Lexical Decision Making Using Control, Phonological and Associated Words at Two SOA's

Psy S348

Don Pugh

For Sally Mcdonald

Table of Contents

1. Introduction 1
2. Method 4
  2.1 Subjects 4
  2.2 Procedure 5
  2.3 Apparatus 5
3. Results 6
4. Discussion 7

1. Introduction

Neely (1976) has defined a lexical decision task as reacting as quickly as possible to a visually presented letter string as an English word or non-word.

Neely (1977) has noted that if a semantically related target word is presented before the decay of the activation from the prime word, that reaction time will be quicker than if a non-related word is presented. For instance, Ratcliff & McKoon (1981b) report that responses to the word 'nurse' would be faster following 'doctor' than following 'bread.' The speed of mean reaction time resulting from the facilitation effect was reduced from 75 to 30 milliseconds as the probability that the prime and the following word were related increased from 1/8 to 7/8.

Schvaneveldt, Meyer and Becker (1976) also noted that when the two prime words such as river and bank were unrelated to the target word, such as money, the reaction time to the target word was increased and was similar to reaction times for non-related words. They argued for selective access to lexical memory based on a bias towards one meaning rather than another.

The theory behind reaction times to target words following the presentation of prime words is based initially on Collins & Quillian (1969) who suggested that human memory like a computer data base consists of a vast interconnected lattice-like network of nodes with each containing a concept. These nodes are constructed in a hierarchy with links from superordinate to subordinate concepts and to modifiers. It requires time to move from node to node with each step being additive in the measured time.

Ratcliff & McKoon (1981a) suggest 50-100 milliseconds is required for activation to move from one link to another adjoining link. Links have different strengths or travel time. Searches are conducted in parallel with activation spreading from stimulated concept nodes to adjacent nodes until an intersection is obtained. Priming traces activation outwards to linked concepts from the primed node. Thus priming is the facilitation of the response to a target word by a proceeding word(Ratcliff & McKoon, 1981b) Ratcliff & McKoon (1981a) and Martindale (1981) suggest that the size of priming is related directly to the closeness in meaning and typicality of category instances because of distance and the time taken for activation to spread. Other factors are also involved.

Howard, Shaw and Heisey (1986) in comparing 18-25 year old university students with 58-59 year old adults have found a significant age difference in the slowing of reaction times from primed to associative words. Age is factor which must be accounted for in the speed of automatic activation. Another factor is reading fluency. Zecker and Zinner (1987) reported that poorer readers failed to show the significant increase in reaction time to primed and associated words, demonstrated by normal readers.

Martindale (1981) has suggested that we all carry semantic and phonological lexicons in our minds which are connected to printed word units. A semantic analyser system with four or five levels operates with vertical and horizontal connections. Collins & Loftus (1973) have expressed the theory in neurological terms stating that activation of a concept occurs when it is accessed in the lexicon. Activation automatically spreads to related concepts horizontally and vertically. Activation weakens as it moves from its source along associative pathways.

The strength of activation and its duration is related to the strength of association of concepts. When activation of one concept occurs, it spreads quickly to related concepts but decreases over time. Thus the semantic network is thought to be organised along lines of semantic similarity. When activation of two concepts occur, the path between the concepts is retrieved and decisions and responses may occur.

Schvaneveldt and Meyer (1973) also suggest a spreading activation and location shifting model to explain the effects of lexical decision making. They have also concluded that the decreased reaction times in recognising semantically related words was caused by the spreading activation theory. Nodes for semantically related words are located closer to each other in semantic memory than non-related words. Activation shifts from the priming word to semantically related concepts. It takes less time for focussed attention to react to an activated word than to shift to and analyse an inactivated word. The subjects were believed to use a priming word to direct their attention to words semantically related to the priming word.

Shulman and Davidson (1977) found that the speed of reaction to orthographically illegal, unpronounceable strings of letters was greatly lengthened as compared with strings of semantically related words. The assumption was that reaction time decreases as a function of the level of activation of a word to its prime in semantic memory. The fastest reaction time was predicted to occur when the category and target are strongly associated(Lorch, 1982). Inferred knowledge should take longer to activate.

To trace the effects of time on the decay of activation, the time between onset of the prime and the onset of the target (stimulus onset asynchrony SOA) may be varied. Ratcliff & McKoon (1981b) reported that facilitation reached asymptote between 100 and 150 milliseconds with facilitation and 300 to 400 milliseconds with no facilitation. Longer SOAs within a set limit give the subject more time to encode the category word and to activate all relevant associations of the category(Lorch, 1982). When the target is presented, the subject may need only to select the appropriate word from memory. Excessively long SOAs, however, may lead to the decay of activation.

Research on the relationships of phonological words to associative and non-words has been reviewed by Meyer, Schvaneveldt and Ruddy (1974). They noted that reaction times took longer for homonyms than non-homonym English words because of phonemic encoding. They suggest that a comparison is made with a phonological lexical memory that may be distinct or distant from associative semantic memory.

Meyer *et al* (1974) found that phonemic similarity with graphemic similarity facilitated recognition slightly over recognition of non-words. Termed encoding-bias, this is explained because of the reduction in encoding and memory retrieval due to the similarity of the prime and target words as compared with a lexical memory search for a non-word.

The effect of distance between concepts may be measured by using related words, closely associated with the prime words, phonological words which sound similar to the prime words and non-words as a control condition. By manipulating SOA and distance we can measure the time that activation takes to spread and the distance that the activation has travelled.

An experiment was undertaken to discover the effects on reaction times of different SOAs and the relationships of prime words on control non-words, homonyms and associated words. Three results are expected to be noted.

It is expected that mean reaction time will be faster for primed associated concepts than for unrelated control words. The mean reaction time for phonological words should also be faster than the recognition of control words but slower than the recognition of associative words. Finally, the mean reaction times for an SOA of 300 milliseconds will be faster than the mean reaction times for the SOAs of 1000 milliseconds.

2. Method

2.1 Subjects

Forty eight Murdoch University students of mixed sexes enrolled in a third year Learning and Motivation Psychology course performed the experiment as part of their assessment. Students were English speakers with English mostly as their native language. Ages ranged over 34 years, with a mode of 22 and a mean age of 27.4 years. Subjects were aware of the expectations of the experiment.

2.2 Procedure

The computer was programmed to generate prime words followed by a non-word, phonological or associative word with a stimulus onset asynchrony (SOA) of 300 or 1000 milliseconds following the appearance of the prime. Students were asked to read the target word quietly when it appeared, then decide if the target word was really an English language word. They were told to press any key as soon as they recognised the target as a word rather than a non-word.

With the subject's response, or after a set delay, the computer screen cleared and a new prime word was presented followed automatically after the SOA with presentation of a target word. Words were visual for two seconds.

A lack of a response was recorded as an error. The sequence of trials within each block was randomised. One hundred blocks were presented for each condition of priming words followed by control, homonym or associated word for both 300 and 1000 milliseconds The computer measured and tallied the reaction times following the end of the presentation.

Three categories of data was collated for the two conditions, 300 and 1000 millisecond delays under the category headings of reaction time delay for neutral or control, phonological and associative words.

2.3 Apparatus

The experiment was performed on a Commodore Amiga 1000.

3. Results

All the 48 subject's mean reaction time were computed for the levels of 300 and 1000 milliseconds and for the conditions of control word, associative word and phonological word.

Means and standard deviations for forty eight subjects are presented in table 1.

Table 1: Means and Standard Deviations for Control, Phonological and Associated Words under Two Different SOAs.

Category	*SOA*	*Mean*	*StDeviation*
Control	300	511.5	65.05
Phonological	300	503.1	61.3
Associated	300	474.1	71.8
Control	1000	533.7	58.9
Phonological	1000	522.4	68.1
Associated	1000	492.9	56.9

An examination of the means for both the SOAs of 300 and SOA of 1000 milliseconds indicates a progressive increase in reaction times from the control through the phonological to the associated word condition. Reaction times for the 1000 milliseconds SOA were also longer than for the 300 SOA.

Use of repeated measures t-tests indicated no significant differences between control and phonological means for both 300 and 1000 milliseconds conditions. [$t=1.63$ $p>.05$, $t=1.89$ $p>.05$]

Use of repeated measures t-tests does indicate a significant difference between control and associated condition mean reaction times for both SOAs of 300 and 1000 milliseconds conditions. [$t = 8.04$ $p < .05$, $t = 7.57$, $p < .05$]

Significant differences were also found between means of phonological words at SOAs of 300 and 1000 milliseconds and between means of associated words across SOAs of 300 and 1000 milliseconds [$t = 2.64$ $p < .05$, $t = 2.72$, $p < .05$]

Results indicate significant differences between mean reaction times. Non-words reaction times are slower as compared with the faster reaction times for associated words. ($p < .05$) A non-significant difference was found for reaction times between non-words and phonological words. ($p > .05$) Significant differences were found in the speed of mean reaction times for both phonological and associated words across SOAs of 300 and 1000 milliseconds

4. Discussion

Three results were found. It was noted that mean reaction time was faster for primed associated concepts than for unrelated control words. The mean reaction time for phonological words was not significantly different from the recognition of control words and was slower than the recognition of associative words. Finally, the mean reaction times for SOA of 300 milliseconds were faster than the mean reaction times for the SOAs of 1000 milliseconds.

It was found that mean reaction time was reduced for recognising associated words than control words. This result was also found by Lorch (1982) and Ratcliff & McKoon (1981) both of whom noted that reaction times were consistently faster when the prime and target words were strongly associated than when they were weakly associated. Lorch (1982) uses the metaphor of turning on a light with the light corresponding to the prime word. All the surrounding objects or concepts are illuminated, but objects closer to the light are more strongly illuminated or activated than objects further away.

The explanation (de Groot, 1983) is that semantic memory is associatively structured. There is automatic spread of activation from the prime word's representation along the lattice paths in the semantic lexicon to activate concepts along the way. The target's representation is activated thus lowering recognition thresholds for words associated with the prime. The closer the target word to the prime word in the lexicon, the more accessible the link becomes between the words and the higher is the level of activation. Consequently, the presence of the prime leads to earlier activation.

A second explanation by Posner and Snyder (1975) and Neely (1976) suggests that facilitation is also caused by conscious attention focussed by the prime to predict associated target words. When predictions are correct, facilitation in reaction speed occurs. de Groot *et al* (1982) suggest that strong associations between targets and primes lead to a higher probability of correct predictions and thus faster reaction times.

A third process described by de Groot, and Thomassen (1986) is meaning integration. When both words are recognised, a search is undertaken for some meaning between the words. If meaning is found, the subject is biased to a *yes* response, thus shortening the lexical decision making.

When targets are non-words, a relatively time consuming search of the mental lexicon is conducted to try to match the target letter string with a known word or logogen. The search must exhaust the entire dictionary extending reaction times. In contrast, if a match is made the correct logogen 'fires' and the search may stop earlier enhancing reaction times(de Groot, 1986).

Also when targets are unrelated to primes, the misdirection causes an inhibition in subject reaction time. Use of control words are an example of words which cannot be predicted. Inhibition may be caused, de Groot *et al* (1982) argues, by fluent readers believing that words are always meaningful and related and these readers will continue to search for word meanings involuntarily. Some deadline may have to be exceeded before the search is terminated. If no meaning is found, de Groot (1986) states that the subject is biased towards a non-word response, thus lengthening mental processing and the time taken to make a decision based on the lexicon.

Furthermore, Neely (1977) notes that attention is effective with longer SOA times, (400 milliseconds) since facilitation and inhibition from conscious attention is slower to build than that caused by spreading activation.

The mean reaction time for phonological words was hypothesised as being faster than the recognition of control words but slower than the recognition of associative words. In this experiment no significant difference was found between the reaction times for control words and phonological words. de Groot, Thomassen & Hudson (1982) report that temporal activation patterns differ for different types of semantic relationships between the prime and the target. The representation of non-associated words which, nevertheless, sound similar to the prime word is unaffected by the wave of activation.

It is suggested that control words and phonological words are not activated by the prime words because they are not directly or closely connected to the prime concepts and are located at some distance from the prime. de Groot (1983) has found only weak evidence to support multiple step automatic spreading activation. She suggests a multiple-storage memory of disconnected units that contain core word and peripheral representations.

In Lorch's (1982) light metaphor, phonological and control words are represented by shadowy objects perhaps in their own enclaves lurking in recesses of the mind beyond the immediate reach of activation.

The theory of inhibition may also be applied to phonological words as well as control words since the predict and match strategy cannot be used.

Finally, the mean reaction times for the SOA of 300 milliseconds were hypothesised to be faster than the mean reaction times for the SOAs of 1000 milliseconds. Reaction times, indeed, were found in this experiment to be significantly faster for SOAs of 300 milliseconds than for 1000 milliseconds. de Groot, Thomassen & Hudson (1982) noted that the degree of facilitation found in a target related to a prime depends on the SOA as well as the relationship between the words. When no relationship is found, the result may indicate that the chosen SOA is too long, permitting a decay of activation or too short, preventing establishment of activation.

Neely (1977) used 400 milliseconds, and suggested that activation decreased after 240 milliseconds. McKoon and Ratcliff (1986) found that newly associated pairs may prime in SOAs as short as 150 milliseconds. de Groot *et al* (1982) found that 460 milliseconds permitted both automatic activation and facilitation by conscious attention.

de Groot *et al* (1982) found that 920 milliseconds was too long and caused the subjects attention to be diverted from the task by boredom while waiting for the target word to appear. de Groot (1986) later found that reaction times decreased from 100 to 400 milliseconds, then increased with longer SOAs. She found 1240 milliseconds led to both decreased facilitation and inhibition.

In this experiment, the 1000 milliseconds delay appears to have lengthened reaction time significantly as a result of decay of activation and the development of ennui.

An area for further research would be to use reaction times as an indirect measure of racial prejudice by pairing linked and non-linked prime and target words. For instance, according to semantic activation theory, prejudiced Australians would react faster to Australian and smart or Aboriginal, and drunk, than, white and drunk. Such applications would be of value to social psychologists and sociologists.

This would certainly test some of the assumptions made about spreading activation.

An excellent analysis & precis of background info. A.

5. References

Collins, A. M. & Quillian, M. R. (1969). Retrieval time from semantic memory. Journal of Verbal Learning and Verbal Behaviour. 8. 240-247.

Collins, A. M. & Loftus, E. F. (1975). A spreading-activation theory of semantic processing. Psychological Review, 82(6). 407-428.

de Groot, A. M. B., Thomassen, A. J. W. M. & Hudson, P. T. W. (1982). Associative facilitation of word recognition as measured from a neutral prime. Memory & Cognition, 10(4). 358-370.

de Groot, A. M. B. (1983). The range of automatic spreading activation in word priming. Journal of Verbal Learning and Verbal Behaviour. 22. 417-436.

de Groot, A. M. B. & Thomassen, J. W. N. (1986). Primed-lexical decision: The effect of varying the stimulus-onset asynchrony of prime and target. Acta Psychologica, 61. 17-36.

Howard, D. V., Shaw, R. J., & Heisey, J. G. (1986). Aging and the time course of semantic activation. Journal of Gerontology, 41(2). 195-203.

Lorch, R. F. (1982). Priming and search processes in semantic memory: A test of three models of spreading activation. Journal of Verbal Learning and Verbal Behaviour. 21. 468-492.

Martindale, C. (1981). Cognition and Consciousness Homewood: Dorsey Press.

McKoon, G. & Ratcliff, R. (1986). Automatic activation of episodic information in a semantic memory task. Journal of Experimental Psychology Learning, Memory and Cognition, 12(1). 108-115.

Meyer, D. E., Schvaneveldt, R. W. & Ruddy, M. G. (1974). Functions of graphemic and phonemic codes in visual word-recognition. Memory and Cognition, 2(2). 309-321.

Neely, J. H. (1977). Semantic priming and retrieval from lexical memory: Roles of inhibitionless spreading activation and limited-capacity attention. Journal of Experimental Psychology, 106(3). 226-254.

Neely, J. H. (1976). Semantic priming and retrieval from lexical memory: Evidence for facilitatory and inhibitory processes. Memory and Cognition, 4(5). 648-654.

Posner, M. I. & Snyder, C. R. R. (1975) Facilitation and inhibition in the processing of signals. In P. M. A. Rabbitt & S. Dornic (EDS.), Attention and Performance. New York: Academic Press.

Ratcliff, R. & McKoon, G. (1981a). Does activation really spread. Psychological Review, 83(5). 454-462.

Ratcliff, R. & McKoon, G. (1981b). Automatic and strategic priming in recognition. Journal of Verbal Learning and Verbal Behaviour, 20. 204-213.

Schvaneveldt, R. W. & Meyer, D. E. (1973). Retrieval and comparison processes in semantic memory. In S. Kornblum (Ed.). Attention and performance IV. New

York: Academic Press.

Schvaneveldt, R. W., Meyer, D. E., & Becker, C. A. (1976). Lexical ambiguity, semantic context, and visual word recognition. Journal of Experimental Psychology Human Perception and Performance, 2(2). 243-256.

Shulman, H. G. & Davison, T. C. (1977). Control properties of semantic coding in a lexical decision task. Journal of Verbal Learning and Verbal Behaviour, 16(1). 91-98.

Zecker, S. G. & Zinner, T. E. (1987). Semantic code deficit for reading disabled children on an auditory lexical decision task. Journal of Reading Behaviour, 19(2). 177-190.