Education and Science

Original Article

Vol 48 (2023) No 216 229-246

Myths or Facts: Prevalence, and Predictors of Neuromyths among Turkish Teachers *

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Abstract

Neuromyth is a concept used for misconceptions regarding the brain and its relation to learning. Identifying the prevalence of neuromyths is seen as the first step of dispelling them. The purpose of this study is to determine the prevalence and predictors of neuromyths among teachers in Türkiye. The educational neuromyths survey, which contains 19 general brain knowledge statements and 21 neuromyth statements, was conducted on 730 primary and secondary school teachers during the 2020-2021 educational year's spring semester. The findings showed that the most prevalent myths among teachers were learning styles, multiple intelligences, and an enriched environment. Hemispheric dominance, Mozart effect, BrainGYM, critical periods, fatty acids, learning while sleep, 10 % myths were believed more than 50% of teachers. The predictor analyses revealed that gender, teaching experience, reading popular science publications did not significantly predict the number of endorsed myths. Significant predictors were general brain knowledge, reading peer-reviewed journals, and taking neuroscience education. At the end of the study, recommendations for further research and practice are presented.

Keywords

Neuromyths

Brain

Learning styles

Educational neuroscience

Neuroscience

Multiple intelligences

Article Info

Received: 08.02.2022

Accepted: 07.19.2023

Published Online: 10.30.2023

DOI: 10.15390/EB.2023.12089

* This research was presented as an oral presentation at the "14. Uluslararası Bilgisayar ve Öğretim Teknolojileri Sempozyumu".

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Introduction

Neuromyth is a concept formed by combining the words "myth" and "neuron" to refer to misconceptions about the brain (Çağıltay & Tunga, 2022). Although the origin of the term dates back to the 1980s (Howard-Jones, 2014), it gained prominence with the report of the Organization for Economic Cooperation and Development (OECD) in the early 2000s in the educational context. The OECD (2002) drew attention to the increasing number of misconceptions about the brain among educators and redefined the term as "a misconception generated by a misunderstanding, a misreading, or a misquoting of facts scientifically established (by brain research) to make a case for the use of brain research in education and other contexts" (p. 111). The myths of three (critical term), hemisphere dominance (right-left-brained), and enriched environment have been recognized in this report. Subsequently, various other neuromyths such as the use of 10% of the brain, fatty acids, learning styles, BrainGYM, learning while sleeping, Mozart effect, and multitasking have been identified over the years.

Identifying neuromyths in education is important because it helps prevent the spread of false information and misunderstandings about how the brain works, and how it relates to learning and education. The survival of neuromyths causes detrimental effects and thus enabling waste of valuable resources such as time, budget and preventing the use of effective methods (Pasquinelli, 2012). Janati Idrissi, Alami, Lamkaddem, and Souirti (2020) stated that the endorsement of neuromyths has influenced teachers' pedagogical decisions and encouraged the use of ineffective practices. In other words, neuromyths can sometimes be used to promote interventions and treatments that are not supported by research. These interventions may be ineffective or even harmful to students. By debunking neuromyths, educators and parents can help protect students from potentially harmful practices. For example, employing learning styles that claim students learn better when they are supported with their preferred type of instruction as a teaching strategy is the most obvious example of the damaging effect of neuromyths on education (Kirschner, 2017). By identifying and correcting myths, teacher education can become more effective and provide teachers with accurate information about the brain and learning. Therefore, understanding the current state of teachers' neuromyth endorsement can help create educational neuroscience programs to dispel them. Neuromyths can sometimes influence educational policy, such as funding decisions and curriculum development. By debunking these myths, policymakers can make more informed decisions about how to allocate resources and support evidence-based teaching practices.

Numerous studies have been conducted over the years to determine the prevalence of neuromyths among educators for this purpose. However, despite all these efforts, a recent systematic review showed that teachers from different countries of the world continued to believe neuromyths, and educational neuromyths are still prevalent (Torrijos-Muelas, González-Víllora, & Bodoque-Osma, 2021). In Türkiye, there are a scarce number of studies regarding neuromyths (Taşkıner Şereflioğlu & Kılıç Mocan, 2021). By identifying and debunking neuromyths, educators can make more informed decisions about teaching strategies, and focus on evidence-based approaches that are more likely to be effective. This can ultimately lead to better learning outcomes for students, and a more efficient use of educational resources. Therefore, it is aimed to address the prevalence and predictors of neuromyths among teachers in Türkiye by overcoming the limitations of previous studies (Dündar & Gündüz, 2016; Gülsün & Köseoğlu, 2020; Karakus, Howard-Jones, & Jay, 2015) in Türkiye.

Neuromyths

Neuroscience deals with the human nervous system by putting emphasis on how the human brain works and its functionality. Accelerating the advances in neuroscience studies at the beginning of this century has increased attention to brain-related subjects among educators as occurred in many other disciplines (Dündar & Gündüz, 2016). Neuromyths that are misconceptions about the brain have also emerged from this growing interest, unfortunately. The lack of communication between neuroscientists and educators and the difficulty and complexity of transfering neuroscience studies into school contexts caused the appearance and adoption of neuromyths (Goswami, 2006; Howard-Jones & Fenton, 2012).

In the extant literature, it has been reported numerous neuromyths. The myth of %10 is one of them. This myth claims that humans use only %10 of their brains (OECD, 2007). Another example of neuromyth is the Mozart effect that asserts listening to classical music makes people more intelligent (Rauscher & Shaw, 1998; Steele, Bass, & Crook, 1999; Waterhouse, 2006). Similarly, the hemispheric dominance known as the right-brained and left-brained thinking myth says that the dominantly used brain hemisphere determines an individual's ability. If people use the right side of their brain dominantly, they will become more successful at creative tasks rather than academic tasks or vice versa (Geake, 2008; Lindell & Kidd, 2011; OECD, 2007). The critical term that says certain things can no longer be learned after which the first three years of childhood, and multitasking, multiple intelligence, and learning while sleeping are also some other examples of neuromyths (OECD, 2002, 2007). Studies (Çağıltay & Tunga, 2022; De Bruyckere, Kirschner, & Hulshof, 2015; Kirschner & van Merriënboer, 2013) have explicated more other neuromyths, including their origins of and the scientific arguments made to refute dispel them (also see appendix to list of neuromyths)

There are several factors contributing to survival and the spread of neuromyths. Oversimplification or misunderstanding of scientific facts are the origins of neuromyths, that's make neuromyths seem reasonable and logical, on the other side, it has enabled hard to identify and dispel them (OECD, 2002, 2007). Furthermore, several forms of media have reinforced the prevalence of neuromyths. For example, the myth of 10% that claims people use only 10% of their brain was promoted in Hollywood movies namely Lucy, Limitless (De Bruyckere et al., 2015). The hemispheric dominance myth is another example of this situation. When you made a quick search on the internet, you can reach almost one million results about this myth and plenty of websites that provide online-test to determine users' dominant hemisphere and the services like MentalUp, DualBrain, Cognifit, CogniMed, etc. that are designed to exercise neglected hemisphere of the brain. These commercial extensions of neuromyths that are getting benefit from the survival of neuromyths by selling brain exercise games, brain-based educational programs, or simply classical music tapes for better memory and higher cognitive performance have also contributed pervasion of neuromyths (Çağıltay & Tunga, 2022).

Though research has provided sufficient evidence to dispel neuromyths, most neuromyths have survived for more than 20 years and are still alive (Torrijos-Muelas et al., 2021). Chronologically, one of the earliest attempts against the spread of neuromyths was the OECD (2002, 2007) reports and the first neuromyth survey published by Herculano-Houzel (2002). Herculano-Houzel (2002) conducted this first neuroscience literacy survey containing 95 multiple-choice items and revealed that the public had several misconceptions about the brain and, several factors such as education level, reading popular science magazines and newspapers affected neuromyth endorsement. Subsequently, OECD (2007) published a chapter named "Dispelling Neuromyths" contains scientific explanations of the following myths; critical term, hemispheric dominance, multitasking, the myth of %10, and memory games. Moreover, numerous studies have been continued to publish for the purpose of debunking neuromyths. For example, the learning styles myth has been criticized and dispelled by researchers (Kirschner, 2017; Rohrer & Pashler, 2012) due to the lack of evidence. However, recently conducted studies indicated that teachers continued to believe this neuromyth (Janati Idrissi et al., 2020; Menz, Spinath, & Seifried, 2021; Torrijos-Muelas et al., 2021; Tovazzi, Giovannini, & Basso, 2020). Endorsement of neuromyths can hinder the reach of educational objectives (Menz et al., 2021). Therefore it is important to identify prevalent neuromyths among teachers and determine predictor factors to overcome this problem is required.

Neuromyths studies in Türkiye

Recent review study that examines educational neuroscience studies conducted in Türkiye found that the number of educational neuroscience studies including neuromyths is inadequate and it seems that educational neuroscience is still understudied in Türkiye (Taşkıner Şereflioğlu & Kılıç Mocan, 2021). In addition, this review also found that there are only three neuromyth studies conducted in Türkiye. Likewise, we have found three studies that investigate neuromyths' prevalence in Türkiye (Dündar & Gündüz, 2016; Gülsün & Köseoğlu, 2020; Karakus et al., 2015) and these studies in have some limitations.

In detail, the first study conducted by Karakus et al. (2015) collected data from a total of 278 primary and secondary school teachers working in Istanbul and Mersin by using the neuromyth survey of Dekker, Lee, Howard-Jones, and Jolles (2012). The research findings showed that Turkish teachers believed in several neuromyths, and there was no significant difference in general brain knowledge among teachers in terms of demographics, namely gender, age, and department. Subsequently, Dündar and Gündüz (2016) conducted a more comprehensive study. They collected data from 2,932 pre-service teachers who studied at six different universities by using a 59-item survey which combined three surveys (Dekker et al., 2012; Herculano-Houzel, 2002; Howard-Jones, Franey, Mashmoushi, & Liao, 2009). Analyses were conducted to determine the effect of reading books, newspapers, and popular science journals, as well as gender, on neuromyth endorsement. The findings were similar to the previous study, as pre-service teachers adopted numerous neuromyths and had limited knowledge about the brain. The final study was carried out by Gülsün and Köseoğlu (2020) to investigate the prevalence of neuromyths among biology teachers by employing the survey of Dekker et al. (2012). The study aimed to determine the most and least endorsed neuromyths among biology teachers. The research findings showed that biology teachers had endorsed numerous neuromyths and had limited knowledge about the brain.

In terms of their limitations, although the study by Karakus et al. (2015) made a significant contribution to the literature by reporting on the prevalence of neuromyths among Turkish teachers for the first time, the study did not include any analysis about the predictors and protectors of neuromyth endorsement. Additionally, the sample used by Gülsün and Köseoğlu (2020) was narrow, consisting only of biology teachers. Considering the biology department curriculum, it may not be appropriate to generalize the findings from this group to teachers in other disciplines, such as social sciences or linguistics. It is noteworthy that predictor analysis was not conducted in this study as well. The study by Dündar and Gündüz (2016) examined the prevalence of neuromyths and their predictors among pre-service teachers. While this study addressed some of the limitations of previous research by including predictor analysis, it may not be representative of inservice teachers, whose professional experience may be a significant factor in neuromyth endorsement. Studies such as that of Macdonald, Germine, Anderson, Christodoulou, and McGrath (2017) have shown that younger individuals tend to have more accurate knowledge about neuromyths and endorse them less frequently than their older counterparts. Thus, a more diverse sample in terms of age would be necessary to gain a comprehensive understanding of the prevalence and predictors of neuromyths among Turkish teachers.

Furthermore, some items used in these studies have been removed from educational neuromyth surveys due to recent developments in neuroscience. For instance, Moreno-Jiménez et al. (2019) reported that the item "Learning is not due to the addition of new cells to the brain" should be removed from the survey due to contradictory findings found in recent neuroscience studies. It should also be noted that other changes in the items used in neuromyth surveys may have occurred since the original survey was created by Dekker et al. (2012). Additionally, existing surveys lack items about certain myths, such as multitasking, learning while sleeping, and multiple intelligence myths. Determining the prevalence of these myths among Turkish teachers can contribute to the literature.

To address the limitations of previous research on neuromyths among Turkish teachers and contribute to the literature, the present study aims to determine the prevalence and predictor factors of neuromyths among Turkish teacher with a larger and more representative participant group by using a revisited version of the neuromyth survey. The research questions of the study are as follows:

1. What is the prevalence level of educational neuromyths among Turkish teachers?
2. What factors predict the educational neuromyths endorsements of Turkish teachers?

Method

In accordance with the aim of this study, a correlational research design has been employed. In contrast to experimental studies, correlational research studies are used to investigate relationships between two or more variables without manipulating of them. Therefore, this kind of research is also labeled as descriptive research. Correlational studies have conducted to either predict possible outcomes or explain human behaviors (Fraenkel, Wallen, & Hyun, 2012). In our case, we aimed to determine predictors of neuromyth endorsement of Turkish teachers, thats' why we employed this methodology.

Participants

The sample included 730 primary and secondary school teachers from 15 different cities in Türkiye. All participants work in public schools affiliated with The Ministry of Education. One hundred-six (14.5%) participants were male and 624 (85.5%) females. The years of teaching experiences of participants ranged from 1 to 37 years and the mean of teaching experience was 15.64 years (*SD*=7.09). The departments of teachers are shown in Table 1.

Table 1. Distribution of teachers per deparments

Department	Frequency (f)	Percent (%)
Primary school	439	60.1
English	58	7.9
Science education	49	6.7
Turkish	44	6.0
Mathematics	43	5.9
Psychological counseling and guidance	25	3.4
Technology and design	25	3.4
Social sciences	14	1.9
Religious and moral knowledge	12	1.6
Physical education	9	1.2
Visual arts	4	.5
Music	4	.5
Special education	4	.5
Total	730	100

Instruments

Demographic Questions

Gender, teaching experience, department, reading peer-reviewed journals, reading popular science publications, and taking an educational neuroscience course or participating in neuroscience training information were collected from participants.

Neuromyths Survey

The statements in this study were mainly adapted from a number of previous studies, but the survey conducted by the survey of (Dekker vd., 2012) was the primary source. From this survey, all statements (15 neuromyths and 17 general brain knowledge statements) from the survey were included in the first version of our survey. Three general brain knowledge statements (item31, item32 and item34, see Appendix) were adapted from the survey conducted by Herculano-Houzel (2002) Two neuromyth statements about the Mozart effect and dyslexia were taken from the study conducted by (Macdonald et al., 2017). As Gardner (2020) has stated, learning styles are not the same as the multiple intelligences theory. To avoid using learning styles statements to flag the multiple intelligences theory, we wrote a statement for the multiple intelligences theory based on Gardner's (1983) own study. Additionally, there are no items about both multitasking and learning while sleep myths in the existing surveys, therefore additional neuromyth statements pertaining to these topics were written. Furthermore, an extra statement was formulated for the hemisphere dominance myth that explicitly implies that right-brained people are more successful in creative tasks while left-brained people are successful in academic and analytical tasks. In total, 41 items were included in the first version of the survey.

All statements were translated into Turkish by two experts, and then the survey form was presented to four experts, all of whom have Ph.D. degrees in education and are interested in survey construction and educational neuroscience. To ensure the content validity of the survey, we calculated the content validity index proposed by Davis (1992). He suggested that there should be at least three experts in validity stage, and each item should have a higher value than 0.80 to be acceptable. Accordingly, we took 40 items in which 31 of them were from the survey of Dekker et al. (2012), either without any changes or with minor revisions.

The item “Learning is not due to the addition of new cells to the brain” was dropped because of existing contradictory findings (Moreno-Jiménez, et al., 2019). Five statements revised as follows. 1) The statement “Vigorous exercise can improve mental function” was changed as “Physical exercise can improve mental function” due to its ambiguity 2) The statement “Boys have bigger brains than girls” changed as “In the same age group, the average male brain is bigger than the female brain.” 3) We added “completely” to the statement “Mental capacity is hereditary and cannot be changed by the environment or experience”. 4) The statement “Brain development has finished by the time children reach secondary school” was changed as “Brain development has finished by the children reach puberty”. 5) The statement “We use only 10% of our brain” reworded as “We use only certain percentages of our brain”. Other statements were used without any revision. Finally, forthy statements composed of 21 neuromyth and 19 brain knowledge statements were included in the survey (see Appendix). The overall content validity index of this tool has been calculated as .98. Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz, and Demirel (2013) suggested that Kuder-Richardson coefficient instead of Cronbach's alpha in reliability analysis for measurement tools that use dichotomous responses. Therefore, the KR-20 coefficient was calculated as 0.71, which indicates an acceptable level of reliability.

Procedure

Data was collected via an electronic survey from the participants during the 2020-2021 educational year's spring semester. Participants answered the statements with "true", "false", and "I don't know" options. The use of surveys can also feed the myths. Therefore, after data collection, participants were invited to the Educational Neuroscience seminar given by an academician who works in the educational neuroscience field. In addition, an information form containing corrections of neuromyths was sent to participants.

Data Analysis

Multiple regression analysis conducted to determine predictors of teachers' general brain knowledge and neuromyths endorsement. The number of believed myths were used as dependent variable. Gender, teaching experience, reading peer-reviewed journals, reading popular science publications and taking a educational neuroscience course or participating in traning, and the number of correct answer to general brain knowledge statements were used as predictors. Descriptive statistics were used to describe teachers demograhic characteristics and prevelance of each neuromyths.

Findings

Descriptive statistics of teachers' demographics is shown in Table 2. Overall, 70.4% of teachers reported that they are interested in neuroscience, and the remaining 29.6% are not. Although teachers have highly interested in neuroscience, only 7% of teachers have taken neuroscience-related courses or participated in related training. A total of 85.8 % of teachers stated that they read popular science publications. In addition, 20.3% of teachers stated that they have read peer-reviewed scientific journals.

Table 2. Summary of Descriptive Question

Questions		Frequency	Percent
Have you ever taken a course or training related to neuroscience before?	Yes	679	93.0
	No	51	7.0
	Total	730	100
Are you interested in neuroscience?	Yes	514	70,4
	No	216	29,6
	Total	730	100
Do you read peer-reviewed journals?	Yes	148	20.3
	No	582	79.7
	Total	730	100.0
Do you read popular science magazines?	No, i dont read	104	14.2
	Sometimes	572	78.4
	Yes, always	54	7.4
	Total	730	100

General Brain Knowledge

An analysis of the responses for each general brain knowledge statement is given in Table 3. A total general brain knowledge score was calculated by adding the number of correct responses of teachers. That is, having a higher score indicates greater knowledge. The number of correctly responded statements ranged from 4 to 18. The mean of correctly responded statements was 11.62 (*SD*= 2.42). Fifteen statements were responded to correctly by more than 50% of teachers. The remaining four statements were correctly answered by less than 50% of teachers.

Table 3. Correctness of responses for each general brain knowledge statements

General Brain Knowledge Statements	Correct		Incorrect		Do not Know	
	f	%	f	f	%	f
There are sensitive periods in childhood when it's easier to learn things.	715	97.95	0	0	15	2.05
Physical exercise can improve mental function.	686	93.97	9	1.23	35	4.79
Mental capacity is completely hereditary and cannot be changed by the environment or experience.	683	93.56	18	2.47	29	3.97
When we sleep, the brain shuts down.	660	90.41	22	3.01	48	6.58
Learning occurs through modification of the brains' neural connections.	636	87.12	7	0.96	87	11.92
We use our brains 24 hours in a day.	609	83.42	41	5.62	80	10.96
Academic achievement can be affected by skipping breakfast.	596	81.64	71	9.73	63	8.63
Keeping a phone number in memory until dialing, recalling recent events and distant experiences, all use the same memory system.	556	76.16	61	8.36	113	15.48
Brain development has finished by the time children reach puberty.	536	73.42	47	6.44	147	20.14
Information is stored in the brain in a network of cells distributed throughout the brain.	467	63.97	29	3.97	234	32.05
The brains of boys and girls develop at the same rate.	431	59.04	72	9.86	227	31.1
Production of new connections in the brain can continue into old age.	426	58.36	94	12.88	210	28.77
The brain is the body organ that consumes the most oxygen	424	58.89	30	4.17	266	36.94
Circadian rhythms ("body-clock") shift during adolescence, causing pupils to be tired during the first lessons of the school day.	422	57.81	39	5.34	269	36.85
Normal development of the human brain involves the birth and death of brain cells.	402	55.07	41	5.62	287	39.32
In the same age group, the average male brain is bigger than the female brain.	237	32.47	203	27.81	290	39.73
When a brain region is damaged other parts of the brain can take up its function.	179	24.52	325	44.52	226	30.96
The left and right hemispheres of the brain always work together	179	24.52	421	57.67	130	17.81
Memory is stored in the brain much like as in a computer. That is, each memory goes into a tiny piece of the brain item taken from.	0	0	626	85.75	104	14.25

In detail, the most correctly responded statements were 1) "There are sensitive periods in childhood when it's easier to learn things" by 97.95% of teachers, 2) "Physical exercise can improve mental function." by 93.97%, 3) "Mental capacity is completely hereditary and cannot be changed by the environment or experience." by 93.56 % of teachers and 4) "When we sleep, the brain shuts down." by 90.41 % of teachers. None of the teachers did correctly respond to the statement "Memory is stored in the brain much like as in a computer. That is, each memory goes into a tiny piece of the brain item taken from."

Multiple regression was conducted to determine which variables predict the general brain knowledge of teachers as indicated in Table 4. (R^2 = .079, $F(6, 723) = 11.38$, $p < 0.05$). Analysis revealed that taking educational neuroscience course (β = .11, $p < .001$), reading both popular science publications (β = .12, $p < .001$) and peer-reviewed journals (β =.12, $p < .001$), having interest in neuroscience (β = .14, $p < .001$) variables were significant predictors of general brain knowledge scores of teachers. However, gender (β = -.03, $p > 0.05$) and teaching experience (β = - .03, $p > 0.05$) were not significantly predict this score. This finding showed that taking an educational neuroscience course, reading both popular science publications and peer-reviewed journals, and having an interest in neuroscience lead to an increase general brain knowledge scores of teachers.

Table 4. Regression Analysis Summary for General Brain Knowledge and Predictors (*N*=730)

Variable	B	SE B	β	t	p	sr^2
Gender	-.21	.25	-.03	-.87	.39	-.03
Teaching experience	-.01	.01	-.03	-.73	.46	-.03
Neuroscience course	1.01	.34	.11	2.96	.003*	.10
İnterest	.76	.20	.14	3.85	<.001*	.14
Peer-reviewed journals	.72	.22	.12	3.24	<.001*	.11
Popular science publications	.85	.26	.12	3.35	<.001*	.12

*p < .05

Prevalence of Neuromyths

Table 5 summarizes the responses of teachers for each neuromyth statement. A total believed/endorsed neuromyth score was calculated by adding the number of incorrect responses of teachers. The number of believed neuromyth statements ranged 8 from to 21. The mean was 16.30 (*SD*= 1.90). Fourteen of the 21 neuromyths were endorsed by more than 50% of the teachers. Among them the most prevalent neuromyths were:

1. "Individuals learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic)" believed by 97.4%,
2. "There are different types of intelligence such as verbal, mathematical, spatial, rhythmic, kinesthetic, introvert and extrovert" by 96.3%
3. believed by "Environments that are rich in stimulus improve the brains of pre-school children" believed by 90,55 % of teachers.

The least endorsed myth statements were respectively

1. "Individual learners show preferences for the mode in which they receive information (e.g., visual, auditory, kinesthetic)." by 2.6 % of teachers,
2. "Extended rehearsal of some mental processes can change the shape and structure of some parts of the brain." by 7.67%,
3. "Learning problems associated with developmental differences in brain function cannot be remediated by education." by 8.9% of teachers.

Table 5. Correctness of responses for each neuromyths

Neuromyth statements	Incorrect		Correct		Do not Know	
	f	%	f	f	%	f
Individuals learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic).	711	97.4	7	0.96	12	1.64
There are different types of intelligence such as verbal, mathematical, spatial, rhythmic, kinesthetic, introvert, and extrovert.	702	96.3	15	2.06	12	1.65
Environments that are rich in stimulus improve the brains of pre-school children.	661	90.55	35	4.79	34	4.66
Differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners.	640	87.67	20	2.74	70	9.59
Exercises that rehearse co-ordination of motor-perception skills can improve literacy skills.	640	87.67	17	2.33	73	10
A common sign of dyslexia is seeing letters backwards.	622	85.21	59	8.08	49	6.71
Short bouts of co-ordination exercises can improve integration of left and right hemispheric brain function.	610	83.56	8	1.1	112	15.34
We only use a certain percentage of our brain.	605	82.88	102	13.97	23	3.15
Students who use dominantly the right hemisphere of their brain are creative, while students who use the left hemisphere of their brain as dominant are more successful in rational-academic tasks.	564	77.26	35	4.79	131	17.95
It has been scientifically proven that fatty acid supplements (omega-3 and omega-6) have a positive effect on academic achievement.	559	76.58	11	1.51	160	21.92
There are critical periods in childhood after which certain things can no longer be learned.	487	66.71	129	17.67	114	15.62
Listening to classical music increases children's reasoning ability.	473	64.79	34	4.66	223	30.55
Children are less attentive after consuming sugary drinks and/or snacks.	466	64.1	91	12.52	170	23.38
During sleeping, complex skills such as learning a foreign language can be acquired by listening to instructional audio.	463	63.42	41	5.62	226	30.96
Regular drinking of caffeinated drinks reduces alertness.	352	48.22	218	29.86	160	21.92
The brains of today's children, who have been intensely exposed to digital technology from the moment they were born, have changed to perform multi-tasks.	250	34.29	207	28.4	272	37.31
Children must acquire their native language before a second language is learned. If they do not do so neither language will be fully acquired	210	28.77	447	61.23	73	10
If pupils do not drink sufficient amounts of water (=6–8 glasses a day) their brains shrink.	172	23.56	232	31.78	326	44.66
Learning problems associated with developmental differences in brain function cannot be remediated by education.	65	8.9	530	72.6	135	18.49
Extended rehearsal of some mental processes can change the shape and structure of some parts of the brain.	56	7.67	414	56.71	260	35.62
Individual learners show preferences for the mode in which they receive information (e.g., visual, auditory, kinesthetic).	19	2.6	641	87.81	70	9.59

* The table was created after the evaluation of the answers to the items as correct and incorrect.

To explore predictors of the number of believed neuromyths by teachers, multiple regression was conducted, as shown in Table 6. (R^2 = .12, $F(7, 722) = 15.69$, $p < .05$). General brain knowledge (β = -.30, p <.001), taking educational neuroscience course (β = -08, $p < 0.05$), and reading peer-reviewed journals (β = -.07, $p < .001$) variables have significant predictors. Other variables namely gender (β = -.00, $p > .05$), teaching experience (β = -.00, $p > .05$), and interest (β = -.04, $p > .05$) in neuroscience did not significantly predict. The findings revealed that increasing general brain knowledge, reading peer-reviewed journals, and taking neuroscience education caused a decrease in the endorsement of neuromyths.

Table 6. Regression Analysis Summary for Prevalence of Neuromyths and Predictors (N=730)

Variable	B	SE B	β	t	p	sr^2
Gender	.02	.19	.00	.09	.92	.00
Teaching experience	-.00	.01	-.00	-.10	.92	-.00
Neuroscience course	-.62	.26	-.08	-2.34	.02*	-.08
İnterest	-.19	.15	-.04	-1.23	.22	-.04
Peer-reviewed journals	-.34	.17	-.07	-2.00	.04*	-.07
Popular science publications	-.17	.20	-.03	-.85	.39	-.03
General brain knowledge	-.23	.03	-.30	-8.27	.001*	-.29

*p < .05

Discussion

This study aimed to determine the prevalence and predictors of neuromyths among teachers in Türkiye. The research findings disclosed that the general brain knowledge of teachers in Türkiye was limited and they believed in many neuromyths. As stated in the review of (Torrijos-Muelas et al., 2021) teachers around the globe still endorsed neuromyths especially learning styles. In this present study, the most prevalent myth is also learning styles, followed by multiple intelligences and enrich environment myths. These findings were compatible with earlier studies conducted in Türkiye (Dündar & Gündüz, 2016; Gülsün & Köseoğlu, 2020; Karakus et al., 2015) and in Morocco (Janati Idrissi et al., 2020) in Canada (Craig, Wilcox, Makarenko, & MacMaster, 2021) in German (Menz et al., 2021) in China (Ching, So, Lo, & Wong, 2020) in Latin America (Gleichgerrcht, Lira Luttges, Salvarezza, & Campos, 2015) in Caribbean (Bissessar & Youssef, 2021) and in Spain (Ferrero, Garaizar, & Vadillo, 2016; Ruiz-Martin, Portero-Tresserra, Martínez-Molina, & Ferrero, 2022).

Predictors analysis revealed that general brain knowledge was the foremost predictor of neuromyths. This finding is in line with earlier studies (Ching et al., 2020; Dündar & Gündüz, 2016; Janati Idrissi et al., 2020). It is also found that taking a neuroscience-related course and reading peer-reviewed journals are the other two significant predictors of the neuromyth endorsement. This finding is also consistent with recently conducted neuromyths research (Macdonald et al., 2017). However, other predictor of neuromyth endorsement are inconsistent with previous studies. In contrast to existing studies (Dündar & Gündüz, 2016; Janati Idrissi et al., 2020) that reported neuromyths are more frequently believed by females than by males, gender did not significantly predict neuromyth endorsement in present study. Similarly, teaching experience didn't significantly predict neuromyth endorsement unlike Macdonald et al. (2017) whose study found that younger teachers have less neuromyth endorsements.

Furthermore, the regression analyses revealed that the general brain knowledge of teachers was influenced by several factors, such as taking neuroscience courses, showing interest to neuroscience, and reading peer-reviewed journals and popular science publications. The findings indicate that teachers who make an effort to improve their science literacy tend to have more knowledge about the brain and neuroscience. This aligns with similar studies conducted by Dündar and Gündüz (2016), and Ferrero et al. (2016). On the other hand, two demographic variables, namely gender and professional experience, did not have a significant impact on teachers' general knowledge about the brain in this

study. Bissessar and Youssef (2021) found similar findings. However, other studies have reported different findings regarding these variables. For instance, Janati Idrissi et al. (2020) found that teachers' general brain knowledge decreased as they aged. Macdonald et al. (2017) found that in the general participant group, females and younger individuals believed in fewer neuromyths, while in the sample group consisting of educators, only the age variable reached a significant predictor result.

Additionally, the findings revealed that the endorsement levels of both the multiple intelligence (96.3%) and learning styles (97.4%) myths were very similar. This raises the question of whether teachers are able to distinguish between multiple intelligence and learning styles, as there is evidence to suggest that teachers may confuse these concepts (Papadatou-Pastou, Touloumakos, Koutouveli, & Barrable, 2021). In light of these findings, it is possible to speculate that teachers, as members of the humanistic community, may be more inclined to believe statements that are humanistic in nature, such as learning styles and multiple intelligences, as opposed to other neuromyths. That is also a possible explanation for why statements involving gender differences, which can be seen as discriminatory, such as differences in brain size (32.47 %) was among the least endorsed in present study. For example, research has shown that some teachers still hold onto this myth even after being presented with evidence to the contrary (Menz et al., 2021). Therefore, neuromyths with humanistic tones may be more enduring than other neuromyths, and alternative discourses should be developed to dispel them instead of relying solely on scientific explanations.

Conclusion and Suggestions

The present study had two major conclusions. Firstly, although the majority of teachers had an interest in educational neuroscience, only a small percentage of them had the chance to receive training about neuroscience. Secondly, having greater knowledge about the brain can safeguard against neuromyths. Therefore, it is suggested that the curriculum of teacher education programs needs to be revised by adding educational neuroscience topics or courses. In other words, it can be summarized that neuromyths are still prevalent, but they can be eliminated through educational neuroscience interventions. The study revealed that participants who had greater general brain knowledge endorsed fewer neuromyths.

It is believed that studies like the present study, which reported the most commonly believed neuromyths, will be helpful in solving this problem. These types of studies have the potential to serve as a needs analysis for future interventions that aim to dispel neuromyths by showing what content should be provided in neuromyth education programs. Specifically, this study showed that teachers need to be informed about learning styles that may directly cause ineffective practices, as stated in studies like Kirschner (2017). Although it has been known and discussed among scholars for almost a decade that the concept of learning styles is a myth, it appears that this information has not reached the teacher community. Therefore, it is important to increase communication between scholars and teachers to effectively spread scientific knowledge. This is also valid for other neuromyths as well. For instance, the OECD published its first report against neuromyths in 2002, yet these myths continue to persist in the education community.

In the Turkish context, the language barrier may contribute to the problem of neuromyths. Most articles and reports against neuromyths are written in English, and the lack of Turkish resources on this issue may hinder efforts to dispel these myths among Turkish teachers. Therefore, developing reports, open-source informative papers, and other instructional materials such as short video clips written and produced in Turkish could be helpful in effectively combating neuromyths among Turkish teachers. Additionally, further research focusing on the refutation of neuromyths is also necessary. Ruiz-Martin et al. (2022) conducted research that included such an intervention, and the findings showed a large effect of the intervention on reducing the prevalence of neuromyths shortly after the training and in the long term.

Another issue is about the measurement of neuromyths. As Sullivan, Hughes, and Gilmore (2021) stated, an interdisciplinary team of neuroscientists, educators and psychometricians should revise the neuromyth and brain knowledge statements in a periodic time. Conducting cognitive interviews with teachers and other potential participant groups related to survey statements can contribute to this effort. The wording of some statements seems problematic in terms of social desirability. For example, several questions were received regarding the statement concerning the enriched environment. Teachers may have provided incorrect responses to the enriched environment myth because they may have thought that the statement was related to the importance of pre-school education. Especially for those living in countries like Türkiye, where the enriched environment myth has never been popular among teachers and academics, this statement should be reviewed. The argument can also be applied to BrainGYM statements. There are no widely known BrainGym-like applications and practices in Türkiye.

Finally, the explained variance is small, other variables can also be added to the model such as epistemological beliefs, science literacy, critical thinking skills, digital literacy, information literacy skills. Furthermore, given that this study found that neuromyths are still widely held, it is clear that further research focusing on ways to debunk neuromyths is necessary.

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Appendix[3]

1. We use our brains 24 hours in a day.
2. **Children must acquire their native language before a second language is learned. If they do not do so neither language will be fully acquired.**
3. In the same age group, the average male brain is bigger than the female brain.
4. **If pupils do not drink sufficient amounts of water (=6-8 glasses a day) their brains shrink**
5. **It has been scientifically proven that fatty acid supplements (omega-3 and omega-6) have a positive effect on academic achievement**
6. When a brain region is damaged other parts of the brain can take up its function.
7. **We use only certain percentages of our brain**
8. The left and right hemispheres of the brain always work together.
9. **Differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners.**
10. Brain development has finished by the time children reach puberty.
11. **There are critical periods in childhood afterwhich certain things can no longer be learned.**
12. Information is stored in the brain in a network of cells distributed throughout the brain.
13. **Individuals learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic).**
14. Normal development of the human brain involves the birth and death of brain cells.
15. Academic achievement can be affected by skipping breakfast.
16. Mental capacity is hereditary and cannot be changed by the environment or experience.
17. Physical exercise can improve mental function.
18. **Environments that are rich in stimulus improve the brains of pre-school children.**
19. **Children are less attentive after consuming sugary drinks and/or snacks.**
20. Circadian rhythms ("body-clock") shift during adolescence, causing pupils to be tired during the first lessons of the school day.
21. **Regular drinking of caffeinated drinks reduces alertness.**
22. **Exercises that rehearse co-ordination of motor-perception skills can improve literacy skills**
23. **Extended rehearsal of some mental processes can change the shape and structure of some parts of the brain.**
24. **Individual learners show preferences for the mode in which they receive information (e.g., visual, auditory, kinesthetic).**
25. **Learning problems associated with developmental differences in brain function cannot be remediated by education.**
26. Production of new connections in the brain can continue into old age.

[3] *neuromyths items are written in bold*

27. **Short bouts of co-ordination exercises can improve integration of left and right hemispheric brain function.**
28. There are sensitive periods in childhood when it's easier to learn things.
29. When we sleep, the brain shuts down.
30. The brains of boys and girls develop at the same rate.
31. The brain is the body organ that consumes the most oxygen
32. Keeping a phone number in memory until dialing, recalling recent events and distant experiences, all use the same memory system
33. **Listening to classical music increases children's reasoning ability.**
34. Memory is stored in the brain much like as in a computer. That is, each memory goes into a tiny piece of the brain item taken from.
35. **A common sign of dyslexia is seeing letters backwards.**
36. **There are different types of intelligence such as verbal, mathematical, spatial, rhythmic, kinesthetic, introvert and extrovert.**
37. **Students who use dominantly the right hemisphere of their brain are creative, while students who use the left hemisphere of their brain as dominant are more successful in rational-academic tasks.**
38. **During sleeping, complex skills such as learning a foreign language can be acquired by listening to instructional audio.**
39. **The brains of today's children, who have been intensely exposed to digital technology from the moment they were born, have changed to perform multi-tasks.**
40. Learning occurs through changes to the connections between brain cells.