The Semantic Association in the Mental Lexicon

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Abstract

The organization of mental lexicon has been extensively debated and discussed in the contemporary psycholinguistics. Specifically, this study investigated into the nature of organization of semantically related and unrelated concepts in the mental lexicon. A group of 19 participants (age range: 17-23 years; 11 females & 8 males) was required to judge the semantic association between the word pairs presented through reaction time software (DMDX). The participants judged the semantically associated word pairs faster compared to the semantically unrelated pairs. This finding could be explained by the Spreading activation theory of lexical processing (Collins & Loftus, 1975; Dell, 1986). The semantic features that are in common to the words of the stimulus pairs received double activation and this facilitated a faster judgment in the case of semantically associated word pairs compared to unassociated word pairs.

Key words: Spreading activation theory, Speech production, Architecture of the mental lexicon, Lexical processing.

The selection of words during speech production is an effortless act for a native speaker. However, the underlying processes in word production are far from the simplicity with which it is performed. For example, while naming a picture, the speaker performs a visual analysis to identify the features of the picture and activates the conceptual knowledge (lemma) associated with that picture. The activated lemma further activates the word form (lexeme) associated with it down the process. This is known as the lexical selection. Once the lexical item associated with the concept in question is selected, the phonological encoding takes place, where the speaker correctly selects the various phonemes necessary for the speech articulation and these selected phonemes are sent to the speech articulation circuit for their execution. Thus, a seemingly simple task such as picture naming involves various underlying processes such as visual analysis, semantic activation, lexical selection, phonological encoding and finally the speech articulation (Costa, Colomẽ, & Caramazza, 2000).

Spreading Activation Theory in Lexical Selection

The concept of Spreading Activation Theory – an idea originally introduced by Collins and Loftus (1975) – has received widespread acceptance in the contemporary cognitive-linguistic literature. The notion behind this theory is that each concept spreads a proportion of its activation to other representations with which it is linked. For example, when naming the picture of a *dog*, the concepts associated with that stimulus such as '*an animal*', '*has a tail*', '*has four legs*', '*pet*', '*faithful*' etc. are activated. However, some of these features are also applicable to other animals too; say *cat*. The spreading activation theory thus postulates that the presentation of the picture of a *dog* also partly activates the concept *cat* and other members that share the similar features (Caramazza, 1997; Collins & Loftus, 1975; Dell, 1986). In other words, the concept *cat* becomes a competitor while selecting the concept of *dog* (Semantic Interference Effect) (Glaser & Glaser, 1989; Roelofs, 1992; Starreveld & La Heij, 1995). However, under normal conditions, the speaker does not face such difficulties as s/he correctly picks up the right item (*dog*). This selection process could be damaged in aphasic subjects leading to, what is known as *semantic paraphasias* (Caramazza & Hillis, 1990).

The partial activation received by the semantically related concepts has some important bearing on our understanding of the functional

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architecture of mental lexicon. In the previous example, the presentation of the stimulus *dog* activates other semantically related concepts such as *cat* and various other concepts in the mental lexicon that share some of the features (not all) of the target item. Though there is a lack of consensus on the amount of activation received by each of these related concepts in the mental lexicon, it is widely accepted that the amount of activation received by related concepts is proportional to the number of features shared by both the target and the related items. Therefore, it is possible to assume that the concept of *cat* receives higher activation compared to other members that do not share any features with the target item (for example, *stone*). In a way, we can assume that the concepts *cat* and *dog* are closely located in the mental lexicon compared to concepts *stone* and *dog*. This type of conceptualization about the organization of the items in the semantic storage has gained strong evidences from reaction time studies.

A related and simple, yet interesting question is the robustness with which a word-pair is judged on its semantic association. Put it in a simpler way, *are semantically associated word-pairs judged faster compared to unassociated pairs on their semantic association?* Rubenstein, Lewis, and Rubenstein (1971) and Stanners and colleagues (1971) have reported that semantically associated word pairs are judged faster with compared to the unassociated word pairs. However, this needs to be tested empirically again to check the validity of the finding as well as a theoretical explanation should be put forth for the observed finding. We address this issue in this study.

Objectives

The objectives of the study were to replicate the findings of previous findings and more importantly, if similar findings were obtained, provide an explanatory hypothesis for the faster judgment time in the case of semantically associated word pairs compared to the unassociated word pairs.

Method

Subjects

Nineteen subjects (11 females & 8 males) volunteered to participate in the present study. The subjects were the undergraduate students of Manipal University. All the subjects had English as their medium of instruction starting at the age of 4-5 years. The mean age of the participants was 20 years (age range 17-23 years).

Materials

A pool of 110 items consisting of 56 semantically related and 54 unrelated items was initially selected. Five proficient English speakers rated these items for their semantic association. The raters' task was to write either *'yes'* or *'no'* against each word-pair if the pair was semantically related or unrelated, respectively. Three raters did not agree on three semantically associated items and two semantically unassociated items. One rater did not agree on two semantically associated and two semantically unassociated items. However, the items the single rater did not agree were same as that of the other three raters, therefore, finally rejecting three semantically related and two semantically unrelated items from the test stimuli. Thus, the final version consisted of 53 semantically related and 52 unrelated word pairs. Among these 105 items, three semantically related and two semantically unrelated items were randomly selected for training purpose.

Procedure

The subjects were made to sit in a soundproof room and verbal instructions were given about the task. This was followed by the presentation of training items and the subjects were made familiar with the task and the response. The stimuli were presented through a computer using DMDX reaction time software (Foster & Foster, 2003). A semantically associated word-pair was indicated by 'm' button press and unassociated pair by 'n' button press on the keyboard. The subjects were instructed to rest their middle and index fingers on these buttons while performing the task in order to avoid time delay in reaching the button while responding.

The stimulus words appeared as black capital letters in Times New Roman font in white background. The font size remained 26 across the stimuli. Before the presentation of each stimulus, a fixation point (+) appeared for 500 ms in the center of the screen on which the participants were instructed to fixate. This was followed by the first word of the word pair for a duration of 750 ms. This was further followed by a blank screen for 500 ms and the second word of the word pair. The second word remained on the screen for 2000 ms. The DMDX's clock was set on with the presentation of the second word. 100 word-pairs were randomly categorized into five blocks of 20 each. At the end of each block, a rest period (1 minute) was given and for each subject, the testing was completed in a single sitting. The chronological sequence of the testing procedure is seen in Figure 1.

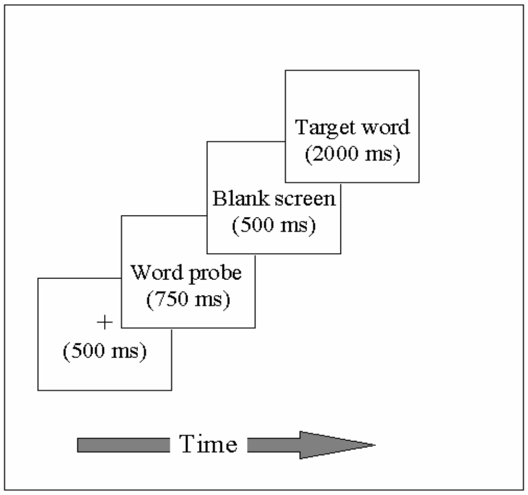

Figure 1: The chronological sequence of the testing procedure.

Results

The responses of the trial items were eliminated from the reaction time analysis. The remaining data was analyzed with SPSS.11 software for Windows. For the entire group of subjects, 73/1026 responses (7.11 %) in semantically associated condition and 72/874 responses (8.23%) were either wrong or *'no'* responses. For the statistical analysis, the reaction time (RT) from correct responses was used. The group mean for the semantically associated condition was 737 ms (SD = 134) whereas in the unassociated condition, the mean RT was 866 ms (SD = 171). The mean reaction times were submitted to Paired sample Student *t*-test to find out the differences between the two conditions, if any. The *t*-test results revealed a significant difference between the semantically associated and unassociated word pairs ($t = -6.51, p < 0.001$). The individual performance across the subjects is given in Figure 2. A closer look at the Figure 2 reveals that the reaction times were shorted for semantically associated word pairs on an individual basis.

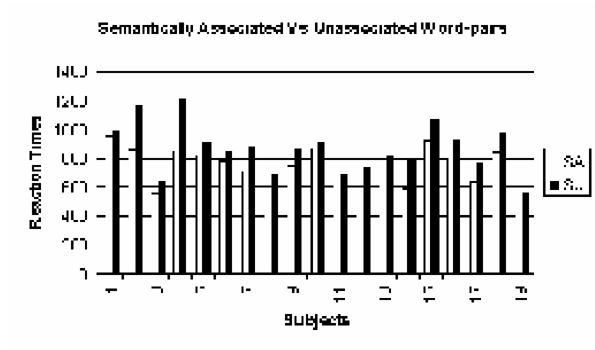

Figure 2: The reaction times (ms) on semantically associated versus unassociated conditions across the subjects.

Discussion

The findings of the present study supported that of similar studies done in the past (e.g., Rubenstein et al., 1971; Stanners et al., 1971). In the following section, we provide an explanatory hypothesis for the observed findings from the perspectives of spreading activation theory of lexical access (Collins & Loftus, 1975; Dell, 1986). As mentioned in the introduction, the members in the mental lexicon receive partial activation when a related item is activated. The activation strength is a function of the number of features shared by the target item with its distracters (Caramazza, 1997). Therefore, an item that shares a large number of features with the target item will be highly activated compared to the items that receive only minimal activation. These highly activated items' lexical nodes could act as strong competitors to the target items at the lexical selection stage.

Reaction time studies have added significantly to our existing knowledge on the semantic organization in the mental lexicon. In the current study, all the subjects required lesser time to judge a word pair as semantically associated compared to one that was semantically unassociated. According to the Spreading Activation Theory (Collins & Loftus, 1975; Dell, 1986), lesser amount of time for semantically related word pair could be interpreted as follows: upon seeing the first word, the subject activates its corresponding semantic concept from his/her mental lexicon. This partially activates the semantically related items (to the target) as well. The presentation of the second word of the word pair soon after the first word elicits an activation of its corresponding semantic representation. This in turn could activate some of the features of the first word that are just activated by the first word. Therefore, as depicted in Figure 3, the set of features shared by both words (for example, *animal*) are highly activated compared to other features that are not common to both the words of the stimulus pair. During the semantic association judgment, these highly activated semantic features could facilitate a faster *'yes'* response.

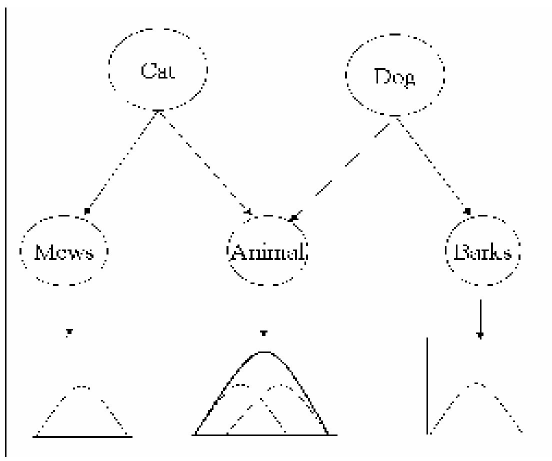

Figure 3: An increased activation of the semantic feature (animal) shared by both words of the stimulus pair.

In the case of a semantically unassociated word-pair (Figure 4), each word activates a set of semantic features corresponding to its concept. However, there is no facilitation of any semantic features resulting from the lack of overlap of features between the word pairs, unlike in semantically associated condition. Hence, the subject has to search for all the semantic features to ascertain the presence of any heightened activation (i.e., semantic association) before making an accurate *'no'* judgment. Logically, this process is more time consuming compared to semantically associated condition where the presence of a highly activated feature (semantically associated) ascertain the semantic association between the words of the stimulus pair. In simpler terms, in the absence of any such heightened activation, the subjects need to search the entire semantic features (of both words of the word pair) before making a correct response; at the expense of increased response time.

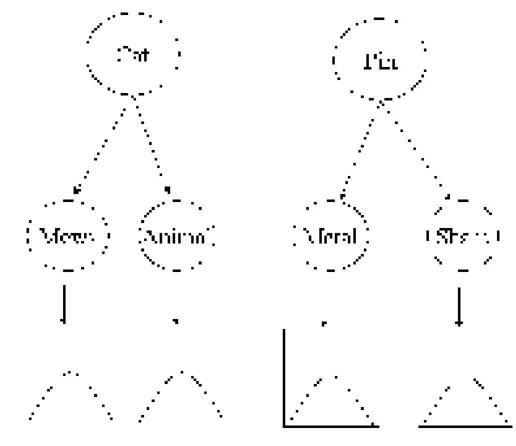

Figure 4: Absence of heightened activation (semantic association) in semantically unrelated word pair.

Conclusions

The current study supported the findings of previous similar studies on the representation of associated and unassociated words in the mental lexicon. More importantly, an explanatory hypothesis based on the spreading activation theory has been put forth to explain the observed findings. The mechanism behind faster judgment time in the case of semantically associated word pairs in contrast to the unassociated word pairs may hypothesized be due to the presence/absence of heightened activation (semantic association). That is, the presence of heightened activation terminates the search and a *'yes'* response is made whereas the absence of such activation demands continued search until all the features are searched, in order to make an accurate *'no'* response, at the expense of increased response time.

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