PRIMA EDUCATIONE 2021

MAŁGORZATA CHOJAK
Maria Curie-Skłodowska University in Lublin, Poland
ORCID: https://orcid.org/0000-0002-7558-7630
malgorzata.chojak@mail.umcs.pl

ELA LURIA
Levinsky College of Education in Tel Aviv, Israel
ORCID: https://orcid.org/0000-0001-9201-2188
ela.luria@levinsky.ac.il

MAYA SHALOM
Beit Berl College, Kfar Saba, Israel
ORCID: https://orcid.org/0000-0002-3637-6478
maya.13x@gmail.com

Neuromyths among Polish Teachers – Research Results and Practical Implications

Neuromity wśród polskich nauczycieli – wyniki badań i praktyczne implikacje

Abstract: The article presents the results of research conducted among Polish teachers. Their aim was to check the prevalence of neuromyths in schools and kindergartens, and to identify predictors of both belief in neuromyths and the level of knowledge about the structure and functioning of the brain. The obtained results partially confirmed the reports from international studies. Neuromyths turned out to be very popular among Polish teachers, even despite the high level of basic knowledge in the field of neurobiology. The research also revealed a number of factors that determine the level of the above-mentioned knowledge. The influence of age, gender, seniority, workplace, interest in training in neuroeducation, earlier access to knowledge in the field of neurobiology or the use of neuromyths-based work methods in educational practice has not been confirmed.

Keywords: neuromyth; teacher; brain; neurofact; education

DOI: 10.17951/PE/2021.5.115-131

Abstrakt: W artykule zaprezentowano wyniki badań przeprowadzonych wśród polskich nauczycieli. Ich celem było sprawdzenie powszechności neuromitów w szkołach i przedszkolach oraz wskazanie predyktorów zarówno wiary w neuromity, jak i poziomu wiedzy dotyczącej budowy i funkcjonowania mózgu. Uzyskane wyniki częściowo potwierdziły doniesienia z międzynarodowych badań. Neuromity okazały się bardzo popularne wśród polskich nauczycieli, nawet pomimo wysokiego poziomu podstawowej wiedzy z zakresu neurobiologii. Badania uwidoczniły również szereg czynników, które warunkują poziom wyżej wskazanej wiedzy. Nie potwierdzono wpływu wieku, płci, stażu pracy, miejsca pracy ani zainteresowania dokształcaniem w problematyce neuroedukacji, wcześniejszym dostępem do wiedzy z zakresu neurobiologii czy stosowaniem w praktyce edukacyjnej metod pracy opartych na neuromitach.

Słowa kluczowe: neuromit; nauczyciel; mózg; neurofakt; edukacja

INTRODUCTION

In recent years, research in the field of neurosciences has gained more and more popularity (e.g. Herculano-Houzel 2002). Neuroscientific knowledge has undoudtebly spurred interest among educators as well; being inclined towards implementing these insights into their own educational activities (e.g. Pickering, Howard-Jones 2007; Zambo, Zambo 2009, 2011; Bartoszeck, Bartoszeck 2012; Serpati, Loughan 2012; Rato, Abreu, Castro-Caldas 2013; Karakus, Howard-Jones, Jay 2015). Neuromyths, or misconceptions about brain research in education are also widespread, leading at times to the implementation of ineffective teaching-learning methods (e.g. Goswami 2004, 2006; Pasquinelli 2012), with the possibility of causing a reduction in the quality or ineffectiveness of educational activities.

The term "neuromyth" is a relatively young term. It was first introduced by the neurosurgeon Alan Crockard in the 1980s to refer to unscientific ideas about the brain in medical culture (Crockard 1996). The semantic scope of the concept was expanded when, in 2002, the organizers of the Brain and Learning project in the UK highlighted many theories about the mind and the brain that arise outside the medical and scientific community in general. They called these theories "neuromyths". The term was intended to denote any misconceptions generated by misunderstandings, misreading, or misquoting scientifically established facts about brain research (OECD 2002).

Currently, this concept is most often defined as theories, principles or products which are based on unreliable scientific research or on erroneous interpretations of available reliable research (Geake 2008; Alferink, Farmer-Dougan 2010). These can include well-known proposals for working with children: the theory of multiple intelligences, individualization based on learning styles or educational kinesiology, but also claims regarding the functioning of the brain, e.g. using only 10% of the brain, the existence of left and right hemispheric individuals, multitasking (Howard-Jones, Franey, Mashmoushi, Liao 2009).

These are all classified as neuromyths as they fail to meet the following conditions:

- it does not harm (confirmed by research that it has no side effects, even if used incorrectly),
- has a good theoretical basis (it is based on scientifically proven theories),
- it is possible to conduct another empirical verification of its effectiveness (i.e. repeat the research),
- its effectiveness has been confirmed based on empirical data (there are reliable studies whose results have confirmed the effectiveness of the intervention),
- standards for its application have been developed (here: methodological guidelines),
- its limitations can be identified (i.e. situations in which it will not be effective, for example),
- the studies to which the intervention relates were conducted in a manner consistent with the principles of scientific practice (Lord 2005).

In 2009, for the first time in Great Britain, research was conducted on teachers' knowledge of the functioning of the nervous system and the possibility of applying it in educational practice (Howard-Jones et al. 2009). In subsequent years, similar projects were implemented in the Netherlands (Dekker, Lee, Howard-Jones, Jolles 2012; Simmonds 2014), Portugal (Rato, Abreu, Castro-Caldas 2013), Latin America (Bartoszeck, Bartoszeck 2012; Gleichgerrcht, Lira Luttges, Salvarezza, Campos 2015; Hermida, Segretin, Soni García, Lipina 2016), Australia (Bellert, Graham 2013; Horvath et al. 2018), Switzerland (Tardif, Doudin, Meylan 2015), Greece (Deligiannidi, Howard-Jones 2015), China (Pei et al. 2015), Turkey (Karakus, Howard-Jones, Jay 2015), Spain (Ferrero, Garaizar, Vadillo 2016), the United States (Lethaby, Harries 2015) and Canada (Macdonald et al. 2017). Their results showed that neuromyths are very popular regardless of where you live, your age, sex, level of education or area taught. It is also important that despite the development of neuroscience, the number of neuromyths not only does not decrease, but is constantly growing. The percentage of teachers who are convinced of the truthfulness of neuromyths and the effectiveness of actions based on them does not decrease as well.

In the literature on the topic, several factors have been found to explain the popularity of neuromyths:

- differences in education and vocabulary in pedagogy and neuroscience (Howard-Jones 2014),
- different levels of analyzes carried out in both disciplines – from single neurons to international education policies (Goswami 2006),
- limited availability of the results from original empirical research (e.g. paid access, or access only to a specific group of specialists), which favors increased reliance on media reports or interpretations of pseudoscientists (Ansari, Coch 2006),

- lack of specialists and organizations specializing in both disciplines (Ansari, Coch 2006; Goswami 2006),
- the attractiveness and ease of putting into practice explanations that are apparently based on neuroscience but have a strong marketing foundation (McCabe, Castel 2008; Weisberg et al. 2008),
- the so-called media noise, which is evident in the fact that the media, often presenting new reports, omit important information (e.g. research methodology), do it in a simplified manner or provide information that is irrelevant, but of a marketing nature (Wallace 1993; Beck 2010; Pasquinelli 2012),
- the so-called Dunning–Kruger effect, i.e. a psychological phenomenon in which unskilled people in some area of life tend to overestimate their skills in this area, while highly qualified people tend to underestimate their abilities (Kruger, Dunning 1999),
- the so-called attitude of "neurorealism" (Racine, Waidman, Rosenberg, Illes 2006), in which people tend to have greater confidence in any results or publications that refer to, for example, research in the field of neurobiology – even if it is pseudoscientific or irrelevant to the topic at hand (McCabe, Castel 2008; Weisberg et al. 2008; Michael et al. 2013).

An important fact also concerns the problem of internationality and cultural conditions. The mere translation of a text written in a specialized language can be a source of error. Often, the inability to verify research in another country results in unprovable assumptions (consciously or unconsciously).

Regardless of the above, so far no research into neuromyths has been conducted in Poland. This research therefore wishes to examine the popularity of neuromyths among educators in Poland, the factors which neuromyths determine teachers' attitudes in this area and whether there are any premises for designing information and corrective measures.

MATERIALS AND METHODS

Participants

This research study was conducted among 85 teachers from Poland, from schools in the vicinity of Lublin and Warsaw. Information about the planned research and a request to send a link to the electronic questionnaire among teachers was sent to the management of the randomly selected institutions in Lublin and Warsaw. Positive responses were received from one school in Warsaw, three kindergartens in Lublin and four primary schools. The majority were women (96.5%) between the ages of 30 and 40. The demographic characteristics of the sample are presented in Table 1.

Table 1. Distribution *N*, (%) of teachers-subjects, according to personal characteristics

		N	%	Total
Sex	women	82	96.5	100%
	men	3	3.5	
Age	under 30	15	17.6	100%
	31–40	31	36.5	
	41–50	20	23.5	
	more than 51	22	22.4	
Seniority	up to 5 years	28	32.9	100%
	6–10	9	10.6	
	11–15	17	20	
	16–20	10	11.8	
	more than 20	21	24.7	
Place of work	public kindergarten	24	28.2	100%
	private kindergarten	8	9.4	
	public primary school	31	36.5	
	private primary school	22	25.9	

Source: Authors' own study.

68% of the respondents indicated having knowledge in the field of neurobiology and neuroeducation. Over 76% of the respondents showed interest in improving their knowledge in this field. In addition, 80% of the teachers had indicated using some method based on neuromyths in their work (including 30% of them using 3 or more methods). Most often methods used were based on the theory of learning styles (54%), multiple intelligences theory (46%) and supporting education with educational kinesiology (44%).

Procedure

The subjects of the study were recruited from schools in selected regions of Poland. An e-mail with a link to the online questionnaire was sent to the management team, with a request to send it to the employed teachers. The study was presented as an attempt to gather information on teachers' views on the application of brain research findings to education. The term "neuromyth" was not mentioned in the information for teachers.

The online Neuromyths Questionnaire contained 28 statements about the brain and its effects on learning (see Appendix). Of these, 21 statements were educational neuromyths as defined by the OECD (2002) and Howard-Jones et al.'s questionnaire (2009). The remaining 7 statements were general information statements about the brain. The order in which the statements about myths and facts were presented was random. The questionnaire consisted of a three-option answer format "correct", "incorrect" or "I don't know".

The dependent variables were the percentage of the above-mentioned responses to neuromyth statements (where a higher percentage of adverse responses reflects more faith in myths) and the percentage of the above-mentioned responses to factual statements (where a higher percentage of correct answers indicates a higher level of knowledge). In addition, the teachers provided basic information about their age, gender, seniority, workplace (public kindergarten, non-public kindergarten, public primary school, non-public primary school), previous contact with knowledge about neurobiology, the use of methods related to neuromyths in their school and an indication on the interest in neuroscientific learning (independent variables).

Data analysis

Data was analyzed using the Social Sciences Statistics Package (SPSS) version 26.0 for Windows. The statistical threshold of $\alpha = 0.05$ was used in all analyzes. Spearman's rho(r_s) correlation tests were performed to investigate the relationship between the dependent and independent variables.

In another analysis, the correlation between the percentage of incorrect answers to questions about neuromyths and the percentage of correct answers to questions about neurofacts was checked. In addition, the correlation between the independent variables was also checked.

To investigate which factors predicted neuromyths, a regression analysis was performed for the percentage of myths (dependent variable), taking into account gender, age, workplace, seniority, contact with knowledge in the field of neurobiology and neuro-education, interest in training in this field and the use of neuromyths in educational practice. A second regression analysis was performed to investigate predictors of neurobiological knowledge. The proportion of correct responses to neurofacts was the dependent variable, and the predictors were the same variables as in the previous regression.

RESULTS

Overall, about 55% of the teachers believe in every third neuromyth (including 14% which indicate support for half of the neuromyths included in the Questionnaire). The most popular myths in Poland are: "People learn better when they receive information in their preferred learning style" (98.8% of incorrect answers), "Positive emotions increase the amount of dopamine in the brain and children achieve better academic results" (94.1%), "Short exercises in educational kinesiology can improve the integration of the left and right hemispheres of the brain" (94.1%) and "Children have many types of intelligence" (91.8%). Less than 10% of the respondents believe that when we sleep, the brain turns off (2.4%), cognitive abilities are hereditary and cannot be modified by experience (8.2%), and that excessive media use does not change the structure of children's brains (9.4%). Additionally, few teachers believe that the first language must be spoken well, before the second language is learnt (5.9%), and that boys' and girls' brains develop at the same rate (4.7%) (see Figure 1).

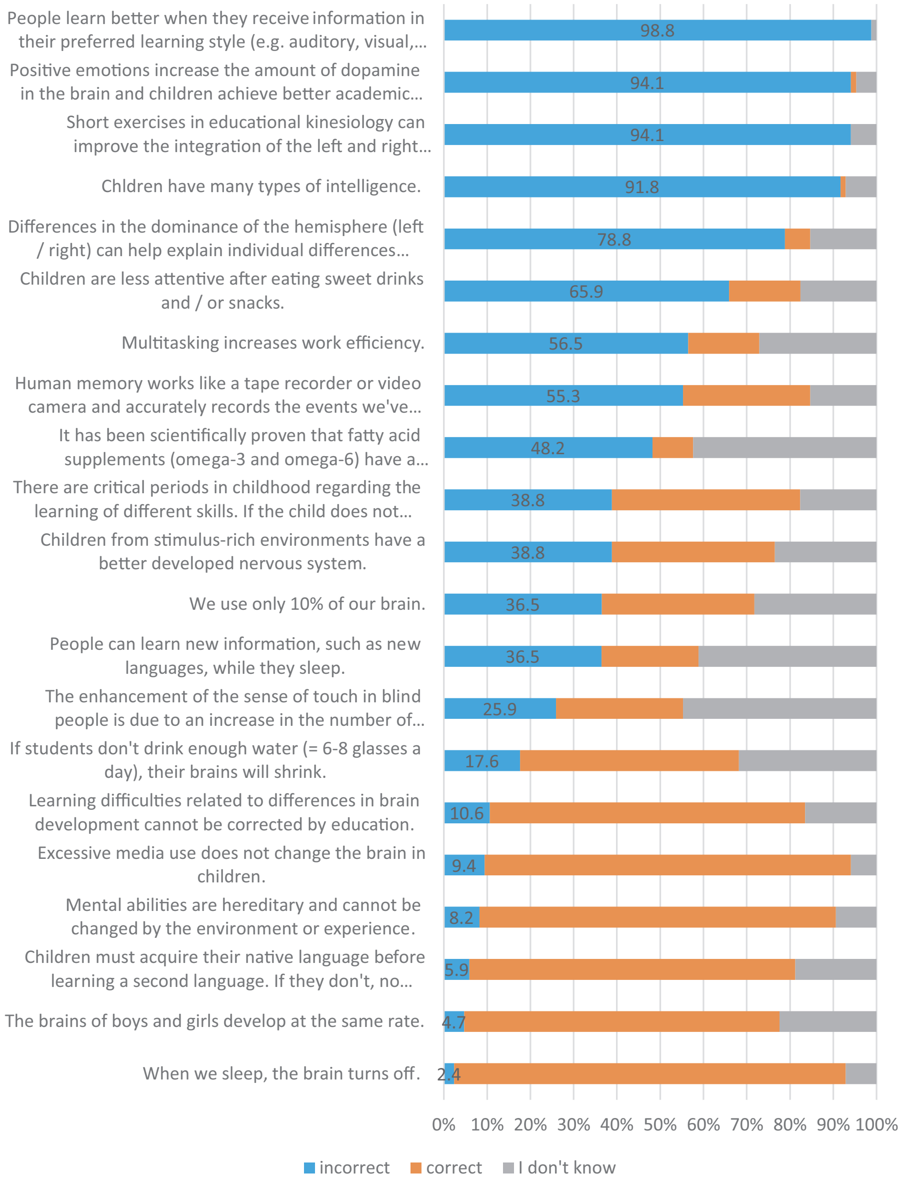

Figure 1. Incorrect answers to each neuromyth theory
Source: Authors' own study.

The analysis of the rho-Spearman correlation did not show any correlation between the percentage of incorrect responses to neuromyths and independent variables, i.e. age, gender, seniority, workplace, contact with knowledge about neuroeducation, the use of methods related to neuromyths in school practice and an indication of interest in neuroscientific training.

With regard to neurofacts, only about 52% of teachers gave correct answers to at least 5 out of 7 statements. The fewest correct answers concerned the neurofact that regular drinking of caffeinated beverages lowers cognitive performance (37.6%) and that differences in the structure of the brain can explain the different frequency of occurrence of certain disorders in children (48.2%) (Figure 2).

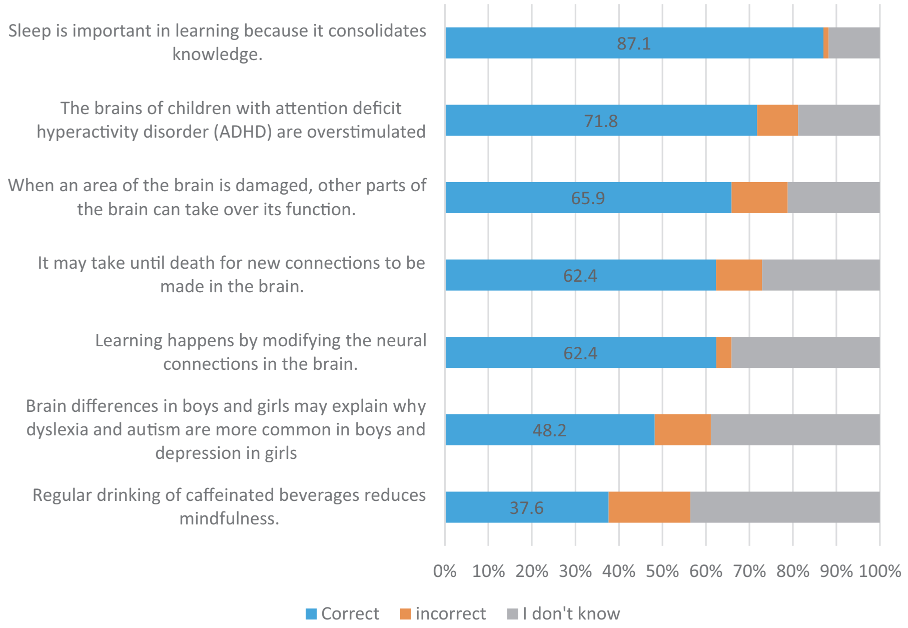

Figure 2. The percentage of correct answers to each neurofact statement
Source: Authors' own study.

The analysis of the Spearman's rho correlation in relation to neurofacts illustrates that the percentage of correct answers was dependent on seniority in education, contact with various sources of knowledge in the field of neurobiology, and an interest in various forms of training in the field of neuroeducation (see Table 2). The most correct answers to all the statements were provided by the teachers with less than 5 years of work experience, who had contact with knowledge in the field of neurobiology and who were interested in further education in the field of neuroeducation.

Table 2. Analysis of the Spearman's rho correlation for the percentage of correct responses to neurofacts

	Sex	Age	Seniority	Place of work	Contact with knowledge	Interest in training	Using neuro-myths at work
r_s	0.029	–0.159	–.268	0.130	–.252	–.338	0.177
p (two-sided)	0.791	0.147	0.013	0.236	0.020	0.002	0.105
N	85	85	85	85	85	85	85

Source: Authors' own study.

The analysis of the Spearman's rho correlation showed a correlation between the percentage of incorrect answers to the statements concerning neuromyths and the percentage of correct answers to the statements concerning neurofacts (r_s = 0.268, p = 0.013).

Moreover, the analysis of correlation showed dependencies regarding the relationship between contact with neurobiological knowledge and the workplace (r_s = –247, p = 0.023). Lack of contact with knowledge in neurobiology was declared by the largest number of teachers from public kindergartens (41.6%), while it was most often used by the teachers from public primary schools (67.7%).

The results also showed a correlation between the interest in further training in neuroeducation and the age of the respondents (r_s = 251, p = 0.020), seniority (r_s = 288, p = 0.008) and earlier contact with publications in the field of neurobiology (r_s = 303, p = 0.005). The willingness to continue education was most often declared by the teachers aged 31 to 40 (96.8%), with work experience between 6 and 15 years (88.2%) and previously exposed to knowledge in the field of neurobiology (79%).

The analyses further revealed a relationship between the use of neuromyths in educational practice and a contact with knowledge in the field of neurobiology (r_s = –280, p = 0.010) and an interest in training in the field of neuroeducation (r_s = –250, p = 0.021). The greatest number of neuromyths was used in practice by people who had frequent contact with knowledge in the field of neurobiology and declared interest in training in the subject of neuroeducation.

None of the analyzed factors (gender, age, seniority, workplace, contact with knowledge in the field of neurobiology, interest in training in neuroeducation and the use of neuromyths in professional work) predicted the belief in neuromyths. The model explained a significant percentage of the variance (R^2 = 0.096) in the myth scores, F (8.75) = 0.096, p = 0.446.

The level of knowledge in the field of neurofacts was predicted on the basis of seniority and interest in training in the field of neuroeducation (see Table 3). None of the other factors predicted the level of knowledge in the field of neurobiology. The model explained the percentage of variance (R^2 = 0.235) in the neurophactic scores, F (8.75) = 2.872, p = 0.008.

Table 3. Predictors of neurofacts

	Non-standardized coefficients		t	p	95.0% confidence interval for B	
	B	standard error			lower limit	upper limit
Correct answers	35.548	21.389	1.662	0.101	−7.061	78.156
Sex	21.998	13.410	1.640	0.105	−4.716	48.713
Age	8.236	4.524	1.820	0.073	−0.777	17.249
Seniority	−7.964	2.928	−2.720	0.008	−13.798	−2.131
Place of work	1.685	2.011	0.838	0.405	−2.321	5.692
Contact with knowledge	−0.931	2.759	−0.337	0.737	−6.428	4.566
Interest in training	−6.719	3.295	−2.039	0.045	−13.284	−0.155
Using neuromyths at work	5.890	3.638	1.619	0.110	−1.357	13.136

Source: Authors' own study.

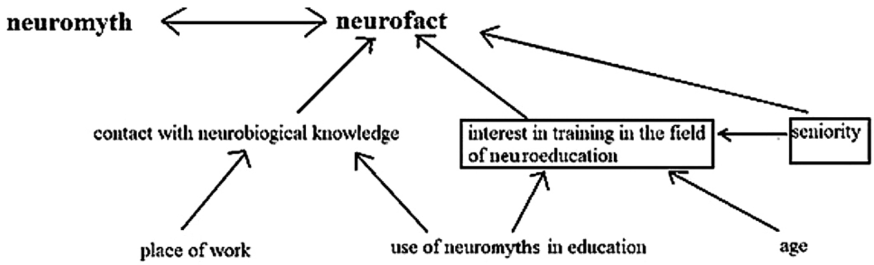

Figure 3. Diagram of statistically significant correlations of the studied variables (α = 0.05)
* arrows point to the dependent variable, the box marks the predictors of dependent variables
Source: Authors' own study.

DISCUSSION

This study analyzed general knowledge about the brain and the prevalence of neuromyths among teachers in specific regions in Poland. Additionally, a number of potential factors that could be related to these outcomes were also investigated. Findings showed that more than half of the teachers believed in 8 out of 21 neuromyths. The most popular were learning styles, stress-free learning, educational kinesiology, and the theory of multiple intelligences. In addition, none of the factors mentioned below turned out to be predictors in the belief in neuromyths: gender, age, place of employment, work experience, contact with neurobiological knowledge, interest in training in neuroeducation and the use of neuromyths in professional practice.

With regard to neurofacts, only about 52% of the teachers answered correctly to at least 5 out of 7 statements. Most often, teachers gave incorrect answers to the question concerning the influence of caffeine on cognitive abilities and the influence of gender on the occurrence of specific developmental disorders. The percentage of correct answers to neuro-facts correlated with professional experience, contact with knowledge in the field of neurobiology and an interest in training in the field of neuroeducation. The predictors of correct answers turned out to be seniority and an interest in further training in the field of neuroeducation.

Moreover, contact with knowledge in the field of neurobiology was conditioned by the workplace. Interest in training in the field of neuroeducation was most often indicated by the younger respondents, with an average work experience and earlier contact with knowledge in the field of neurobiology. The use of neuromyths in education significantly correlated with previous contact with knowledge in the field of neurobiology and an interest in further training in this field. In addition, the greater number of neuromyths used in practice showed a significant relationship with a higher indication of knowledge in the field of neurobiology and greater interest in training in the field of neuroeducation. Statistical analyses further showed that greater belief in neuromyths positively correlated with greater knowledge in the field of neurobiology.

The obtained results confirm the reports from previous studies on the prevalence of neuromyths (review by Chojak 2019). As in other countries, in Poland there is a common belief in the effectiveness of educational kinesiology and job individualization based on learning styles, as well as the truth of the theory of multiple intelligences. What is new is the high level of belief in the effectiveness of stress-free learning.

Contrary to the results obtained by Ansari and Coch (2006), Goswami (2006), Pickering and Howard-Jones (2007), Lindell and Kidd (2011), Dubinsky, Roehrig, and Varma (2013) Rato et al. (2013), Busso and Pollack (2015) as well as Tardif et al. (2015), teachers surveyed in Poland with a high level of belief in neuromyths turned out to be people who indicated: a high level of knowledge in the field of neurobiology, frequent contact with this knowledge and interest in further education in this field.

This may indicate that the level of knowledge does not protect against belief in neuromyths or against their implementation in educational practice. Similar to Polish research results were those obtained by Dekker et al. (2012) and Gleichgerrcht et al. (2015). This is also in line with Weisberg et al.'s results. His experiments showed that people with some neuroscientific knowledge (people who had attended an introductory course in cognitive neuroscience) were fooled by neuroscientific explanations in the same way as laymen. Only experts in neuroscience (defined as people who had an associate's degree in cognitive neuroscience or related fields) were able to correctly identify false neuroscience (Weisberg et al. 2008).

Given the usual time constraints, teachers and students cannot be expected to become experts (i.e. neuropedagogues, educated in pedagogy and neurobiology or neurology). Therefore, any training or courses should emphasize debunking neuromyths and learning to critically evaluate various neuroscientific discoveries. This would enable teachers to develop a critical approach to the information received and to analyze scientific research more closely before incorporating any neuroscientific findings into their own teaching practice (Lilienfeld, Lynn, Ruscio, Beyerstein 2012).

Such an educational strategy has been confirmed by research into myths in the field of psychology which have shown that one of the most effective actions is to debunk myths directly in the early stages of studies (Guzzetti, Snyder, Glass, Gamas 1993; Kowalski, Taylor 2009, 2011), and to develop an understanding of how research is conducted and presented in neuroscience. This understanding should take precedence over learning facts (e.g. detailed brain anatomy) that are likely to be obsolete in a few years' time (Ansari, Coch 2006).

Dialogue between teachers and experts in the field of neuroscience seems to be important (Jolles et al. 2006; Hruby 2012). As Dommett et al. (2011) showed, a possible framework for how this could be achieved is to allow teachers to decide on the topics of neuroscience workshops and to devote a lot of time to communication between neuroscientists and teachers in order to reflect on the implementation of neuroscientific knowledge into teaching practice. At the same time, scientists themselves may be advised to carefully check translations of their research for popular media. They should also clearly explain what can and cannot be deduced from their data (Beck 2010).

In conclusion, it should be emphasized that it is necessary to conduct further research into psycho-pedagogical and personality determinants of belief in neuromyths and their application in the education process. The commonality of such attitudes means that financial resources, the time of teachers, parents and children, and their resources are wasted. The apparent lack of effects may also reduce the level of parental trust in teachers and deteriorate the quality of cooperation, which determines the effectiveness of the education process (Sylvan, Christodoulou 2010; Pasquinelli 2012).

The results obtained in this study indicate the need to prepare courses for teachers (during and after studies) based on debunking neuromyths and shaping the skills of critical thinking. This is necessary due to, on the one hand, the high popularity of neuromyths and, on the other hand, the high interest of teachers in interventions based on neuroscience. The training offered can be supplemented with information about the latest research or interactive access to the website (with the above-mentioned content) with the possibility of supporting teachers (or coordinating research with their participation) in experimental testing on the effectiveness of various teaching methods or teaching aids.

The second important conclusion is the need to develop neuropedagogy as a bridge between teachers and neurobiologists or doctors. Scientists specializing in this area of research could coordinate all activities, including the issues of neurobiological determinants of the process of broadly understood education, conducting research on this topic, but also analyzing the results of research obtained by specialists from other disciplines and popularizing them among teachers.

REFERENCES

Alferink L.A., Farmer-Dougan V. (2010). Brain-(not) Based Education: Dangers of Misunderstanding and Misapplication of Neuroscience Research. *Exceptionality*, *18*(1), pp. 42–52. DOI: https://doi.org/10.1080/09362830903462573

Ansari D., Coch D. (2006). Bridges over Troubled Waters: Education and Cognitive Neuroscience. *Trends in Cognitive Sciences*, *10*(4), pp. 146–151. DOI: https://doi.org/10.1016/j.tics.2006.02.00

Bartoszeck A.B., Bartoszeck F.K. (2012). How In-Service Teachers Perceive Neuroscience as Connected to Education: An Exploratory Study. *European Journal of Educational Research*, *1*(4), pp. 301–319. DOI: https://doi.org/10.12973/eu-jer.1.4.301

Beck D.M. (2010). The Appeal of the Brain in the Popular Press. *Perspectives on Psychological Science*, *5*(6), pp. 762–766. DOI: https://doi.org/10.1177/1745691610388779

Bellert A., Graham L. (2013). Reading Comprehension Difficulties Experienced by Students with Learning Disabilities. *Australian Journal of Learning Disabilities*, *10*(2), pp. 71–78. DOI: https://doi.org/10.1080/19404150509546791

Busso D.S., Pollack C. (2015). No Brain Left Behind: Consequences of Neuroscience Discourse for Education. *Learning Media and Technology*, *40*(2), pp. 168–186. DOI: https://doi.org/10.1080/17439884.2014.908908

Chojak M. (2019). *Neuropedagogika, neuroedukacja i neurodydaktyka – fakty i mity*. Warszawa: Difin.

Crockard A. (1996). Confessions of a Brain Surgeon. *New Scientist*, *2061*(68).

Dekker S., Lee N.C., Howard-Jones P., Jolles J. (2012). Neuromyths in Education: Prevalence and Predictors of Misconceptions among Teachers. *Frontiers in Psychology*, *3*(429). DOI: https://doi.org/10.3389/fpsyg.2012.00429

Deligiannidi K., Howard-Jones P. (2015). The Neuroscience Literacy of Teachers in Greece. *Procedia – Social and Behavioral Sciences*, *174*, pp. 3909–3915. DOI: https://doi.org/10.1016/j.sbspro.2015.01.1133

Dommett E.J., Devonshire I.M., Plateau C.R., Westwell M.S., Greenfield S.A. (2011). From Scientific Theory to Classroom Practice. *Neuroscientist*, *17*(4), pp. 382–388. DOI: https://doi.org/10.1177/1073858409356111

Dubinsky J.M., Roehrig G., Varma S. (2013). Infusing Neuroscience into Teacher Professional Development. *Educational Researcher*, *42*(6), pp. 317–329. DOI: https://doi.org/10.3102/0013189X13499403

Ferrero M., Garaizar P., Vadillo M.A. (2016). Neuromyths in Education: Prevalence among Spanish Teachers and an Exploration of Cross-Cultural Variation. *Frontiers in Human Neuroscience*, *10*(496). DOI: https://doi.org/10.3389/fnhum.2016.00496

Geake J. (2008). Neuromythologies in Education. *Educational Researcher*, *50*(2), pp. 123–133. DOI: https://doi.org/10.1080/00131880802082518

Gleichgerrcht E., Lira Luttges B., Salvarezza F., Campos A.L. (2015). Educational Neuromyths among Teachers in Latin America. *Mind, Brain, and Education*, *9*(3), pp. 170–178. DOI: https://doi.org/10.1111/mbe.12086

Goswami U. (2004). Neuroscience and Education. *British Journal of Educational Psychology*, *74*(1), pp. 1–14. DOI: https://doi.org/10.1348/000709904322848798

Goswami U. (2006). Neuroscience and Education: From Research to Practice? *Nature Reviews Neuroscience*, *7*, pp. 406–413. DOI: https://doi.org/10.1038/nrn1907

Guzzetti B.J., Snyder T.E., Glass G.V., Gamas W.S. (1993). Promoting Conceptual Change in Science: A Comparative Meta-Analysis of Instructional Interventions from Reading Education and Science Education. *Reading Research Quarterly*, *28*(2), pp. 117–159. DOI: https://doi.org/10.2307/747886

Herculano-Houzel S. (2002). Do You Know Your Brain? A Survey on Public Neuroscience Literacy at the Closing of the Decade of the Brain. *Neuroscientist*, *8*(2), pp. 98–110. DOI: https://doi.org/10.1177/107385840200800206

Hermida M.J., Segretin M.S, Soni García A., Lipina S.J. (2016) Conceptions and Misconceptions about Neuroscience in Preschool Teachers: A Study from Argentina. *Educational Research*, *58*(4), pp. 457–472. DOI: https://doi.org/10.1080/00131881.2016.1238585

Horvath J.C., Donoghue G.M., Horton A.J., Lodge J.M., Hattie J.A.C. (2018). On the Irrelevance of Neuromyths to Teacher Effectiveness: Comparing Neuro-Literacy Levels Amongst Award-Winning and Non-award Winning Teachers. *Frontiers in Psychology*, *9*(1666). DOI: https://doi.org/10.3389/fpsyg.2018.01666

Howard-Jones P.A. (2014). Neuroscience and Education: Myths and Messages. *Nature Reviews Neuroscience*, *15*(12), pp. 817–824. DOI: https://doi.org/10.1038/nrn3817

Howard-Jones P.A., Franey L., Mashmoushi R., Liao, Y.C. (2009). The Neuroscience Literacy of Trainee Teachers. *British Educational Research Association Annual Conference*. Manchester: University of Manchester.

Hruby G.G. (2012). Three Requirements for Justifying an Educational Neuroscience. *British Journal of Educational Psychology*, *82*(1), pp. 1–23. DOI: https://doi.org/10.1111/j.2044-8279.2012.02068.x

Jolles J., de Groot R.H.M., van Benthem J.F.A.K., Dekkers H.P.J.M., de Glopper C.M., Uijlings H.B.M. (2006). *Brain Lessons: A Contribution to the International Debate on Brain, Learning and Education, Based on the Results of an Invitational Conference Organized by the Netherlands Organization for Scientific Research (NWO)*. Maastricht: Neuropsych Publishers.

Karakus O., Howard-Jones P., Jay T. (2015). Primary and Secondary School Teachers' Knowledge and Misconceptions about the Brain in Turkey. *Procedia – Social and Behavioral Sciences*, *174*, pp. 1933–1940. DOI: https://doi.org/10.1016/j.sbspro.2015.01.858

Kowalski P., Taylor A.K. (2009). The Effect of Refuting Misconceptions in the Introductory Psychology Class. *Teaching of Psychology*, *36*(3), pp. 153–159. DOI: https://doi.org/10.1080/00986280902959986

Kowalski P., Taylor A.K. (2011). Effectiveness of Refutational Teaching for High-and Low-Achieving Students. *Journal of the Scholarship of Teaching and Learning*, *11*(1), pp. 79–90.

Kruger J., Dunning D. (1999). Unskilled and Unaware of It: How Difficulties in Recognizing One's Own Incompetence Lead to Inflated Self-Assessments. *Journal of Personality and Social Psychology*, *77*(6), pp. 1121–1134. DOI: https://doi.org/10.1037/0022-3514.77.6.1121

Lethaby C., Harries P. (2015). Learning Styles and Teacher Training: Are We Perpetuating Neuromyths? *ELT Journal*, *70*(1), pp. 16–27. DOI: https://doi.org/10.1093/elt/ccv051

Lilienfeld S.O., Lynn S.J., Ruscio J., Beyerstein B.L. (2011). *50 Great Myths of Popular Psychology: Shattering Widespread Misconceptions about Human Behavior*. Chichester: John Wiley and Sons.

Lindell A.K., Kidd E. (2011). Why Right-Brain Teaching is Half-Witted: A Critique of the Misapplication of Neuroscience to Education. *Mind, Brain, and Education*, *5*(3), pp. 121–127. DOI: https://doi.org/10.1111/j.1751-228X.2011.01120.x

Lord S. (2005). *Evidence-Based Practice 2 – the New Zealand Experience*. London: WCPT keynote.
Macdonald K., Germine L., Anderson A., Christodoulou J., McGrath L.M. (2017). Dispelling the Myth: Training in Education or Neuroscience Decreases but Does Not Eliminate Beliefs in Neuromyths. *Frontiers in Psychology*, *8*(1314). DOI: https://doi.org/10.3389/fpsyg.2017.01314
McCabe D.P., Castel A.D. (2008). Seeing Is Believing: The Effect of Brain Images on Judgments of Scientific Reasoning. *Cognition*, *107*(1), pp. 343–352. DOI: https://doi.org/10.1016/j.cognition.2007.07.017
Michael R.B., Newman E.J., Vuorre M., Cumming G., Garry M. (2013). On the (Non)persuasive Power of a Brain Image. *Psychonomic Bulletin & Review*, *20*, pp. 720–725. DOI: https://doi.org/10.3758/s13423-013-0391-6
Nelson C.A., Bloom F.E. (1997). Child Development and Neuroscience. *Child Development*, *68*(5), pp. 970–987. DOI: https://doi.org/10.1111/j.1467-8624.1997.tb01974.x
OECD. (2002). *Understanding the Brain: Towards a New Learning Science*. Paris: OECD Publishing.
Pasquinelli E. (2012). Neuromyths: Why Do They Exist and Persist? *Mind, Brain, and Education*, *6*(2), pp. 89–96. DOI: https://doi.org/10.1111/j.1751-228X.2012.01141.x
Pei X., Howard-Jones P., Zhang S., Liu X., Jin Y. (2015). Teachers' Understanding about the Brain in East China. *Procedia – Social and Behavioral Sciences*, *174*, pp. 3681–3688. DOI: https://doi.org/10.1016/j.sbspro.2015.01.1091
Pickering S.J., Howard-Jones P. (2007). Educators' Views on the Role of Neuroscience in Education: Findings from a Study of UK and International Perspectives. *Mind, Brain, and Education*, *1*(3), pp. 109–113. DOI: https://doi.org/10.1111/j.1751-228X.2007.00011.xjuslin
Racine E., Bar-Ilan O., Illes J. (2005). fMRI in the Public Eye. *Nature Reviews Neuroscience*, *6*(2), pp. 159–164. DOI: https://doi.org/10.1038/nrn1609
Racine E., Waidman S., Rosenberg J., Illes J. (2006). Contemporary neuroscience in the media. *Social Science & Medicine*, *71*(4), pp. 725–733. DOI: https://doi.org/10.1016/j.socscimed.2010.05.017
Rato J.R., Abreu A.M., Castro-Caldas A. (2013). Neuromyths in Education: What Is Fact and What Is Fiction for Portuguese Teachers? *Educational Research*, *55*(4), pp. 441–453. DOI: https://doi.org/10.1080/00131881.2013.844947
Serpati L., Loughan A.R. (2012). Teacher Perceptions of Neuroeducation: A Mixed Methods Survey of Teachers in the United States. *Mind, Brain, and Education*, *6*(3), pp. 174–176. DOI: https://doi.org/10.1111/j.1751-228X.2012.01153.x
Simmonds A. (2014). *How Neuroscience is Affecting Education: Report of Teacher and Parent Surveys*. Wellcome Trust.
Sylvan, L.J., Christodoulou, J.A. (2010). Understanding the role of Neuroscience in Brain Based Products: A Guide for Educators and Consumers. *Mind, Brain, and Education*, *4*(1), pp. 1–7. DOI: https://doi.org/10.1111/j.1751-228X.2009.01077.x
Tardif E., Doudin P.A., Meylan N. (2015). Neuromyths among Teachers and Student Teachers. *Mind, Brain, and Education*, *9*(1), pp. 50–59. DOI: https://doi.org/10.1111/mbe.12070
Wallace M. (1993). Discourse of Derision: The Role of the Mass Media within the Educational Policy Process. *Journal of Education Policy*, *8*(4), pp. 321–337. DOI: https://doi.org/10.1080/0268093930080402
Weisberg D.S., Keil F.C., Goodstein J., Rawson E., Gray J.R. (2008). The Seductive Allure of Neuroscience Explanations. *Journal of Cognitive Neuroscience*, *20*(3), pp. 470–477. DOI: https://doi.org/10.1162/jocn.2008.20040

Zambo D., Zambo R. (2009). What Future Teachers Think about Brain Research. *Teaching Educational Psychology*, *5*(2), pp. 39–49.
Zambo D., Zambo R. (2011). Teachers' Beliefs about Neuroscience and Education. *Teaching Educational Psychology*, *7*(2), pp. 25–41.

APPENDIX

I am interested in what you think about various information about the human brain. The survey is anonymous because I care about honest answers. For each claim, please indicate if you think this is true, false or not orientated. Thank you in advance for your time.

Question*	Answer		
	True	False	I don't know
Adaptation of teaching to the intelligence profile of multiple children increases the effectiveness of teacher's activities (O).			
Children must acquire their native language before learning a second language. If they don't, no language will be fully mastered (HO).			
Children have many types of intelligence (O).			
Children are less attentive after eating sweet drinks and/or snacks (HJ).			
Children from stimulus-rich environments have a better developed nervous system (HJ).			
When an area of the brain is damaged, other parts of the brain can take over its function (D, H).			
If students don't drink enough water (= 6–8 glasses a day), their brains will shrink (HJ).			
When we sleep, the brain turns off (D).			
Using media does not change the structure of the brain in children (O).			
Short exercises in educational kinesiology can improve the integration of the left and right hemispheres of the brain (HJ).			
People can learn new information, such as new languages, while they sleep (O).			
Human memory works like a tape recorder or video camera and accurately records the events we've experienced (O).			
The brain of children with attention deficit hyperactivity disorder (ADHD) is over-stimulated (O).			
The brains of boys and girls develop at the same rate (D).			
Science is not about creating new cells in the brain.			
People learn better when they receive information in their preferred learning style (e.g. auditory, visual, kinesthetic) (HJ).			
IQ level is not related to school performance.			
Positive emotions increase the amount of dopamine in the brain and children achieve better academic results (O).			
The learning process takes place through the modification of brain neurons.			

Question*	Answer		
	True	False	I don't know
Regular drinking of caffeine-containing drinks reduces mindfulness. (HJ)			
Differences in the structure of the boys' and girls' brains may explain why dyslexia or autism are more common in boys and depression in girls (O).			
Differences in the dominance of the hemisphere (left/right) can help explain individual differences between students (HJ).			
Sleep is important in science, because during this dream phase we consolidate what we learn (O).			
Learning difficulties related to differences in brain development cannot be corrected by education (HJ).			
We use only 10% of our brain (HJ).			
There are critical periods in childhood regarding the learning of different skills. If the child does not master them at that time, then it will be impossible (HJ).			
Multitasking increases work efficiency (O).			
Making new connections in the brain can last until death (D).			
Strengthening the sense of touch in the blind is caused by an increase in the number of receptors in the fingertips, not changes in the brain (H).			
Mental abilities are hereditary and cannot be changed by the environment or experience (D, H).			
It has been scientifically proven that fatty acid supplements (omega-3 and omega-6) have a positive effect on academic achievement (HJ).			

* source of items: D – Dekker et al. (2012), H – Herculano-Houzer (2002), HJ – Deligiannidi and Howard-Jones (2015), HO – Horvath et al. (2018), O – authors' own.

Ending of test, please give some information about you:

1. Are you interested in the subject of education based on brain research? (Yes/No)
2. Would you like to participate in workshops on the possibilities of using brain research to improve the effectiveness of education? (Yes/No)
3. Have you had contact with the knowledge about the application of the results of brain research in education? List sources.
4. Have you used this method during your lessons (choose yes/no for each of them): educational kinesiology, theory of multiple intelligences, individualization based on learning styles, individualization based on the results of the diagnosis of lateralization, individualization based on the sex of the child, teaching based solely on pleasant emotions (stress-free), digitization of education, I have not used any of the above.
5. Your age: …
6. Your gender: …
7. Your place of work: …
8. Your seniority at work: …