Neuromyths about neurodevelopmental disorders in Chilean teachers

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Abstract

Misconceptions about how the brain works (neuromyths) are shown to be common among educators, but little is known about neurodevelopmental disorders (NDDs) neuromyths. Here, we explored the prevalence of both general and neurodevelopmental disorders neuromyths in Chilean teachers and other educational professionals. One hundred forty-four participants answered an online neuroscience knowledge, interest, and training questionnaire. Regression analysis showed that both teachers and non-teachers endorsed more neuromyths related to NDDs compared to general neuromyths and that familiarity with the NDDs but not necessarily neuroscience training or interest plays an important role in the endorsement of these neuromyths. The findings indicate that dyscalculia is the least known neurodevelopmental disorder. Although inclusion politics demand training for all educational actors, the current findings suggest effective translational efforts between neuroscience and education fields should continue.

Keywords: neuromyths, neurodevelopmental disorders, teachers, Chile.

INTRODUCTION

In recent years, the knowledge and findings from neurosciences have been spread across the scientific field, reaching public discussion (Pallarés-Domínguez, 2017). Educators have seen those findings as an opportunity to bring new ideas to the classroom and as a background to justify their teaching practices (Carballo, 2019). Despite the great interest in the field, neuroscience is complex and diverse, with ongoing developments and areas of limited understanding. This complexity can lead to misinterpretations and the emergence of neuromyths (Goswami, 2006; Varas-Genestier & Ferreira, 2017).

Neuromyths refer to false beliefs regarding neuroscientific knowledge, despite being refuted in their field (Pallarés-Domínguez, 2017). Neuromyths are often hard to dispel as they often link to intuitive thoughts and experiences (Rousseau, 2021) and linger on the social imaginary. In the educational field, researchers have reported that in-service teachers (teachers from now on), pre-service teachers (students enrolled in an undergraduate degree to become school teachers), and parents widely accept erroneous beliefs about learning and brain function (Torrijos-Muelas et al., 2020). Studies that have looked for possible factors that predict belief in neuromyths have shown that informal information about the brain increases their prevalence (Dekker et al., 2012; Hughes et al., 2020) but that access to scientific knowledge about the brain (Herculano-Houzel, 2002; Howard-Jones et al., 2009), and solid educational qualifications (Hughes et al., 2020) would act as a protective factor. Despite this, it has been reported that access to formal knowledge about neuroscience alone is not enough to reduce belief in neuromyths (Howard-Jones et al., 2020; Im et al., 2018; Privitera, 2021; Rousseau, 2021).

If not contrasted, false beliefs about how the brain works may influence the decisions and design of pedagogical strategies (Geake, 2008). Lilienfeld (2007) reported that didactic techniques based on neuromyths have caused detriment to students and may put learning methodologies at risk. Ruhaak and Cook (2018) studied the endorsement of neuromyths in pre-service teachers. They found that those students who identified the neuromyths were less likely to implement them in their practices, whilst those who endorsed neuromyths were more likely to organise their instructions based on ineffective methodologies, lack of evidence-based, and an incorrect arrangement of time in the class. However, it has been suggested that the relationship between the endorsement of neuromyths by educators and their teaching practices is unclear. Horvath et al. (2018) compared neuromyths rates between award-winning teachers and non-award-winning teachers and their results showed no differences in the prevalence of neuromyths endorsement among them. In addition, Krammer et al. (2021) observed that the neuromyth acceptance rates in pre-service teachers were marginally associated with their own grades as students.

The neuromyths of typical brain development is a recent phenomenon that has received significant attention and concern in the scientific field with multiple publications (see the revision of Torrijos-Muelas et al., 2021). On the contrary, there is scarce research on false beliefs about neurodevelopmental disorders. Neurodevelopmental disorders (NDDs) are characterised as conditions manifested in the early development period that may affect a person in different areas, such as personal, social, academic or occupational life (American Psychiatric Association [APA], 2013). The NDDs include intellectual disabilities, communication disorders, autism spectrum disorder (ASD), attention-deficit/hyperactivity disorder (ADHD), specific learning disorder (SpLD), and motor disorders. The present study examined neuromyths related to ADHD, SpLD, ASD and Down syndrome.

According to The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-V), ADHD presents a persistent pattern of inattention, hyperactive and impulsive behaviour that interferes with daily life activities. SpLD refers to learning and academic skills difficulties that may be expressed in the reading, writing (known as dyslexia) and maths domains (known as dyscalculia). ASD refers to social communication and social interaction difficulties, such as social-emotional reciprocity, nonverbal communication, and relationships. Intellectual disability is characterised by a deficit in intellectual functioning (e.g. reasoning, problem-solving, planning), and in the adaptive domain that impacts personal independence and social responsibility (APA, 2013). In some cases, intellectual disability may be associated with Down syndrome, a chromosomal abnormality affecting cognitive skills and muscular development (World Health Organization, 2019).

Gini et al. (2021) explored the prevalence of neuromyths about neurodevelopmental disorders compared to general neuromyths in both educators and the general population in the UK. They found that for all participants, the knowledge of developmental conditions was lower than general neuroscience topics, showing a lack of knowledge about neurodevelopmental disorders. Another study (Papadatou-Pastou et al., 2017) explored general neuromyths and those related to special education among pre-service teachers. The results indicated that pre-service teachers were more likely to make errors on the special education-related items (e.g. “The defining feature of dyslexia is reversing letters”), compared to the general neuroscience-related items, with a difference of 15.8%. Wrong ideas about neuroscience can lead to stigma and prejudice about neurological conditions (Corrigan & Watson, 2002). For example, by lowering expectations and constraining opportunities for participation in people with disabilities (Cortiella & Horowitz, 2014). The prejudice against neurodevelopmental disorders impacts the person with a diagnosis and their families, as reported by Serchuk et al. (2021), who observed mental health issues and low quality of life associated with stigma in parents of children with NDDs; thus, investigating the prevalence of misconceptions on these topics may help tackle discrimination.

Endorsement of neuromyths has shown to be present across countries, including Chile (Biso Ávila et al., 2018; Ferreira & Rodríguez, 2022; Gleichgerrcht et al., 2015; Maureira et al., 2021; Painemil et al., 2021; Varas-Genestier & Ferreira, 2017). Among the most studied neuromyths (for a revision of the original questionnaire, see Dekker et al., 2012), there are four that have shown to be most endorsed by Chilean teachers: the learning style model (auditory, visual, kinesthetic); the hemispheric dominance as individual differences; the idea that coordination exercises improve literacy skills; and the belief that environments rich in stimulus improve the brain of preschool children (Gleichgerrcht et al., 2015; Painemil et al., 2021; Varas-Genestier & Ferreira, 2017).

Since 2009, Chile has significantly increased the funding and human resources for attention to student diversity as a consequence of legal dispositions (República de Chile, 2009). Implementing such measures has challenged educators, who must work together as an interdisciplinary team and with the educative community (MINEDUC, 2013). Nevertheless, there are worldwide stigma and misinformation about the needs and characteristics of students with neurodevelopmental conditions, as has been reported for children with autism spectrum and intellectual disability (Chávez Gonzales et al., 2016; Corrigan & Watson, 2002; Gurdián-Fernández et al., 2020). As such, in addition to examining inclusion practices, it is imporant to examine any misconcepts or beliefs related to neurodevelopmental disorders that may hinder or impact on inclusion practices. Although there is currently no research that has examined the relationship between what teachers believe about neurodevelopmental disorders and solutions or interventions they apply in the classroom, there is evidence that neuromyths influence policymakers to invest public resources, rolling out interventions based on neuromyths such as learning styles (visual, auditory, and kinaesthetic) or the Mozart Effect, playing classical music to babies to improve IQ (Rousseau, 2021). Evidence from our unpublished focus groups suggests that teachers often use visual overlays to help students with dyslexia based on the belief that all students with dyslexia have reading problems caused by visual stress. In addition, endorsement of incorrect facts about neurodevelopmental disorders can increase stigma and reduce access to diagnosis as well as intervention therapies.

In the current study, we examined the prevalence of general neuromyths about the brain and neuromyths about neurodevelopmental disorders in a sample of Chilean teachers, undergraduate students and professionals who work on education. Despite national legal provisions for special education requiring qualified professionals, no prior studies have examined the prevalence of misconceptions about neurodevelopmental disorders among Chilean educators, and there are no previous studies assessing neuromyths in dyscalculia. Hence, this study is distinguished by its specific focus on neuromyths related to neurodevelopmental disorders, its emphasis on the distinction between general and neurodevelopmental neuromyths to examine if neuromyths related to neurodevelopmental disorders are a specific issue, and the comparison between different groups of neurodevelopmental disorders to examine if neuromyths are a specific issue for certain neurodevelopmental disorders only. Based on the literature reviewed, we expected an extensive endorsement of general neuromyths, especially for the four most popular ones. We also predicted higher endorsement for the neurodevelopmental neuromyths than the general ones. Finally, we predicted that for neurodevelopmental disorders that teachers and non-teachers were least familiar with, they would endorse most neuromyths related to that NDD, such as dyscalculia.

METHODS

Participants

The current is a survey study and thus an opportunity sample was used. A post-hoc power-analysis showed that with 2 groups and using the sample size obtained, the power to detect an effect was large (d = 0.8).

The sample was 144 participants, with 67.4% females, from Chile's central and southern regions. Both teachers and non-teachers were recruited via direct contact with educational institutions. Primary and secondary schools in Chile and university faculties were approached for participation in the research project. They were invited to participate in a larger project, including an intervention. The first part of the project included answering an online questionnaire, which data is presented in the present paper.

The participants comprised teachers (49.3%), who will be called the 'teachers' group, and a second group who will be called 'non-teachers' composed of undergraduate students from the social and humanities field (34.1%), other professionals (9.7%), such as speech therapists, and technicians who worked in education (6.9%). The teachers' group age was M = 39.7 (SD = 10.14), and the non-teachers were M = 27,3 (SD = 8,87), the differences were significant, $t(142)$= 7.84, p<.001, d= .20).

The mean for years of experience for teachers was 14.3 (SD=10.8), who mainly worked at the primary school level and included preschool, secondary, and higher education in-service educators.

Materials

Participants completed the survey by Gini et al. (2021), which included three sections: a section that asked about background information, questions about general neuromyths and neuromyths or statements related to neurodevelopmental disorders. The background information section asked participants about:

Sociodemographic information: included demographic information like age and their educational role, if they had one.

It also asked participants about their familiarity with learning difficulties using a three-point scale (0 not familiar at all, 1 somewhat familiar, 2 very familiar) for six conditions: ADHD, ASD, dyslexia, dyscalculia and Down syndrome, after which a mean score was calculated.

Interest in the neuroscientific matter was explored with two items: "Are you interested in knowing how the brain works?", in a slider question ranged from nothing (0) to a lot (100), and "Do you consider the neuroscientific knowledge relevant to your professional performance?" using a three-point scale (0 no, 1 somewhat, 2 yes a lot). We also asked whether participants have received formal training in neuroscientific matters, on a three-point scale (0 no, 1 yes a little, 2 yes a lot).

Access to neuroscientific publications was rated on a three-scale question (usually, sometimes, never). For those with positive answers, we requested to select their preferred source of neuroscientific information among television, newspaper, radio, social networks, journals, books, podcasts, YouTube channels and browsers.

The Neuromyths questionnaire evaluates both general neuromyths and neurodevelopmental neuromyths. All questions have four possible answers: "True," "Probably true," "Probably false," and "False", following the recommendation of a previous study (Gini et al., 2021). The questions were presented in random order.

General neuromyths were assessed with the Spanish version of the neuromyths questionnaire developed originally by Dekker et al. (2012). The questionnaire has been widely used in studies on English speakers (Im et al., 2018; Lithander et al., 2021; Macdonald et al., 2017) and Spanish speakers, including Chile. The current questionnaire consisted of 19 statements (10 correct, 9 incorrect) about general knowledge of the brain, based on modifications to its original version, which includes the most prevalent neuromyths found in Chilean educators (Gleichgerrcht et al., 2015; Maureira et al., 2021; Painemil et al., 2021; Varas-Genestier & Ferreira, 2017).

Neurodevelopmental neuromyths were evaluated through 30 statements from Gini et al. (2021). The questions were translated by a Spanish native speaker and back translated to English. The questionnaire contained non-specific neurodevelopmental neuromyths that apply to more than one neurodevelopmental disorder and statements that referred to specific neurodevelopmental disorders (including ASD, ADHD, Down syndrome, and learning disabilities). Some examples of statement for ASD are: "Children with autism are unable to notice social rejection" (false), "Autism only occurs in boys" (false); for ADHD: "Most ADHD children outgrow their symptoms and subsequently function normally in adulthood" (false), "Children with ADHD have difficulties with focus and concentration" (true); for Down Syndrome: "People with Down syndrome are always happy and affectionate" (false), "Children with Down syndrome cannot understand what they are reading" (false); for learning disabilities: "In some children dyslexia is caused by visual problems" (false), "Children with dyslexia can often excel in other areas" (true). The present study also included 7 additional items about dyscalculia that were not included in the original survey by Gini et., al 2021. The dyscalculia questions were developed with 3 experts within the field of developmental dyscalculia, based upon their experience (see Appendix 1). It is not possible to control the level of difficulty of the different statements for the different groups of neurodevelopmental disorders. However, all questions related to the symptoms, the diagnosis and support that can be associated with these groups. Comparing these different statements still provides important information about whether teachers and non-teacher can identify some simple facts about developmental dyscalculia and other neurodevelopmental disorders.

In order to compare the percentage of correct responses between the general and neurodevelopmental neuromyths questionnaires, the answers were recoded to a dichotomic value of true and false. For regression analyses, the scores on a 1-4 scale were used, with lower scores indicating more belief in neuromyths.

Procedure

This study was approved by the ethical committee of the Universidad Autónoma de Chile, reference number 13-22.

Participants answered an online questionnaire distributed via QuestionPro. They were presented with information about the study and completed a consent form. The questionnaire was anonymous and took around 20 minutes to be completed. Participants were not compensated for completing the questionnaire.

RESULTS

Neuroscientific interest

First, we analysed participants' interest and familiarity with neuroscientific knowledge based on their group: teachers and non-teachers. The results showed that both teachers and non-teachers had an average level of interest in neuroscientific knowledge above 90% (SD=15,2) on a scale of 0 to 100. Furthermore, 85.9% of teachers and 94.5% of non-teachers considered neuroscientific knowledge a highly relevant topic for their professional development, X^2 = 4.28, p>.05. We also asked whether the participants had undertaken courses covering the development of children with developmental disabilities during the formal undergraduate training or as post-training. Among teachers, 77.5% reported having prior training in this area (both a lot and a little), compared to 86.3% of non-teachers. However, this difference did not reach statistical significance, X^2 = 1.90, p= .168. Regarding access to neuroscientific publications, 69.9% of non-teachers mentioned that they usually or sometimes follow them, whereas the percentage for teachers was 64.8%, X^2 = .42, p >.05. In general, scientific journals were the most popular source of information about neuroscience, followed by browsers (such as Google) and books. In sum, both groups had an equal interest in neuroscience and had similar training in this area.

Knowledge and neuromyths of general brain facts

The 19 general neuromyths statements were organized to determine their accuracy. In the overall sample, we found that 65.3% of general statements about the brain were answered correctly. Table 1 displays the correct responses by group: teachers and non-teachers. As shown in the table, the statement most effectively identified as a neuromyth was "Mental capacity is hereditary and cannot be changed by the environment or experience," with a success rate above 85% in both groups. In contrast, the neuromyths with the most acceptance rates were the hemispheric dominance as an individual characteristic, the learning style model (VAK), the coordination exercises as an improvement of brain integration, and the idea that rich stimulant environments are positive for preschool children. These last two neuromyths received more than the 90% of incorrect endorsement.

Table 1
General neuromyths, percentage of correct responses by group, and statistical differences

Neuromyths statements	Teachers	Non-teachers	χ^2
The left and right hemispheres of the brain always work together. (T)	**43.7**	68.5	9.01**
When a brain region is damaged other parts of the brain can take up its function. (T)	69.0	56.2	2.53
Learning occurs through modification of the brain's neural connections. (T)	91.5	91.8	.003
Information is stored in the brain in a network of cells distributed throughout the brain. (T)	74.6	83.6	1.73
Production of new connections in the brain can continue into old age. (T)	78.9	74.0	.47
Vigorous exercise can improve mental function. (T)	84.5	94.5	3.86*
Normal development of the human brain involves the birth and death of brain cells. (T)	83.1	90.4	1.68
There are sensitive periods in childhood when it's easier to learn things. (T)	93.0	93.2	.002
We use our brains 24 hours a day. (T)	95.8	87.7	3.09
Circadian rhythms ("body-clock") shift during adolescence, causing pupils to be tired during the first lessons of the school day. (T)	78.9	80.8	.08
We only use 10% of our brain. (F)	60.6	69.9	1.37
Individuals learn better when they receive information in their preferred learning style (e.g., VAK visual, auditory, kinesthetic). (F)	**25.4**	**17.8**	1.21
Learning is due to the addition of new cells to the brain. (F)	67.6	50.7	4.26*
Environments that are rich in stimulus improve the brains of preschool children. (F)	**4.2**	**11.0**	2.31
Short bouts of coordination exercises can improve the integration of left and right hemispheric brain function. (F)	**4.2**	**12.3**	3.09
Brain development has finished by the time children reach secondary school. (F)	90.1	87.7	.22

Differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners. (F)	**29.6**	**31.5**	.06
The brains of boys and girls develop at the same rate. (F)	57.7	65.8	.97
Mental capacity is hereditary and cannot be changed by the environment or experience. (F)	85.9	97.3	6.06*

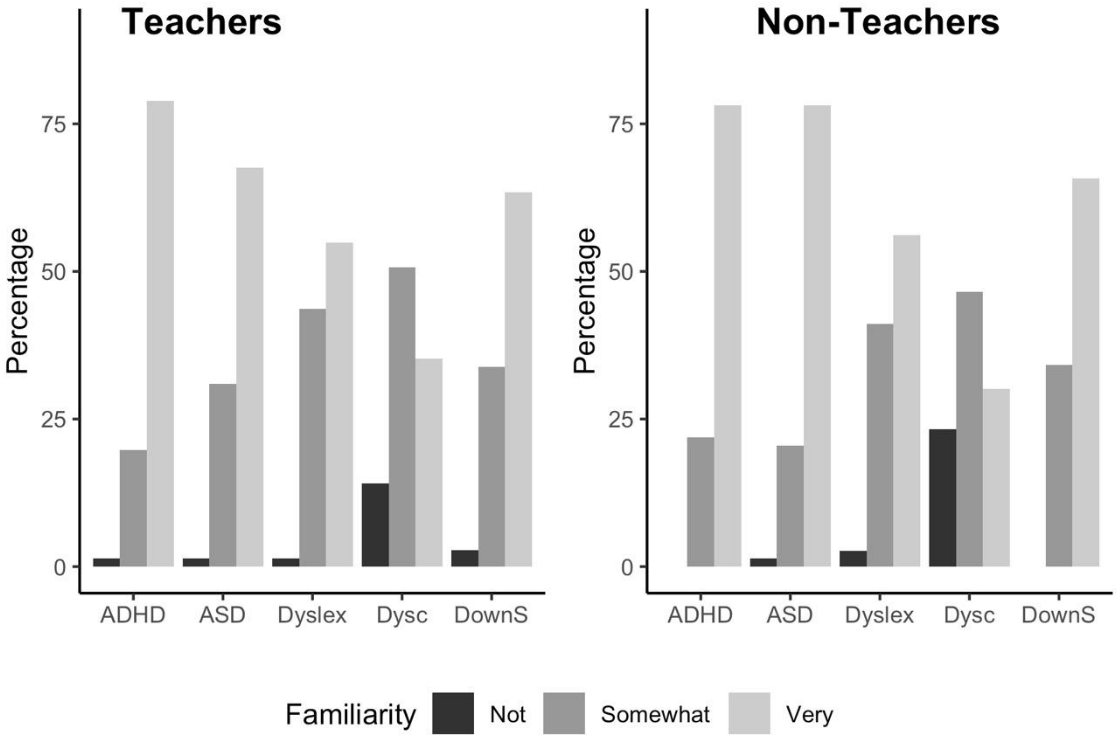
Note. T= True; F= False. Percentages in bold highlights items with less than 50% of correct responses. *p<.05, **p<.01

Knowledge and neuromyths of neurodevelopmental disorders

Participants were asked to rate their knowledge about five neurodevelopmental disorders. For both groups, teachers and non-teachers, answers showed that ADHD and ASD presented the highest familiarity rates; on the contrary, dyscalculia was the most unknown (Figure 1).

Figure 1

Bar plot of neurodevelopmental disorders familiarity



Note. ADHD= attention-deficit/hyperactivity disorder; ASD= autism spectrum disorder; Dyslex= Dyslexia; Dysc= Dyscalculia; DownS= Down syndrome. Familiarity: Not familiar at all, somewhat familiar, very familiar.

Teachers were more likely to have experience of working with children with special educational needs (97.2%), compared to 60.3% of the non-teacher group; X^2= 29.02, p<.001. To examine how familiar each group was with the different neurodevelopmental disorders, a mixed ANOVA was run as a follow-up analysis with the group as between-subjects and familiarity with the disorder as within-subjects factors. There was a significant main effect of familiarity $F(4,568)$ = 52.41, p <.001, η^2 = .270. All the conditions showed significantly different degrees of familiarity, the highest for ADHD (*M* = 2.77, SD = .43) and the lowest for Dyscalculia (*M* = 2.13, SD = .70). However, the group effect was not significant $F(1,142) = .004$, $p > .05$, $\eta^2 = <.001$, as well as the interaction effect between group and familiarity $F(4,568) = 1.76$, $p > .05$ $\eta^2 = .012$. This shows that both teachers and non-teachers were equally familiar with the different neurodevelopmental disorders but both groups were least familiar with dyscalculia and most familiar with ADHD and autism.

Next, the neuromyths statements rates related to neurodevelopmental disorders were analysed. Overall, neurodevelopmental disorders neuromyths showed an average rate of 62.2% correct responses. When compared by conditions, the highest correct scores were on ASD (above 68%), followed by non-specific statements about neurodevelopmental disorders. At the same time, the lowest accuracy was applied to statements related to dyscalculia (see Table 2). As can be seen in Table 2, the teachers showed significantly lower scores and endorsed more neuromyths related to non-specific neurodevelopmental disorders but there were no differences for the other neurodevelopmental groups between teachers and non-teachers.

Table 2

Comparison between teachers and non-teachers on neuromyth scores for different NDDs

		Teachers		Non-teachers		Mean comparison	
ND type	Number of items	*M*(SD)	Correct %	*M*(SD)	Correct %	*t*	*d*
Non-specific NDDs	7	2.88(.42)	63.7	3.06(.38)	73.2	2.67*	.402
ADHD	9	2.74(.33)	57.9	2.85(.36)	62.5	1.97	.350
ASD	5	3.05(.45)	68.1	3.17(.42)	75.0	1.60	.455
Dyslexia	5	2.72(.47)	57.1	2.72(.44)	59.7	.044	.458
Dyscalculia	7	2.59(.34)	52.5	2.54(.39)	49.3	.859	.374
Down syndrome	4	2.90(.45)	65.5	3.05(.40)	71.2	2.02	.433

Note. Responses were scored on a scale of 1–4, with lower scores indicating belief in neuromyths. Correct% = percentage of correct responses for each neurodevelopmental disorder. Corrected p-value with Bonferroni at $p<.008$*; *d* = Cohen's effect size

A linear regression was used to examine if neuromyth endorsement scores were predicted by type (general versus neurodevelopmental) or by participant group (teachers, non-teachers). Results showed that neuromyth type, but not participant group significantly predicted the neuromyth endorsement (see Table 3). Also, the variables of neuroscientific interest and neuroscientific training were tested in a separate model, showing a non-significant prediction (Table 4).

Table 3

Results from Linear regression of group and neuromyth types.

Term	β	95%CI	*t*	*p*
Intercept	1.614	[1.311, 1.917]	10.48	<.001
Type	.552	[.360, .743]	5.66	<.001
Group	-.146	[-.337, .044]	-1.51	.132
Type x Group	.114	[-.006, .235]	1.86	.063

Note. $F(3, 284) = 187.303$, $p<.001$

Table 4

Results from Linear regression of factors predicting endorsement of neuromyths.

Term	β	95%CI	*t*	*p*
Intercept	2.380	[1.188, 3.573]	3.93	<.001
Neuro. interest	.002	[-.010, .015]	.36	<.714
Neuro.training	-.055	[-.540, .454]	-1.71	.864
Interest x Training	<.001	[-.005, .005]	-.06	.952

Note. $F(3, 284) = 1.108$, p= 346

DISCUSSION

The present study examined the endorsement of general neuromyths and neuromyths about neurodevelopmental disorders in teachers, undergraduates and professionals who work in education. As mentioned in a systematic review (Torrijos-Muelas et al., 2020), the first studies about neuromyths arose almost two decades ago. However, the brain's false beliefs seem encysted in the general public, especially among educators. This is the first study exploring beliefs regarding neurodevelopmental disorders in Chile, and there is just one previous publication on the topic made in the United Kingdom (Gini et al., 2021); thus, our findings may contribute to identifying the current state of neurodevelopmental disorders information among educators. The main findings and practical implications will be addressed below.

In general, we found slight differences in success rates between general and neurodevelopmental neuromyths, with higher performance in the first one for both groups. For the general neuromyths, participants showed a good level of brain knowledge, with 65.3% successfully identifying the correct statements. These results were located in a medium point of previous studies with teachers and pre-service teachers in Chile, which have obtained from 50% to almost 80% of success (Ferreira & Rodríguez, 2022; Gleichgerrcht et al., 2015; Maureira et al., 2021; Varas-Genestier & Ferreira, 2017), and are similar to international studies (Dekker et al., 2012; Ferrero et al., 2016; Hughes et al., 2020). Accessing neuroscientific facts and getting training have been pointed as an advantage to confronting misinformation (Ching et al., 2020; Howard-Jones et al., 2009; Macdonald et al., 2017; Papadatou-Pastou et al., 2017). However, although the participants of the current study reported both a high interest in neuroscience and training experiences in the topic, the findings confirm that neuroscience knowledge in educators is roughly similar across the countries, with no clear trend of improvement. As previously suggested (Dekker et al., 2012; Gleichgerrcht et al., 2015; Im et al., 2018), more neuroscience literacy does not necessarily have an impact on preventing belief in neuromyths. Additionally, for Latin American educators, access to quality information may be outdated since most of the science is published in English (Gleichgerrcht et al., 2015; Varas-Genestier & Ferreira, 2017). Although our participants reported mostly access to neuroscientific information through scientific journals, it is essential to note that low-quality information and fake news are widely spread (UNESCO, 2018).

Participants in both groups endorsed more neuromyths related to NDDs than about the general brain. However, endorsement of NDD neuromyths was not predicted by interest in neuroscience or previous training. Yet, significant disparities were observed in the levels of familiarity with the neurodevelopmental conditions investigated (ADHD, ASD, Dyslexia, Dyscalculia, and Down Syndrome). Notably, ADHD exhibited the highest level of knowledge among participants, followed by ASD, while the greatest lack of awareness characterized dyscalculia. These findings are consistent with the participant’s scores on neurodevelopmental neuromyths; the more familiarity, the fewer neuromyths endorsement. It could be argued that this familiarity also relates to the prevalence of the disorder groups. However, although exact rates may vary due to the age of the individuals, the diagnostic criteria and assessment tools used, prevalence studies show that autism and ADHD 5-10% (Francés et al., 2022; Yáñez et al., 2021). Learning difficulties such as dyslexia and dyscalculia also have prevalence rates between 3-10% (Moll et al., 2014; Morsanyi et al., 2018). Thus, the different levels of understanding of neurodevelopmental disorders are unlikely to be influenced by the prevalence rates of these disorders but rather with the familiarity of the disorder group. Indeed, teachers and non-teachers endorsed fewer neuromyths related to NDDs with which they were more familiar. As such, it should be explored in future studies whether providing more knowledge and thus improve familiarity with the NDDs can improve the endorsements of neuromyths related to these NDDs. However, it is important to note that familiarity did not emerge as a significant predictor of accuracy in a prior study (Gini et al., 2021). Conversely, the finding that the type of neuromyth (general vs neurodevelopmental) was a significant predictor of accuracy was similar to the results reported by Gini et al. (2021). The findings suggest that Chilean educational professionals need to be better-informed about NDDs in general and do not necessarily require more neuroscience training.

Our analysis revealed that teachers endorsed significantly more neuromyths about non-specific neurodevelopmental statements compared to non-teachers. Examples of non-specific statements are: “Learning difficulties associated with developmental differences in brain function in children with disorders cannot be improved by education”, “Disorders can be caused by adverse immune reactions to vaccinations”, and “What a child with learning difficulties can understand can be measured by what that child can say”. Notably, teachers expressed a high level of interest in neuroscientific knowledge and considered it relevant to their professional development, and most of them reported experience working with children with SEN. However, their involvement with the topic in terms of training and access to neuroscientific publications was lower (although not significantly) than other professionals. Therefore, although teachers acknowledge the importance of learning about neuroscience, the scarce adequate training and access to up-to-date information might contribute to their susceptibility to believing in neuromyths (Im et al., 2018; Rousseau, 2021).

In recent years fruitful awareness campaigns have arisen about neurodevelopmental disorders that may be linked to the current results, in terms of familiarity of NDDs being linked to fewer neuromyths related to these NDDS. Professionals, families and the neuroatypical populations have greatly endeavoured to increase understanding and acceptance. For example, ASD has been in the spotlight regarding formal training for teachers and the creation of foundations around the world, families being willing to share experiences, the setting of an international awareness day (e.g. https://www.autismspeaks.org/world-autism-month), and ASD being featured in television programmes and movies, where the stereotypical representations are advancing to be overcome (Dean & Nordahl-Hansen, 2022). In Chile, a bill that seeks to guarantee the social inclusion of people with ASD is currently being discussed in parliament and more than 65 civil society organizations have participated in its discussion. Inclusion politics have positively impacted the educational and participation opportunities of people with neurodevelopmental disorders (República de Chile, 2022). Nevertheless, the experiences are unequal and rely upon the effectiveness of the system and the teachers' preparation and attitudes (Gelber Nuñez et al., 2019; Heyder et al., 2020; Martínez & Rosas, 2022; San Martín et al., 2017). Studies have suggested that misinformation may lead to spending time, effort, and resources on ineffective pedagogical strategies (Dekker et al., 2012; Macdonald et al., 2017). Early identification and intervention of neurodevelopmental issues are crucial to enhancing children's quality of life and prognosis (Inguaggiato et al., 2017; Ponce-Meza, 2017); hence relying on misconceptions and stereotypes of conditions may delay or even obstruct interventions. As an example, the idea that all dyslexic people do letter reversals may hinder the diagnosis for those who do not present this sign but do struggle with reading (Macdonald et al., 2017).

On the contrary, the results of this study shed light on the limited familiarity and knowledge surrounding dyscalculia between teachers and non-teachers. The findings indicate that dyscalculia is the least known neurodevelopmental disorder among the surveyed participants. This knowledge gap is concerning, as the low accuracy rates in identifying statements related to dyscalculia suggest a lack of understanding and awareness about this specific disorder. Importantly, this study is the first of its kind to examine neuromyths related to dyscalculia, highlighting the novelty and significance of the findings. Given that dyscalculia can have a profound impact on an individual's mathematical abilities and overall academic performance, the observed less recognition and understanding raises concerns about the support and resources available to individuals with this condition (Beddington et al., 2008; Rahbar Karbasdehi et al., 2019).

As previously stated (MINEDUC, 2013; República de Chile, 2009), inclusion laws and integration programmes have positively increased the access of students with special educational needs in the classroom, which will be reinforced with the new ASD law (República de Chile Diputados, 2021). Thus, most teachers are expected to handle with student diversity in their classrooms. However, the current study shows that teachers as well as non-teachers endorse a number of neuromyths related to these NDDs and that familiarity with the NDDs but not necessarily neuroscience training or interest plays an important role in the endorsement of these neuromyths. As such, it can be argued that all teachers should have access to training related to NDDS as training in neurodevelopmental conditions is mainly saved for special educational needs teachers.

Regarding the limitations of the present study, it is important to recognise that the endorsement of neuromyths cannot be directly associated with practice and educational outcomes (Ferreira & Rodríguez, 2022; Horvath et al., 2018; Krammer et al., 2021), but it has been argued that teachers who endorse them spend time and resources in pseudoscience-based training programmes (Gleichgerrcht et al., 2015), which can guide the implementation of false brain-based strategies in educational practice. Another significant limitation is the small sample size which reduces the generality of the results. In addition, it should be taken into account that the non-teacher group consists of a wide range of professionals as well as students. Thus, this heterogeneity of the group should be considered when comparing it with the teacher group.

Future studies should not only focus on the ability to identify neuromyths but also examine the impact of neuromyths on actual educational practice. For instance, evaluating how neuromyths affect teachers' attitudes towards students with special educational needs (SEN), their choice of interventions, and pedagogical approaches for supporting these SEN students.

To our knowledge, this is the first study exploring beliefs regarding neurodevelopmental disorders in Chile. Our findings highlight the importance of quality information about neurodevelopmental disorders for educators, which adds to a substantial body of evidence of the high prevalence of neuromyths in educators and teachers, highlighting the urgent need for training and awareness campaigns. Finally, it is fundamental to establish interdisciplinary collaboration between neurosciences and education, to translate the knowledge on neural mechanisms of learning effectively, and to impact positively on students.

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Appendix 1

List of Developmental Dyscalculia statements, whether they were True or False

Item	True/False
If a student continues to struggle with maths, it is very likely that they have dyscalculia.	False
Dyscalculic students tend to have problems only with numbers, and they can read and write at typical levels.	False
Students with dyscalculia likely have other learning difficulties.	True
The best way of helping students with dyscalculia is by teaching them to remember numeric data.	False
Students with dyscalculia have difficulties with the whole maths curriculum.	False
The dyscalculic brain is wired differently, which causes maths problems but is often linked with strong points such as creativity, strategic thinking, and intuitive thinking.	False
Dyscalculia is due to a reasoning problem about quantities and the meaning of what numbers represent.	True