

## Bilingualism and its Contribution to Executive Function

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Abstract:

The goal of this paper is to identify a relationship between language proficiency(LP) and executive function(EF) within both monolinguals and bilinguals. There's an existing debate that focuses on research related to the benefit of having two active linguistic systems that consistently compete to assume dominance. As a function of the necessary maintenance of the two language processing domains, bilinguals are expected to exhibit increased executive function when compared to monolinguals on tasks that measure EF. Studies that have looked into the subject matter have ranged widely in the methodological approaches used for the analysis of EF. As a consequence of the need for methodological repetition, the two studies involved in this paper attempt to mimic the common procedures used for the analysis of EF. Study one incorporates a self-report questionnaire with a focus on correlations between questions that measure LP and EF, where around 850 young adults from Napa, California, will participate. Study two is a quasi-experimental design that compares two naturally occurring groups within the local city, where roughly 900 monolinguals and bilinguals are compared on tasks that measure inhibition, working memory, and cognitive flexibility. This research should help us better our understanding of the benefits tied to bilingualism and what they might suggest for language curriculums and possible improvements.

*Keywords:* Executive function, language proficiency, bilingualism

### Bilingualism and its Contribution to Executive Function

An elaborative understanding of the structures that contribute to executive function is needed for further improvement in areas where optimizations can help students and independent learners reach their goals more efficiently. With the assumption that the acquisition and use of a second language is beneficial to the development of EF, then an enhanced performance on everyday activities should be expected as a result of the large domain that EF happens to occupy. Used as an umbrella term for top-down cognitive processes, executive functions refer to a collective joint of processes that involve inhibition, working memory, and flexibility in the shift of cognitive tasks (Minna et al., 2018). In theory, during a bilingual's production of speech, both fluent language systems become active and influence verbal decision making (Ross & Melinger, 2017). Since both linguistic systems are active at the same time, the production of one word should elicit competitive behavior between lexical alternatives. To prevent the risk of interference between the two systems, a level of efficiency must be met where unnecessary terms can be inhibited and sets of lexical terms can be switched across without creating a collision. Additionally, within fluent bilinguals, a consistent moderation of activation levels between the two languages would be necessary for choosing the appropriate choice of words for the correct context (Minna et al., 2018). It's in this sense that executive function processes are exercised and trained, where repeated uses of task-switching actions, including language-switching, aid in further EF development.

Despite the proposed advantages acquainted with second language acquisition, another perspective argues that there's a potential disadvantage associated with bilingualism. Since both

language systems are simultaneously active within a fluent bilingual, there exists a potential problem of conflict that isn't available to the monolingual speaker. During the intake of verbal information, the bilingual speaker needs to add a dimension of selection to the typical sequence of linguistic processing. This sequence includes dimensions such as register, collocation, and synonym (Bialystok, 2011). Research on nonverbal tasks has concluded that a general-purpose executive control system is used for selection and conflict resolution, so the EF system should seemingly become active to resolve conflicts created by the joint activation of the two lingual systems (Bialystok, 2011). Additionally, if the EF system is ordinarily recruited in lingual processing, then the relationship between the two should improve with repeated practice, resulting in a more proficient selection of the target language. In this manner, fluent bilinguals should be more proficient at verbal tasks involving EF compared to bilinguals with less proficiency as a result of repeated practice. Additionally, monolinguals should likely exhibit a slight advantage when it comes to verbal tasks that require bilinguals to resolve conflicts between the two linguistic systems using EF. However, as a function of increased use of executive control function, bilinguals should have an advantage when it comes to nonverbal executive control tasks.

### **Executive Control and Measures**

To support the claim that language proficiency and second language acquisition is supplemental to cognitive processes involving EF, demonstrations involving EF are needed to describe any relationships that might be found. Since EF covers a wide domain of top-down cognitive processes, specific areas should be assessed to collectively determine variations of EF between individuals with varying degrees of LP. A general agreement amongst researchers has

operationalized EF as a function of three core components; inhibition, working memory, and cognitive flexibility(Diamond, 2012). From these three core components, higher order EF's, such as reasoning and problem solving, can be abstracted and measured.

**Inhibition:** Inhibition refers to an individual's ability to control attentiveness, behavior, and strong internal predispositions. Without an extent of inhibition, we'd become a victim to the constant stimuli within our environment. At the level of perception, inhibitory control enables us to select and focus on which stimuli we'd like to attend to or suppress(Diamond, 2012). In relation to bilingualism, inhibitory control allows us to refrain from committing to the non-target language when it's inappropriate for the given social context. Similarly, someone's ability to fight temptations and persevere on a strenuous task can be reflective of that individual's EF. For this reason, tasks that measure a participants' ability to refrain from obtrusive stimuli, while completing a given objective, can be used to assess varying levels of inhibition within a given population. In one outside study, researchers examined the differences in performance between young monolingual and bilingual children on a global-local task where the ability to inhibit attention to salient aspects of perceptual displays was investigated. Results of this study showed that the bilingual children were faster to react in both congruent and incongruent trials where salient aspects were distinguished(Bialystok, 2011).

Since we're trained to abstract meaning from words that we see, we tend to ignore superficial characteristics of words such as font style or ink color. A popular assessment of inhibition is the Stroop task, where words can be congruent("blue" in blue ink) or incongruent("red" in green ink) with the ink they're printed in(Duñabeitia et al., 2014). When participants are asked to report the color of the ink, they're forced to inhibit reinforced tendencies

that work against their decision-making skills. Proficiency within this task is measured as a function of latency and the total number of errors. Thus, the Stroop task can be used, with validity ensured, to operationalize inhibition in an analytical approach to measuring EF.

**Working Memory:** Working memory(WM) is an important component of EF that reflects an individual's ability to withhold small portions of verbal and non-verbal information in the mind to successfully complete a task involving that information. WM is an important aspect of perception, where incoming stimuli are encoded, stored, and then manipulated during the process of interpretation. Unlike short-term memory, working memory relies on the dorsolateral prefrontal cortex, which becomes active when withheld information is manipulated(Diamond, 2012). When measuring WM, it's important to account for the bi-directional relationship between inhibition and WM. For example, inhibition is needed during the use of WM, where ideas and facts need to be focused on independently before they collectively form some sense of meaning; where inhibition prevents unnecessary stimuli from interfering with existing thoughts and facts that are being manipulated. On the other hand, WM is needed for the storage of information during the process of inhibition, where concepts need to be encoded and evaluated before deciding what needs to be inhibited(Diamond, 2012). Then, to properly measure WM, participants should take part in an activity where the retention and manipulation of instructions is necessary for success, and where the influence of inhibition should also be considered. The Hearts and Flowers task is an assessment that requires participants to remember two rules; press on the same side as the stimulus for stimulus one, and press on the opposite side of the stimulus for stimulus 2. This tasks requires participants to mentally withhold instructions, and then manipulate or use that information to carry out the correct response(Diamond, 2012). With the

utilization of this task, there's an expectation that bilinguals will react faster to each stimulus as a function of their enhanced EF development. Since inhibition is needed for selective focus on the Heart and Flowers task, bilinguals should be able to inhibit unwanted information more efficiently due to their constant use of inhibition for language processes.

**Cognitive Flexibility:** Cognitive flexibility(CF) is an essential component of EF and LP, where the term refers to an individual's ability to quickly and flexibly adapt to behavior to changing situations (Davidson et al., 2006). Said differently, cognitive flexibility refers to our ability to rearrange our perceptions to find new interpretive frameworks and approaches to problem or concepts. As a consequence of consistently switching between two languages, bilinguals are a suspect of enhanced flexibility when it comes to adaptation and re-interpretation. Commonly, CF is investigated using task-switching and set-switching tasks(Diamond, 2012). A popular task used for assessing CF is the Dimensional Change Card Sort(DCSS). Within this task, individuals are shown two target cards and asked to sort a series of cards with respect to an initial dimension(e.g., color) and then a secondary dimension(e.g., shape)(Zelazo et al., 2014). Essentially, the goal of the task is to measure an individual's ability to quickly adapt to changing contexts in order to successfully sort an object according to the appropriate construct. This task can be used to compare CF between monolinguals and bilinguals, where bilinguals should be more efficient as a function of their experience with language-switching.

### **The Present Study**

This study aims to retest typical methods used in the analysis of executive function and its relationship to language proficiency. Methods will be designed around the relational analysis between EF and LP, where popular tasks for measuring EF will be used to improve reporting

when results are used and compared to studies that seek to replicate our findings. Currently, issues within the topic of research are contributed to unaccounted variables and variations in methodologies. Factors, like age differentials and inconsistent use of methodology, make it difficult for meta-analyses to draw conclusions around the topic. In response, the methodology within this study will be tailored towards young adults, where we'll use popular and valid measures to ensure efficiency when comparisons are made.

### **Method: Study 1**

#### **Participants**

Within this study, roughly 850 young adults from Napa County, California, are expected to participate in a correlational study assessing both executive function and language proficiency. Utilizing a convenience sampling method, researchers will iterate through a database to select participants around a target age of 20 for the study. This sample should be reflective of the County's population, so around 50% of the population is expected to be Caucasian, with another 20% likely being Hispanic/Latino. The remaining fifth of the population is expected to be shared amongst Asian-Americans, African Americans, and others.

#### **Measures**

In this study, participants will take part in a self-report questionnaire that measures the attitudes and perceptions of participants with respect to a self-determined degree of executive function and language proficiency

**Language proficiency.** This portion of the self-report questionnaire offers ten statements that aim to measure LP as a function of the beliefs and perceptions held by participants. Responses are made using a Likert Scale ranging from 1 through 5. "1" stands for "strongly



disagree,” and “5” stands for “strongly agree.” In one statement, the questionnaire asserts, “I can communicate efficiently between groups that speak differently.” In another assertion, the questionnaire states, “It’s easy for me to adjust the structure of the way I speak to address the needs of others.” For a full list of statements, refer to Appendix A.

**Executive Function.** The self-report questionnaire proposes ten statements that aim to measure EF as a function of the beliefs and perceptions held by participants. Using a Likert Scale, participants will choose responses ranging from 1 to 5, where “1” stands for “strongly disagree,” and “5” stands for “strongly agree.” Responses are reflective of the beliefs and perceptions held about the proposed statements. In one statement, we assert, “I can view important issues from more than one perspective.” In another location, we state, “I enjoy trying to solve difficult problems that need to be broken down creatively and strategically.” For a full list of statements, refer to Appendix A.

## **Design**

Study one is a correlational design that will seek to find any signs of a relationship between language proficiency and executive function. In the form of a traditional survey, the correlational design will include a self-report questionnaire containing 20 questions. Researchers expect that there’ll be a positive relationship between EF and LP.

## **Procedure**

Using an online database, random selections will be used to accumulate roughly 850 participants for a correlational study measuring EF and LP. After being directed to the website, FakeSurveys.com, participants will be prompted with an informative consent page. If and only if the participants agree to the conditions on the consent page, they’ll be directed to a page

containing the survey. Each participant will vary in the time needed for the questionnaire's completion, but the average duration is estimated to be around forty-five minutes. Whether the participants decide to discontinue or continue the survey, they'll be given an incentive worth twenty-five dollars. Following the survey, the participants will be debriefed online about the purpose and goals of the study.

### **Method: Study 2**

Limitations surrounding study one can stem from reasons related to social-desirability, retrospective bias, and the possible presence of demand characteristics. Additionally, the initial study was a correlational one where extraneous variables are difficult to catch, and where it's also troublesome to determine the direction of influence between the two variables. Study two will utilize a quasi-experimental design to increase internal validity while comparing monolinguals and bilinguals on tasks that measure EF. As a function of their heavy experience with conflict resolution and inhibition, bilinguals should perform better overall on tasks that measure cognitive flexibility, inhibition, and working memory.

### **Participants**

This particular study should use around 900 young adults for an analysis of executive control function with language proficiency as a parameter. Researchers should use a stratified random sampling method to select participants from the broad area of Napa, County. The stratification of the sampling method should allow researchers to draw balanced proportions of participants with respect to the density and diversity of particular sections of the region. This study will be conducted in cooperation with the local school districts, where we'll be able to send a non-invasive email to high school seniors and community college students, so we expect the

average age to be around nineteen years old with a standard deviation of two. Due to the demographics of the local county, we expect a large number of bilinguals to be Hispanic/Latino or Asian-American, where a large number of monolinguals will likely be Caucasian. After sampling the targeted populations, we expect around forty-four percent of the total sample to be bilingual or multilingual, where the remaining percentage is monolingual.

### **Measures**

Within this study, researchers will first administer a language proficiency test along with a series of executive control tasks to examine the strength of any relationships between executive function and language proficiency. To properly assess executive function, each participant will need to take part in a series of tasks that measure inhibitory control, cognitive flexibility, and working memory.

**Language Proficiency Examination.** To properly determine whether or not a student is bilingual or multilingual, researchers should assess each participants ability to read, understand, and manipulate sentences within another language besides English. Test questions will consist of translational and comprehensive exercises to determine if participants are fluent in at least one of four languages. Those four languages are Chinese, Spanish, Latin, and Portuguese. Responses to questions will be recorded with multiple choice answers to questions like, “What’s the Spanish equivalent to the word ‘elephant’?” Out of four options, the participant would have to select the response, where three possible responses are invalid. Available responses to the previous proposed question might be “A: elephante,” “ B: elepante,” “ C: eleyfante,” or “D: elefante.” For a full list of questions, refer to Appendix B.

**Stroop Test.** This test requires participants to read words that describe colors, but the ink of the text can either be congruent (“blue” in blue ink) or incongruent (“blue” in red ink) with what the word describes. The idea of the task is that it measures inhibition by exposing participants to a common stimulus that literate people have been conditioned to respond to, but participants are put into situations where they need to restrain any reflexive actions. The efficiency of a participant on this task is measured by the number of errors they make in proportion to the total number of words shown, with latency also being a factor of consideration. An instance of this task might ask the participant to read out the word “red,” when the color of the text is actually green. For a complete reference to the words and their associated colors used for the proposed study, refer to Appendix B.

**Hearts and Flowers Task.** To assess working memory, which refers to an individual's ability to retain and manipulate information, researchers should administer the Hearts and Flowers Task. This assessment requires participants to remember the instructions provided by the researcher in regards to the necessary actions needed for each exposure to one of two stimuli. Each participant will need to remember two rules; press on the same side of the visual stimulus when exposed to a heart, and press on the opposite side of the visual stimulus following exposure to a flower. The heart or flower will be placed on either the right or left side of each portion of a small paper page, where red ink will be used for each stimulus to eliminate any issues tied to the implicit selection of varying colors of text. Scores on this task can be measured as a function of both latency and total errors made. For one particular instance of this assessment, an individual might be exposed to three images of hearts and four images of flowers within a constrained amount of time, where the ability to retain and manipulate small loads of information can be

measured as a function of performance. For a full layout of instructions and stimulus sequences, refer to Appendix B.

**The Dimensional Change Card Sort.** One component of executive function is cognitive flexibility, which refers to an individual's ability to quickly rearrange perceptions and behaviors when adaptation is needed for new and unfamiliar situations. The Dimensional Change Card Sort(DCCS)offers researchers a way to evaluate the degree of proficiency within participants when they're required to quickly make decisions when proposed with an unfamiliar situation. For this task, participants are presented with a stimulus of varying dimensions(e.g., color, shape, etc), where they'll be asked to select a particular card that matches the initial stimulus the most closely. For example. When presented with the word "Shape" and a picture of a purple truck, the participant has to decide between either a card that shows a purple volleyball or another card that shows a green truck. Participants are scored based on how quickly they make a decision, and also as a function of the total errors made. For a full illustration of the task and the proposed stimuli, refer to Appendix B.

## **Design**

Study 2 is structured as a quasi-experimental design, where we focus on executive function and its dependency on language proficiency. Given that bilingualism is a naturally occurring trait in participants, there's no direct path for manipulation of language proficiency within this particular study. Instead, tasks will focus on the analyzation of executive function within each participant.

**Matched Groups.** Proficiency in any given language is strengthened and developed through repeated practice and time. For this reason, there's little that researchers can do to

manipulate language proficiency within a true experimental setting. Instead, it's best to treat LP as a naturally occurring trait amongst participants. By differentiating participants by their ability to fluently speak in one or more languages, researchers will be able to create two organized groups where the degree of LP differs significantly. To confidently assure that the two groups are differentiable by the single quality of LP, researchers will utilize a strategy where variables like age, education, and wealth are taken into account when the two groups are constructed. For example, if the monolingual group is overly saturated with participants older than the expected mean, then measures can be taken to assure that a balanced proportion of younger participants are present within that same group. After exposing both groups to a series of EF tasks, differences amongst the two can be analyzed and interpreted. Each participant will undergo the examinations in a school setting at a local high school within the city of Napa, where small resting breaks are encouraged to help each participant perform well without any unsettling distractions.

### **Procedure**

Initially, researchers will use a stratified random sampling method to reach out to possible participants from Napa, County. With the cooperation of the local school districts and the local college administration, researchers should be able to easily and safely reach out to potential participants through their school emails without being invasive. Participants with interest will be redirected to a consent page where they'll select from available options for scheduling. Along with scheduling options and a location for consent signatures, participants will be shown an incentive. Each participant that takes part will be offered a \$50 Starbucks card. Roughly two months after the emails and scheduling forms are sent out and confirmed,

researchers will begin to conduct the measures. To begin, each participant will undergo an assessment of language proficiency. This assessment will help researchers determine whether or not the participants are monolingual. If not, the participants will be assigned to the bilingual/multilingual group. Following the labeling of any particular participant, they should be offered a bathroom break to rid the participants of any distractions. Additionally, all participants will be offered bottled water to prevent them from exhibiting unwanted factors related to dehydration. Next, researchers will conduct the second part of the study. A series of three executive control tasks will be issued to each participant. Researchers will record the latency and the total number of errors for each task. Following the conduction of these tasks and the recording of data, each participant will be debriefed about the true purpose of the study.

### **Discussion**

In an effort to identify any relationships between executive control function and language proficiency, the proposed studies were designed to measure qualitative traits of EF, where LP is used to segregate participants on an organized and structured basis. A lack of methodological repetition within studies that focus on bilingualism and EF helped the researchers of this study emphasize the importance of similarity in the context of procedures and data collection. The improved understanding of EF and its dependency on LP will hopefully highlight the importance of language acquisition for school environments and community members.

### **Strengths and Limitations**

The inability to manipulate language proficiency has created issues related to the internal validity of the two studies proposed within this paper. Study one utilized a self-report questionnaire to determine if there was a relationship between self-perceptions tied to LP and

EF, but the correlational design prevented the researchers from ruling out any third variables.

The possible presence of issues caused by demand characteristics, socially-desirable behavior, and retrospective bias has limited the potential significance of any findings from study one.

Study two enabled the researchers to increase the internal validity of EF measurements, where matched groups were useful for the reduction of unwanted differences on traits like age.

Unfortunately, the inability to determine the direction of influence and temporal precedence of the two variables degrades the empirical value of findings from the studies. The two studies conducted were still very useful for analytical purposes, where an improved sense of understanding will allow researchers to create studies that are better at measuring both EF and LP.

### **Future Directions**

Study one failed to account for any biases related to the psychological presentation of the participants within the study, so it's highly advised that any future replications incorporate a methodological approach to assessing behavior and changes in mood. A simple self-report questionnaire focused on daily hassles can be introduced to study one to prevent variation between participants as a function of their unpredictable mood. For study two, it'd be important for future researchers to make sure that they account for the possible contributions to EF that older age might offer. Study two focused on young adults with an average age of 19, so it'd be helpful if a new study created several groups where age is a factor behind the segregation of participants. One study could expose three bilingual groups of different age to the same series of EF tasks used for study 2, where they'd be compared to three monolingual groups of different age.



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### **Appendix A**

#### Items on Language Proficiency

1. I'm confident in my ability to converse in my first-learned language. 1 2 3 4 5
2. I can communicate efficiently between groups that speak differently. 1 2 3 4 5
3. Being knowledgeable of a second language could or has helped me perform more efficiently in scenarios where communication is important. 1 2 3 4 5
4. I can easily read and write in two or more languages. 1 2 3 4 5
5. During my childhood, I spoke more than one language to communicate with friends or family members. 1 2 3 4 5
6. I find it difficult to quickly switch between languages when I need to communicate using two or more languages at the same time. 1 2 3 4 5
7. I have no need for learning or understanding more than one language. 1 2 3 4 5
8. It easy for me to adjust the structure and tone of my speech to address the needs of others. 1 2 3 4 5
9. When reading articles or books, I find it difficult to interpret and pick up new unfamiliar words and phrases. 1 2 3 4 5
10. How important is it to you to be able to communicate effectively using two or more languages? \_\_\_\_

#### Items on Executive Function

1. Overall, I'm a good problem solver. 1 2 3 4 5
2. I enjoy trying to solve difficult problems that need to be broken down creatively and strategically. 1 2 3 4 5
3. I can view important issues from more than one perspective. 1 2 3 4 5
4. When I need to complete a task, I can do so without losing focus. 1 2 3 4 5
5. When I suddenly get the urge to carry out an action, I quickly do so. 1 2 3 4 5
6. I can quickly pick up new patterns in relevant tasks where the solution isn't always obvious. 1 2 3 4 5
7. I can easily sense and understand the differences between distinct social environments within my community. 1 2 3 4 5
8. I think heavily and critically about the consequences of my day to day actions. 1 2 3 4 5
9. When reading articles or books, I find it difficult to interpret and pick up new unfamiliar words and phrases. 1 2 3 4 5
10. What measures do you take to solve unfamiliar problems where you might lack experience? \_\_\_\_