

# Influence of Semantic Priming on Reaction Time Measures in Typically Developing Children Ganesh A. C.<sup>1</sup> and Subba Rao T. A.<sup>1</sup>

## Abstract

*Semantic priming has been established as a method to measure lexical retrieval and the data obtained provides controlled measures of reaction time. In the Indian context very few attempts have been made in this direction. This study aimed to develop a reaction time measurement paradigm using the DMDX software for measuring lexical retrieval in children under two different conditions; with and without auditory priming. Twenty school going children (10 boys and 10 girls) in the age range of 5 to 6 years participated in the study. A picture naming task that was programmed with DMDX software version 3.2.6.4 was used for data collection. Reaction time measures for picture naming were obtained for each participant using with and without prime conditions. A total of 25 line drawings were used as stimulus pictures. Data was statistically analyzed and the results showed that there was a significant difference in the reaction time for the retrieval of target words between priming conditions. Target words were retrieved faster in lexical priming conditions (890.93 ms) rather than no prime conditions (1048.86 ms). These results are consistent with the findings of earlier reported studies.*

**Keywords:** DMDX, lexical naming, prime words, lexical retrieval, reaction time

Priming refers to an increase in the accuracy or probability or speed of response to a stimulus as a consequence of prior exposure to the stimulus. Priming may also reflect a meaning-integration process that occurs after access of the target and affects the decision stage of the task. Semantic priming has been a focus of research in the area of cognitive sciences for more than thirty years and is commonly used as a tool for investigating other aspects of perception and cognition, such as word recognition, language comprehension, and knowledge representations. It has long been established that reaction times are decreased in response to words preceded by semantically related words ('cat'-'dog') in comparison with words preceded by semantically unrelated words ('bus'-'dog'), which is referred to as semantic priming effect. Since then semantic effect has been extensively studied between associatively related pairs (Lupkar, 1984; Neely, 1991); between spoken words, using the lexical decision task (Radeau & Monique, 1983); single word shadowing (Slowiaczek, 1994) and between an auditory prime and a visual target (Swinney, Onifer, Prather & Hirshkowitz, 1979).

Semantic studies have been used empirically to study, hypotheses regarding linguistic planning and processing for speech-language production. This type of paradigm allows an investigator to

gain a high level of experimental control over many aspects of word production such as the lexicalization process (Brooks & MacWhinney, 2000). Although several possible mechanisms may underlie this phenomenon, two of the more commonly considered processes are automatic spread of activation through interconnected conceptual nodes or the generation of attention mediated expectancies (Neely, 1991).

Although several experimental methods might be used to assess the influence of perceptual and conceptual properties of objects on speed and efficiency of lexical retrieval, a semantic priming paradigm (McNamara & Holbrook, 2003; Pellowski & Conture, 2005) seems particularly useful. This paradigm allows for experimental manipulation of the time course or speed of covert linguistic planning processes that lead to a participant's overt speech language production. The procedure permits the experimenter to pair the auditory lexical representation with the visual lexical representation of the target picture rather than solely relying on the written form of the target word (Nation & Snowling, 1999). Such priming methods have been successfully used to evaluate wide-ranging aspects of semantic and lexical processing in adults as well as children (Bowles & Poon, 1985; Moss, McCormick, & Tyler, 1997; Nation & Snowling, 1999; Pellowski &

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Conture, 2005; Plaut & Booth, 2000; Schreuder, Arcais & Glazenburg, 1984).

Priming paradigms are an ideal method of testing children's knowledge of semantic relations without requiring the child to consciously articulate that knowledge. Two priming studies have addressed the development of children's taxonomic and thematic concepts. McCauley, Weil, and Sperber (1976) studied semantic priming in 6- and 8-year-old children. These children participated in a picture naming task in which prime–target pairs were (a) high thematic (associative) – high taxonomic (categorical; e.g., cat–dog), (b) high thematic–low taxonomic (e.g., bone– dog), (c) low thematic–high taxonomic (e.g., lion–dog), or (d) low thematic–low taxonomic (e.g., airplane–dog). Thematic priming was demonstrated in both groups, whereas only the 8-year-old children demonstrated taxonomic priming. In both cases, the prime served to facilitate the speed of picture naming.

Mcgregor and Windsor (1996) studied effects of priming on the naming accuracy of preschoolers with word-finding deficits. Eight preschoolers with word-finding deficits and 16 controls with normal word-finding abilities (8 preschoolers and 8 adults) named 40 pictured objects under primed and un-primed conditions and results indicated that the participants made use of the lexical primes and there was a shift in the form of correct responses from simple nouns in the un-primed condition to compound nouns in the primed condition. Nation and Snowling (1999) used semantic priming to find out developmental differences in sensitivity to semantic relations among those with good and poor comprehension. They concluded that those with good comprehension showed priming for category-related targets, irrespective of the degree of prime-target association and poor comprehension are less sensitive to abstract semantic relations than normal readers.

A picture-naming task (Glaser, 1992) is often used in semantic priming experiments and the procedure typically requires the participant to verbally name a target picture displayed on a computer monitor. The associated computer measures the participant's speech reaction time—defined as the time from onset of the target picture to onset of the participant's verbal response. This

measure is thought to allow the experimenter to approximate the time course of the participant's lexical access or encoding or other cognitive processes. This generally involves the experimenter presenting a prime such as an auditorily presented word related to the target picture, immediately before, during, or after the onset of the target. Radeau (1983) used an auditory lexical decision paradigm to determine occurrence of semantic priming between spoken words and to investigate the organization of the mental lexicon in preliterate children. 30 undergraduates and 24 first grade children (aged 6 years 2 months to 7 years) were tested on a lexical decision task. In both groups, significant facilitation was found for semantically related words compared with unrelated ones and results showed that semantic priming occurred in the auditory modality.

It is reasonable to assume that on the neural level, accessing a word is more efficient when the word's meaning has been recently primed. This logic has led to a number of investigations into the neural mechanisms underlying semantic priming. There is evidence that brain regions showing less activity for primed than unprimed words have been linked to semantic retrieval of word meanings. Copland, Wilson, McMahon, Zubicaray, Chenery, and Eastburn (2003) studied brain activity during automatic semantic priming revealed by event-related functional magnetic resonance imaging. Results showed that semantically related words demonstrated neural facilitation in the left middle temporal gyrus and left anterior inferior frontal sulcus.

From the above review it is evident that semantic priming paradigm in children is a well established method and it is possible to measure lexical retrieval from semantic priming. Data that is obtained from this provides controlled measures of reaction time. In the Indian context very few attempts have been made in this direction. Utilization of reaction measures brings in an experimental outlook to lexical retrieval tasks, which are primary in any therapeutic process. Thus, the objectives of this study were to develop a reaction time measurement paradigm using DMDX software Version 3.2.6.4 for measuring lexical retrieval in children under two different conditions -with and without auditory

priming and to compare the retrieval of target words in children with that of previously available data in adults.

**Method**

**Participants**

Twenty children in the age range of 5-6 years participated in the study. Those who had no history of neurological, psychological, cognitive, behavioural or visual problems were chosen for the study. All the participants attended an English medium primary school.

**Experimental Paradigm**

To collect data on speech reaction time during two picture naming conditions (with and without semantic prime) a computer assisted picture-naming experiment was developed using DMDX software. Details of the software are given in Appendix-A. The following two picture-naming conditions were employed in a counter balanced order across participants:

- (a) No-prime condition, in which no auditory stimulus were presented before picture display
- (b) Related-prime condition, participants were semantically primed with a related auditory stimulus 700 ms before target picture display.

A 700-ms stimulus onset asynchrony (i.e., time period from the onset of the auditory prime to the onset of the target picture) was utilized to ensure that none of the auditorily presented primes would temporally overlap the visual onset of the target picture. Participants were comfortably seated to view a laptop screen and were told to name the picture on the screen. The instructions were 'Name the picture as fast as you can and as soon as you see it'. The DMDX software controlled the presentation of the target picture as well as auditory prime, and recorded the speech reaction time in milliseconds.

**Data Collection**

Data were collected in the following two conditions:

No-prime condition: Ten participants were shown a set of 25 target pictures (Appendix B) one at a time, with the onset of subsequent pictures dictated by the participant's responses through activation of a gating switch on a microphone linked to the desktop computer. The computer recorded the participant's speech reaction time and presented the next picture 1,200 ms after each of the participant's spoken responses. Figure1 gives the pictorial representation of the no prime condition.

**Format of a Trial for the Unprimed Group**

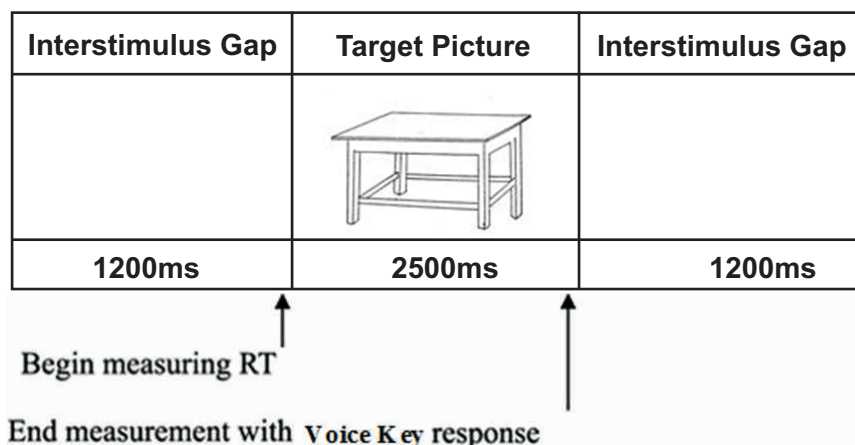


Fig. 1. Pictorial representation of no prime condition.

**Format of a Trial for the Primed Group**

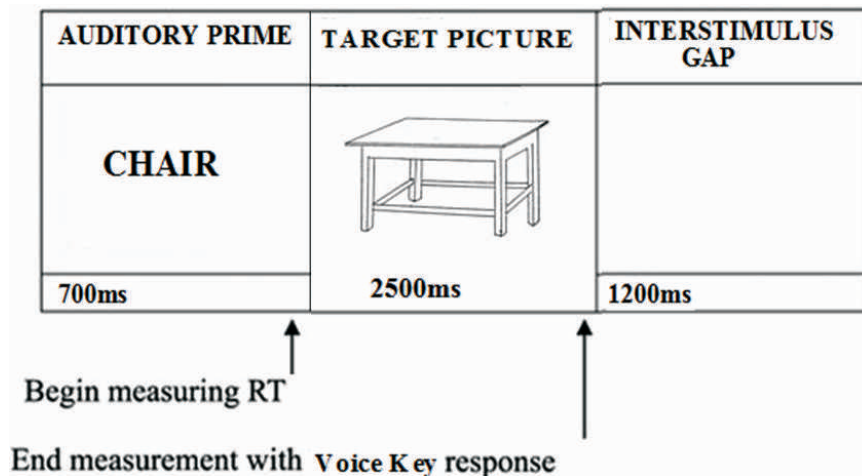


Fig. 2. Pictorial representation of prime condition.

**Related-prime condition:** The other 10 participants were shown a set of 25 target pictures with one exception compared to the no-prime condition. Participants were primed with a related auditory stimulus of 700 ms before picture presentation in free field, with a pair of standard computer speakers (e.g., related auditory prime = cat, target picture = dog). As with the no prime condition, the computer recorded the participant's speech reaction time and presented the next prime and picture 1,200 ms after each of the participant's spoken responses. Figure 2 gives the pictorial representation of the prime condition.

**Instrumentation**

DMDX software Version 3.2.6.4 (Jonathan, 1993) developed by the University of Arizona, which can assess the priming, was used. This was installed in Compaq Presario C700 Laptop, running on Microsoft Windows Vista Ultimate. Creative Computer Associates Microphone (Model No. 1124) was used to record the participants' verbal responses.

**Responses**

Verbal mode of response was selected for this study and first utterance from the speaker was locked as the response. So, reaction time is the time duration between stimulus presentation and the appearance of the first verbal output. Reaction time in milliseconds was recorded and saved in Microsoft Excel by the software. Further data was analyzed using SPSS 16 version software.

Reaction time data excluded error and lost trials. Errors were trials in which subjects used words other than the target name of the pictures (e.g. repeating the priming word), repetition at the onset of the word or self-corrected the earlier response. Lost trials were identified as attempts by participants to respond with non-speech sounds (tongue clicking or lips smacking), stopped performing the task (started talking to the experimenter) and trials in which the microphone was not able to pick up the response (the voice was too soft).

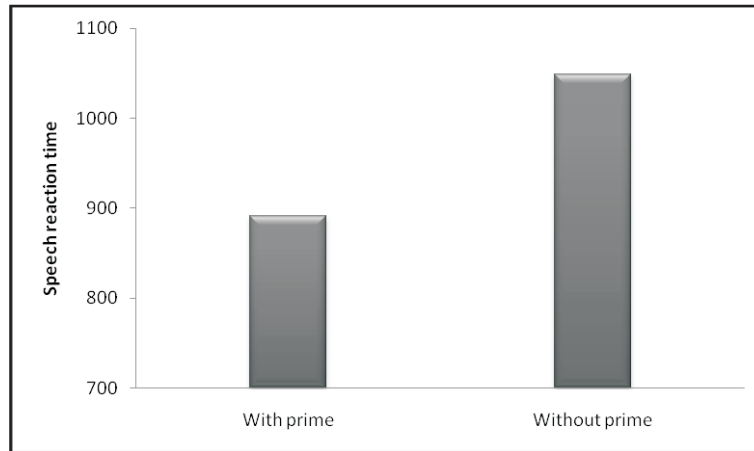


Fig. 3. Speech reaction time for prime and without prime conditions in children

**Results and Discussion**

The aim of the study was to develop a reaction time measurement paradigm using DMDX software for measuring lexical retrieval in children and to obtain and compare reaction time measurements with and without priming. The study also aimed to compare differences for retrieval of words in children and adults. The reaction times (RTs) of the picture naming task for the two age groups in the two different conditions were analyzed. The reaction time was recorded from the onset of picture presentation to the onset of the subject's voice and measured for all the

target words in milliseconds. Statistical analyses were performed using SPSS software. Three stimuli pictures pumpkin, knife and ladder did not elicit a naming response from all the subjects and were not included for the data analysis.

Results showed that there was a statistically significant difference in the retrieval time for target words in two priming conditions i.e., with prime and without prime conditions. As it can be observed from Figure 3 that target words were retrieved faster in 'lexical priming conditions' in comparison to 'no prime conditions'. The mean retrieval time was 890.93 ms with a standard deviation of 294.75 in lexical priming condition

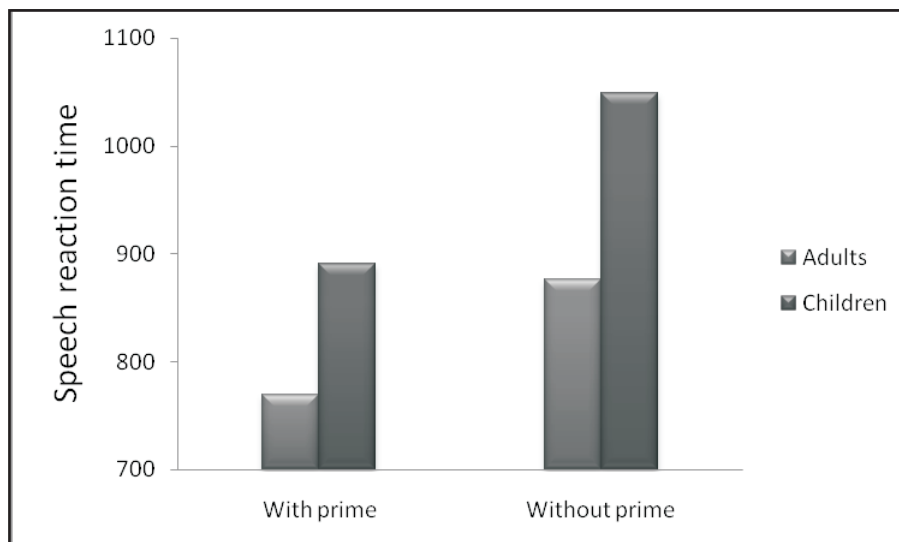


Fig. 4. A comparison of speech reaction time for prime and without prime conditions in children and adults

whereas the mean was 1048.86 ms with a standard deviation of 394.55 in no prime conditions. Paired sample Student t-test was used to find out whether the difference between the two means was statistically significant. The results revealed a significant difference ( $t = -4.94$ ,  $p < 0.001$ ) between the mean values, indicating that retrieval time was significantly shorter for with prime condition. The results obtained are consistent with previous studies which report that the naming of an object is faster when it is preceded by semantic priming than when there is no prime condition (Moss, McCormick, & Tyler, 1997; Nation & Snowling, 1999; Pellowski & Conture, 2005).

Semantic priming effect can be explained using the Spreading Activation Model (Collins & Loftus, 1975). According to this model, processing of a prime word causes activation to spread from the prime throughout the conceptual network. More activation will accumulate at concepts close to the prime than at concepts far from the prime. This residual activation then facilitates the semantic decision on the target word. For example, because dog and cat are closer in memory than are dog and book, more activation accumulates at dog when cat is the prime than when book is the prime, and decision times are correspondingly faster.

Several distributed network models of semantic priming have been proposed recently. According to Plaut and Booth (2000) priming is caused because related primes and targets are closer to each other in a high-dimensional semantic space than are unrelated primes and targets and concepts are represented by patterns of activity over a large number of interconnected units. Related concepts have similar patterns of activity. Semantic priming occurs because in processing a target word the network begins from the pattern created by processing of the prime and this pattern is more similar to the target's representation when the prime is related than when it is unrelated to the target. In effect, the network gets a head start in processing the target when it is preceded by a related prime.

A similar study was done on adults by Ganesh, Manjunath, and Vijay Kumar (2007) which showed that the mean RT without prime was 875.88 ms, and with prime it was 769.40 msec.

This data was compared with reaction time data in children. As can be observed in Figure 4, adults show about 150 ms less RT than children. Maturation in adults may be a factor for this effect. This study implies that a quantitative method of measurement of lexical retrieval in children may be useful in providing an experimental outlook to lexical retrieval tasks, which are primary in any therapeutic process and also in the language acquisition domain.

### Conclusion

Results of this study indicated that individuals exhibited significantly faster speech reaction time during semantic priming conditions than no priming conditions. Therefore, presentation of semantically related words before the picture-naming response appeared to 'speed-up' lexical retrieval in children. Studies need to be carried out in future along similar lines on more number of participants using varied paradigms and sophisticated measurement tools.

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**Appendix - A**

**DMDX Program**

DMDX is a member of the DMASTR family, and represents an extension of the original DOS programs (DM and DMTG) to a Windows 95/98 environment and will be programmed according to the test stimuli. It is developed by The University of Arizona. It is a run-time environmental experimental stimulus for gathering responses. Its strength lies in its precise control. It is appropriate for perceptual experiments (auditory, visual) where very accurate timing is required. A Computer based coding system is used for observational data recording. It provides the researcher with a reliable and accurate way of coding observational data. Stimuli were programmed by using DMDX software. Stimulus presentation time (time for which stimulus was displaced on the monitor) was fixed for 2500 ms and the inter stimulus gap (time between disappearance of one picture to appearance of the following picture) was fixed to 1200ms, with the help of DMDX.

**Appendix - B**

**Pictures and primes used in the Semantic priming task**

<i>No</i>	<i>Picture</i>	<i>Related prime</i>
1	apple	orange
2	banana	apple
3	tree	bush
4	table	chair
5	star	heart
6	spoon	fork
7	car	boat
8	sock	shoe
9	carrot	radish
10	pumpkin	corn
11	knife	blood
12	pig	cow
13	elephant	zebra
14	flower	leaf
15	pencil	paper
16	comb	hair
17	frog	fish
18	butterfly	bird
19	sun	moon
20	monkey	donkey
21	hat	coat
22	ladder	steps
23	key	lock
24	boy	girl
25	pant	shirt