The Comparison of perception of the metaphor in Turkish and Persian bilingual7-11 years old children based on QEEG

Abstract

Bilingualism is the ability to speak or understand two languages or the regular use of two languages. The measurement tool used in this research was the tool for measuring metaphor perception and reaction time in children developed by Pouscoulous and Tomasello (2019) and the quantitative electroencephalogram device, which was implemented on 30 children aged 7 to 11 years. There was no significant difference between the groups in terms of the correctness of the answer content about the metaphors. According to QEEG analysis, the significant difference in absolute power between the bilingual and monolingual groups is only at point T5 and in beta, beta1 and high beta waves – bilinguals are less than monolinguals – by 25%, 35%, and 19%, respectively.

Key words: Bilingual, Monolingual, Metaphor, Metaphor perception measurement, Reaction time

1. Introduction

Bilingualism refers to a state in which a person is able to communicate in both learned languages and use those two languages across the four main language skills: speaking, listening, reading, and writing. Bilingualism is defined as the ability to express correctly and use sufficiently the words of both languages (Küpelikilinc, Nicola, Ringler, & Maria, 2007, as cited in Odacıoğlu & Uysal, 2016). Many studies on bilinguals indicate an increased range of cognitive abilities in these individuals (Cummins, 1981). Recently, various studies have confirmed the superiority of executive and cognitive functions in bilingual children, as well as the superiority of children in cognitive functions in some languages over others, which has led to a great deal of emphasis and advocacy for bilingualism in children. For example, Goksan, Argyri, Clayden, Liegeois, and Wei (2020) showed in a study that executive control skills and inhibitory attention in bilingual children are greater than in monolingual children. In the same study, using magnetic resonance imaging, it was shown that structural and functional connectivity at rest is also greater in bilingual adults than in monolingual adults. Furthermore, the results of a study by Sulpizio, Del Maschio, Del Mauro, Fedeli, and Abutalebi (2020) showed that cognitive flexibility and the flexibility of brain connections are modulated more easily and to a greater extent in bilinguals than in monolinguals, leading to better information access and use of two languages by bilingual individuals. However, the results of some studies have cast doubt on the full confirmation of this issue (Bialystok & Senman, 2004; Devine & Hughes, 2014).

The scope of literary knowledge and perception is culture-dependent, meaning that findings and meta-analyses indicate faster theory of mind and more advanced cognitive function in China, Canada, and the United States compared to the Hong Kong region (Liu, Wellman, Tardif, & Sabbagh, 2008). Also, children from Australia performed better than those from Austria and Japan (Wellman, Cross, & Watson, 2001).

These studies demonstrate the following positive effects of being bilingual: 1) ability to analyze, break down, and have extensive awareness of language; 2) expansion of academic skills; 3) increase in the overall range of concepts in individuals; 4) increase in creative thinking; and 5) increased sensitivity to meeting the needs of the listener (Kessler & Quinn, 1980). Among these, the ability to comprehend metaphor (verbal and non-verbal) is the ability to create a new concept by coordinating previous thought systems. A metaphor is used when one expression is used in place of another. Metaphor is applying an object or word to a second, unusual meaning. Extensive studies show that metaphor comprehension improves and expands in adulthood, but the onset of these changes usually begins in childhood (Zoltan, 2010). Therefore, the ability to comprehend metaphor in children who have been exposed to two languages from an early age is a useful indicator for examining the teaching and simultaneous use of two languages in an individual, in order to assess the improvement or lack thereof of metaphorical perception performance.

The ability to produce, comprehend, and use metaphor is called metaphorical competence (Knowles & Moon, 2006). Given the importance of human cognitive and mental development in childhood, many researchers have tried to assess children's metaphorical competence from an early age. Regarding the comprehension and processing of metaphor in children, Jean Piaget (1959), as the founder of the stage theory of development, believed that the faculty of thought — or, in his words, human intelligence — develops through a chain of distinct qualitative stages. According to him, children gradually understand various concepts more deeply during infancy, childhood, and adolescence. Based on Piaget's theory, all children develop by passing through four stages, and their reasoning at lower stages is qualitatively different from their reasoning at higher stages. The four stages he proposes for a child's cognitive and intellectual development are: 1) sensorimotor stage: birth to two years; 2) preoperational stage: two to seven years; 3) concrete operational stage: seven to eleven years; and 4) formal operational stage: eleven to sixteen years (as cited in Siegler & Alibali, 2005; translated by Kharazi, 2008).

Findings from functional magnetic resonance imaging (fMRI) indicate the involvement of the angular gyrus in the rapid processing of auditory information, suggesting that understanding information in a less familiar language or with more difficult literature slows down the processing of these areas and reduces reaction speed. The input of sensory information, knowledge related to language, and prior familiarity can be effective predictors of the success of future processing (Kajiura, Jeong, Kawata, Yu, et al., 2021).

Studies using event-related potentials (ERP) and EEG findings have reported many differences in brain function when bilinguals and monolinguals use metaphor. Specifically, increased activity in the left inferior frontal gyrus is associated with greater inhibition by bilinguals, differences in memory performance, and executive functions, while greater activity in the superior temporal gyrus, which is responsible for semantic processing, has shown increased performance in bilinguals (Lai, Dam, Conant, Binder, & Desai, 2015). Furthermore, Citron and Goldberg (2020) consider the degree of familiarity with the second language and the complexity of the metaphors used to be factors contributing to differences in EEG results between bilinguals and monolinguals.

Weiland, Bambini, and Schumacher (2014) do not consider processing differences to be effective only in terms of response timing and delay; rather, based on fMRI findings, they consider factors such as emotional arousal due to language differences to be a cause of performance differences and greater activation of the left amygdala in response to metaphors in the native language. Also, Mashal and colleagues (2015) found that metaphors in a person's second language generally activate the right hemisphere more, meaning that metaphors in the second language are retrieved and learned as new information in the brain. In this regard, according to the fMRI findings of Citron and Goldberg (2020), they addressed greater activity in the left amygdala when processing non-native language metaphors and concluded that interest in metaphors in the native language is greater than attention to them in the second language. Furthermore, the findings of Deckert, Schmoeger, Geist, Wertgen, and Willinger (2021) from ERP results show that the left anterior prefrontal cortex has greater activity for metaphors that are more concrete and closer to reality in bilinguals; also, the parahippocampal gyrus shows more activity than other areas in bilinguals when hearing a metaphor in the second language.

In a related study, Grundy and Anderson (2018) examined differences in brain function in bilingual adults and showed from EEG results that signal complexity in bilinguals indicates better cognitive function in them. These researchers' observations showed greater complexity of brain signals in occipital regions in bilinguals compared to monolinguals, leading them to conclude that learning a second language contributes to more automatic and efficient processing of phenomena.

In the present study, two groups of children were studied: monolingual Persian-speaking children and bilingual Persian- and Turkish-speaking children who had learned both Persian and Turkish simultaneously in the family and used both languages daily. The aim of the study was to investigate the differences in metaphor processing regions in bilingual and monolingual children based on brain mapping, and also to investigate the difference in performance between these two groups in reaction time to the metaphor processing task. The subjects were selected from among students aged 7 to 11 years. Additionally, criteria for inclusion in the bilingual group were: the student being born in Tehran, parents being born in one of the Turkish-speaking regions of Iran, and speaking Turkish at home. On the other hand, being a monolingual Persian speaker was the inclusion criterion for the monolingual group. Furthermore, students with a history of moving or temporarily relocating from Tabriz or Tehran were not included in the sample, and students with a history of psychiatric or psychological illness, seizures, or stuttering were also excluded from the study.

2. Methodology

Descriptive and inferential statistics were used to analyze the data using SPSS-24 software. Means and standard deviations of quantitative variables were reported for description, and frequency distribution tables were drawn for qualitative variables. In the analysis, an independent t-test was used to compare the mean metaphor processing scores between the two groups. Also, one-way analysis of variance (ANOVA) was used to analyze the triple-task metaphor performance across different age groups.

2-1. Participants

The research sample consisted of a group of 15 bilingual children (Persian and Turkish) living in Tehran, selected based on the sample size formula using the mean metaphor processing scores from previous studies, and a second group of 15 monolingual Persian-speaking children. The first group consisted of children aged 7 to 11 who were born in Tehran into a family of Turkish origin, whose parents were born in one of the Turkish-speaking regions of Iran, and who had been exposed to Turkish from childhood; their first language was Turkish and they spoke Turkish at home. The second group consisted of children aged 7 to 11, matched for the type of school they attended (public school) and their grade level. The second group consisted of students born into Persian-speaking families in Tehran, and their parents were also born in Tehran.

2-2. Experimental Items and Test Design

2-2-1. Computerized Metaphor Perception Test

To assess metaphor perception in children, the tool introduced by Pouscoulous and Tomasello (2019) was used. In this task, 30 novel metaphors are explained using 30 pairs of images, and all the selected images and metaphors in the categories have been chosen according to the children's age. To display shapes and tools, images were used that the child is familiar with according to their age, mainly related to body parts and dressing. In this task, primarily visual and behavioral metaphors were used, and since these metaphors are based on observable physical similarities, they are easier for children to interpret than metaphors relying on objective realities (Gentner, 1988). Since the metaphorical expressions in this task are embedded in reference assignment, it can be argued that selecting the correct image instead of a similar one requires two practical inferences: interpretation of the metaphor and reference assignment. While children can perceive physical similarities similarly to adults, they may not have sufficient knowledge to understand the abstract-practical or psychological similarities between the source and target domains in a metaphor (Winner, 1988).

To administer this stage of the test, a visual program was specifically designed and used to test the understanding of words related to the metaphor task (literal meanings, metaphorical meanings, and unrelated meanings). In each section, there was a page corresponding to each of the thirty test metaphors in the task. On each page, all three images showed an object: one image showed the literal meaning of the metaphorical expression (e.g., a hat) and what the metaphorical expression metaphorically refers to (e.g., a roof). In addition, on each page there was an unrelated image that showed neither the literal nor the metaphorical meaning of the expression. This section was included to prevent children from selecting the correct image through inference by elimination—that is, matching a picture whose meaning they do not understand to an object whose name they do not know.

In this test, the target image showed the characteristic that the metaphor described. For example, the metaphor "carrot with long hair" was used to refer to a carrot with long greens, while the other object had another distinctive but unrelated feature, for example, a carrot with black marks but very short greens. The only clue given to the children to select the reference object was the metaphorical expression.

These sentences were designed as a test using a computer program, in which the sentences were presented to the subjects in a completely random order, and their repetitive sequence was varied to eliminate any logical progression in responding to the sentences. Additionally, the reaction time and response speed of the subjects to the test sentences were recorded as reaction time. The test was presented in the following manner: first, a sentence was presented in Persian, and simultaneously three images related to that sentence appeared on the monitor. The child selected their desired option using three buttons embedded on the keyboard. The sentences were presented in Persian.

Table: Metaphor, Target Image, and Non-target Image

Metaphor	Target Image	Non-target Image
Carrot with long hair	Carrot with long greens	Sliced carrot pieces
Car with a backpack	Car with a roof rack on the road	Car with a package inside
Dog with brown shoes	White dog with brown paws	White dog with a brown body
House with a hat	House with a prominent gabled roof	Tower with a flat roof
Car with a limp (leg)	Car with a missing wheel	Car with wheels and a limping driver
Big-bellied bottle	Round brown bottle	Tall green long-necked bottle
Insect with a jacket (sweater)	Ladybug with red wings	Ant with a striped brown body

Metaphor	**Target Image**	**Non-target Image**
Mountain with white hair	Mountain with snowy peaks	Brown mountain with grassland
Heater with a high fever	Heater with an open flame	Radiator
Fridge with a full belly	Fridge full of items	Refrigerator with the door closed
Tree with golden hair	Tree with yellow autumn leaves	Bare, dried-up tree without leaves
Thirsty river	Dried-up river	River with a bridge
Red-flower girl	Girl with a red ribbon in her hair	Girl with yellow flowers
Very tall ladder	Tall man / very tall person	Stool / four-legged stand
Angry sky	Sky with thunder and lightning	Bright, sunny sky
Full-of-flowers garden	Flower-printed cushion	Autumn garden
Spotted shirt	Patterned shirt	Shirt with polka dots and a collar
Flower with long nails	Red rose with thorns	Flower basket

2-2-2. Quantitative Electroencephalography (QEEG) Device

Although philosophers have pondered the relationship between brain and mind for centuries, neuroscientists in recent years have been able to investigate this issue using imaging tools such as fMRI and EEG. With these tools, the physiology of mental processes can be imaged during an activity. For example, these tools show which brain region is involved when a subject is engaged in a linguistic activity such as listening to a story or producing a word. Similarly, with the advancement of non-invasive imaging methods, it has become possible to more precisely examine the organization of language in the brain of bilingual speakers (Pourmohammad, 2017). One of these methods is brain mapping, or QEEG, which quantitatively examines functional brain waves simultaneously across all points of the cerebral cortex. In this study, the analytical points in the temporal and frontal regions of both the right and left lobes were examined. This was analyzed using simultaneous Neuroguide analysis, and the report was presented based on changes in absolute power of frequency bands as percentage differences (Asadollahpour Kargar, Bakhshipour Roudsari, & Babapour Kheyraddin, 2017).

3. Research Procedure

Participants first completed a consent form and a subject information form along with demographic information including gender, age, educational status, etc. After the sampling process, the two groups were matched for educational grade and age. Children in both groups were definitely born in Tehran. Children in the bilingual group had Iranian Turkish-speaking parents who were born in Turkish-speaking regions, and Turkish was spoken at home with the student, and the student was fluent in Turkish. The second group was selected from students with Persian-speaking parents who were born in Tehran and who had not been exposed to another language from childhood.

Before the main session began, a practice session was conducted in a quiet room with white noise, in a dimly lit background. Participants were asked to look directly at a black dot positioned 40-60 cm from the images in the center of the screen during stimulus presentation. After that, with the quantitative brain mapping cap attached, each participant was ready to respond to the Pouscoulous and Tomasello task. At this point, before the main test began, an EEG was recorded for 5 minutes as a baseline. Then the main test was administered while simultaneously recording EEG. The components of this test were played as images from a computer monitor, and the child selected their desired option using the keyboard. During their responses, brain maps were recorded.

4. Statistical Findings

The descriptive findings of the present study include the mean responses of monolingual and bilingual participants, and the total of both groups, to the computerized task images, as presented below. Additionally, the mean responses to the tasks and participants' response times at different ages are described.

The mean metaphorical response scores in the monolingual and bilingual groups were 13.93 and 15, respectively. Furthermore, the mean reaction times in seconds for the monolingual and bilingual groups were 3.81 and 4.11, respectively (Table 1-4).

Table 1-4. Mean metaphorical response and mean reaction time in monolinguals and bilinguals

	Mean	**Standard Deviation**
Metaphorical response in monolinguals	13.93	5.95
Metaphorical response in bilinguals	15	5.95
Reaction time in monolinguals	3.81	0.58
Reaction time in bilinguals	4.11	0.63

The mean metaphorical response of subjects aged 7 to 11 years is shown in Figure 1-4. The calculated mean metaphorical response for 7-year-olds was 18.33 (SD = 4.94); for 8-year-olds: 10.50 (SD = 1.91); for 9-year-olds: 12.66 (SD = 5.57); for 10-year-olds: 10.33 (SD = 5.77); and for 11-year-olds: 13 (SD = 6.63).

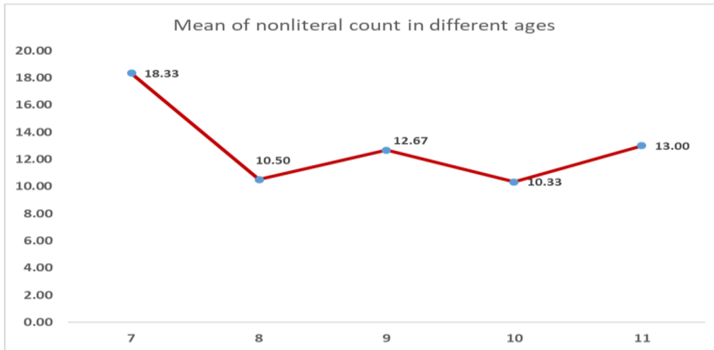


Figure 1-4. Mean metaphorical response of subjects aged 7 to 11 years (graph image placeholder)

The mean metaphorical response time of subjects aged 7 to 11 years is shown in Figure 2-4. The calculated mean metaphorical response time for 7-year-olds was 3.99 (SD = 0.78); for 8-year-olds: 3.89 (SD = 0.57); for 9-year-olds: 4.16 (SD = 0.61); for 10-year-olds: 3.74 (SD = 0.20); and for 11-year-olds: 3.83 (SD = 0.48).

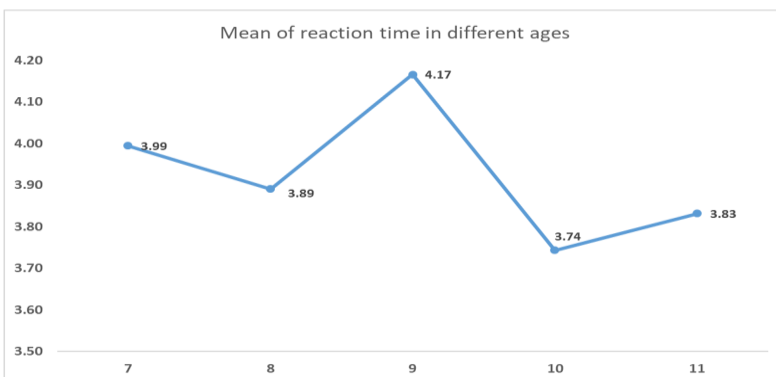


Figure 2-4. Mean metaphorical response time of subjects aged 7 to 11 years (graph image placeholder)

The distribution of metaphorical responses of monolinguals and bilinguals aged 7 to 11 years is shown in Figure 3-4. As can be seen, the mean number of metaphorical responses of monolinguals was 13.90; the mean number of metaphorical responses of bilinguals was 15; the mean reaction time for metaphorical responses of monolinguals was 3.81; and the mean reaction time for metaphorical responses of bilinguals was 4.11.

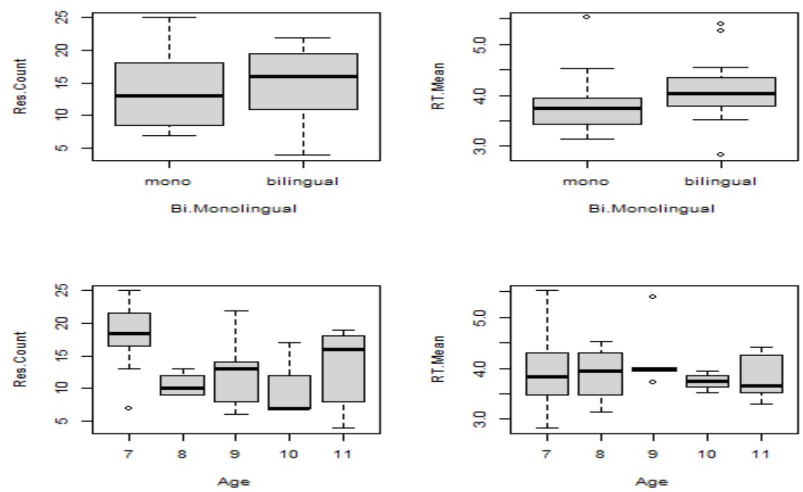


Figure 3-4. Distribution of metaphorical responses of monolinguals and bilinguals aged 7 to 11 years (graph image placeholder)

The independent t-test for metaphorical response and reaction time in monolingual and bilingual groups showed that there was no significant difference between the mean response and reaction time speed in the two groups (Table 2-4).

Table 2-4. Independent t-test results for metaphorical response and reaction time in monolingual and bilingual groups

	Degrees of freedom	t value	Significance level
Metaphorical response	28	0.49	0.62
Reaction time	27.76	1.33	0.19

To compare the mean reaction times and mean metaphorical responses at different ages (7 to 11 years), analysis of variance was used (Table 3-4). The results of ANOVA showed that mean reaction times at ages 7 to 11 did not differ significantly ($p = 0.875$), but there was a significant difference among mean metaphorical responses at ages 7 to 11 in at least one age group (7-year-olds compared to other age groups) ($p = 0.038$).

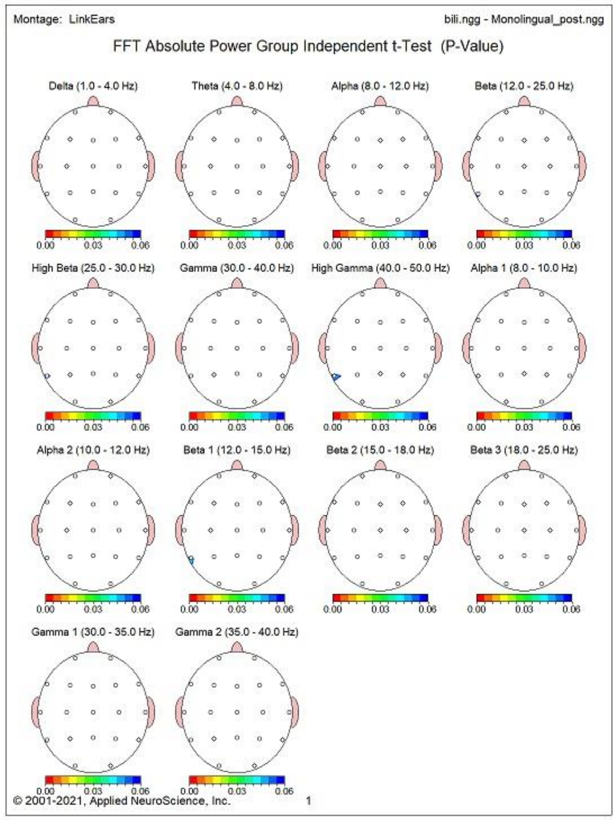
Table 3-4. Analysis of variance for metaphorical response and reaction time at ages 7-11 years

	Source	df	Sum of squares	Variance	F ratio	p-value
Metaphorical response	Age	4	323.8	80.95	2.986	0.0382
	Error	25	677.7	27.11		
Reaction time	Age	4	0.51	0.12	0.3	0.875
	Error	25	10.62	0.42		

4-1. Descriptive Findings from Brain Mapping

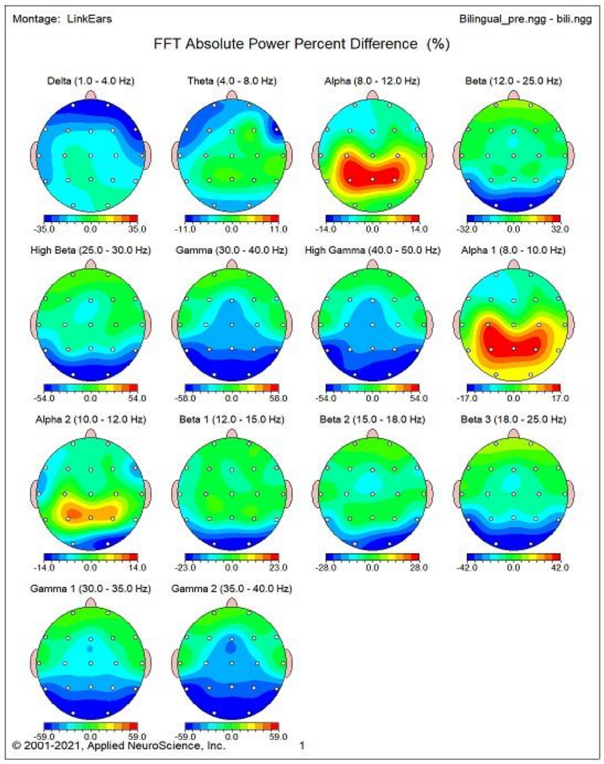
According to the QEEG analysis, the significant difference in absolute power between the bilingual and monolingual groups is only at point T5 and in beta, beta1, and high beta waves – bilinguals lower than monolinguals by 25%, 35%, and 19%, respectively ($p < 0.05$).

Figure 1-4. Significant results of dependent t-test for pre-test and during-test absolute power in monolingual and bilingual groups (image placeholder)



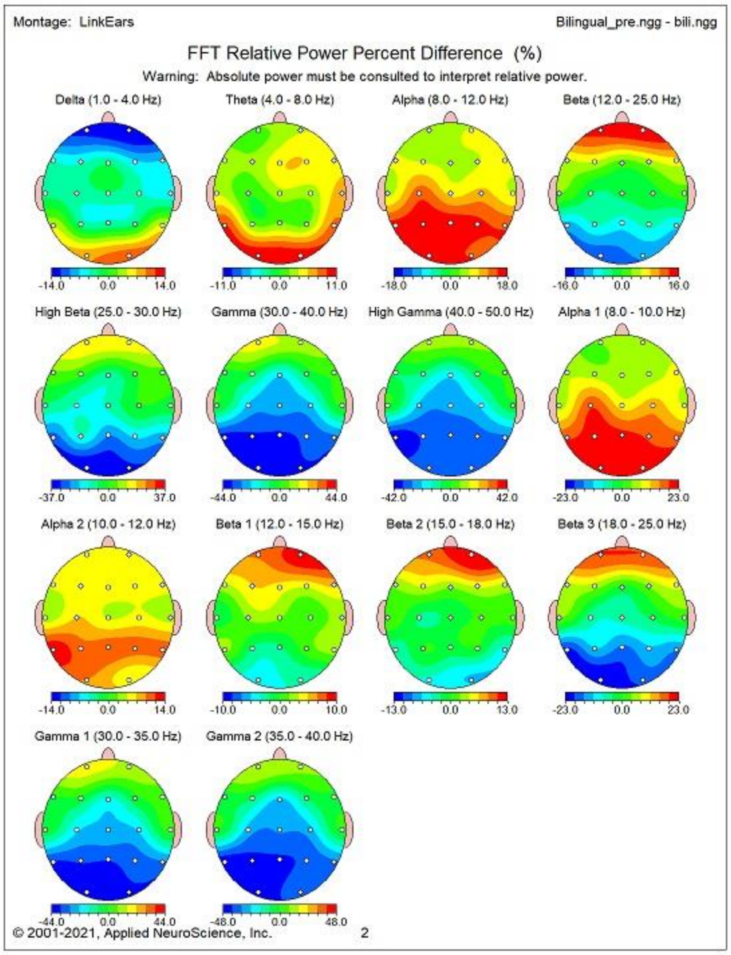
The comparison of absolute power in the bilingual group between pre-test and during-test brain mapping showed a significant difference in delta at Fp1 and Fp2 (32% and 35%, respectively), and a significant difference in theta at F7 and F3 (9% and 6%, respectively). A significant difference in beta and high beta was observed in all posterior regions – maximum 54% in occipital area to minimum 9% at Pz. In all the above cases, the pre-test score was lower than the during-test score.

Figure 2-4. Comparison of pre-test and during-test absolute power in the bilingual group (image placeholder)



Relative power showed a significant difference in alpha (about 17%) and high beta (minimum 22% to maximum 36%) in all posterior head regions. In alpha, the pre-test score was higher than the during-test score; in other cases, the pre-test score was lower than the during-test score.

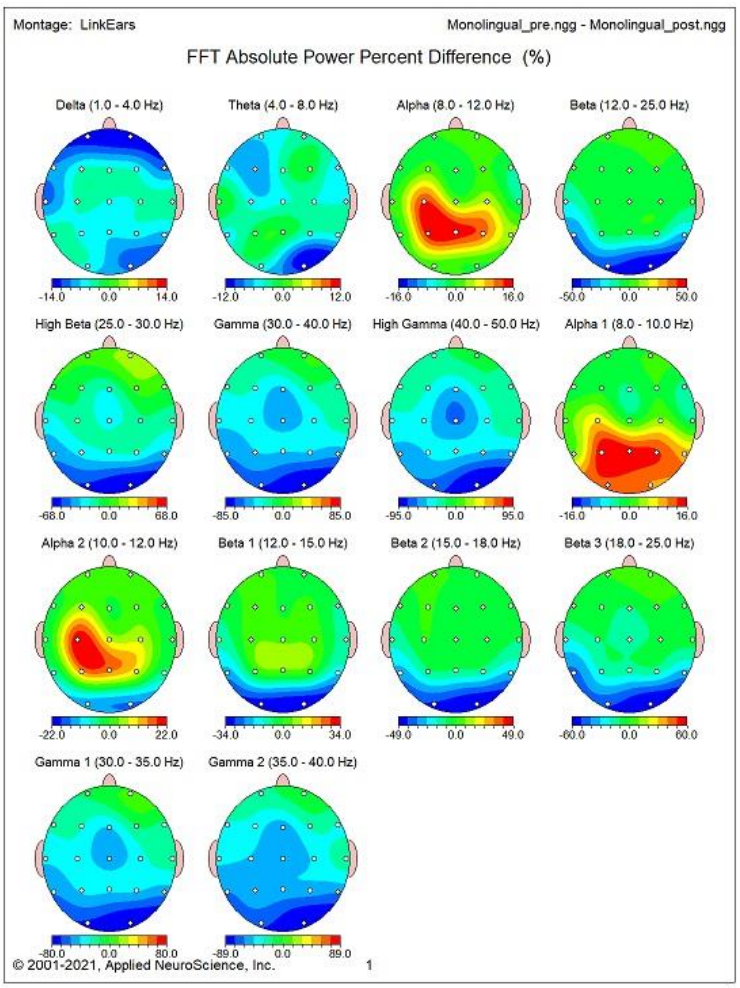
Figure 3-4. Comparison of pre-test and during-test relative power in the bilingual group (image placeholder)



Also, in the comparison of pre-test and during-test brain mapping in the monolingual group, a significant difference in absolute delta power was observed at Cz, Pz, O1, and O2 (5%, 7%, 5%, and 11%, respectively), as well as a significant difference in theta at F7 and F3 (6% and 8%). A significant difference in beta and high beta was observed in all posterior regions –

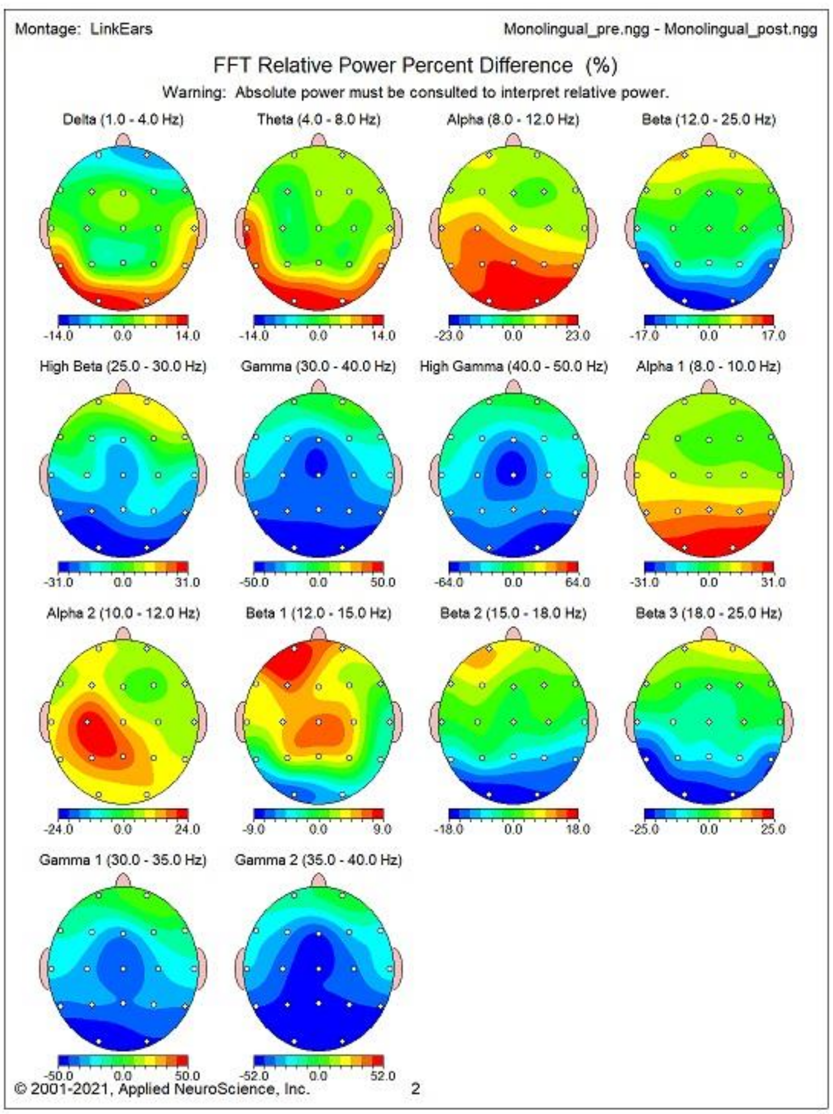
maximum 67% in occipital area to minimum 6% at Pz. In all the above cases, the pre-test score was lower than the during-test score.

Figure 4-4. Comparison of pre-test and during-test absolute power in the monolingual group (image placeholder)



At the relative power level, a significant difference in alpha (about 20%) and beta and high beta (minimum 4% to maximum 30%) was observed in all posterior head regions. In alpha, the pre-test score was higher than the during-test score; in other cases, the pre-test score was lower than the during-test score.

Figure 5-4. Comparison of pre-test and during-test relative power in the monolingual group (image placeholder)



5. Discussion

According to the statistical findings of the present study, the mean metaphorical responses at ages 7 to 11 years show no significant difference. This means that the performance of monolingual and bilingual children in selecting metaphorical or literal responses at ages 7 to 11 is not different, and 7-year-old monolingual children gave similar metaphorical responses to images as their peers. Likewise, 8-, 9-, 10-, and 11-year-old children also performed similarly to their same-age peers in responding metaphorically to images. Speed of processing and the number of metaphorical, non-metaphorical, and unrelated responses did not differ between the two groups. The results of this study are consistent with the findings of Vaezi, Ardchi, and Rahimi (2012), Chacko et al. (2017), and inconsistent with the findings of Mohsen Akbari (2013), De Grauwe et al. (2010), Wiśniewska (2017), Jankowiak et al. (2021), and Bice et al. (2020).

In explaining the lack of difference in metaphorical response and reaction time to images, age can be pointed to. According to Piaget's theory, children aged 7 to 11 years have similar rates of metaphorical responses, and this might be evaluated differently across a wider age range. On the other hand, given that school instruction in monolingual and bilingual regions of Iran is similar and aligned, the important factor of formal education, which is uniformly monolingual, may have contributed to the similarity in performance between monolingual and bilingual children.

Another factor explaining the similarity in performance between Turkish-Persian bilingual and Persian monolingual children could be the linguistic, phonological, syllabic, and cultural similarities in the use of metaphors. Because the Turkish and Persian languages, especially in Iran, due to extensive interactions between the two languages under the influence of education and communication, have become very closely overlapped. Furthermore, Turkish speakers use the same alphabet as monolinguals, and the closeness of many words can explain the similarity in children's performance in responding to metaphors. Although according to the findings of this study the mean metaphorical response in the bilingual group was slightly higher than monolinguals, this difference is not statistically significant.

Also, according to the findings, reaction time and response speed in 7-to-11-year-old bilinguals compared to their monolingual peers is not significant. This means that reaction time relative to metaphorical responding was reversed. In the bilingual group, where the mean metaphorical response was slightly higher than the monolingual group, reaction speed was slightly higher, and it seems that bilingual children needed more time to understand, process, and respond correctly to metaphors. These findings are consistent with the studies of Hosseinizadeh, Abdollahi, and Shahgholian (2018), Zirnstein, van Hell, and Kroll (2018), Morales and Bajo (2015), Gollan, Montoya, and Werner (2002), and inconsistent with the findings of Folds, Phillip, Badets, and Couch (2018).

In analyzing faster responding in monolingual children, it can be explained that monolingual children, due to their familiarity with metaphorical concepts, responded more quickly to the task, whereas bilingual children examined the task more carefully to better understand the metaphorical concepts and then responded. It seems that the slower reaction speed in the bilingual group is due to this reason.

According to the brain map analysis, the significant difference in absolute power between bilingual and monolingual groups is only at point T5 and in beta, beta1, and high beta waves – bilinguals lower than monolinguals – by 25%, 35%, and 19%, respectively. This means that during response to the metaphorical task, the mentioned point showed more active performance in the monolingual group than in the bilingual group. Point T5 is known as Wernicke's area in terms of brain region classification. Wernicke's area is responsible for speech processing and word recognition, and it seems that because this point showed more active performance in the monolingual group, metaphor concept recognition was better in the monolingual group. In explaining this, it can be noted that children who have been exposed to bilingualism and have been familiar with Turkish and Turkish metaphorical concepts from childhood, and learn Persian educationally starting from school, may show weaker performance in recognizing Persian metaphorical concepts and speech processing. This is consistent with the fMRI findings of Kajiura, Jeong, Kawata, Yu, et al. (2021), which indicate involvement of the angular gyrus in rapid processing of auditory information and state that understanding information in a less familiar language or with more difficult literature slows down processing in these areas and reduces reaction speed in bilinguals. According to this study, sensory information input, knowledge related to language, and prior familiarity can be effective predictors of success in future processing in monolinguals.

The results of comparing absolute power in the bilingual group between pre-test and during-test brain mapping showed a significant difference in delta at Fp1 and Fp2 (32% and 35%, respectively), and a significant difference in theta at F7 and F3 (9% and 6%, respectively). A significant difference in beta and high beta was observed in all posterior head regions – maximum 54% in the occipital region to minimum 9% at Pz. In all the above cases, the pre-test score was lower than the during-test score.

It seems that point F3 plays a role in solving the metaphorical task. Since point F3 is involved in decision-making and solving cognitive problems, it likely has a more prominent performance in metaphorical responding in both monolingual and bilingual groups compared to other points on the brain map. This is consistent with the findings of Lai, Dam, Conant, Binder, and Desai (2015), according to which increased activity in the left inferior frontal gyrus is associated with greater inhibition by bilinguals, differences in memory performance and executive functions in general, and greater activity in the superior temporal gyrus, which is responsible for semantic processing, reported better performance in bilinguals. Also, the study by Rapp, Leube, Erb, Grodd, and Kircher (2004) examined the neural correlates of metaphor processing at the sentence level and stated that comparing metaphorical meaning with literal meaning showed no evidence of greater right-hemisphere involvement in metaphor processing, but a significant signal increase for metaphorical sentences was observed exclusively in the anterior regions of the left hemisphere at point (F3). This is also consistent with the findings from the brain map in the present study.

Summarizing studies based on EEG, bilinguals process metaphors in a way that is consistent with increased attentional speech (Narsia et al., 2018), and the age of second language acquisition affects functional connectivity of theta, alpha, and gamma frequencies (Sorth & Rutman, 2021). Also, some studies indicate greater and more widespread coherence in the alpha and beta frequency ranges compared to monolinguals (Bice, Yamasaki, & Prat, 2021), which is also consistent with the findings of the present study.

6. Conclusion

Summarizing the results of the present study, although there was no significant difference between correct metaphorical responses and reaction time between the monolingual and bilingual groups, the mean response to metaphorical tasks and reaction time of bilinguals compared to monolinguals across different age groups was slightly higher. Also, according to the brain mapping findings, point T5, which corresponds to Wernicke's area in the brain and is responsible for speech recognition, was more active during the metaphorical task in both groups compared to other points. Additionally, point F3, which is involved in decision-making and solving cognitive problems, became more active in the brain map of both groups during the test.

7. Limitations of the Study

- Matching of monolingual and bilingual groups in terms of intelligence was not performed.
- Cultural and economic factors were not examined when matching the groups.
- A limited number of tools were used to examine differences in metaphor use.
- The age range of participants in the study was limited.
- Although monolinguals and bilinguals reside in the same country, both groups may have been exposed to the standard language.
- There was a limitation in the sample size of participants.

8. Suggestions for Future Research

- In future research, monolingual and bilingual groups should be matched for intelligence.
- Cultural and economic factors should also be examined when matching groups.
- Other tools should be used to examine differences in metaphor use.
- Different age groups of monolinguals and bilinguals should be studied.
- A larger number of participants should be used in similar studies.

References (Persian)

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