



Role of Executive Functions in Lexical Selection

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Abstract

Keywords

- executive control
- response inhibition
- cognitive flexibility
- conditional naming

Objectives This article determines the number of correct responses under confrontation naming, producing category coordinates, superordinates, and features associated with the target.

Materials and Methods Thirty participants in the age range of 18 to 30 years served as participants. The study was carried out in Malayalam, the native language of the participants. A conditioned naming task was administered to the participants.

Statistical Analysis Within-group analysis was carried out using Friedman's test.

Results It was found that the participants erred more in naming category coordinates, derivatives, and superordinates.

Conclusion The amount of cognitive control varied for each of these conditional naming tasks, and with increasing complexity in cognitive control, scores on conditional naming tasks also differed, showing the relationship between these two aspects.

Introduction

Lexical access is defined as the retrieval of the most appropriate word from the lexicon. Research pertaining to lexical access has been one of the significant areas of research in psycho-linguistics. Many models pertaining to lexical access have been explained till date. The three-stepped interactive activation model has been proposed to date. The three-stepped interactive activation model has been considered to be an influential model in this direction.^{1,2} According to this model, lexical activation takes place in three steps. The first step would involve the conceptual activation phase, followed by the lemma node activation phase, and the third phoneme retrieval phase. Based on the concept and context, conceptual activation occurs; many lemma nodes may correspond to this conceptual activation and may get activated subsequently. Following this, one lemma node exceeding the threshold of activation would get activation. Subsequently, the phonemes pertaining to the retrieved lemma node would get activated. Though the model has been explained consid-

ering the picture naming task as a reference, the model holds good for spontaneous speech and narration also.²

The relationship between lexical selection and cognitive control has attracted researchers recently. The primary evidence for these grounds has been derived through studies on semantic facilitation and inhibition. The blocked naming task has been used experimentally for tapping the facilitation and inhibition.³ In the blocked naming task, pictures of a particular lexical category are presented as one block. On the other hand, pictures belonging to different lexical categories are presented in another block and are termed as an unrelated block. The naming latencies and accuracy for the related and unrelated blocks are compared. If the naming latency is short and accuracy is better for the semantically related block than the unrelated block, facilitation is assumed to operate, and the visa-versa indicates inhibition. The facilitation and inhibition are assumed to constrain the process of lexical activation. Since the process is constrained, some amount of cognitive control is also thought to be involved.

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The lexical selection or the lemma node activation is assumed to have an intricate relationship with cognitive control.⁴ The process of lexical selection would involve choosing the correct word from the lexicon; hence, this particular process would involve some amount of cognitive control. However, it is noteworthy that the attention required is automatic, and given these requirements, it is likely that abilities to discriminate among linguistic representations are grounded in general response selection abilities.⁵

Controlled semantic cognition, or semantic control, refers to the process of accessing lexical-semantic content from long-term memory.⁶ Cognitive control is utilized in this process while searching for semantic information that would help identify the target and in the form of inhibition to suppress competitors. Researchers have unified the idea of semantic control into a broader framework of “neural multifunctionality.” This refers to the dynamic interaction among the neural networks specializing in cognitive, affective, and praxis functions.⁷ Furthermore, it has been showed that top-down cognitive control is recruited during semantic retrieval with increasing retrieval demands, even when retrieval did not require selecting against competing representations.⁸

In recent years, the term executive function has pitched in, and its relationship with lexical selection has been studied by investigators. The term executive function refers to a cluster of cognitive processes which can have conscious control of thoughts and actions. In other words, this cluster of the cognitive process has control over how the thoughts are channelized and the action is monitored; hence is considered to be pivotal. The term executive function ascribes specific processes like cognitive flexibility, working memory, response inhibition, etc. These processes are essential for goal-directed activities.⁹

Some studies have explored the relationship between lexical-semantic activation and executive functions. However, it is noteworthy that the population considered for each of these studies is diverse. For instance, a study⁷ explored the relationship between executive function and object action naming in older participants. Two hundred sixty-four individuals between 55 and 84 years were enrolled in the study. Six tasks tapping executive function were administered to the participants in addition to object naming and action naming tasks. The researchers reported that the executive function predicted the naming speed and accuracy, highlighting the relationship between executive functions and performance on naming tasks. Another study¹⁰ investigated the relationship between executive functions and naming performance in children ($n=111$) between 8 and 10 years. Executive functions like inhibitory control, working memory, and planning were tested. A generative naming task was administered. It was reported that there was a positive correlation between the tasks on executive functions and performance on naming performance. A systematic review¹¹ was carried out with the aim of exploring the relationship between executive functions and lexical-semantic activation in bilinguals. The study reported inadequate evidence about the relationship between executive

functions and lexical-semantic activation in bilinguals, as the profiles in these individuals are heterogeneous.

The executive functions have a bearing on the process of lexical semantic activation. The relationship between the lexical items is assumed to build the base for the conceptual semantic relationship. This process would require attention in the making, at least in the developmental stages/phases, hence can have an essential role in designing the conceptual relationship. The process of lexical selection has a definite bearing on the process of executive function as the process of cognitive flexibility and response inhibition is considered pivotal in the step. A lack of cognitive flexibility would result in errors pertaining to lexical selection, while errors related to cognitive flexibility would limit the semantic accessibility or information conveyed within the target word. There is a clear dearth of studies deciphering the relationship between lexical selection and executive function. The current study aimed to unveil this relationship using a conditioned naming task.

Need for the Study

Models of cognitive control have a bearing on the models of lexical selection. The current study used a conditional naming paradigm. In contrast, previous studies have used the naming task as the linguistic task to determine the relationship between cognitive control and linguistic task. The ability of a person to switch between the lexical items belonging to different categories and also the ability to switch between items of varying complexity levels would exercise cognitive control. However, the naming task might be simple for neurotypical participants, and lesser cognitive control would be required for performance. Hence, it was decided to choose the conditional naming task in the current study. The conditional naming paradigm constrained the lexical selection, that is, the participants were either asked to name a picture, produce a category coordinate, name the superordinate category, or produce a feature about the target picture. The quantum of cognitive control varied for each of these conditions. The number of correct and incorrect responses was computed, and the errors were analyzed to determine the relationship between cognitive control and lexical selection.

Aim of the Study

To determine the relationship between cognitive control and lexical selection.

Objectives

To determine the number of correct responses under confrontation naming, producing category coordinates, superordinates, and feature associated with the target.

Materials and Methods

A cross-sectional within-group comparison study design was employed for the study.

Thirty participants aged 18 to 30 years were recruited for the study based on purposive sampling. No specific tests

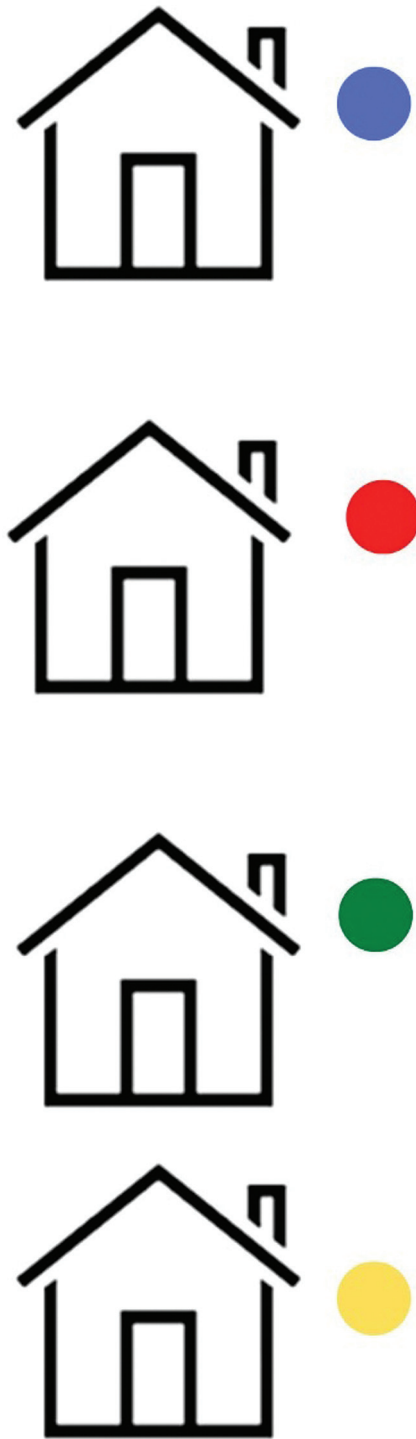


Fig. 1 ·Schematic representation of conditions.

were used for participant recruitment. The participants had no history of cognitive, communication, or sensory deficits. The participants were selected after signing the informed consent. The informed consent work ensured the details regarding participation, the time required, the procedure employed, and the power to refrain from participation.

All the participants were bilinguals, with the native language as Malayalam and the second language as English. As all the participants were bilinguals, the Language Experi-

ence and Proficiency Questionnaire (Ramya and Goswami, 2009) was administered to determine their bilingual history and language usage. A rudimentary criterion revealed that all the participants were high proficient bilinguals (on the undertaking, speaking, and reading domains, they rated their proficiency as four on four and three on four or four on four for the speaking domain). Hence, the participants considered for the study were deemed as high proficient bilinguals. However, proficiency in the second language was immaterial in the current task as the conditioned naming task required the participants to use their native language only.

The stimulus included 32 pictures of lexical items, including flowers, fruits, vegetables, common objects, insects, animals, and birds that are commonly encountered. Each picture was presented with a colored dot above it, as shown in ►Fig. 1. All the stimuli were collected directly from the E-resources. Validation of the stimuli as such was not performed. However, most of the pictures converged to the 260 picture set (Snodgrass and Vanderwart, 1980). Stimulus presentation was done through PowerPoint slides. Each slide was presented for 5 seconds. The order of stimulus presentation was randomized, and no specific order was followed. Care was taken to verify that the number of dots of each color was equal. Hence, eight pictures each were associated with the given color. Specific software like DMDX and E Prime were not used for stimulus presentation as the objective was to determine the accuracy, not the reaction time.

Procedure

The participants were instructed to name each of the lexical according to the color of the dot associated with the picture. The first slide in the presentation contained information regarding the task to acclimatize the participants. If the picture was presented with a blue dot, the task was to name the superordinate of the given lexical, whereas a red dot indicated naming another lexical in the same category of the given lexical. A yellow dot indicated naming a feature of the given lexical, and a green dot was the indication of naming the given lexical itself. Responses were recorded and transcribed. The details of the conditions used in the conditioned naming task are explained schematically in ►Table 1. In order to acclimatize the participants to the task, a trial item was presented. However, in the trial item, only one particular color was associated, and the participants were instructed what to perform when the other colors were presented. The duration of data collection per, a participant was 15 minutes.

Scoring and Analysis

Responses were categorized as correct responses, incorrect responses, and no responses. Each correct response was given a score of 1, while the incorrect response was given a score of 0. The incorrect responses were further classified as substitution errors and other errors. Substitution errors included the errors in which the participants interchanged the task to be done. Other errors included the conditions, where the participants could memorize the respective task

Table 1 Details of the different conditions used in conditioned naming

Sl. no.	Particulars	Conditioned naming	Number of pictures under each block
1	Pictures with blue dot	Name the superordinate of the picture	8
2	Pictures with red dot	Naming another lexical from the same category	8
3	Pictures with yellow dot	Naming a feature of the lexical presented	8
4	Pictures with green dot	Name the lexical itself	8

correctly but gave an incorrect response. The number of correct responses on each of the four conditions was compared with each other. In other words, only within-group analyses were carried out.

Results

The number of correct responses was analyzed. The scores were tabulated and analyzed for each condition, that is, naming the lexical, derivative, superordinate, and category coordinate. The total percentage of correct responses computed (across the 4 conditions and 30 participants) was 68%. The mean scores for four conditions (naming, superordinate naming, category coordinate naming, and feature naming) were 7, 5, 4, and 3, respectively (all values are rounded off to the nearest whole number value). The median scores were 7, 5, 3, and 3. The interquartile range was 2.78, 3.15, 4.16, and 2.98, respectively. The data were subjected to the test of normality using Shapiro–Wilk’s test of normality. The *p*-value was 0.038 showing that the data were nonnormally distributed.

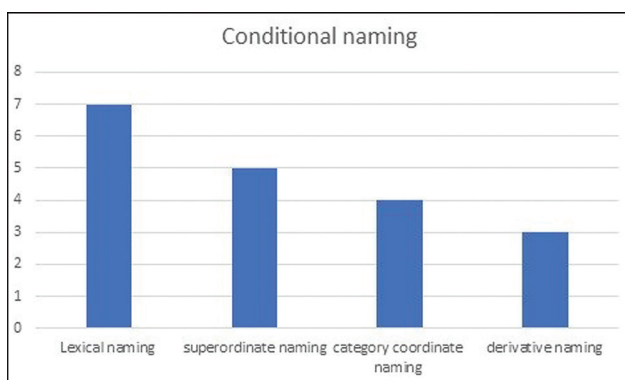
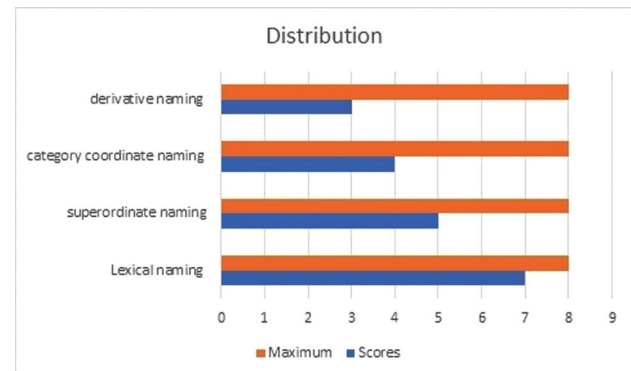
The trend of responses seen in most participants was naming followed by feature naming, followed by superordinate naming, followed by category coordinate naming. However, the combinations also were seen for some participants, and the performance was heterogeneous overall. Performance across the four different conditions in conditional naming is shown in ►Fig. 2, and the distribution of scores on each condition with the maximum score is shown in ►Fig. 3.

In order to verify if there was any statistically significant difference across the four conditions, Friedman’s test was

carried out (as the data did not abide by the properties of normal distribution), and the chi-square value obtained was 2.03. The corresponding *p*-value showed a significant difference. Thus, there was an evident difference in the performance across the four conditions. In order to verify if there was any significant difference between the conditions, Wilcoxon’s signed rank test was carried out. On comparing the lexical naming category with coordinate naming, lexical naming, and superordinate naming, lexical naming with derivative naming, *|z|* scores obtained were 2.24, 2.18, and 2.06. On comparing the category coordinate naming with derivative naming and superordinate naming, the *p*-values obtained were 2.34 and 2.02, respectively. On comparing the derivative naming with superordinate naming, the *|z|* score obtained was 1.82. The overall results showed that there was a significant difference between the four conditions except for the derivative naming versus superordinate and superordinate versus category coordinate conditions.

Discussion

The relationship between cognitive control and lexical selection is generally assessed through picture naming. There are few language production models which incorporate the role of cognitive control. Some studies in this direction^{7,10,11} have shown that individual differences in specific executive functions predict performance on language tasks especially naming tasks. For example, in healthy younger and older adults, it has been found that inhibitory control skills prognosticated the ability of the participant to deal with

**Fig. 2** Performance across the four different conditions in conditional naming.**Fig. 3** Distribution of scores on each condition with the maximum score.

lexical-semantic competition.⁷ Picture naming task is assumed to oversimplify the process of lexical selection, especially in neurotypical participants owing to which the current study used conditioned naming. The items on a confrontation naming task are arranged in a sequence and item complexity. In other words, objects of different complexity levels are arranged in an order. Owing to this, the strain on cognitive load is minimal. The blocked or continuous naming task is specifically designed to tap the lexical-semantic activation.² In the blocked naming task, the semantically related pictures are presented as one block, while the semantically unrelated pictures are presented as another block. The vocal reaction time and accuracy for semantically related and unrelated blocks are compared with one other to deduce the mechanism of lexical semantic activation.⁶ Cognitive control is required to switch between the blocks. However, the current study did not use the blocked naming task as the premise was not to compare the cognitive control for related and unrelated blocks but for different conditions associated with naming.

The premise of the current study is that lexical retrieval is dependent not only on the language but also on the interaction between the language and cognitive processes. The study utilized a conditioned naming task specifically designed for the study. The participants were asked to name the picture or produce the generic name of the lexical category, produce another lexical belonging to the same lexical category as the lexical, or produce a feature associated with the lexical based on the color of the dot associated with the picture. The cognitive control required in performance varied across the four conditions, as evidenced by the descriptive and inferential statistics.

The task used in the current study was moderately complex (based on the opinion compiled in a small pilot study preceding the current study). It was decided to rely on the accuracy of scores. The participants were well acclimatized with the color of the dots and asked to respond within 5 seconds. The distribution of responses (► **Fig. 2**) showed that the participants performed better when they were asked to name the lexical followed by superordinate naming, category coordinate naming, and naming the derivatives. While naming the lexical item as such, the cognitive load was minimal for this condition. The only constraint was that the participant was required to associate the picture with the dot's color and name the lexical as such. Under superordinate naming, the participant was asked to produce the superordinate or the name of the lexical category. This task was hypothesized to be easy; however, it was observed that it imposed some constraints on the participant. It was observed that few of the participants named the lexical item itself instead of producing the name of the superordinate category. The third condition required the participant to produce another lexical from the same category. This task induced cognitive load as the participant was required to switch between the lexical item, think of another item belonging to the same lexical category, and produce the response. This task, as expected, was challenging for the participants, and the last task required the

participants to produce a derivative. The derivative was sometimes evident in the picture, and sometimes the task required the participant to extrapolate from the target item and produce a response. The findings of the current study can be considered as preliminary as it was done on an exploratory basis on young neurotypical adults, hence the results of the present study could not be compared with the findings of the previous studies carried out in this direction as the earlier studies used the confrontation naming task or the blocked naming paradigm which was relatively easy in terms of task complexity.^{7,11} The primary limitation of the study was that participants in a limited age range were considered. The number of participants was also limited. There were no specific or stringent criteria followed with respect to the stimulus. Therefore, in future studies, these must be considered.

Conclusion

The study was carried out to determine the relationship between lexical selection and cognitive control. Thirty Malayalam speaking neurotypical participants in the age range of 18 to 30 years were considered. A conditioned naming task was administered to participants. The participants were asked to name, produce category coordinate, superordinate, or feature based on the color of the dot. As the task complexity increased, scores reduced, which emphasized the relationship between cognitive control and lexical selection. The quantum of cognitive control would be relatively more for complex conditions.

Authors' Contributions

S.R.S.: Literature search, clinical studies, experimental studies, data acquisition, data analysis, manuscript preparation, manuscript editing, manuscript review.

H.J.: Literature search, clinical studies, experimental studies, data acquisition, data analysis, manuscript preparation, manuscript editing, manuscript review.

C.S.: Manuscript preparation, manuscript editing.

A.B.P.: Concepts, design, definition of intellectual content, literature search, statistical analysis, manuscript preparation, manuscript editing, manuscript review, guarantor.

Statement of Institutional Review Board Approval
Yes.

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Conflict of Interest
None declared.

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