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Effect of Bimodal Bilingualism on the Performance of Selective Attention, Attention Switching Task and Attention Network Task

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Abstract

Introduction: *Bilingualism is thought to be strongly associated with higher order cognitive processing such as attention switching under cognitive load. According to a code-switching theory (Peal & Lambert, 1962), switching between languages provides the bilingual individual with a higher degree of mental flexibility and concept formation. This cognitive advantage may be based on use of inhibitory functions of the frontal lobe such that interference from another language is inhibited and one can selectively attend to the language that is currently in use (Green, 1998).*

Bialystok, Craik, Klein, and Viswanathan (2004) found that complex attention performance under a cognitive load among bilingual adults exceeded that of the same-age monolingual adults. In a study with children, Yang (2007) reported higher performance among bilinguals compared to monolinguals on an attention network test that involves several aspects of executive control and attention shifting skills.

Research suggests that that the cognitive advantage associated with bilingualism is specific to languages that share output modalities. When a bimodal-bilingual user simultaneously uses two languages with different output modalities (e.g., spoken language and Sign Language), neither language is actively suppressed, as compared to bilingual speakers who can only use one spoken language at a time, hence it is expected that deaf people will perform similarly on selective attention tasks, but may show variation on attention-switching task due to bilingual proficiency level. Emmorey et al. (2008) proposed that deaf people who are users of two same-modality signed languages (e.g., ASL and ISL) should demonstrate similar cognitive benefits to those observed in dual spoken-language bilinguals. The effect of these differences on the cognition of deaf readers and proficient signers has not been explored. It is essentially ''uncharted territory''.

Need for the study: *Early deafness is thought to affect low level sensorimotor processing such as selective attention, whereas bilingualism is thought to be strongly associated with higher order cognitive processing such as attention switching under cognitive load. Empirical studies on bilingualism and cognition thus far have been limited to participants whose hearing ability falls within normal limits especially in Indian population. This study explores the effects of bimodal-bilingualism (in ASL and Spoken Kannada) on attention control skills.*

Aim: *To compare the performance of bimodal bilinguals (ASL and Spoken Kannada) and monolingual (ASL) adults on selective attention, attention switching task & Attention Network Task*

Method:

Participants: A total of forty hearing impaired subjects in the age range of 18 to 22 years participated in the study. All the subjects had severe to profound congenital hearing loss and were using hearing aids and these subjects were diploma students in pph. They were divided into two groups group one consisted of thirty individuals who used ASL predominantly for their communication and second group consisted of twenty bimodal bilinguals who used ASL in educational setting and their rest of the communication was using verbal mode (native Kannada speakers).

Procedure: two experiments were carried out.

1. Selective attention and attention switching task: Stimulus presentation and recording of responses were controlled by Dmdx software. The stimuli were presented on computer and responses were collected via any key pressed on the keyboard. Each of the attention conditions involved four cross-symbols (1) arranged in a square format in the center and corresponding 4cross-symbols in the periphery, with different instructions for each condition. Experiment comprised 120 test trials divided into three blocks (conditions) of 40 trials each. RT was recorded in milliseconds on all trials, for the ''central'' attention condition, the participant was asked to ignore the four distracters in the periphery and attend to the four crosses in the central vision and instructed to hit the key exactly ''one red'' cross appeared in the central vision (target). If not, asked to retain from hitting the key. For ''peripheral'' *condition, the participant was asked to ignore the distracters in the center and press any key if exactly ''one red'' cross appeared in peripheral vision (target), third was the attention-switching condition, involved two types of cognitive load: switching between targets in the central and peripheral regions over trials and refraining from hitting the key or spacebar when a non target stimulus appeared after a repeated sequence of three targets.*

2. Attention Network Task-Flanker Task (ANT): The task was designed using Dmdx software. The task consisted of a combination reaction time task with flankers. A row of 5 visually presented blue lines with arrowheads are shown pointing to the left or to the right. Target was a leftward or rightward pointing arrowhead at the center. Target was flanked on either side by two congruent or incongruent arrows (same or opposite direction), or by neutral lines. The task of the participant is to indicate the direction of the central target by pressing the right or left mouse button as quickly as possible.

These tasks were carried out in a relatively quiet environment, all the subjects were instructed verbally and also using written mode. Ten practice trials were included with clinician's feedback. The reaction times of all correct responses and number of wrong responses were scored.

Results: *Independent "t" test was conducted to compare the differences between two groups. The variables included were reaction times of responses for the selective attention, attention switch and attention shifts in ANT. The number of errors in each of the tasks were also analyzed and subjected to statistical analysis. The results showed that there was no statistically significant difference in performance between the groups of bimodal bilinguals and monolinguals for all the tasks mentioned ($p>0.05$).*

Discussion: *The results hence, indicated that there was no positive benefit of bimodal bilingualism on attention control skills considered in the present study. The results are in consonance with findings of Emmorey, Luk, Pyers, and Bailystok (2008), 15 hearing adults who are accustomed to speaking English while signing in ASL at the same time (bimodal-bilingual users) did not differ from 15 monolinguals (one spoken language) in performing a task requiring inhibition and mental flexibility. The authors argued that this is a consequence of simultaneous use of two different language output modalities such as spoken and signed language. This appears to promote development of a distinct neural system that permits simultaneous use or merging of these two languages, unlike using two spoken languages consecutively, which requires suppression or inhibition of one language during utilization of the other language. Another explanation would be however, subjects used ASL as the only signed language. They were able to read and write English, ranging from low to high fluency. Some of these individuals may not produce clear speech production but fluent in reading and writing English. If an individual is highly fluent in reading and writing English, then this individual is considered proficient in this language even if his/ her speech production is unclear.*

***Conclusion**: The results of the present study indicated no significant advantages on attentional abilities in bimodal bilinguals. The reading and writing abilities of the subjects would influence these findings. Studies in this direction considering the reading, writing abilities of hearing impaired may shed more light about the cognitive gains in bimodal bilinguals.*

INTRODUCTION

Bilingualism is thought to be strongly associated with higher order cognitive processing such as attention switching under cognitive load. According to a code-switching theory (Peal & Lambert, 1962), switching between languages provides the bilingual individual with a higher degree of mental flexibility and concept formation. This cognitive advantage may be based on use of inhibitory functions of the frontal lobe such that interference from another language is inhibited and one can selectively attend to the language that is currently in use (Green, 1998).

Bialystok, Craik, Klein, and Viswanathan (2004) found that complex attention performance under a cognitive load among bilingual adults exceeded that of the same-age monolingual adults. In a study with children, Yang (2007) reported higher performance among bilinguals compared to monolinguals on an attention network test that involves several aspects of executive control and attention shifting skills.

Research suggests that that the cognitive advantage associated with bilingualism is specific to languages that share output modalities. When a bimodal-bilingual user simultaneously uses two languages with different output modalities (e.g., spoken language and Sign Language), neither language is actively suppressed, as compared to bilingual speakers who can only use one spoken language at a time, hence it is expected that deaf people will perform similarly on selective attention tasks, but may show variation on attention-switching task due to bilingual proficiency level. Emmorey et al. (2008) proposed that deaf people who are users of two same-modality signed languages (e.g., ASL and ISL) should demonstrate similar cognitive benefits to those observed in dual spoken-language bilinguals. The effect of these differences on the cognition of deaf readers and proficient signers has not been explored. It is essentially ‘‘uncharted territory”.

Over the past twenty years, there has been a renewed interest in the possibility that early sensory deprivation may lead to enhanced perceptual and cognitive development in the remaining modalities (Bavelier and Neville, 2002; Pascual-Leone et al., 2005; Sadato, 2005). However, in the case of early auditory deprivation there has been some debate over whether early profound deafness results in visual attention deficits (Quittner et al., 2007) or compensatory changes to attentional processes.The division of labor hypothesis (Quittner et al., 2007) holds that integrative processes, such as multi- sensory integration, are essential for normal development. Thus, in the absence of auditory input, there is a loss of redundancy and a consequent impairment in the development of normal visual processing.

In contrast to the deficit view, several research groups have reported a reorganization of visual attention following early auditory deprivation that results in some degree of compensation. The argument being put forward here is that the visual system reorganizes to compensate for the lack of auditory input, such that visual skills now take over the functional role performed by audition in the typically developing child. In support of this view, many studies suggest that there is a spatial redistribution of visual attention toward the periphery, allowing deaf individuals to better monitor their peripheral environment based upon visual rather than auditory cues. A selective enhancement in deaf adults for stimuli that are peripheral has now been demonstrated using a variety of behavioral paradigms. Loke and Song (1991) showed that deaf participants reacted to a peripheral stimulus with an abrupt onset more rapidly than did hearing participants. Using kinetic perimetry, Stevens and Neville (2006) reported that deaf adults were better at detecting a moving light in the periphery but showed no such enhancement in a static perimetry task presented at fixation.

Need for the Study

Early deafness is thought to affect low level sensorimotor processing such as selective attention, whereas bilingualism is thought to be strongly associated with higher order cognitive processing such as attention switching under cognitive load. Empirical studies on bilingualism and cognition thus far have been limited to participants whose hearing ability falls within normal limits especially in Indian population. This study explores the effects of bimodal-bilingualism (in ASL and Spoken Kannada) on attention control skills.

Aim

To compare the performance of bimodal bilinguals (ASL and Spoken Kannada) and monolingual (ASL) adults on selective attention, attention switching task & Attention Network Task

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in a square format in the center and corresponding 4cross-symbols in the periphery, with different instructions for each condition. Experiment comprised 120 test trials divided into three blocks (conditions) of 40 trials each. RT was recorded in milliseconds on all trials, for the ‘‘central’’ attention condition, the participant was asked to ignore the four distracters in the periphery and attend to the four crosses in the central vision and instructed to hit the key exactly ‘‘one red’’ cross appeared in the central vision (target). If not, asked to retain from hitting the key. For ‘‘peripheral’’ condition, the participant was asked to ignore the distracters in the center and press any key if exactly ‘‘one red’’ cross appeared in peripheral vision (target), third was the attention-switching condition, involved two types of cognitive load: switching between targets in the central and peripheral regions over trials and refraining from hitting the key or spacebar when a non target stimulus appeared after a repeated sequence of three targets.

2. Attention Network Task-Flanker Task (ANT): The task was designed using Dmdx software. The task consisted of a combination reaction time task with flankers. A row of 5 visually presented blue lines with arrowheads is shown pointing to the left or to the right. Target was a leftward or rightward pointing arrowhead at the center. Target was flanked on either side by two congruent or incongruent arrows (same or opposite direction), or by neutral lines. The task of the participant is to indicate the direction of the central target by pressing the right or left mouse button as quickly as possible.

These tasks were carried out in a relatively quiet environment, all the subjects were instructed verbally and also using written mode. Ten practice trials were included with clinician’s feedback. The reaction times of all correct responses and number of wrong responses were scored.

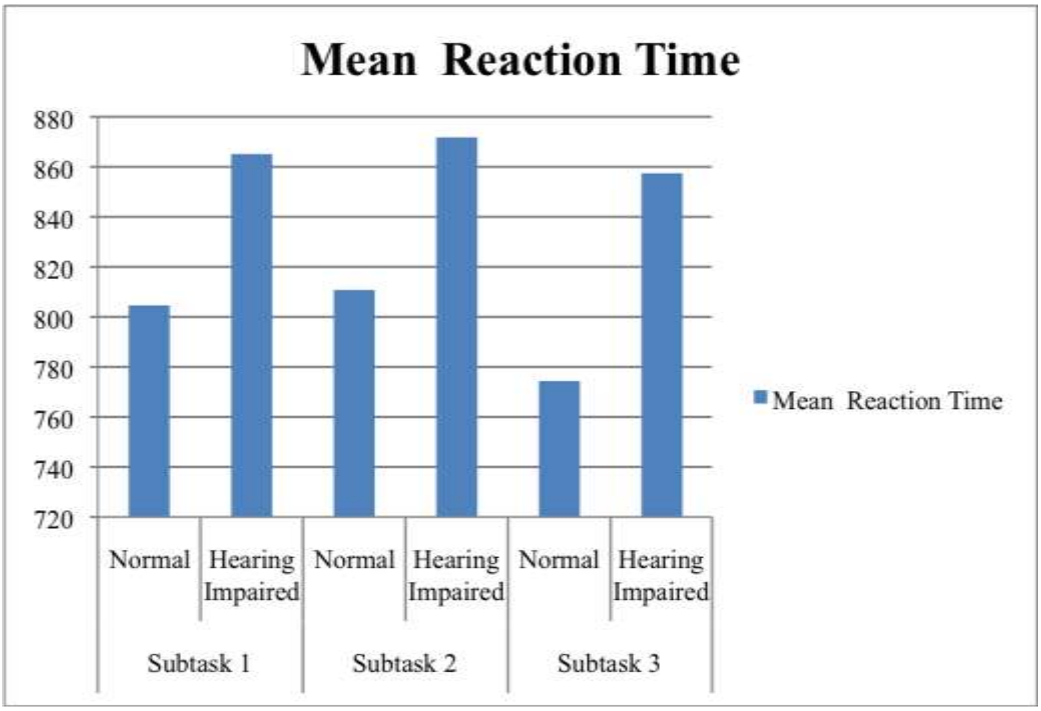
Results

The mean reaction times for selective attention task and ANT were subjected to statistical analysis using SPSS version 10 software. The mean reaction time was obtained. The errors for each task was also calculated and mean errors for different tasks by both groups was obtained. The results are as follows.

Table 1: Mean Reaction Time for Selective Attention and Attention Switching Task

Selective Attention And Attention Switching Task		Mean Reaction Time	Standard Deviation	P value
Subtask 1	Normal	804.85	288.81	
	Hearing Impaired	865.30	309.85	0.657
Subtask 2	Normal	810.90	304.08	
	Hearing Impaired	871.88	314.12	0.664

Subtask 3	Normal	774.45	284.39	0.525
	Hearing Impaired	857.42	288.50.	

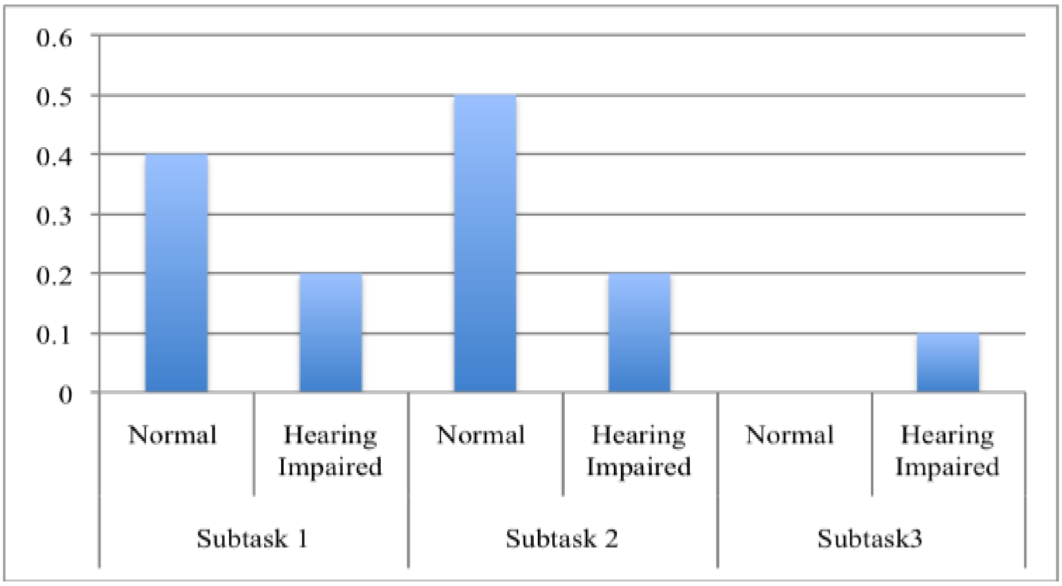


Graph 1: Mean Reaction Time for Selective Attention and Attention Switching Task

Table 1 and graph 1 reveals that, the mean reaction time for individuals with hearing impairment is greater than normal individuals in all the subtasks i.e. mean reaction time for normal for subtask 1 is 804.85 and for hearing impaired is 865.30, for subtask 2 the mean reaction time were 810.90 for normal and 871.88 for individuals with hearing impairment and for subtask 3 it was found to be 774.45 for normal and 857.42 for hearing impaired. However, independent sample test shows no significant difference between these groups i.e. p> 0.05 for all the subtasks between normal's and hearing impaired.

Table 2: Mean scores of errors

Selective Attention And Attention Switching Task		Mean	Standard Deviation	P value
Subtask 1	Normal	0.40	0.51	0.335
	Hearing Impaired	0.20	0.42	
Subtask 2	Normal	0.50	0.70	0.331
	Hearing Impaired	0.20	0.63	
Subtask3	Normal	0	0	0.343
	Hearing Impaired	0.10	0.31	

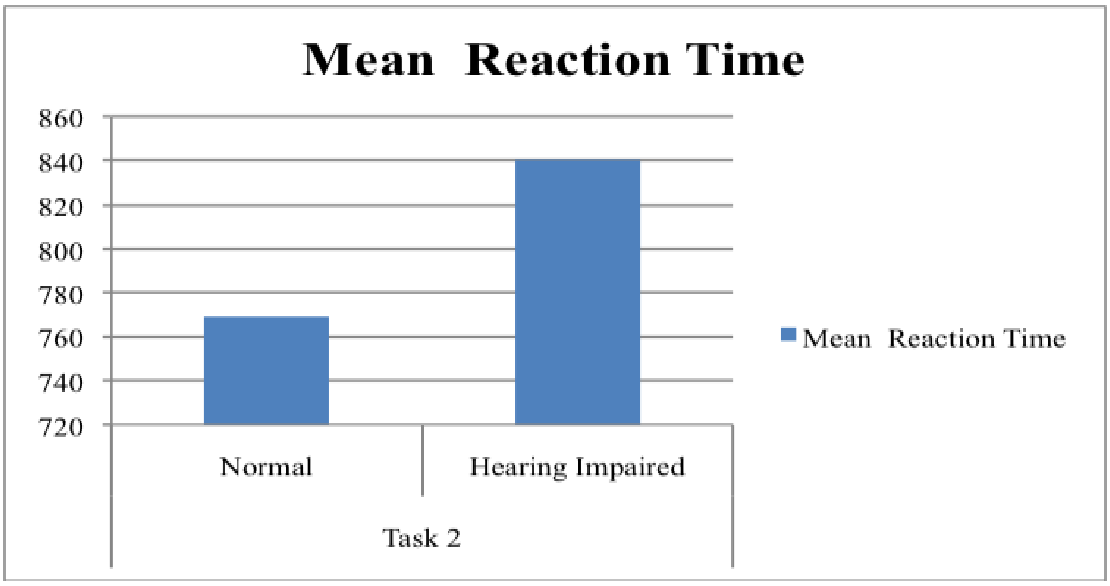


Graph 2: Mean scores of errors

It is evident from table 2 and graph 2 that mean error for subtask 1 and subtask 2 were more for normal compared to that of hearing impaired i.e. mean for subtask 1 is 0.40 and 0.20, subtask 2 is 0.5 and 0.20 for normal and hearing impaired respectively and in subtask 3 a mean score of 0 were found for normal where as for hearing impaired mean score obtained was of 0.1. However independent sample test shows no significant difference between these groups i.e. p> 0.05 for all the subtasks between normal's and hearing impaired.

Table 3: Mean Reaction Time for Attention Network Task

ANT		Mean Reaction Time	Standard Deviation	P value
Task 2	Normal	769.07	107.17	0.358
	Hearing Impaired	840.05	212.26	



Graph 3: Mean Reaction Time for Attention Network Task

Table 3 and graph 3 depicts the mean reaction time for task 2 i.e. attention network task (ANT). The mean reaction time in ANT for normals was less compared to that of normal. However independent sample test reveals the results obtained were not statistically significant i.e. p> 0.05

Table 4: mean error for ANT

ANT		Mean	Standard Deviation	P value
Error	Normal	1	2.21	
	Hearing Impaired	1.3	2.05	0.757

From table 4 it is clear that the mean error for normal was less compared to that of normal, i.e., a mean score of I for normal and 1.3 for hearing impaired. However independent sample test reveals the mean error obtained for hearing impaired and normal group were not statistically significant i.e. p> 0.05.

Independent “t” test was conducted to compare the differences between two groups. The variables included were reaction times of responses for the selective attention, attention switch and attention shifts in ANT. The numbers of errors in each of the tasks were also subjected to statistical analysis. The results showed that there was no statistically significant difference in performance between the groups of bimodal bilinguals and monolinguals for all the tasks mentioned (p>0.05).

Discussion

The results hence, indicated that there was no positive benefit of bimodal bilingualism on attention control skills considered in the present study. The results are in consonance with findings of Emmorey, Luk, Pyers, and Bailystok (2008), 15 hearing adults who are accustomed to speaking English while signing in ASL at the same time (bimodal-bilingual users) did not differ from 15 monolinguals (one spoken language) in performing a task requiring inhibition and mental flexibility. The authors argued that this is a consequence of simultaneous use of two different language output modalities such as spoken and signed language. This appears to promote development of a distinct neural system that permits simultaneous use or merging of these two languages, unlike using two spoken languages consecutively, which requires suppression or inhibition of one language during utilization of the other language. Another explanation would be however; subjects used ASL as the only signed language. They were able to read and write English, ranging from low to high fluency. Some of these individuals may not produce clear speech production but fluent in reading and writing English. If an individual is highly fluent in reading and writing English, then this individual is considered proficient in this language even if his/ her speech production is unclear.

Conclusion

The results of the present study indicated no significant advantages on attention abilities in bimodal bilinguals. The reading and writing abilities of the subjects would influence these findings. Studies in this direction considering the reading, writing abilities of hearing impaired may shed more light about the cognitive gains in bimodal bilinguals.

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