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Lexical Inhibitory Mechanisms-Evidence from two Negative Priming Experiments in Young Normal Adults

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INTRODUCTION

Lexical retrieval models propose that both activation and inhibition between concepts, words, and phonemes are essential to retrieve it. Activation and inhibition appear to play an important role in regulation in language processing. Inhibition is recruited so that competition between related concepts can be overcome and a target production achieved when semantic activation occurs and spreads from one concept to its related concepts,

Inhibitory processing is typically measured using a negative priming task. Negative priming is thought to occur due to selective inhibition (Houghton & Tipper 1994; Fox 1995). Negative Priming (NP) refers to a slowed response identification time to a target stimulus that has been previously ignored. Some of interesting property of NP is cross-language phenomenon (Neumann, McCloskey & Felio 1999) and semantic NP. The studies on priming are limited in Indian context for example, Ganesh & Subba Rao (2008) demonstrated reduced reaction time on auditory semantic priming task. Studies on NP have not been observed.

The present study attempts to measure two way negative priming in Kannada-English bilinguals and in living and non-living categorically related objects in young adults. This will help in further understanding of adult language processing and its disorders.

AIMS

The present study proposes to use NP tasks to compare across language (Kannada and English) and congruency in lexical items further exploring semantic categories of living and non living things.

EXPERIMENT 1: METHODOLOGY

Participants

Twenty adults aged 18-25 years (mean 23.11) participated in the study.

Stimuli and apparatus

Categorically related NP task consisted of 4 experimental conditions i.e. unrelated condition (living and nonliving) & semantically related (living and nonliving). Black and white line drawings of objects from the International Picture Naming Project at the Center for Research in Language, University of California, San Diego were shown on a computer for a naming task. Prime & probe displays consisted of two superimposed pictures one is target stimuli (red colour) and other one is distracter (blue) which was programmed with DMDX software Version. 3.2.6.4. Reaction time (RTs) in millisecond was recorded.

Results

Paired sample t-test revealed that there was statistically significant difference for living categorically related items, the NP mean value of -85.15msec (1005.41ms and 1090.56ms for categorically related and unrelated trials) was statistically significant ($t = 3.5$, at $p < 0.05$).Similarly for non-living categorically related items the NP mean value of -92.55msec (970.74 and 1063.29 for categorically related and unrelated trials) which was also significant ($t = 3.39$, at $p < 0.05$). The results also reveal that RT difference of (27msec) between living and non-living objects.

EXPERIMENT 2

Subjects

Twenty normal bilinguals adults aged 18-25 years (mean 23.11) (L1-kannada and L2-english) participated in the experiment.

Stimuli & apparatus

Cross-language NP task consisted of 4 experimental conditions i.e. unrelated condition (UR L1-L2 and UR L2-L1) & ignored repetition (IR L1-L2 and IR L2-L1). 80 prime-probe bi-syllable target word pairs were selected. Prime & probe displays consisted of target stimuli (red colour) and distracter (blue) which was programmed with DMDX software Version 3.2.6.4. RTs in millisecond were recorded.

Results

Experiment 2 found significant cross-language negative priming from translation equivalents for both L1-L2 and L2-L1 conditions. Paired sample t-test was done and the NP mean value of -44.24ms (672.41ms and 716.66ms for unrelated and ignored repetition trials)

was statistically significant ($t = -3.33$, at $p < 0.05$). Similarly L2-L1 tasks showed NP mean value of -50.55 (657.88ms and 708.44ms for unrelated and ignored repetition trials) which was also significant ($t = -3.17$, at $p < 0.05$).

Discussion

Results were in consonance with the study done by Damian 2000; Zubicaray, McMahon, Eastburn & Pringle 2008 (Experiment 1) and Fox 1996; Neumann, McCloskey & Felio 1999 (Experiment 2). The present findings provide evidence for the role of inhibitory processing resources in selective attention and for their applicability to language processing.

This result showed that words which share a high degree of meaning overlap should produce cross-language priming. This is probably because of strong lexical links in this direction for translation equivalents. There was no significant difference between cross language NP between two languages. These results suggest that balanced bilinguals access common conceptual representations across languages.

Conclusion

This preliminary study explored NP effect in bilinguals and in Naming of Categorically Related Objects. It has been known from the literature that different populations have different levels of inhibitory control and this can be revealed by using NP. NP can be used to determine if any inhibition insufficiency in individuals means then treatment may be devised that addresses this insufficiency. In the present study only age matching was done and variety of clinical population could not be presented. Future studies will need to keep this factor in view.

INTRODUCTION

In our environment a vast amount of information bombards our senses. But in order to achieve goals, we must distinguish between relevant and irrelevant stimuli. Traditionally, visual selection has been thought of as an excitatory process in which attended information is enhanced from the recently presented irrelevant background, however it has been proposed that such an excitatory process might be supplemented by inhibitory processes that suppress information belonging to irrelevant stimuli. According to Houghton & Tipper (1994), both activation of lexical information and inhibition of irrelevant information will lead to retrieve words and memories from long term memory.

Semantic representations will be activated in long-term memory when there is a presentation of the stimulus (Anderson 1994).

Activation is considered to be an increase in the level of the resting state of that representation. When the stimulus activates lexical representation (e.g., a word "dog"), the activation of that word spreads throughout a connected network such that all concepts related to that word are also activated and also according to how strongly the concepts are associated to the stimulus. This spreading activation to associated lexical representations is excitatory and facilitates retrieval of related concepts (Collins & Loftus 1975). To retrieve a word, it must be sufficiently activated so that a threshold value is obtained that is higher than the other related words or concepts. The highest activated word is then selected instead of the other possible responses.

Interference occurs for the most highly activated word, if the several related concepts are activated. Interference causes bottlenecks, so that production is temporarily limited. When interference occurs, inhibition is recruited (Anderson 1994). Inhibition reduces the level of activation of competing responses that may be irrelevant or inappropriate for the context. This competition amongst related lexical representations produces interference, which can be resolved by inhibitory mechanisms. If inhibitory mechanisms are slowed, intermittently active, overactive, or absent, the lexical representation that is produced May not always be the most highly activated. This could occur because unresolved interference between competitors may lead to selection of an incorrect word, the inability to retrieve a word, or intermittent target word retrieval.

Evidence for such an inhibitory mechanism is largely derived through the phenomenon of negative priming. In negative priming experiments, each trial typically involves two stimuli, one to be attended and one to be ignored. If the ignored stimulus on one trial becomes the target stimulus on the next trial, responding to it is slower than would have been the case if the previous trial were completely unrelated. Such an effect has been demonstrated with a wide variety of stimuli and experimental procedures and suggests that cognitive processing of irrelevant information crucially influences the processing of relevant information.

Support for the inhibitory account of NP comes from the selective inhibition theory of visual selective attention (Houghton & Tipper 1994), selective attention is necessary in daily life because there are an infinite number of stimuli in the environment that must be either attended to or ignored. Initially, all stimuli are attended to and facilitated, but then irrelevant stimuli are quickly suppressed so that further processing of the attended stimuli can proceed. In the NP paradigm, all stimuli on the prime display are initially attended to and

analyzed in an automatic fashion. The participant then selectively attends to the target word, and the distracters words are suppressed.

Since Dalrymple-Alford & Budayr's (1966) first observation of negative priming with a Stroop colour naming task , negative priming has been observed with a variety of stimuli and tasks, including naming (Tipper & Cranston 1985), location judgment (Tipper, Brehaut & Driver 1990; Tipper, Weaver & Houghton 1994), lexical decision (Yee 1991), categorization (Tipper & Driver 1988), perceptual matching (DeSchepper & Treisman 1996), and size judgment (MacDonald & Joordens 2000; MacDonald, Joordens & Seergobin 1999). In addition, the negative priming effect generalizes across various forms of materials, including simple symbols (Tipper et al. 1990), letters (Tipper & Cranston 1985), objects (Tipper 1985; Tipper & Driver 1988), faces (Grison, Tipper & Hewitt 2005), words (Malley & Strayer 1995), colored words (Neill 1977), and nonsense shapes (DeSchepper & Treisman 1996).

One of the properties of NP is the semantic inhibition. The inhibition revealed via negative priming appears to be associated with deep level object identity, and can spread to related objects. For example, if a competing picture of a CAT is ignored; subsequent response to the word "CAT" is slowed. There is no physical relationship between the picture and word representing CAT, and therefore the inhibition must be at a deep semantic level. Furthermore, ignoring a picture of a CAT produces subsequent slowing when responding to DOG (categorically related) and ignoring a word in one language (e.g., the Spanish word PERRO) can impair subsequent processing of the same word in a different language (DOG) i.e. cross language NP (Neumann, McCloskey & Felio 1999). Such findings suggest that the inhibition can spread through semantic networks (Houghton & Tipper 1994).

Also it is evident from literature that NP occurs across languages (Fox 1996; Neumann, McCloskey & Felio 1999) and also in various categorically related objects (Damian 2000; Zubicaray, McMahon, Eastburn & Pringle 2008). The present study attempts to measure reaction times, in young adults during cross language NP tasks and across categorically related items

NEED FOR THE STUDY

The literature review above validates the use of NP in measuring semantic inhibition skills across various tasks. Reduced negative priming may indicate various conditions that affect semantic

processing. Reduced negative priming has been observed in patients with Alzheimer's disease (Vaughan, Hughes, Jones, Woods & Tipper 2006), and in the elderly subjects (Verhaeghen & de Meersman 1998; Gamboz, Russo & Fox 2002). Adult language disorders like aphasia (Toblin & Hinkley 2007), Wernicke's aphasia (Weiner, Connor & Obler 2004) have also shown reduced NP. This suggests that decline in inhibitory control is a general feature of many groups with reduced information processing efficiency.

Deeper semantic processing could be achieved by requesting participants to judge words not on their lexicality but on some other semantic variable, such as living versus non-living. Manipulation of variables such as those mentioned may all provide more specific information regarding inhibitory processing in both aphasia-control and aphasia participants so that treatment studies can be devised.

The way in which Indian bilingual or multi-linguals learn more than two languages is different as compared to western world, although some similarities are seen. As a specific urban phenomenon sequential acquisition of English from the age of about 3-4 years is well accepted. In comparison Western literature reports simultaneous bilingual studies. English is acquired by Indians with increasing interest as a second language during school years. Despite starting the process 3-4 years after the L1.i.e Kannada in this study, the utility of English is perceived as higher than that of L1. Such influence of L2 can be effectively studied under Indian conditions.

Given India's multiple language environments and a uniform demand for English, India offers fertile experimental ground. The present study proposes to use NP tasks to compare across language (Kannada and English) and congruency in lexical items further exploring semantic categories of living and non living things.

METHODOLOGY

EXPERIMENT 1

Participants

Twenty adults aged 18-25 years (mean 23.11) participated in the study. Those who had no history of neurological, psychological, cognitive, behavioural or visual problems were chosen for the study.

Instrumentation

DMDX software Version 3.2.6.4, developed by the University of Arizona which can assess for the priming was used. This was installed

in Compaq Presario CQ-45 Laptop, running on Microsoft Windows vista. Creative Computer Associates Microphone of the model number 1124 was used to record the participant's verbal responses.

Materials and procedure

The semantic negative priming task involves superimposed pictorial stimuli presented in two conditions: one in which ignored and named objects are categorically related (semantic ignored) and other involving unrelated objects (control) (Tipper 1985).

Black and white line drawings of objects from the International Picture Naming Project at the Center for Research in Language, University of California, San Diego were shown on a laptop computer screen for the naming task.

Prime and probe displays comprised two superimposed pictures: the target (red) and distracter (green). Within prime displays, each target was unrelated to the ignored distracter.

This was also the case within the probe displays. For the semantic ignored condition, the ignored distracters in the prime display were categorically related to the following probe target, whereas in the control condition they were unrelated.

The experimental block consisting of 100 trial pairs in each of the two conditions, semantic ignored (25, in which prime distracter and probe target objects were categorically related of both living and nonliving things) and control (50, in which prime distracter and probe target objects were unrelated), according to the following sequence: a crosshair was presented first for 500 msec, followed by an identical blank period, then superimposed prime target/distracter pictures were presented for 750 msec eliciting a naming response. Following this, a pattern mask was presented for 250 msec, after which a blank interval of 1000 msec was inserted. Probe target/distracter pictures were then presented in an identical manner.

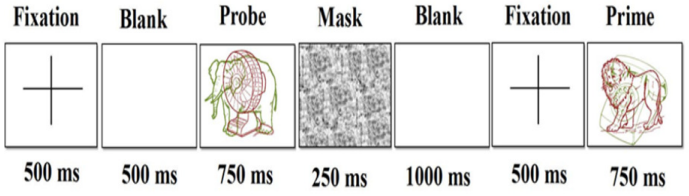

Fig. 1. *Diagram showing the sequence for presentation of prime and probe stimuli*

Responses

Verbal instructions were given initially to name the red colour picture as quickly as possible ignoring the green colour picture, and these were repeated in printed form on the computer screen, followed by a short series of practice trials. 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 presentations to appearance of the first verbal output. Reaction time in millisecond was recorded and saved in Microsoft excel by the software. Further data was analyzed using SPSS 17.0 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, repetition at the onset of the word or self-corrected on the earlier response. Lost trials identified as attempts by participants to respond with non-speech sounds trials in which the (tongue clicking or lips smacking), stopped performing the task (instead talking to the experimenter) and certain trials in which the microphone was not able to pick up the response (the voice was too soft).

Results

The mean reaction time was measured using DMDX software. 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. The data was analyzed with SPSS.17 software for Windows. For the statistical analysis, the reaction time (RT) from correct responses was used and Paired sample Student *t*-test was used to find out whether the difference between the two means is statistically significant. The RTs values were significantly prolonged on NP tasks for both living and nonliving conditions which is shown in Fig. 2 and Table 1.

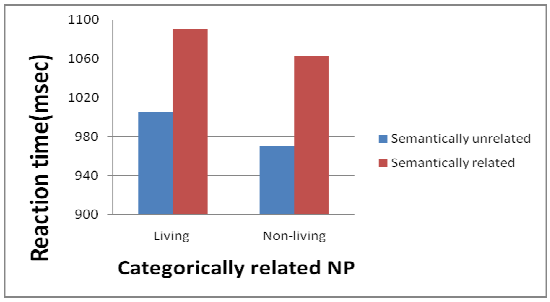

Fig. 2. *Mean reaction time of NPs in the categorically related conditions and unrelated condition*

Table 1. *Mean naming latencies (RT, msec) and percent (%) errors according to experimental condition*

	Categorically related		**Control (unrelated)**	
	Living	Non-living	Living	Non-living
Reaction time(RT)	1090.56	1063.29	1005.41	970.74
% errors and lost trials	6.5	7.5	1.6	2.3

As shown in the Table 1 and Fig. 3 there was statistically significant difference in the retrieval time for target words in two conditions i.e. unrelated and categorically related conditions. For living categorically related items the NP mean value (-85.15msec) was statistically significant (t = 3.5, at $p < 0.05$). Similarly non-living categorically related items the NP mean value (-92.55msec) which was also significant (t = 3.39, at $p < 0.05$). The results also reveal that RT difference of (27msec) between living and non-living objects.

EXPERIMENT 2

Experiment 2 aimed to establish whether cross-language negative priming would occur when prime flankers and probe targets were translation equivalents of each other. Since translation equivalents for concrete words presumably share more conceptual features than semantic associates

Participants

Twenty adults aged 18-25 years (mean 23.11) participated in the study. Those who had no history of neurological, psychological, cognitive, behavioural or visual problems were chosen for the study. All were normal bilinguals (L1-kannada and L2-english).

Instrumentation

The apparatus were same as in the Experiment 1

Materials and procedure

Authors have noticed that in a study by Dehaene, Spelke, Pinel, Stanescu & Tsivkin (1999) on Russian-English bilinguals, numerical were used to study the cross language phenomenon. In this study the numerical were not considered. It was felt that due to code-mixing, generally the numerical are interchanged and used between languages. 40 prime-probe bi-syllable translation equivalent target word pairs were selected and presented according to the following sequence: a crosshair

was presented first for 500 msec, followed by an identical blank period, then prime target/distracter word were presented for 750 msec eliciting a naming response. Following this, a blank interval of 1000 msec was inserted. Probe target/distracter pictures were then presented in an identical manner. Cross-language NP task consisted of 4 experimental conditions i.e. unrelated condition (UR L1-L2 and UR L2-L1) & ignored repetition (IR L1-L2 and IR L2-L1).

Prime & probe displays consisted of target stimuli (red colour) and distracter (blue). In the UR (L1-L2) and IR (L1-L2) conditions prime stimuli were presented in Kannada and consisted of a target word (in lowercase letters) and a distracter word (in uppercase letters), one above the other. The probe stimuli consisted of an uppercase distracter word in Kannada and a lowercase target, which was English word.

In the UR (L2-L1) and IR (L2-L1) conditions prime stimuli were presented in English and consisted of a target word (in lowercase letters) and a distracter word (in uppercase letters), one above the other. The probe stimuli consisted of an uppercase distracter word in English and a lowercase target, which was Kannada word.

Table 2. *Sample of conditions for word trials in cross-language NP*

Sample of Conditions for Word Trials in the Experiment 2				
Conditions	UR (L1-L2)	IR (L1-L2)	UR (L2-L1)	IR (L2-L1)
Prime Display	HI ¸ÀgÀ	Q« ªÀiÁªÀÅ	inject wander	spider donkey
Probe Display	RESPOND ªÀiÁvÀÄ	Mango DI	vÁvÀ request	PÀvÉÛ window

Responses

The responses were same as in the Experiment 1

Results

The data was analyzed with SPSS.17 software for Windows. For the statistical analysis, the reaction time (RT) from correct responses was used and Paired sample Student *t*-test was used to find out whether the difference between the two conditions are statistically significant. The RTs values were significantly prolonged on NP tasks for both UR and IR conditions across both languages which were shown in Fig. 3 and Table 3. For L1-L2 tasks the NP mean value of (-44.24) was statistically significant (t = -3.33, at $p < 0.05$). Similarly L2-L1 tasks showed NP mean value of (-50.55) which was also significant (t = -3.17, at $p < 0.005$).

Table 3. *Mean Reaction Time for both LI-L2 unrelated and ignored repetition and L2-L1 unrelated and ignored repetition conditions*

	Reaction Time (RT)			
	L1-L2		**L2-L1**	
Experimental condition	Mean value	Standard Deviation	Mean value	Standard Deviation
Ignored repetition	716.66	132.61	708.44	182.26
Unrelated	672.41	131.88	657.88	122.77
Priming	44.24		50.55	

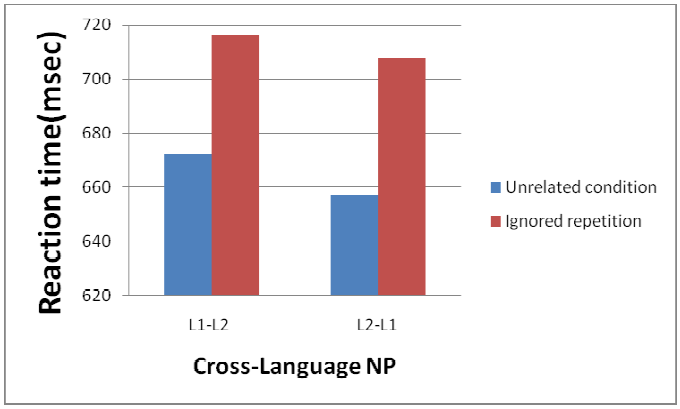

Fig. 3. *Mean reaction time for both LI-L2 unrelated and ignored repetition and L2-L1 unrelated and ignored repetition conditions*

Discussion

The Results were in consonance with the study done by Damian, 2000; Zubicaray, McMahon, Eastburn & Pringle 2008 (Experiment 1) and Fox 1996; Neumann, McCloskey & Felio 1999 (Experiment 2). The present findings provide evidence for the role of inhibitory processing resources in selective attention and for their applicability to language processing.

The present findings provide evidence for the role of inhibitory processing resources in selective attention and for their applicability to bilingual language processing. In both Experiment 1 and Experiment 2 found significant negative priming on both translation equivalents for both categorically related objects and L1-L2 and L2-L1 conditions.

Despite evidence that numerical were used (e.g. Dehaene, Spelke, Pinel, Stanescu & Tsivkin 1999) as stimuli the categorise wise lexical item were selected as the stimuli are more close to a SLPs work with language specific disorders. This result showed that NP also operates at a semantic level of representation and also words which share a high degree of meaning overlap (translation equivalents) should produce cross-language priming. This is probably because of strong lexical links in this direction for translation equivalents. There was no significant difference between cross language NP between two languages. These results suggest that balanced bilinguals access common conceptual representations across languages.

This study sought to examine the performances of a group of participants with normal young adults on a Bilingual NP Task and NP in Naming of Categorically Related Objects.

The main focus of the study was the difference in performances between the two conditions i.e. unrelated and ignored or semantic repetition. There was overall RT difference between the two conditions. Interactive activation models provide a connectionist semantic and phonological network in which inhibitory as well as excitatory connections influence word production in categorically related objects and also in bilinguals. The selective inhibition hypothesis states that initially all visual stimuli are activated, but because all of these stimuli compete for dominance, inhibitory processes are recruited to reduce the activation on non-target stimuli. In this manner, the activation of non-essential or non-target stimuli is reduced relative to the selected target so that further processing of the target can occur. This study supports the previous literature about the presence of NP across cross-language and in categorically related items.

When a target word is encountered and activated, its semantic and phonological associates are also automatically activated according to the strength of association. If an individual inhibitory mechanism delayed, disrupted, absent, or overactive the activation of these associates may not be reduced as needed to produce the target word. As a result, naming errors may occur. Persons with aphasia often exhibit inadequate inhibitory processes to overcome response competition (Tobin & Hinckley 2007) and also same results seen in Wernicke's aphasia (Weiner, Connor & Obler 2004).

Also during sentence processing, interpreting a word that has multiple meanings requires that its contextually appropriate sense be accessed. It is generally thought that competition between the word's multiple meanings must be resolved, and this function has been attributed to inhibition (Gernsbacher & Faust 1991).

Normal variation in academic achievement and intelligence scores is influenced by inhibitory abilities. This variation includes differences between individuals and between different developmental stages, as well as between those with specific reading and language difficulties. To the degree that inhibitory abilities play a role in working memory span measures. NP can be used to determine if any inhibition insufficiency in individuals means then treatment may be devised that addresses this insufficiency.

CONCLUSION

This preliminary study explored NP effect in bilinguals and in Naming of Categorically Related Objects. It has been known from the literature that different populations have different levels of inhibitory control, and that this can be revealed by using NP. NP can be used to determine if any inhibition insufficiency in individuals means then treatment may be devised that addresses this insufficiency. In the present study only age matching was done and variety of clinical population could not be presented. Future studies will need to keep this factor in view.

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Appendix I

Category labels and stimuli used in the experiment

Living
DOMESTIC ANIMALS: cat, cow, dog, horse, pig.
FOREST ANIMALS: tiger, lion, elephant, zebra, leopard.
BIRDS: hen, eagle, peacock, parrot, eagle.
INSECTS: spider, Scorpio, fly, cockroach, butterfly.

Non-living
FRUIT: apple, banana, grape, watermelon.
VEHICLES: bus, car, bicycle, car, truck.
CLOTHING: belt, shirt, pant, sock, tie.
FURNITURES: table, sofa, table, desk, chair.
SHAPES: circle, square, triangle, cross, star.

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