Connection Of Musical Training, Bilingualism And Multi-Tasking

Final Paper

The study conducted by Moradzadeh, Blumenthal, and Wiseheart (2015) explored the effects of musical training and bilingualism on two aspects of executive function: task switching and dual-task performance. In the study, the experimenters define task switching as the ability to change between activities with the goal of not compromising performance on either task, and it is a skill that may reflect cognitive flexibility. They define dual-task performance as the ability to complete two different tasks simultaneously, a skill that is more colloquially known as multi-tasking.

While ample research has investigated the relationship between musical training and certain aspects of cognitive functions, such as working memory, verbal memory, and verbal intelligence, there has been little research on task switching and dual-task performance specifically. Similarly, research on bilingualism in respect to task switching and dual-task performance has been unclear about whether bilingualism is a true advantage in executive function. Some research has shown a significant bilingual advantage, whereas others have shown little to no effect. Additionally, research on the effects of musical training and bilingualism on executive function have been studied separately, but rarely together as combined variables. Moradzadeh et al. (2015) cite these as their primary reasons for pursuing their specific research regarding whether musical training and bilingualism show a combined effect on task switching and dual-task performance.

Based on the results of previous similar studies and inferences about the nature of musical training and language learning, Moradzadeh et al. (2015) expressed several hypotheses regarding the outcome of the experiment. First, the experimenters hypothesized that musical training would increase task-switching and dual-task performance because playing music is a skill that requires the musician to attend to multiple stimuli, such as time signature, key signature, and dynamics, often simultaneously. Second, the experimenters predicted that bilingualism would show an advantage for task switching because language learning requires the learner to switch between the native and foreign languages, which may develop the ability to switch between other tasks more broadly. However, Moradzadeh et al. (2015) were notably less confident in the positive effects of bilingualism on dual-task performance based on the results of past research conducted in this area of study, which have shown mixed support for the benefit of bilingualism on dual-task performance. Regardless, the experimenters postulated that bilingual people would show some advantage in dual-task performance because bilingualism requires the individual to process multiple language components across more than one language to produce the linguistic output. Finally, the experimenters predicted that participants who were bilingual and had been musically trained would show a combined benefit in the executive function tasks, more so than those who possessed only one skill.

The independent variables for the experiment were musical training and bilingualism. There were four experimental groups: monolingual musicians, bilingual musicians, monolingual non-musicians, and bilingual non-musicians. This experiment was conducted at a university; consequently, the participants were students who ranged from ages 18 to 31 years old.

Participants assessed their bilingual expertise on a five-point scale based on fluency. Musicians also assessed their musical ability based on years of training, theory training, ear training, and sight-reading ability. Additionally, the experimenters ensured that the data accounted for differences in socioeconomic status and age.

There were two dependent variables in the experiment: task switching and dual-task performance, which were measured by performance on the Quantity/Identity task, Krantz paradigm, and dual n-back task. Task switching was measured by the Quantity/Identity task, which contained three parts. In the first part of the task, participants were shown numbers on a screen and were instructed to indicate how many numbers were presented. For example, if the stimuli showed “111”, then the subject would be expected to respond “3”. In the second part of the task, subjects were shown sets of numbers again, but were asked instead to indicate the identity of the numbers. For instance, given the previous stimuli, the subject would be expected to respond “1”. In the third part of the task, the subjects were required to switch between the two previously described tasks every third trial. The experimenters measured reaction time in relation to global and local switch costs. Global switch cost refers to the reaction time in response to tasks of the same kind (e.g. consecutive quantity tasks), while local switch costs refers to the reaction time after switching between quantity and identity trials. The experimenters chose to use the Quantity/Identity task to measure task switching because the participants were required to switch between indicating the quantity and identity of the given stimuli.

Dual-task performance was measured by the Krantz paradigm and dual n-back task. In the Krantz paradigm, subjects were asked to track a moving dot with a target box that they controlled with a mouse. Simultaneously, they attended to flashing letters in the middle of the screen and clicked the mouse when they saw the letter “X”. The Krantz paradigm is an effective measure for dual-task performance because the subjects are tested on their ability to attend to two activities at the same time.

Originally, the experiment only included the Quantity/Identity task and the Krantz paradigm; however the experimenters contacted participants a year after the initial testing to complete additional tasks, including the dual n-back task. The dual n-back task tested dual-task performance like the Krantz paradigm, and it consisted of three parts. In the first part, participants were asked to press a button labeled “A” whenever they saw a blue square appear in the same position two times in a row. Then, the participants heard letters being played through speakers and were instructed to press “L” whenever the same letter was repeated twice in a row. After completing both tasks separately, they were asked to perform them simultaneously. This first segment, in which the target stimulus was repeated immediately an identical stimulus, is called a 1-back section. After the 1-back section, the participants repeated the same procedures, but instead were asked to press the correct letter (“A” or “L”) when the target stimulus was the same as the stimulus two before (2-back) instead of immediately repeated, as in the 1-back section. The dual n-back task measures dual-task performance because participants attend to stimuli across visual and auditory modalities - first trained separately, then performed simultaneously. Additionally, adjusting the “n” from 1-back to 2-back was an additional challenge that tested participants’ ability to manage multiple tasks.

The data collected from the Quantity/Identity task suggested that musicians responded faster overall, but they took just as long as non-musicians when responding after a switch between trial types. For instance, musicians’ performance within quantity and identity trials was improved; however, their performance when switching between quantity and identity trials was

comparable to that of non-musicians. This indicated that the musicians displayed an improved global switch cost, but not necessarily a local switch cost. Interestingly, there was no significant advantage of bilingualism for global or local switch trials.

When analyzing the data from the Krantz paradigm, the experimenters generated quantified scores based on reaction time and accuracy of the participants' responses. The data suggested that musicians outperformed non-musicians based on the average dual-task score; however, similar to the data from the Quantity/Identity task, there was no observed benefit of bilingualism or the combined effect of musical training and bilingualism.

For the dual n-back task, all participants demonstrated better accuracy on 1-back than 2-back tasks, most likely because the 1-back condition required a lesser memory load. Similar to the findings suggested by the Quantity/Identity task and Krantz paradigm, musicians demonstrated better performance than non-musicians. Interestingly, monolingual participants achieved slightly higher accuracy than bilingual participants. It is important to note that no task is a perfect representation of a singular cognitive function. For instance, some may argue that the dual n-back task does not only test dual-task performance, but also task switching, visual and auditory memory, and a number of other cognitive processes. Perhaps the inherent differences between the Krantz paradigm and the dual n-back task contributed to the differences in results. Additionally, not all of the participants returned to partake in the dual n-back task, so the difference in participant pool may be a contributing factor.

The results supported some parts of the experimenters' hypotheses, but not all. Long-term musical training is associated with increased ability in task switching and dual-task performance, as supported by better overall performance on the Quantity/Identity task, Krantz paradigm, and dual n-back task. The experimenters hoped to see a bilingual advantage in cognitive functions; however, bilingualism showed little to no effect in any of the tasks administered. Because bilingualism did not have any observed effect on the executive function tasks, there was no additive advantage of having both musical training and bilingualism.

The Quantity/Identity task, Krantz paradigm, and dual n-back task shed light on the nature of cognitive functions in regard to musical talent; however the experiment failed to show any advantage of bilingualism in regard to the executive functions of task switching and dual-task performance. The data suggested that participants with musical talent generally outperformed those with no musical training and bilinguals (though the difference was not as marginal as when tested against non-musicians). An important question arises: why do people with talent in two languages fail to show improved performance on these cognitive function tasks when language learning presumably requires frequent practice in task-switching and dual task processing? In the following experiment proposal we hope to explore potential solutions to this question and provide insight and possible hypotheses for the outcome.

The experimenters' discussion of the results lacked critical explanation for the unexpected non-advantage of bilingualism. Although there was some discussion about the importance of the level of bilingualism each participant had achieved, there was none regarding the importance of the developmental stage during which bilingual participants achieved fluency in their second language. Throughout the field of cognitive science, and psychology more broadly, it is known that there exists a critical time period during childhood for optimal language learning. People who learn a foreign language in childhood achieve fluency much more quickly and easily than adults or teenagers who learn a foreign language because. Perhaps there is significance in the

nature of the second language learning that may show a difference in executive functions. Whether the bilingual participants learned the two languages concurrently or sequentially may be a critical factor that informs their task switching and dual-task abilities, more specifically than the broad label of “bilingual”.

Therefore, it may be of interest for the experimenters to implement a modified version of the experiment that accounts for the variation within bilingualism, which may be relevant to task switching and dual-task performance. This modified version should investigate whether there is a difference in task switching and dual-task performance ability between bilingual people who learn the two languages together from a young age and those who learn one native language and adopt a second language later in development. There would be two experimental groups and one control group: concurrent bilinguals who learned the languages together, sequential bilinguals who learned them separately, and monolinguals. For the purposes of this experiment, we will define concurrent bilinguals as those who were exposed to both languages with near equal frequency during the critical language period. Sequential bilinguals will be defined as those who learn one native language when they first learn how to talk and adopt foreign language skills later on. Because this is a modification of the Moradzadeh et al. (2015) study, the same procedures and materials as the original experiment will be employed. The participants should be tested on the Quantity/Identity task, Krantz paradigm, and dual n-back task. Additionally, for the purpose of consistency, this modified experiment should include participants of the same age range (18-31 years old) as those who partook in the original version.

Because the variation within bilingualism is not often studied, we have not prepared formal hypotheses. However, some potential outcomes can be explored about the outcomes of the modified experiment through inferences about the nature of language learning. Perhaps concurrent bilinguals are more well-practiced in task switching and dual-task processing than sequential bilinguals because these skills have been ingrained since they first started learning the two languages together. In line with this idea, sequential bilinguals may show decreased performance in task switching and dual-task performance because they have less experience with bilingualism, which demands these executive function skills.

However, the opposite conjecture can be supported using different pieces of evidence. Developmental studies have shown that a critical language learning period exists in childhood, so children learn languages significantly more easily than adults. This suggests that children may dedicate fewer attentional resources to the language learning process. If the assumption that practicing cognitive functions improves performance on executive function tasks is accurate, then the more resources spent practicing a skill will improve cognitive function. Since a child does not have to practice a language as frequently or for as long a period of time as someone learning a language as an adolescent or adult, then it is possible that concurrent bilinguals will perform worse on the executive function tasks than sequential bilinguals. If people have a naturally better ability for task switching and dual-task processing in childhood which benefits concurrent bilinguals, then those who learn a foreign language later in life may display better overall task switching and dual-task processing because they are forced to retrain a function that has decayed since childhood.

Yet another potential outcome is that there will be varied performance across the tasks, as in the original experiment by Moradzadeh et al. (2015). In the original study, there was improved performance for musicians on the Quantity/Identity task and Krantz paradigm, but average

performance on the dual n-back task. Similarly, it is possible that in the modified experiment, one bilingual group may show improvement in all but the dual n-back task because the task is so complex and may not be a true indicator of dual-task performance. Additionally, it is possible that improved performance may be split across the two groups. Perhaps concurrent bilinguals, who learned two languages simultaneously, would show increased dual-task performance, but sequential bilinguals would show increased task switching ability due to the nature of each type of language learning which was discussed previously.

A final potential outcome also exists: it is possible that the two groups would show no difference in either task simply because the difference between concurrent and sequential bilinguals does not generate a significant disparity in cognitive function, at least between tasks switching and dual-task performance. This outcome would match the findings from the original Moradzadeh et al. (2015) study, which did not observe any significant advantage in task switching or dual-task performance for bilingual participants.

The previous discussion is an anticipation of the possible outcomes of the hypothetical experiment; however, given the novelty of the topic explored, no formal hypotheses can be made. The evidence of a critical language period suggests that there is a difference between second language learning in childhood and adulthood, which may be manifested in a disparity between bilinguals in task switching and dual-task performance abilities. However, the nature of such a hypothetical disparity is not easily predicted. This experiment would be especially interesting to implement because the difference between concurrent and sequential bilinguals has not been studied as heavily as the effect of bilingualism more broadly.

This proposed experiment is an attempt to address the unanswered questions in the Moradzadeh et al. (2015) study, namely the lack of evidence for a bilingual advantage in task switching and dual-task performance. Perhaps the reason the original experiment did not find evidence for a bilingual advantage is because the study did not account for the different ways people learn languages. It seems intuitive that a concurrent bilingual person who learns both languages at a young age would have a more inherent bilingual ability than a sequential bilingual person who learns a second language at a later stage in development and has to retrain their inherent language learning abilities which diminished after the critical language learning period in childhood. Therefore, the difference between concurrent and sequential bilingualism may be a significant factor that informs task switching and dual-task performance, and it may have influenced the findings of the original Moradzadeh et al. (2015) study.

Studying executive function and cognitive control is essential because both are essential to functioning in everyday life. In particular, task switching and dual-task performance are critical skills that influence how a person behaves and interacts. A college student practices task switching when she takes a fifteen-minute snack break and returns back to her studying undeterred. She performs dual-task processing at the gym when she simultaneously runs on the treadmill and hums the words to the music playing in her earbuds. The Moradzadeh et al. (2015) study is important because it investigates the linkage between executive functions and possible skills (e.g. musical training and bilingualism) that may benefit the former, and thus show an advantage in everyday interactions and learning. There are certain questions left unanswered, namely the impact of the critical language period on bilingual skill, which we hope will be addressed to continue making strides in uncovering the mysteries of cognitive mechanisms.