behavioral methods. The results using behavioral methods showed that in both implicit and explicit memory tests there was an obvious concreteness effect was observed and faster reaction for concrete words compared to abstract words. Results suggested that due to contextual information advantage of concreteness for concrete words was more in comparison to abstract words (Xiao, Zhao, Zhang, & Guo, 2011).

In behavioral measurements, judgment (yes or no) and reaction time were the response criteria

used in the literature for understanding in semantic processing and category judgment. Studies have found that for processing of abstract words needs more reaction time compared to the concrete words.

Electrophysiological measurements

Electrophysiological test measures are used to assess event related potentials in the brain. Event related potentials (ERPs) measures the brain activity by using scalp electrodes in non-invasive method during cognitive processing. Kounios and Holcomb (1994) examined the effect of concreteness and concreteness judgment tasks using lexical decision task on event related potentials (ERPs) and a repetition-priming paradigm respectively. More negative ERPs were elicited for concrete words between 300 and 500 milliseconds after stimulus onset than abstract words.

West and Holcomb (2000) performed sentence verification tasks in which the final word of each sentence was either concrete or abstract on three groups of participants. For each group the truthfulness judgment involved three characteristics these were image generation, semantic decision and evaluation of surface. In three groups there was a variation in magnitude of concreteness effect and for participants in the imagery and semantic groups, this effect was significant. There was a widespread and extended N400 which was sensitive to concreteness observed in both the imagery and semantic conditions. Finally the results of this study supported the dual coding hypothesis.

Study done on sixteen students using event related potentials in which sentences ending with congruent (abstract and concrete) words and anomalous words (Holcomb, Kounios, Anderson, & West, 1999). They found that more negative ERPs were elicited for concrete final words than abstract final words. These results have shown that there were also clear effects of concreteness; this finding further provides corroborative support to the argument that the observed effects of concreteness.

Event related potentials (ERPs) were recorded on 23 right-handed participants using 119 scalp electrodes in lexical decision task. The present examined relationship between word concreteness and word frequency using ERP measurements during a lexical decision task. The results showed that more negative ERPs for concrete nouns than abstract nouns at 200-300 and 300-500ms after stimulus onset, regardless

of word frequency (Zhang, Guo, Ding, & Wang, 2006).

Studies done on semantic judgment for processing of abstract and concrete words through behavioral measurements showed that longer reaction for abstract words compared to concrete words. In electrophysiological measurements, event related potentials have been considered as response criteria in the literature. An electrophysiological findings suggests that more negative for ERPs and widespread of N400 for concrete words compared to abstract words. Thus, suggests that concreteness effect plays a role in processing abstract and concrete words and which is in Constance with dual coding theory. An issue yet unaddressed in the current literature is the processing of abstract and concrete nouns in normal healthy adults and adult language disorders. Ethno- cultural differences exist in older adults within the framework of aging and neurogenic language disorders (Payne 1997). Hence, there is a need to study the processing of different types of words and more over there is a less literature in Indian scenario. Thus, the present study aims for the judgment task using reaction time as measure for processing abstract and concrete words.

Method

Participants

A total of 20 young adults in the age range from 18 to 25 years were included in the study. In that 10 were male and, 10 were females.

The participants were selected based on the following criteria:

- All the participants were native speakers of Kannada language
- None of the participants had any history of significant current or past hearing difficulties, or any history of neurological diseases.

Table 1. *Number of participants in the study*

Participants	Gender	No. of participants
Neuro typical adults	Male	10
	Female	10
	Total	20

Instrument and Stimuli

DMDX is software which was basically developed for behavioral psychology experiments for measuring reaction times (Kenneth, & Jonathan, 2003). There are two separate programs which have to be run before doing any experiment using DMDX. The first software is called TimeDx which confirms the refresh rate and other parameters on the screen of

the monitor for displaying audio or video files. This refresh rate varies across different computers and models. DMDX software works only after running the TimeDx module. In this study, one separate program was done which was loaded on personal computer while carrying out the experiment.

Stimuli of the present study were abstract and concrete words, in which abstract words refer to words where they have no physical referents and concrete words refer to objects or events that are available to the senses. Hundred words were taken in each group from various resources. Further, these words were rated on a 3-point rating scale for familiarity among 20 speech language pathologists (native Kannada speakers). In this rating scale, '0' indicates abstract word (e.g. happy) and '2' indicates the concrete word (e.g. book). The 50 abstract and 50 concrete words were considered for the present study. The speech language pathologists were instructed as follows:

"The purpose of this study is to find out how well each of the following items represents abstract and concrete words. Your task is to rate how good an example of each item in a scale ranging from 0-2. A rating of 0 means you feel the item is Abstract word (e.g. happy), and 1 means you feel the item cannot be differentiated whether it is abstract or concrete word. A rating 2 means, you feel that the item is a very good example of concrete word (e.g. book)." The prepared stimuli were audio recorded in a sound treated room by a Native Kannada adult female speaker. The recording was done on a personal computer using a unidirectional microphone, kept at a distance of 10 cm from the speaker's mouth by using Adobe Audition (3.0), with a resolution of 32-bits and a sampling rate of 44.1 kHz. The recorded stimulus was normalized so that all the test items have the same intensity.

Procedure

The participants were seated in a comfortable position facing the screen of the laptop in a quiet room. A series of words were presented randomly to the participants through head phones (auditory mode). Creative head phones HS-390 were used for auditory stimulus. The participant has to press the button '1' in key pad, if the stimulus is concrete word and the participant has to press the button '0' if the stimulus is abstract word. The inter stimulus interval was 2500millisec. If the participant does not respond within the given duration the DMDX software will consider it as no response. The procedure and duration of the study was explained to the

participant. Prior written consent was taken from the participant for participating in the study. Reaction time was collected for all the Kannada stimuli (Abstract vs. Concrete words). For the analysis, the reaction time was compared between abstract and concrete words and the gender differences also were compared.

Results and Discussion

The main objective of the current study was to observe the differences in the processing of concrete and abstract words in Neuro typical adults using a reaction time as a measure and to find the gender differences if any.

Table 2 summarizes the data. It explains the average reaction times for both concrete and abstract words. Average reaction time for males and females for concrete words were 391.9475 and 394.6587 respectively; for abstract words mean reaction time in males and females were 573.6538 and 578.5500 respectively. The average reaction time in total (combination of males and females) for abstract and concrete words was 393.3031 and 576.1019 respectively. There was 183msec faster reaction time for concrete words than abstract words were observed in total.

Table 2: Mean and standard deviations of reaction time for concrete and abstract words.

Stimulus	Gender	Mean	Std. deviation
Concrete words	Male	391.9	31.9
	Female	394.6	34.6
	Total	393.3	32.2
Abstract words	Male	573.6	23.5
	Female	578.5	19.9
	Total	576.1	21.2

Mixed ANOVA (Analysis of variance) repeated measures ANOVA for comparison of words (concrete & abstract words) with gender as independent factor.

Mixed ANOVA (Analysis of variance) repeated measures ANOVA for comparison of words (concrete & abstract words) revealed a main effect for words (concrete & abstract words) ($F=695.412$, $P<0.0001$) and for gender ($F=0.096$, $P>0.05$) indicating that was a statistically significant difference in the processing of concrete and abstract words and there was no statistically significance difference found across gender. There was no interaction between words and gender ($F=0.025$, $P>0.05$). Figure 1 displays the means of the reaction times for concrete and abstract words for male and female. In which, X- axis represents gender and Y- axis represents the time in milliseconds.

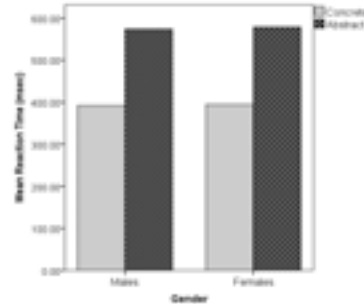


Figure 1: Mean reaction times for concrete and abstract words obtained by male and female participants.

The reaction time was measured for all participants and the results reveal that there is a faster reaction time for concrete words compared to abstract words and there was no gender differences were noticed. These results are consistent with the dual coding theory which explains that concrete words have different processing advantages over abstract words because they have admittance to information from multiple systems and concreteness effect refers to the observation that concrete nouns are processed faster and more accurately than abstract nouns in a mixture of cognitive tasks.

This pattern is also consistent with previous studies. In the literature it has been shown that the reaction times for concrete words are faster than the abstract words. Three experiments done by Kroll, Judith, Merves, and Jill (1986). In one of their experiment they found that concrete nouns had small speed advantage in lexical decision than abstract words. In other study the results shows that concrete words are recognized more quickly and accurately than abstract words (Kiehl, Liddle, Smith, Mendrek, Forster & Hare, 1999). In literature it has been shown that there were more active consistent representations for concrete words than abstract words (Van Hell & De Groot, 1988a, and 1998b).

The present study results are also consistent with other studies which show that abstract words were comprehended more slowly than concrete words on context availability (Schwanenflugel & Stowe, 1989). It suggests that due to contextual information advantage of concreteness for concrete words was more in comparison to abstract words (Xiao, Zhao, Zhang, & Guo, 2011). In other electrophysiological studies explains that there was a more negativity of event related potential (300 to 500 milliseconds) which is in consistent with dual coding theory (Kounios & Holcomb, 1994; West & Holcomb, 2000). Hence, it suggests that the concreteness is an important variable in processing concrete and abstract words.

Conclusions

The present study was conducted to compare the reaction time for processing abstract and concrete words using judgment task. The current study provided data on processing of concrete and abstract words in Neuro typical adults in the age range of 18-25 years. There are systems for functionally and structurally distinct representational systems, an imagery system specific for the depiction and processing of nonverbal stimuli, and verbal system specific for the handling of linguistic stimuli which was explained in dual coding theory (Paivio, 1971; 1986). Imagery processes may occur faster than other processes. (Van Schie, Wijers, Mars, Benjamina, & Stowe, 2005), it is expected that in some aspects larger concreteness differences can be observed than others. The processing differences between concrete and abstract words can be clearly revealed by studied comparing word processing in different stages. The results of the present study shows that the reaction times were faster for concrete words than compared to abstract words and there were no gender differences were observed. The overall conclusion for this study explains that the concreteness will have effect in processing the concrete words than compared to abstract words. Future studies needed that employ larger sample size and further studies can be carried out to address the processing of abstract and concrete words in language disorders.

Acknowledgements

We are heartily thankful to the Director of All India Institute of Speech and Hearing, Dr. S. R. Savithri for allowing us to conduct the study. We would like to thank all the participants for their cooperation.

References

- Holcomb, P. J., Kounios, J., Anderson, J. E., & West. (1999). Dual-coding, context-availability, and concreteness effects in sentence comprehension: An electrophysiological investigation. *Journal of Experimental Psychology: Learning, Memory & Cognition*, 25, 721-742.
- James, C. T. (1975). The role of semantic information in lexical decisions. *Journal of Experimental Psychology: Human perception and performance*, 104, 130-136.
- Jessen, F., Heun, R., Erb, M., Granath, D.O., Klose, U., Papassotiropoulos, A., & Grodd, W. (2000). The concreteness effect: evidence for dual coding and context availability. *Brain and Language*, 74(1), 103-112.
- Kenneth, T. F., & Jonathan, C. F. (2003). DMDX: A window display program with millisecond accuracy. *Behavioral Research Methods*, 35, 116-124.
- Kiehl, K. A., Liddle, P. F., Smith, A. M., Mendrek, A., Forster, B. B., & Hare, R. D. (1999). Neural pathways involved in Processing of concrete and abstract words. *Human Brain Mapping*, 7, 225-233.
- Kiran, S., & Tuchenhagen, J. (2005). Imageability effects in normal Spanish-English bilingual adults and in aphasia: Evidence from naming to definition and semantic priming tasks. *Aphasiology*, 1-15.
- Kounios, J., & Holcomb, P. J. (1994). Concreteness effect in semantic processing: ERP evidence supporting dual-coding theory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 20, 804-823.
- Kroll, Judith, F., Merves., & Jill S. (1986). Lexical access for concrete and abstract words. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 12(1), 92-107.
- Paivio, A. (1971). *Imagery and verbal process*. New York: Holt, Rinehart & Winston.
- Paivio, A. (1986). *Mental representations: A dual coding approach*. New York: Oxford University Press.
- Payne, J. C (1997). *Adult neurogenic language disorders: assessment and treatment: a comparative ethno biological approach*. London: Singular publishing group, inc.
- Schwanenflugel, P. J., & Shoben, E. J. (1983). Differential context effects in the comprehension of abstract and concrete verbal materials. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 9, 82-102.
- Schwanenflugel, P. J., & Stowe, R. W. (1989). Context availability and the processing of abstract and concrete words in sentences. *Reading Research Quarterly*, 24(1), 114-126.
- Tolentino, L. C., & Tokowicz, N. (2009). Are pumpkins better than heaven? An ERP investigation of order effects in the concrete-word advantage. *Brain and Language*, 110, 12-22.
- Van Hell, J. G., & De Groot, A. M. B. (1998a). Conceptual representation in bilingual memory: Effects of concreteness and cognate status in word association. *Bilingualism: Language and Cognition*, 1, 193-211.
- Van Hell, J. G., & De Groot, A. M. B. (1998b). Disentangling context availability and concreteness in lexical decision and word translation. *Quarterly Journal of Experimental Psychology*, 51A, 41-63.
- Van Schie, H. T., Wijers, A. A., Mars, R. B., Benjamina, J. S., & Stowe, L. (2005). Processing of visual semantic information to concrete words: Temporal dynamics and neural mechanisms indicated by event - related brain potentials. *Cognitive Neuropsychology*, 22, 364-386.
- West, W. C., & Holcomb, P. J. (2000) Imaginal, semantic, and surface- level processing of concrete and abstract words: An

electrophysiological investigation. *Journal of Cognitive Neuroscience*, 12(6), 1024-1037.

Xiao, X., Zhao, D., Zhang, Q., & Guo, C. Y. (2011). Retrieval of concrete words involves more contextual information than abstract words:

Multiple components for the concreteness effect. *Brain and Language*, 29, In Press.

Zhang, Q., Guo, C-Y., Ding, J-H., & Wang, Z-Y. (2006). Concreteness effects in the processing of Chinese words. *Brain and Language*, 96, 59-68.

Appendix

Abstract words		Concrete words	
beiga	alo tʃane	ouge	bekku
actura	viʃramɪ	kivi	na:ʃi
tʃinte	ʋiɾama	manmu	acae
dʒi:vana	at kama	tappa	kotiɪ
kahl	avaka: ʃa	tʃandra	III
ko:pa	sandaɾbʰa	ba:ʃi	handɪ
no:va	apa:ʃa	kuri	da:ra
tʃi:tʃe	tendare	hadaga	ha:vu
gavava	prajna	surja	kull
manavijate	kʃamaɪu	na:ʃige	kʃakɪ
priti	tappa	ni:ra	su:dʒɪ
afmavan tʃane	uthe	ba:la	koll
marjade	baravast	kaɪɪ	kere
trupɪ	avama:na	mana	man tʃa
dveʃa	krupe	dana	dʒabɪɪ
beume	adruʃa	tʃacku	ka:ge
niste	arʰa	kalla	bʰa:vi
vidʒa:ʃa	dukʰa	tʃʰatri	tʃa:pe
guna	afma	haldi	samudra
dʰa:ʃa	nɪʃatu	gɪɪ	bangaru
naja	ukʰa	hu:vu	no:ʃa
kana:u	sau:ʃa	tanti	tʃama
nambike	nemmadɪ	hasige	me: dʒu
gaana	e tʃ tʃarice	pustaka	penam
svatantra	ʃanti	kannadɪ	ba tʃulge