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ORIGINAL ARTICLE

Debunking neuromyths: Pre-service teachers' insights on autism spectrum disorder

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Abstract

Teachers' beliefs in certain neuromyths about neurodevelopmental disorders can negatively impact the educational inclusion of students who present them. This study aims to analyse the prevalence of neuromyths about the health and the emotional competences of people with autism spectrum disorder (ASD) in pre-service teachers; and to assess the possible contribution of university training to constructing accurate knowledge about autism. This prevalence was compared in three groups of pre-service teachers: 1st-year students, 4th-year students who will be regular teachers and 4th-year students training to be special education specialists. Additionally, it was proposed to identify the topic with the most myths (health or emotional competences) and the most frequent myths. A validated instrument was completed by 167 pre-service teachers. Overall, the 4th-year specialist group had more correct answers and fewer doubts that the 4th-year regular group, which had more correct answers than the 1st-year group. The prevalence of errors was not statistically different among the three groups. Moreover, participants answered more questions and made more errors about emotional competences in autism than about health. Among the most frequent myths are those concerning empathy or the cause of ASD. Based on these results, some implications for pre-service teacher education are discussed.

KEYWORDS
autism spectrum disorder, emotional competences, health, knowledge, neuromyths, pre-service teachers

Key points

- The knowledge of autism varies notably between regular and specialist pre-service teachers.
- Initial teacher training is insufficient to eradicate some neuromyths about autism.
- Myths about emotional competences in autism are more prevalent than health myths.
- To promote educational inclusion, it would be wise to review the university's teacher training program.

INTRODUCTION

Nowadays there are many misconceptions about the development and functioning of the brain that are socially propagated as if they were real, which are called neuromyths (Organization for Economic Cooperation and Development [OECD], 2002). Research on neuromyths in education has become consolidated in recent years as a broad field of study (Torrijos-Muelas et al., 2021). However, there are still important gaps in research on teachers' scientific knowledge about the neurodevelopmental conditions that their students could present (Gini et al., 2021). The present study focuses on one of these conditions: autism spectrum disorder (ASD).

How do neuromyths originate and persist?

Most neuromyths actually have a scientific basis (Howard-Jones, 2009); that is, they originate from certain scientific facts that are distorted or oversimplified (Pasquinelli, 2012). This may be due to the complexity that sometimes arises when translating neuroscience information into practical applications (Ruhaak & Cook, 2018). Another explanation for the persistence of certain neuromyths is that they stem from scientific hypotheses that were accepted for a period of time. Even though these hypotheses were later refuted as new scientific evidence emerged, they have not been fully eradicated from the public's imagination (Pasquinelli, 2012). For instance, this could be the case for the persistent misconception that ASD may be caused by the administration of certain vaccines at an early age (Bennett et al., 2018).

Furthermore, the proliferation of neuromyths is greatly fuelled by the media, including the press and the Internet, which happens to be one of the main sources of neuroscience information for pre-service teachers (Torrijos-Muelas et al., 2021). Media coverage of certain neuroscience facts often falls into three traps that help spread neuromyths: it includes irrelevant information, presents facts in a sensationalized way, and/or omits important details (Pasquinelli, 2012). For example, misconceptions about alternative treatments to improve certain difficulties for individuals with ASD (Cruchet et al., 2016; Hawkins et al., 2019; Lardieri et al., 2021), as well as beliefs in miraculous cures for autism (Bennett et al., 2018), have been identified in these sources of information.

Neuromyths in education

When educational practices are designed and implemented based on neuromyths, the result is ineffective interventions that waste teachers' energy, time and resources (Ruhaak & Cook, 2018), and negatively impact students' learning and development (Van Dijk & Lane, 2018).

In the case of students with neurodevelopmental conditions, such as ASD, their educational inclusion can be directly affected (Ravet & Williams, 2017). On the one hand, students' learning can be impaired (Bei et al., 2024; Papadatou-Pastou et al., 2017) if teachers have false beliefs about the way students with ASD learn or about the effectiveness of some pseudo-sciences that, through non-experimental and supposedly therapeutic methods, claim to 'cure' certain diseases or conditions (Mulet, 2015). On the other hand, the prevalence of neuromyths among teachers, especially in the early childhood and primary education stages, can hinder the early detection of ASD (Arif et al., 2013). Moreover, these myths contribute to the construction and permanence of prejudices and stereotypes towards people with autism (Corrigan & Watson, 2002), which can negatively affect teachers' and peer group's attitudes when working and interacting with them.

Prevalence of neuromyths in teachers

Given their impact on education, numerous studies published in the past decade have analysed the prevalence of neuromyths in teachers, according to the review by Torrijos-Muelas et al. (2021). The majority of the studies reviewed, including the only one conducted with Spanish teachers (Ferrero et al., 2016), agree that the prevalence of neuromyths in teachers is high. However, of the 39 myths identified in the review, only three were related to neurodevelopmental disorders, and none were specifically related to ASD.

The study by Papadatou-Pastou et al. (2017) analysed pre-service teachers' general neuroscientific knowledge, specific knowledge about some neurodevelopmental conditions, and belief in neuromyths related to education. The results showed a higher number of misconceptions about neurodevelopmental conditions (compared to the other domains assessed). Therefore, according to the authors, prospective teachers had less neuroscientific knowledge about students with special educational needs (SEN) than about neurotypical students. Of the seven neuromyths about neurodevelopmental conditions, the one that produced the most doubts had to do with ASD, and it stated that children with autism are mostly geniuses.

In a study with the general population and in-service teachers, Gini et al. (2021) also found a higher prevalence of neuromyths related to neurodevelopmental conditions (compared to general knowledge about child development). However, ASD was the condition with the highest rate of correct answers by participants, which is interpreted as being due to autism awareness campaigns in recent years. The results of two recent studies conducted

with Italian (Bei et al., 2024) and Chilean teachers (Armstrong-Gallegos et al., 2023) were very similar, as neuromyths about neurodevelopmental conditions were statistically more prevalent than general neuromyths about the brain, and autism was one of the neurodevelopmental disorders about which the participants had better knowledge.

Teacher training as a protector factor of neuromyths

An interesting question is whether the educational training teachers receive helps them to believe in fewer neuromyths than the rest of the population. Surprisingly, some previous studies have identified teacher-training courses as a source that reinforces teachers' beliefs in neuromyths, along with other factors such as social media, peer groups and television news (Blanchette-Sarrasin et al., 2019; Sazaka et al., 2024). The authors suggest two possible explanations for this phenomenon: either the training courses lack a solid scientific foundation and include certain neuromyths, or students misinterpret or distort some concepts and content.

For instance, Gini et al. (2021) found no significant differences between the number of myths about neurodevelopmental conditions in the general population group and in the teachers, and Papadatou-Pastou et al. (2017) found no differences between pre-service teachers in training and recent graduates.

Specific training in special education does not seem to play a role either, given that Van Dijk and Lane (2018) and Bei et al. (2024) found no differences between regular and specialist teachers. In addition, although Ruhaak and Cook (2018) did not make this comparison, they concluded that neuromyths were present in a sample of special education teachers. However, Macdonald et al. (2017) found a significant difference between the general population and education professionals and between education professionals and people with some exposure to neuroscience. For this reason, they concluded that training in neuroscience and education could reduce the prevalence of neuromyths but not eliminate them.

In this regard, courses on neuroscience appear to effectively reduce neuromyths among in-service teachers (Bei et al., 2024; Ruiz-Martin et al., 2022), but they are insufficient for diminishing neuromyths among undergraduate students, as noted in Rousseau's (2021) review. The author further suggests that integrating refutation-based interventions with strategies aimed at mitigating intuitive thinking in educational settings could significantly help debunk these neuromyths. This is a significant point, as one potential source of beliefs in neuromyths among teachers is cognitive biases—specifically, the intuitions and perceptions based on their own experiences (Blanchette-Sarrasin et al., 2019).

Teachers' knowledge and neuromyths about ASD

The analysis of neuromyths specifically related to ASD in education professionals is especially important because of the noteworthy increase in the number of children diagnosed with ASD in recent years (Chiarotti & Venerosi, 2020) and the growing movement for social and educational inclusion supported by international and national regulations. Both of these issues require regular and special education teachers to be prepared to address the needs of students with ASD in mainstream settings (Roberts & Simpson, 2016).

Although no studies have specifically focused on neuromyths related to ASD, there has been some research on teachers' general knowledge about autism. The systematic review by Gómez-Marí et al. (2021) detected a significant lack of knowledge in teachers, especially those working in mainstream classrooms. The study by Sanz-Cervera et al. (2017) compared pre-service teachers' knowledge, misconceptions and gaps in the 1st and 4th-years of teacher training. The results showed that 4th-year prospective teachers had more knowledge and fewer doubts than 1st-year prospective teachers did. However, surprisingly, they also had more misconceptions. Among the 4th-year students, more correct answers and fewer misconceptions were also found in those who were studying the specializations of special education (SE) and speech-language (SL).

Neuromyths about the health and the emotional competences of people with ASD

Our research focuses on the study of pre-service teachers' knowledge of two specific aspects related to people with autism: their health and their emotional competences. On the one hand, we examine the knowledge of prospective teachers about the health of people with ASD by asking them about the causes of autism, comorbidity and some possible interventions. For instance, a neuromyth about the health of people with autism could be the one related to the effectiveness of certain diets in overcoming ASD (Van Dijk & Lane, 2018).

On the other hand, the communication and social interaction difficulties faced by people with ASD are closely linked to the limitations of their emotional competences (Jahromi et al., 2021). These are the body of knowledge, skills and attitudes for understanding, expressing and adjusting emotions appropriately (Bisquerra & Pérez-Escoda, 2007). The emotional competences of people with autism are also considered part of the scientific knowledge that pre-service teachers should have on ASD, considering the neurological

basis of emotions (in the limbic system and other structures of the frontal cortex) (López-Mejía et al., 2009). Some examples of neuromyths regarding the emotional competences of people with ASD could be the false belief that they do not have empathy or do not like to be touched (Gini et al., 2021).

Research problem and objectives

Three research questions are raised: Are neuromyths related to the health and emotional competences of people with ASD prevalent in pre-service teachers' knowledge about autism? Does the academic training in the university teacher-training degree reshape this knowledge? What are the most frequent neuromyths about ASD held by pre-service teachers?

Considering the research questions, the following three objectives are proposed:

1. Comparing the prevalence of neuromyths about ASD in three groups of pre-service teachers: 1st-year, 4th-year regular pre-service teachers and 4th-year pre-service teachers specializing in SE or SL.
2. Comparing the prevalence of two types of neuromyths about ASD (emotional competence and health), both overall and in each of the three groups of pre-service teachers.
3. Identifying the most frequent neuromyths about the emotional competences and health of people with ASD endorsed by pre-service teachers.

MATERIALS AND METHODS

It was proposed a cross-sectional descriptive study in which the prevalence of neuromyths related to ASD was compared in three groups of pre-service teachers analysing the effect of two different variables: the moment of initial training as teachers (first year or last year); and the specialization in special education (regular teacher or special education teacher).

Participants

The study sample consisted of 167 students from the Bachelor's Degree program in Primary Education and the Bachelor's Degree program in Early Childhood Education at the University of Valencia in Spain. The participants were divided into three groups: 1st-year, 4th-year (hereinafter, regular) and 4th-year specialist in SE or SL (hereinafter, specialist). The sample's demographic characteristics are shown in Table 1.

A non-probabilistic sampling technique, specifically convenience sampling, was used to select participants. This approach was chosen based on a specific selection criterion: the course and specialization in which the participants were enrolled. The discrepancy between the number of participants in the 1st-year and 4th-year regular groups and the number in the 4th-year specialist group is representative of the population group studied. The number of students enrolled in the 4th-year of the teaching degree in specializations other than SE and SL is practically three times the number of students enrolled in SE and SL.

TABLE 1 Pre-service teachers' demographic information by the year of the degree and specialty in which they were enrolled.

	1st ($n=71$)	4th regular ($n=74$)	4th specialist ($n=22$)
Sex			
Female	67 (94.4%)	65 (87.8%)	21 (95.5%)
Male	4 (5.6%)	9 (12.2%)	1 (4.5%)
Mean age (SD)	19.51 (2.63)	22.51 (4.28)	21.73 (1.61)
Specific training to work with students with ASD			
Yes	9 (12.7%)	11 (14.9%)	3 (13.6%)
No	62 (87.3%)	63 (85.1%)	19 (86.4%)
Family member with ASD			
Yes	11 (15.5%)	12 (16.2%)	3 (13.6%)
No	60 (84.5%)	62 (83.8%)	19 (86.4%)
Experience working with students with ASD			
Yes	23 (32.4%)	49 (66.2%)	17 (77.3%)
No	49 (67.6%)	25 (33.8%)	5 (22.7%)

We analysed whether there were statistically significant associations between the variables included in Table 1, based on the group of pre-service teachers (1st-year, 4th-year regular and 4th-year specialist). We found differences in age (Kruskal-Wallis $H=59.545$, $p<0.001$), with the 1st-year pre-service teachers being significantly younger than the other two groups in the pairwise comparisons, and in previous experience working with students with ASD (Pearson's Chi-Square $=22.505$, $p<0.001$), with the 1st-year group also having less experience. However, no differences were found between the three groups in gender, specific training to work with students with ASD, or having a family member or close person with ASD.

Materials

The data collection instrument was designed by the authors, and it is divided into two different sections. The first section includes six questions asking for participants' demographic information (listed in Table 1). The second section presents 20 different items on ASD, the first ten of which refer to health issues of people with autism, and the last ten focus on their emotional competences (see Table 2).

TABLE 2 Items included in the questionnaire and their respective correct responses.

Item	T/F
1. One of the many causes that can be closely related to autism is the administration, in specific cases, of the so-called triple virus vaccine (against measles, mumps and rubella).	F
2. Children and adolescents with autism have a higher risk of presenting anxiety disorders than people without autism.	T
3. People with autism have higher prevalence rates of eating disorders than people without autism.	T
4. Some treatments considered alternative, such as aromatherapy, are showing promising results for specific aspects of ASD, such as sensory processing difficulties, although strong scientific support for their effectiveness is still lacking.	F
5. People with ASD have higher prevalence rates of sleep problems than people without ASD.	T
6. Experimental drugs such as sodium chlorite, applied in very low doses, are showing promising results in specific cases of children with ASD, although solid scientific support for their effectiveness is still lacking.	F
7. Diets that restrict the intake of gluten (from wheat and cereals) and casein (from milk and dairy products) are effective in improving behaviour and reducing symptoms in children with ASD.	F
8. There is a high component of heritability in ASD.	T
9. A cure for autism has not yet been found. However, it is reasonably likely that, due to recent advances in locating biological markers of ASD and in psychopharmacology, a cure will be found in the medium/long term.	F
10. The prevalence of epilepsy is higher in people with ASD than in the general population. Similarly, the prevalence of ASD in people with epilepsy is also higher than in the general population.	T
11. One of the most common characteristics of people with ASD is lack of empathy for others.	F
12. Most people with ASD are not interested in engaging in romantic and/or sexual relationships.	F
13. People with ASD experience the same range of emotions as people without ASD and at the same intensity.	T
14. Children and adolescents with ASD are not able to perceive the rejection of their peers; therefore, it does not affect their self-concept and self-esteem.	F
15. Children with ASD may have deficits in their play skills, making it difficult for them to play with their peers, even if they are interested in doing so.	T
16. The employability rate of people with ASD is very low because they generally do not have the necessary cognitive or intellectual capacity to work.	F
17. A child with ASD can enjoy being tickled and hugged by family members in the same way as a child without ASD.	T
18. People with ASD may feel frustrated if they do not meet others' expectations of them, which can lead, among other things, to low self-esteem.	T
19. In countries with access to firearms (such as the USA), the probability of committing a firearm-related crime during adolescence is higher in people with ASD.	F
20. Not all people with ASD display self-injurious behaviour.	T

For each of these two topics, five myths and five facts (true statements) were included. The participant must indicate whether each statement is 'true', 'false' or 'I don't know'. With this instrument, the measures used for the study were the number of correct answers, the number of errors and the number of gaps ('I don't know' responses), both overall (for the whole questionnaire) and separately for the health items and the emotional competence items.

The items of the questionnaire were written by the authors of the study. For a large part of the items (1, 2, 5, 8, 9, 11–13, 16, 18 and 20), the work of Bennett et al. (2018) served as a reference. This publication presents common myths about autism, grounded in an extensive and rigorous literature review of existing research on the subject. The study by John et al. (2018) was also consulted for the formulation of three items (14, 17 and 19), as it explored myths and misconceptions about autism in the general population through focus groups.

Building upon previous research on autism-related topics, the authors proposed the remaining six neuromyths. In particular, two items (3 and 10) were formulated regarding the comorbidity of ASD with other diagnoses such as epilepsy (Capal & Jeste, 2024; Lukmanji et al., 2019) and eating disorders (Baraskewich et al., 2021; Mannion & Leader, 2013). Three other items (4, 6 and 7) address the questionable effectiveness of certain alternative treatments occasionally promoted to improve autism symptoms, such as aromatherapy (Esposito et al., 2020; Hawkins et al., 2019), sodium chlorite consumption (Chica-Londoño, 2022; Lardieri et al., 2021), or gluten- and casein-free diets (Baspinar & Yardimci, 2020; Cruchet et al., 2016; Keller et al., 2021). Another item (15), formulated by the authors, focuses on the play skill difficulties frequently encountered by children with ASD compared to their peers (Bodison, 2015; Erickson-Tomaino et al., 2014). In the development of each item, we aimed to use at least two references, ensuring that these were review publications, including literature reviews, scoping reviews, systematic reviews or meta-analyses to ensure a comprehensive and evidence-based approach.

Finally, it is important to highlight that the emotional competences items included the five types established by Bisquerra and Pérez-Escoda (2007): emotional awareness (Items 11 and 13), emotional regulation (Items 19 and 20), emotional autonomy (Items 14 and 18), social competence (Items 12 and 17) and competences for life and well-being (Items 15 and 16).

Validity through expert judgement

The questionnaire was validated by considering the ratings of five researchers and Ph.D. in the fields of Educational Sciences, Specific Didactics and Neuroeducation, from international (Colombia and Ecuador) and Spanish universities (University of Valencia). The experts were asked to rate on a scale from 1 (= insufficient) to 4 (= excellent) some formal aspects and content of the questionnaire. The average rating by the five experts was positive, in terms of both formal aspects and content. In particular, they rated the design of the instrument as 3.80; the contents related to sociodemographic information as 3.90; and the contents of the questionnaire itself as 3.91. Based on these scores, the validity of the content appears to be adequate.

The preliminary version of the instrument was administered to a pilot group of 36 pre-service teachers who were asked to complete the instrument and identify items that produced any doubts or difficulties. The students pointed out some formal aspects related to the design and the application where they received the instrument. Once these issues had been fixed, the design of the instrument was finalized.

Procedure

This research addresses all ethical procedures required and The Ethics Commission in Experimental Research of the University of Valencia approves it.

To distribute the questionnaire, university lecturers who taught in the 1st and 4th-years of the university degree program to which the participants belonged sent the questionnaire to their students, who agreed to participate voluntarily, without receiving any compensation for it. The questionnaire was completed online via the LimeSurvey platform. The first part of the instrument explained the purpose of the study (without mentioning the term 'neuromyth' at any time). After reading the questionnaire and before answering any of the items, participants gave their informed consent.

Data analysis

The data were analysed using the statistical package SPSS version 26 for Windows. Once the assumptions for the application of parametric tests were checked, for Objectives 1 and 2, mixed analyses of variance (ANOVA) (2 × 3) and Bonferroni post hoc multiple comparison tests were carried out. The independent variables included were the type of item (within-subjects variable, with two levels: health and emotional competences) and the group (between-subjects variable, with three levels: 1st, 4th regular and 4th specialist). Specifically, three mixed ANOVAs were performed, one for each dependent variable (correct answers, errors and gaps). In each case, the main effect of each independent variable and the interactions were analysed, in order to find out the differences between the groups on each type of item and the differences between the two types of items in each group.

For Objective 3, the total error rate for each item was calculated based on its absolute frequency of errors. The items selected as the most frequent were those with an error rate of more than 25%, which would represent a quarter of the total sample, an error prevalence that was considered sufficiently high.

RESULTS

Objectives 1 and 2. Prevalence of neuromyths: Differences among the three groups of pre-service teachers and differences between the two types of neuromyths

Table 3 shows the means and standard deviations obtained by each group and by all the pre-service teachers for the correct answers, errors and gaps on each type of item (health and emotional competences) and on all the items included in the neuromyth questionnaire.

The results obtained for each measure in the mixed ANOVAs and post hoc multiple comparisons are presented in Tables 4 (correct answers), 5 (errors) and 6 (gaps).

In the case of the correct answers, overall, the 4th-year specialist group scored more correct answers than the 4th-year regular group, and the 4th-year regular group scored more correct answers than the 1st-year group. In the case of the health items, the 4th-year specialist group scored more correct answers than the other two groups. In the case of the emotional competences items, the 1st-year group scored lower than the 4th-year specialist and regular groups. In addition, both overall and in each of the three groups, there were more correct answers on the emotional competences items than on the health items.

In the case of errors, there were no statistically significant differences among the three groups overall or on the health items or the emotional competences items. However, more errors were made in general on the emotional competences items than on the health items, although the effect size was small. Specifically, only in

TABLE 3 Means and standard deviations obtained by each group of pre-service teachers and by all the pre-service teachers on each type of item and on all the items on the neuromyth questionnaire.

	Correct answers	Errors	Gaps
	M (SD)	M (SD)	M (SD)
1st (n=71)			
Health items	2.90 (1.61)	1.62 (1.23)	5.48 (2.32)
Emotional competences items	4.65 (2.20)	2.37 (1.47)	2.99 (2.17)
Total items	7.55 (3.13)	3.99 (2.02)	8.46 (4.09)
4th REG (n=74)			
Health items	3.15 (1.65)	1.84 (1.46)	5.01 (2.21)
Emotional competences items	5.72 (2.12)	2.05 (1.67)	2.23 (1.74)
Total items	8.86 (2.76)	3.89 (2.11)	7.24 (3.37)
4th SP (n=22)			
Health items	5.00 (1.92)	1.59 (1.40)	3.41 (1.84)
Emotional competences items	6.55 (2.28)	2.05 (1.52)	1.41 (1.97)
Total items	11.55 (2.66)	3.64 (2.06)	4.82 (2.48)
Total (n=167)			
Health items	3.29 (1.79)	1.71 (1.35)	5.00 (2.30)
Emotional competences items	5.37 (2.26)	2.19 (1.57)	2.44 (1.97)
Total items	8.66 (3.17)	3.90 (2.06)	7.44 (3.77)

Abbreviations: REG, regular; SP, specialist.

TABLE 4 Results obtained in the mixed ANOVA (between groups and items) for correct answers on the neuromyth questionnaire.

Group:	$F_{(2,164)}$	p	η^2_p	**Differences between groups**
Type of item				
All	16.090**	<0.001	0.164	4th SP>4th REG>1st
H	13.652**	<0.001	0.143	4th SP>4th REG, 1st
EC	8.034**	<0.001	0.089	1st<4th REG, 4th SP
Type of item:	$F_{(1,164)}$	p	η^2_p	**Differences between items**
Group				
All	71.299**	<0.001	0.303	EC>H
1st	32.854**	<0.001	0.167	EC>H
4thREG	74.007**	<0.001	0.311	EC>H
4^{th} SP	7.971*	0.005	0.046	EC>H

Abbreviations: EC, emotional competences; H, health; REG, regular; SP, specialist.
*p<0.005; **p<0.001.

the 1st-year group, significantly more errors were found on the emotional competence items than on the health items, although the effect size was small.

In the case of gaps, overall, the 4th-year specialist group had a lower number of gaps than the other two groups. In the case of the health items, the 4th-year specialist group had a lower number of gaps than the other two groups. In the case of the emotional competences items, the 1st-year group had a higher number of gaps than the other two groups (although the difference compared to the 4th-year regular group was only marginally significant). However, there were no statistically significant differences between the 4th-year specialist group and the 4th-year regular group in terms of gaps in emotional competences items. Finally, both overall and in each of the three groups, there were more gaps on the health items than on the emotional competences items.

Objective 3. The most frequent neuromyths

Finally, Table 7 includes the five neuromyths that were identified as the most frequent.

DISCUSSION

The purpose of this study is to answer some questions that can affect the quality of education received by students with ASD in mainstream educational settings, based on the idea that a high prevalence of neuromyths about autism is not desirable in pre-service teachers.

First, because this research was carried out with prospective teachers who are in different stages of their pre-service training, we are able to observe the prevalence of neuromyths about ASD at the beginning of the training and at the end. In this regard, as in the study by Sanz-Cervera et al. (2017), significantly better knowledge about autism was found in 4th-year regular pre-service teachers than in 1st-year pre-service teachers, especially on items related to the emotional competences of people with ASD. Then, the teacher preparation offered in the teaching degree may have a positive influence on pre-service teachers' knowledge about autism. The second finding indicates that specific training related to special education contributes even more to building adequate knowledge about autism, since the group of specialist pre-service teachers showed significantly more correct answers and fewer doubts than the other two groups, especially on questions related to the health of people with ASD.

A dual assessment can be made of this second result. On the one hand, in line with previous research (Gómez-Marí et al., 2021; Sanz-Cervera et al., 2017), specific training in neurodevelopmental conditions seems to be a powerful tool to improve pre-service teachers' knowledge and train competent professionals to work in inclusive settings. On the other hand, this result is not positive if we consider that, in reality, only pre-service teachers who are studying to be special education specialists have adequate knowledge about ASD at the end of their university training. Unfortunately, it does not fit the paradigm of inclusion, in which regular teachers, in coordination with the specialist, have to be prepared to work with students with ASD in the mainstream classroom. The origin of this situation lies, among other things, in the pre-service teacher education program itself, which is based on a multi-track model (Nash & Norwich, 2010) where all pre-service teachers receive generic training, after which some of them specialize in working with students with SEN. Consequently, pre-service teachers are being trained to work with students with ASD, in this case, in non-inclusive settings.

However, although specialist pre-service teachers had more correct answers and fewer doubts than other pre-service teachers, they all believe certain neuromyths about ASD, regardless of their training stage or chosen path (regular or specialist). This idea is because no significant differences were found between the misconceptions of the three groups on either of the two types of items, which agrees with the previous studies that found

TABLE 5 Results obtained in the mixed ANOVA (between groups and items) for errors on the neuromyth questionnaire.

Group:	$F_{(2,164)}$	p	η^2_p	Differences between groups
Type of item:				
All	0.240	0.787	0.003	—
H	0.566	0.569	0.007	—
EC	0.815	0.444	0.010	—
Type of item:	$F_{(1,164)}$	p	η^2_p	**Differences between items**
Group:				
All	6.303*	0.013	0.037	EC>H
1st	9.069*	0.003	0.052	EC>H
4thREG	0.793	0.374	0.005	—
4thSP	1.042	0.309	0.006	—

Abbreviations: EC, emotional competences; H, health; REG, regular; SP, specialist.
*$p<0.005$.

TABLE 6 Results obtained in the mixed ANOVA (between groups and items) for gaps on the neuromyth questionnaire.

Group:	$F_{(2,164)}$	p	η^2_p	Differences between groups
Type of item:				
All	8.767**	<0.001	0.097	4th SP<4th REG, 1st
H	7.304**	0.001	0.082	4th SP<4th REG, 1st
EC	6.541*	0.002	0.074	1st>4th REG, 4th SP
Type of item:	$F_{(1,164)}$	p	η^2_p	**Differences between items**
Group:				
All	175.733**	<0.001	0.517	H>EC
1st	107.004**	<0.001	0.395	H>EC
4th REG	139.064**	0.001	0.459	H>EC
4^{th}SP	21.340**	<0.001	0.115	H>EC

Abbrevitions: EC, emotional competences; H, health; REG, regular; SP, specialist.
*$p<0.005$, **$p<0.001$.

TABLE 7 Absolute frequency of correct answers, errors and gaps in the items of the ASD neuromyths questionnaire with an error rate higher than 25%.

	Correct answers	Errors	Gaps
Item	**Fi (%)**	**Fi (%)**	**Fi (%)**
Item 4. Some treatments considered alternative, such as aromatherapy, are showing promising results for specific aspects of ASD, such as sensory processing difficulties, although strong scientific support for their effectiveness is still lacking.	7 (4.2%)	62 (37.1%)	98 (58.7%)
Item 8. There is a high component of heritability in ASD.	71 (42.5%)	46 (27.5%)	50 (29.9%)
Item 9. A cure for autism has not yet been found. However, it is reasonably likely that, due to recent advances in locating biological markers of ASD and in psychopharmacology, a cure will be found in the medium/long term.	43 (25.7%)	53 (31.7%)	71 (42.5%)
Item 11. One of the most common characteristics of people with ASD is lack of empathy for others.	55 (32.9%)	92 (55.1%)	20 (12%)
Item 13. People with ASD experience the same range of emotions as people without ASD and at the same intensity.	30 (18%)	117 (70%)	20 (12%)

a high prevalence of neuromyths about certain neurodevelopmental conditions in teachers (Armstrong-Gallegos et al., 2023; Bei et al., 2024; Gini et al., 2021; Papadatou-Pastou et al., 2017).

Thus, in line with the conclusions of MacDonald et al. (2017), when it comes to debunking neuromyths related to neurodevelopmental conditions, specific training in this topic seems to help to reduce their prevalence, but it is not sufficient to eliminate them. Torrijos-Muelas et al. (2021) explain that the persistent presence of certain neuromyths among teachers may be due to the inaccessibility of the language of the neuroscientific literature. Hence, the integration of neuroeducation in pre-service teacher training could enable teachers to access reliable information in sources such as peer-reviewed scientific journals, which are protective factor against the formation and proliferation of neuromyths (Bei et al., 2024; Macdonald et al., 2017). However, to date, neuroeducation does not seem to have sufficiently permeated the teacher training curricula, especially in the Spanish education system (Ferrero et al., 2016).

Regarding the comparison of the prevalence of neuromyths according to the two types of items included, the results showed that pre-service teachers are more correct and have fewer doubts on items about the emotional competences of people with ASD than on items about their health, regardless of the stage of training they were in or the specialty they were studying. However, the number of errors was higher on the emotional competence items than on the health items, especially in 1st-year pre-service teachers. The main interpretation of this result is that prospective teachers are more cautious on questions about the health of people with ASD than on questions about their emotional competences.

As a possible explanation for this finding, we believe it may be related to the traditional (albeit dubious) dichotomy between hard science and soft science (Biglan, 1973). Pre-service teachers might be interpreting questions about health as moving in a paradigm with a high level of certainty (as is thought to occur in disciplines conceived as hard science). Thus, they may consider that knowing the correct answer depends on previous study. Then, because they assume that they have not undertaken this study, their main response to questions is 'I don't know'. In contrast, the high number of incorrect responses on the items related to emotional competences suggests that pre-service teachers interpret them as questions that they are able to answer, even though they have not formally studied them. This might be because socio-emotional aspects are considered soft science, possibly due to the abstract nature of emotions, which is surprising because one of the most studied topics in the field of neuroscience (considered hard science) is emotions and their relationship with the prefrontal cortex of the brain (VanLandingham, 2014).

Another possible explanation for pre-service teachers' greater willingness to respond to questions about the emotional competences of people with ASD is that they rely on anecdotal arguments when doing so (Hermida et al., 2016). That is, pre-service teachers may take their own experience as a reference when responding, either because of the contact they have had with people with autism or based on its representation in the media. This representation is likely to provide more information to the public about the social and communication skills, understanding and expression and regulation of emotions in people with ASD than about health issues (Bennett et al., 2018). It should also be noted that these anecdotal arguments do not necessarily correspond to the empirical evidence, which would also justify the high rate of errors on the emotional competence items.

Finally, the finding about the most frequent neuromyths about ASD, which are related to a lack of empathy in people with ASD and the idea that they do not

experience the same emotions as everyone else, could be due to the distortion of some scientific evidence (Pasquinelli, 2012). Although empathy is a psychological concept, neuroscience points out that its biological support lies in 'mirror neurons' (Bekkali et al., 2021). When this neural network is activated, it allows people to detect the emotional and mental states of others and understand their intentions (Gallese, 2001). Some MRI studies suggest that children with ASD may have dysfunctions in this neural network (Larbán, 2012). However, although this deficit would involve difficulties in identifying their own state of mind and that of others, it would not keep them from experiencing emotions or being able to respond appropriately once they become aware of what the other person is feeling (Bennett et al., 2018).

Moreover, scientific hypotheses about the aetiology of autism have existed for years, and although they have been refuted by later scientific evidence, they remain in the collective imagination, such as the idea that certain vaccines can cause ASD (Bennett et al., 2018). Although participants were asked about this neuromyth, and, fortunately, a high prevalence of it was not detected, there was considerable confusion about the heritability of autism. This can be interpreted as a lack of solid knowledge in pre-service teachers about the possible causes of ASD, as Sanz-Cervera et al. (2017) concluded.

These three neuromyths and those referring to the supposed effectiveness of alternative treatments (such as aromatherapy) and the possibility of finding a cure for autism are strongly promoted by the media and the Internet (Lacruz-Pérez et al., 2021), which is possibly the reason for their high prevalence in pre-service teachers. In this regard, although the purpose of some videos and news items is to specifically disprove erroneous beliefs, merely focusing on them produces a false sensation that there is a possible debate on the topic, which may contribute to the perpetuation of the myth (Lacruz-Pérez et al., 2022).

Implications for pre-service teacher education

The persistence of neuromyths among pre-service teachers may lead to inadequate pedagogical practices, which has direct implications for the educational inclusion of students with ASD. For instance, if teachers believe that these students lack empathy or do not experience emotions in a typical way, they may treat them differently, with lower expectations or ineffective approaches. This could increase the barriers to equitable participation for these students in mainstream educational settings. Therefore, it would be advisable to review the curriculum of university institutions that train pre-service teachers to combat these neuromyths and promote more inclusive attitudes and teaching practices. In particular, the first proposal would be to incorporate neuroeducation training into the university training curriculum for pre-service teachers (Bei et al., 2024; Papadatou-Pastou et al., 2017; Ruhaak & Cook, 2018; Torrijos-Muelas et al., 2021). Content on neuroeducation could help teachers to be better prepared to reject neuromyths (Ruhaak & Cook, 2018), identify pseudoscientific actions (Ferrero et al., 2016), and be more critical when implementing certain interventions with students with ASD (Van Dijk & Lane, 2018). Additionally, they would be more familiar with a language that would allow them to communicate with other social and health professionals involved in the education of students with autism (Papadatou-Pastou et al., 2017), and to search for information in reliable sources that they can understand without great difficulty.

Furthermore, it would be strongly recommended that the neurodiversity movement be included in teacher education. Neurodiversity is defined as 'the range of natural diversity that exists in human development' (Pellicano & Den Houting, 2022, p. 386). Therefore, based on this paradigm, autism is considered an example of diversity in all possible brains, considering that all are different (Baron-Cohen, 2017). Thus, working with prospective teachers on recognizing neurodiversity could help dispel some misconceptions such as autism needs a cure (Kapp et al., 2013).

Moreover, the finding that specialist pre-service teachers have more adequate knowledge about ASD reveals a concerning gap in the initial teacher education of regular pre-service teachers. This mismatch affects regular teachers' ability to manage inclusive classrooms, as in a truly inclusive environment, all teachers must have the necessary skills to support students with ASD. This underscores the need to integrate more comprehensive and specific training on ASD into regular teacher education programs to ensure that all teachers, not just specialists, can effectively support students with autism (Sanz-Cervera et al., 2017).

Finally, since the results suggest that pre-service teachers tend to be more cautious regarding health topics but less accurate in socio-emotional aspects, this could indicate the need for greater interdisciplinarity in initial teacher education programs. In other words, incorporating evidence-based education on both the biology of ASD and its psychosocial and emotional aspects could help to balance these misconceptions.

To sum up, to ensure the inclusion of students with autism in mainstream education, it is essential that educators, teacher trainers and policy makers work to address and correct the widespread neuromyths surrounding autism.

Limitations and future lines of research

Certain limitations of the study can lead to new lines of research. First, the results correspond to a single Spanish university, so this research should be generalized to other universities. Moreover, although the type of sample made it possible to infer the possible influence

of training in remodelling pre-service teachers' knowledge about ASD, it would be also interesting to carry out a similar study with in-service teachers from different educational stages, including university education. Future research could also explore comparisons between in-service and pre-service teachers, offering valuable insights into the differences and similarities in their beliefs regarding neuromyths about ASD. In addition, a quantitative methodology was employed by administering a questionnaire in true/false/don't know format. While this format makes it possible to objectively quantify participants' knowledge, misconceptions and gaps, open-ended questions in which participants are allowed to argue and justify their responses may contribute to enriching the results. Furthermore, future research could revise and expand the measurement instruments to encompass a broader spectrum of neuromyths. Additionally, employing qualitative techniques with a more critical approach, such as individual interviews or focus groups, would allow neuromyths about ASD to emerge organically from pre-service teachers, rather than being presented directly, as was done in this study.

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CONFLICT OF INTEREST STATEMENT

The authors report there are no competing interests to declare.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available in Zenodo at https://doi.org/10.5281/zenodo.13980942

ETHICS STATEMENT

This research addresses all ethical procedures required and The Ethics Commission in Experimental Research of the University of Valencia approves it. The procedures followed in this study comply with the principles of the Declaration of Helsinki. Informed consent was obtained from all participants involved in the research.

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REFERENCES

Arif, M.M., Niazy, A., Hassan, B. & Ahmed, F. (2013) Awareness of autism in primary school teachers. *Autism Research and Treatment*, 2013, 961595. Available from: https://doi.org/10.1155/2013/961595

Armstrong-Gallegos, S., Van Herwegen, J. & Ipinza, V.F. (2023) Neuromyths about neurodevelopmental disorders in Chilean teachers. *Trends in Neuroscience and Education*, 33, 100218. Available from: https://doi.org/10.1016/j.tine.2023.100218

Baraskewich, J., von Ranson, K.M., McCrimmon, A. & McMorris, C.A. (2021) Feeding and eating problems in children and adolescents with autism: a scoping review. *Autism*, 25(6), 1505–1519. Available from: https://doi.org/10.1177/1362361321995631

Baron-Cohen, S. (2017) Editorial perspective: neurodiversity–a revolutionary concept for autism and psychiatry. *Journal of Child Psychology and Psychiatry*, 58(6), 744–747. Available from: https://doi.org/10.1111/jcpp.12703

Baspinar, B. & Yardimci, H. (2020) Gluten-free casein-free diet for autism spectrum disorders: can it be effective in solving behavioral and gastrointestinal problems? *The Eurasian Journal of Medicine*, 52(3), 292–297. Available from: https://doi.org/10.5152/eurasianjmed.2020.19230

Bei, E., Argiropoulos, D., Van Herwegen, J., Incognito, O., Menichetti, L., Tarchi, C. et al. (2024) Neuromyths: misconceptions about neurodevelopment by Italian teachers. *Trends in Neuroscience and Education*, 34, 100219. Available from: https://doi.org/10.1016/j.tine.2023.100219

Bekkali, S., Youssef, G.J., Donaldson, P.H., Albein-Urios, N., Hyde, C. & Enticott, P.G. (2021) Is the putative mirror neuron system associated with empathy? A systematic review and meta-analysis. *Neuropsychology Review*, 31(1), 14–57. Available from: https://doi.org/10.1007/s11065-020-09452-6

Bennett, M., Webster, A.A., Goodall, E. & Rowland, S. (2018) *Life on the autism spectrum: translating myths and misconceptions into positive futures*. Singapore: Springer. Available from: https://doi.org/10.1007/978-981-13-3359-0

Biglan, A. (1973) The characteristics of subject matter in different academic areas. *Journal of Applied Psychology*, 57(3), 195–203. Available from: https://doi.org/10.1037/h0034701

Bisquerra, R. & Pérez-Escoda, N. (2007) Las competencias emocionales. *Educación XXI*, 10(1), 61–82. Available from: https://doi.org/10.5944/educxx1.1.10.297

Blanchette-Sarrasin, J., Riopel, M. & Masson, S. (2019) Neuromyths and their origin among teachers in Quebec. *Mind, Brain, and Education*, 13(2), 100–109. Available from: https://doi.org/10.1111/mbe.12193

Bodison, S.C. (2015) Developmental dyspraxia and the play skills of children with autism. *The American Journal of Occupational Therapy*, 69(5), 6905185060p1–6905185060p6. Available from: https://doi.org/10.5014/ajot.2015.017954

Capal, J.K. & Jeste, S.S. (2024) Autism and epilepsy. *Pediatric Clinics of North America*, 71(2), 241–252. Available from: https://doi.org/10.1016/j.pcl.2024.01.004

Chiarotti, F. & Venerosi, A. (2020) Epidemiology of autism spectrum disorders: a review of worldwide prevalence estimates since 2014. *Brain Sciences*, 10(5), 274. Available from: https://doi.org/10.3390/brainsci10050274

Chica-Londoño, V. (2022) Dióxido de cloro: la verdad toxicológica y el riesgo de las noticias falsas. *Iatreia*, 35(4), 424–432. Available from: https://doi.org/10.17533/udea.iatreia.167

Corrigan, P.W. & Watson, A.C. (2002) Understanding the impact of stigma on people with mental illness. *World Psychiatry*, 1(1),

16–20. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1489832/

Cruchet, S., Lucero, Y. & Cornejo, V. (2016) Truths, myths and needs of special diets: attention-deficit/hyperactivity disorder, autism, non-celiac gluten sensitivity, and vegetarianism. *Annals of Nutrition and Metabolism*, 68(1), 42–50. Available from: https://doi.org/10.1159/000445393

Erickson-Tomaino, M., Miltenberger, C. & Charlop, M. (2014) Social skills and play in children with autism. In: Tarbox, J., Dixon, D., Sturmey, P. & Matson, J. (Eds.) *Handbook of early intervention for autism spectrum disorders. Autism and child psychopathology series*. New York: Springer, pp. 341–353. Available from: https://doi.org/10.1007/978-1-4939-0401-3_17

Esposito, D., Belli, A., Ferri, R. & Bruni, O. (2020) Sleeping without prescription: management of sleep disorders in children with autism with non-pharmacological interventions and over-the-counter treatments. *Brain Sciences*, 10, 441. Available from: https://doi.org/10.3390/brainsci10070441

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. Available from: https://doi.org/10.3389/fnhum.2016.00496

Gallese, V. (2001) The shared manifold hypothesis from mirror neurons empathy. *Journal of Consciousness Studies*, 8(5–7), 33–50.

Gini, S., Knowland, V., Thomas, M.S. & Van Herwegen, J. (2021) Neuromyths about neurodevelopmental disorders: misconceptions by educators and the general public. *Mind, Brain, and Education*, 15(4), 289–298. Available from: https://doi.org/10.1111/mbe.12303

Gómez-Marí, I., Sanz-Cervera, P. & Tárraga-Minguez, R. (2021) Teachers' knowledge regarding autism spectrum disorder (ASD): a systematic review. *Sustainability*, 13(9), 5097. Available from: https://doi.org/10.3390/su13095097

Hawkins, J.R., Weatherby, N., Wrye, B. & Ward, K.U. (2019) Bergamot aromatherapy for medical office–induced anxiety among children with an autism spectrum disorder: a randomized, controlled, blinded clinical trial. *Holistic Nursing Practice*, 33(5), 285–294. Available from: https://doi.org/10.1097/HNP.0000000000000341

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), 457–472. Available from: https://doi.org/10.1080/00131881.2016.1238585

Howard-Jones, P. (2009) *Introducing neuroeducational research: neuroscience, education and the brain from contexts to practice*. England UK: Routledge.

Jahromi, L.B., Kirkman, K.S., Friedman, M.A. & Nunnally, A.D. (2021) Associations between emotional competence and prosocial behaviors with peers among children with autism spectrum disorder. *American Journal on Intellectual and Developmental Disabilities*, 126(2), 79–96. Available from: https://doi.org/10.1352/1944-7558-126.2.79

John, R.P., Knott, F.J. & Harvey, K.N. (2018) Myths about autism: an exploratory study using focus groups. *Autism*, 22(7), 845–854. Available from: https://doi.org/10.1177/1362361317714990

Kapp, S.K., Gillespie-Lynch, K., Sherman, L.E. & Hutman, T. (2013) Deficit, difference, or both? Autism and neurodiversity. *Developmental Psychology*, 49(1), 59–71. Available from: https://doi.org/10.1037/a0028353

Keller, A., Rimestad, M.L., Friis-Rohde, J., Holm-Petersen, B., Bruun-Korfitsen, C., Tarp, S. et al. (2021) The effect of a combined gluten-and casein-free diet on children and adolescents with autism spectrum disorders: a systematic review and meta-analysis. *Nutrients*, 13(2), 470. Available from: https://doi.org/10.3390/nu13020470

Lacruz-Pérez, I., Morales-Hernández, A.J., Caurín-Alonso, C. & Tárraga-Mínguez, R. (2022) El eco del autismo en la prensa española: una comparativa de tres décadas. *Revista Prisma Social*, 36, 117–141.

Lacruz-Pérez, I., Sanz-Cervera, P., Pastor-Cerezuela, G., Gómez-Marí, I. & Tárraga-Mínguez, R. (2021) Is it possible to educate, intervene or "cure" autism spectrum disorder? A content analysis of YouTube videos. *International Journal of Environmental Research and Public Health*, 18(5), 2350. Available from: https://doi.org/10.3390/ijerph18052350

Larbán, J. (2012) Autismo temprano, neuronas espejo, empatía, integración sensorial, intersubjetividad. *Cuadernos de Psiquiatría y Psicoterapia del Niño y del Adolescente*, 54, 79–91.

Lardieri, A., Cheng, C., Jones, S.C. & McCulley, L. (2021) Harmful effects of chlorine dioxide exposure. *Clinical Toxicology*, 59(5), 448–449. Available from: https://doi.org/10.1080/15563650.2020.1818767

López-Mejía, D.I., Valdovinos-de Yahya, A., Méndez-Díaz, M. & Mendoza-Fernández, V. (2009) El sistema límbico y las emociones: empatía en humanos y primates. *Psicología Iberoamericana*, 17(2), 60–69. Available from: https://doi.org/10.48102/pi.v17i2.270

Lukmanji, S., Manji, S.A., Kadhim, S., Sauro, K.M., Wirrell, E.C., Kwon, C.S. et al. (2019) The co-occurrence of epilepsy and autism: a systematic review. *Epilepsy & Behavior*, 98, 238–248. Available from: https://doi.org/10.1016/j.yebeh.2019.07.037

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. Available from: https://doi.org/10.3389/fpsyg.2017.01314

Mannion, A. & Leader, G. (2013) Comorbidity in autism spectrum disorder: a literature review. *Research in Autism Spectrum Disorders*, 7(12), 1595–1616. Available from: https://doi.org/10.1016/j.rasd.2013.09.006

Mulet, J.M. (2015) Pseudociencias y medicina. *Revista de la Sociedad Española de Bioquímica y Biología Molecular*, 184, 7–10. Available from: https://riunet.upv.es/handle/10251/65505

Nash, T. & Norwich, B. (2010) The initial training of teachers to teach children with special educational needs: a national survey of English post graduate certificate of education programmes. *Teaching and Teacher Education*, 26(7), 1471–1480. Available from: https://doi.org/10.1016/j.tate.2010.06.005

Organisation for Economic Cooperation and Development. (2002) *Understanding the brain: towards a new learning science*. Paris, France: OECD Publishing. Available from: https://doi.org/10.1787/9789264174986-en

Papadatou-Pastou, M., Haliou, E. & Vlachos, F. (2017) Brain knowledge and the prevalence of neuromyths among prospective teachers in Greece. *Frontiers in Psychology*, 8, 804. Available from: https://doi.org/10.3389/fpsyg.2017.00804

Pasquinelli, E. (2012) Neuromyths: why do they exist and persist? *Mind, Brain, and Education*, 6(2), 89–96. Available from: https://doi.org/10.1111/j.1751-228X.2012.01141.x

Pellicano, E. & den Houting, J. (2022) Annual research review: shifting from 'normal science' to neurodiversity in autism science. *Journal of Child Psychology and Psychiatry*, 63(4), 381–396. Available from: https://doi.org/10.1111/jcpp.13534

Ravet, J. & Williams, J.H. (2017) What we know now: education, neuroscience and transdisciplinary autism research. *Educational Research*, 59(1), 1–16. Available from: https://doi.org/10.1080/00131881.2016.1272429

Roberts, J. & Simpson, K. (2016) A review of research into stakeholder perspectives on inclusion of students with autism in mainstream schools. *International Journal of Inclusive Education*, 20(10), 1084–1096. Available from: https://doi.org/10.1080/13603116.2016.1145267

Rousseau, L. (2021) Interventions to dispel neuromyths in educational settings—a review. *Frontiers in Psychology*, 12, 719692. Available from: https://doi.org/10.3389/fpsyg.2021.719692

Ruhaak, A.E. & Cook, B.G. (2018) The prevalence of educational neuromyths among pre-service special education teachers. *Mind, Brain, and Education*, 12(3), 155–161. Available from: https://doi.org/10.1111/mbe.12181

Ruiz-Martin, H., Portero-Tresserra, M., Martínez-Molina, A. & Ferrero, M. (2022) Tenacious educational neuromyths: prevalence among teachers and an intervention. *Trends in Neuroscience and Education*, 29, 100192. Available from: https://doi.org/10.1016/j.tine.2022.100192

Sanz-Cervera, P., Fernández-Andrés, M.I., Pastor-Cerezuela, G. & Tárraga-Mínguez, R. (2017) Pre-service teachers' knowledge, misconceptions and gaps about autism spectrum disorder. *Teacher Education and Special Education*, 40(3), 212–224. Available from: https://doi.org/10.1177/0888406417700963

Sazaka, L.S.R., Hermida, M.J. & Ekuni, R. (2024) Where did pre-service teachers, teachers, and the general public learn neuromyths? Insights to support teacher training. *Trends in Neuroscience and Education*, 36, 100235. Available from: https://doi.org/10.1016/j.tine.2024.100235

Torrijos-Muelas, M., González-Víllora, S. & Bodoque-Osma, A.R. (2021) The persistence of neuromyths in the educational settings: a systematic review. *Frontiers in Psychology*, 11, 591923. Available from: https://doi.org/10.3389/fpsyg.2020.591923

Van Dijk, W. & Lane, H.B. (2018) The brain and the US education system: perpetuation of neuromyths. *Exceptionality*, 28(1), 16–29. Available from: https://doi.org/10.1080/09362835.2018.1480954

VanLandingham, M. (2014) On the hard and soft sciences in public health. *Public Health Reports*, 129(2), 124–126. Available from: https://doi.org/10.1177/003335491412900204

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