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Two Interventions to Improve Knowledge of Scientific and Dissemination Articles in First-Year University Students

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Abstract

The Representations of science in mass media have shown a significant increase in the last years. However, mass media dissemination activities can extend to pseudoscience due to the fact that not all scientific news are published with the same rigour. Thus, we aimed to develop two theoretical-practical interventions among first-year university students with the purpose of improving their knowledge about scientific studies and original scientific sources, as well as to critically analyze dissemination of scientific research in media. The interventions had a positive impact on knowledge about scientific information sources, particularly Pubmed, in addition to reducing the number of incorrect features linked to both scientific and dissemination articles, suggesting the importance of interventions focused on misconceptions. However, students showed knowledge of correct features of scientific articles, independently of our intervention, and they made more mistakes when attributing incorrect features to scientific articles when compared to dissemination ones.

Keywords: scientific sources; dissemination; Pubmed; neuroscience; university students.

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Dos Intervenciones para mejorar el Conocimiento sobre Artículos Científicos y de Divulgación en Estudiantes Universitarios de Primer Año

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Resumen

La representación científica en los medios de comunicación ha mostrado un aumento significativo en los últimos años. Sin embargo, debido a la falta de rigor científico, dicha divulgación por parte de los medios de comunicación podría considerarse pseudociencia. Por ello, el objetivo del presente estudio fue el desarrollo e implementación de dos intervenciones teórico-prácticas en estudiantes de primer año de universidad con el objetivo de mejorar su conocimiento sobre los estudios científicos y sobre las fuentes científicas originales, además de analizar de manera crítica la difusión científica en los medios de comunicación. Las intervenciones mostraron un impacto positivo en el conocimiento de las fuentes de información científica, destacando entre estas Pubmed, además de una reducción en las características incorrectas de artículos científicos y divulgativos, resaltando entonces, la importancia de intervenciones centradas en conceptos erróneos. Sin embargo, los estudiantes mostraron un conocimiento adecuado de las características correctas de los artículos científicos, independientemente de nuestra intervención, y cometieron más errores a la hora de atribuir características incorrectas a los artículos científicos en comparación con los divulgativos.

Palabras clave: Fuentes científicas; divulgación; Pubmed; neurociencia; estudiantes universitarios.

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Representations of science in mass media, including printed and/or broadcasting media, have shown a significant increase in the last years, particularly in the field of natural sciences (O'Connor & Joffe, 2014; Schäfer, 2012). The popularization of science, that is, to disseminate research, can lead to an interesting dialogue between civil society and scientists, and in consequence, it can generate multiple benefits in both directions (Blanco López, 2004; Jensen et al., 2008; Klar et al., 2020). For example, some of the misconceptions that certain part of the society assumes can be corrected (Blanco López, 2004; Illingworth & Prokop, 2017), and citizens distance from science and technology can be shortened (Howard-Jones, 2014; Vasconcelos, 2016). This can lead to a better understanding of science, critical thinking (Eagleman, 2013), and also, promotion of certain social values (Rull, 2014). Moreover, dissemination activities may give rise to higher involvement of population in scientific research (Alamri et al., 2019). This engagement between science and society is not only necessary from a cultural, social and utilitarian perspective (Blanco López, 2004), but it is also an ethical obligation that the scientific community should conduct, taking into account that much research is funded by public resources (Eagleman, 2013; Jucan & Jucan, 2014).

As mentioned above, divulgation of science can provide multiple advantages to society. However, it is important to outline that citizens can take advantage of it depending on the quality of dissemination (Saguy & Almeling, 2008). Unfortunately, not all scientific news are published with the same rigour, some mass media tend to exaggerate results (Saguy & Almeling, 2008), or may not be transparent or accurate enough (Guenther et al., 2017a). Nevertheless, dissemination activities should share not only striking results but also the negative ones or the necessary process to carry out the studies (Resnick, 2014). Some of the reasons behind these problems are that scientific journalism is focused on the most alarmistic findings in order to attract public attention (Saguy & Almeling, 2008) and difficulties encountered when understanding scientific language and processes (Guenther et al., 2017a).

As a result, sometimes, mass media dissemination activities can extend to pseudoscience, that is, a false knowledge masked as science and characterized by a lack of a valid scientific method and reliable evidence (Majima, 2015). It has been suggested that pseudoscience can be assumed as inoffensive based on the premise that society is capable enough to distinguish science from pseudoscience (Cortiñas-Rovira et al., 2015). However, several authors point out that pseudoscientific beliefs and practices are common in nowadays societies (Afonso & Gilbert, 2010; Majima, 2015; Tsai et al., 2015), and some outline the need to discredit these theories not supported with facts or evidence (Majima, 2015).

In recent years, there is a significant enhancement of mass media interest in neuroscience (O'Connor et al., 2012; O'Connor & Joffe, 2014; Racine et al., 2010). There is a tendency to show an excessive optimism about advantages of experimental results (Racine et al., 2010) and/or to over-extrapolate them, reaching conclusions far from the original ones (O'Connor et al., 2012). Likewise, part of the scientific journalism does not usually provide relevant or accurate data about the study they are informing about and around 35% of the news does not include the original source of information (Racine et al., 2010). Particularly in the neuroscience's field, myths about the brain have dangerously increased (Davidson, 2017; Howard-Jones, 2014), being extended also across primary and secondary education, where a significant number of teachers presents false beliefs and myths about the human brain (Dekker et al., 2012; Düvel et al., 2017; Ferrero et al., 2016). It is very alarming that, although neuromyths seem to be more common in people without exposition to neuroscience education –suggesting that specific courses in neuroscience help to reduce these false beliefs– even experts in the field sometimes endorse them (Macdonald et al., 2017a).

Regarding university students, pseudoscience beliefs are less prevalent in this population than in citizens with lower educational status (Macdonald et al., 2017a). However, university students also believe in pseudoscientific claims (Afonso & Gilbert, 2010; Peña & Paco, 2004; Tsai et al., 2015; Tseng et al., 2014). Furthermore, university students misinterpret the data presented in media reports of science, overestimating its analytic ability (Norris et al., 2003). Interestingly, an analytic style of thinking can be a protective factor against pseudoscience, as it negatively contributes to unfounded beliefs (Ståhl & van Prooijen, 2018; van Elk, 2019). Therefore, it may be interesting to encourage critical and analytic thinking among university students. Critical thinking can be developed, for example, by allowing students an autonomous discovery of information (Snyder & Snyder, 2008), promoting class discussion (Hemming, 2000) or instigating intellectual conflicts which can lead to constructive controversies (Johnson & Johnson, 2009). Some efforts to do this can be found in elementary school, where improvements in critical thinking occur as a result of grade transition (Koerber et al., 2015). In higher educational levels, such as university, interventions focused on raising student's critical thinking are reported across different fields of knowledge (Cone et al., 2016; Foster & Lemus, 2015; Holmes et al., 2015; Ngai, 2007; Yazici, 2004). In particular, practical applications of "learning by doing" results positive, leading to higher critical thinking skills (Ngai, 2007; Yazici, 2004). In science, recent findings report that practise in making decisions based on data (Holmes et al., 2015) or introduction of practical exercises (Foster & Lemus, 2015) triggers to significant improvements in undergraduates' critical thinking competence (Foster & Lemus, 2015; Holmes et al., 2015). Regarding health sciences, it is reported that a laboratory curriculum course, which consists of providing formative feedback and clinical reasoning, can also be beneficial in terms of development of critical thinking (Cone et al., 2016). However, the studies mentioned above do not specifically aim to assess the improvement of critical thinking in order to differentiate between pseudoscience and science. Interestingly, the development of an interdisciplinary course on science, in which knowledge about the differences between science and pseudoscience is included, can not only facilitate critical thinking, but also promote engagement in science (Rowe et al., 2015). However, it is interesting to note that despite the alarming neuro-pseudoscientific claims (Davidson, 2017; Dekker et al., 2012; Düvel et al., 2017; Howard-Jones, 2014), as far as we know, there are no theoretical-practical interventions focused on encouraging university students to think critically about the importance of reliable dissemination of neuroscience. Thus, our main objective has been to improve knowledge about scientific studies and its dissemination. For this reason, we have developed two studies among first-year university students with the purpose of improving their knowledge about scientific studies and original scientific sources, as well as to critically analyze dissemination of scientific research in the media. In Study 1, we aimed to know whether students would be able to differentiate between scientific sources and channels used for the dissemination of science news after a theoretical-practical intervention. In Study 2, we aimed to know whether students would be able to understand an original scientific source and to rewrite a research article for its dissemination as a science news after a theoretical-practical intervention.

Materials and methods

Sample and Data Collection

In Study 1, the initial sample was composed of 123 first-year students of Degree in Psychology, average age of 18.62 (range 18-26) (27 men and 96 women). Of this total sample, 108 subjects (87.80%) answered pre-intervention questionnaire, 104 completed the intervention (84.55%) and 73 (59.34%) answered post-intervention questionnaire. From these 73 students, 6 (8.22%) did not participate in the intervention, while the remaining 67 subjects (91.78%) did complete the intervention.

In this first study, our research team developed a pre-post questionnaire (*Questionnaire on reliable sources of scientific information*). This questionnaire was designed for the purpose of this study. It included 19 items in which students should rank different types of sources of scientific information (articles, scientific conferences, books, dissemination Youtube channels, TED talks, podcast, news, TV programs and web pages with non-rigorous information) according to a Likert scale (1 -unreliable source- to 5 -totally reliable source-). They were asked about the reliability of each type of source of information and whether the source of information was familiar to them. The sources of scientific information were previously selected according to the subjective criteria of 5 researchers in the field of neuroscience and behavioural science. These experts classified into low, medium and high reliability each of the items (Table 1).

Table 1
Classification, sources, and examples provided on the Questionnaire on reliable sources of scientific information.

Classification	*Sources*	*Examples*
High scientific reliability	Original scientific sources	Pubmed articles Conferences in scientific congress Books from faculty library
Medium scientific reliability	Dissemination by scientists on the Internet or mass media	Dissemination YouTube channels Dissemination podcasts TED talks
Low scientific reliability	Dissemination by non-experts (for example, journalist), not scientific rigorous, and/or pseudoscientific	Science section of news TV programs about paranormal events Web pages with non-rigorous information

In order to conduct Study 1, we administered the *Questionnaire on reliable sources of scientific information* to students. Once they had responded, they were given indications and theoretical information about reliable sources of information and they were explained the activity they need to carry out. Thus, professors involved in this project explained that they need to work in pairs in order to find a dissemination article, news, podcast, YouTube video etc. about a research finding in neuroscience and its original scientific source. At this point, professors explained how to look for some key information related to the original article in the dissemination source (such as the name of the main author, workplace, scientific journal) and how to use this information to look for in scientific databases. In this study, we emphasized the use of Pubmed, a biomedical and life sciences powerful database. Once they find the original article and both sources of information have been read, students were asked to make an oral presentation in which they should summarize the information presented in the article and they should compare both sources, scientific and dissemination, trying to answer questions about what kind of language (generalized, specialized, formal, informal...) does each source use, how are they structured, which one provides more information, do they include references to other authors who have previously been working in the same field, do the documents present similar results and findings and which document is using generalizations, exaggerations or categorical statements. The students not only presented their own work, but they also had to attend presentations of their peers and participate in a final debate promoted by professors, in which they discussed about scientific dissemination and rigorous interpretation of the original scientific source. Study 1 ended with the administration of post questionnaire (*Questionnaire on reliable sources of scientific information*). This post questionnaire included also questions about their participation in the project and their level of satisfaction (score: lowest satisfaction 0 to highest satisfaction 10).

In Study 2, the initial sample was composed of 120 first-year students of Psychology. Average age of the students was 19 (range 18-44) (26 men and 104 women). Ninety-one students (75.83%) answered the pre-intervention questionnaire, 84 (70.00%) participated and completed the intervention and 86 (71.66%) answered the post-intervention questionnaire. From these 86 subjects, 67 (77.90%) completed intervention, while 19 students (22.10%) did not.

In this second study, our research team designed a pre-post questionnaire for the purpose of the study. The questionnaire is named Questionnaire on knowledge of scientific and dissemination articles. This questionnaire was designed to analyse the importance of different features of neuroscience scientific articles and dissemination articles. The students were asked about how they could describe neuroscience scientific articles and dissemination articles according to a Likert scale (from 1 - not important - to 5 - very important -). The questionnaire included a total of 15 items: 5 items that describe scientific articles, 5 items that describe dissemination articles and 5 items that describe both types of articles (Table 2). The items were selected according to the subjective criteria of 5 researchers in the field of neuroscience and behavioural science.

Table 2
Items of the Questionnaire on knowledge of scientific and dissemination article.

Item	***Type of article***
1. An attractive and striking title	Dissemination
2. A structure divided into different sections, such as introduction, method, results and conclusions	Scientific
3. Graphic material that helps to better understand the written text	Both
4. A specialized and technical language	Scientific
5. An everyday and accessible language	Dissemination
6. A general structure, divided into a title, general body and conclusions	Dissemination
7. Possible applications of the study and future lines	Both
8. An informative and descriptive title for the content of the article	Scientific
9. The intention to inform and entertain at the same time	Dissemination
10. Mention of the researchers of the article and their workplaces	Both
11. Citations and scientific references of previous works	Both
12. A detailed description of the methodology, allowing others to replicate the study	Scientific
13. Use of examples to make the objectives and results of the research understandable	Dissemination
14. Before publication, it is subjected to a process of expert review	Scientific
15. Reported results are obtained in research approved by an ethics committee	Both

In Study 2, we administered *Questionnaire on knowledge of scientific and dissemination articles* in the first place. Then, the students were explained the activity they had to do. In groups of 3 to 4, they had to read a scientific article from the field of neuroscience. This article was provided by professors. The students were asked to write a journalistic article with the aim of disseminating research findings of the article. The document would be concise, readable, and intended to reach a broad audience. The articles selected were in English and with a level of complexity adjusted for first-year students. The students received theoretical information and examples about differences between a scientific article and a dissemination one. They were also instructed to make rigorous science content, providing truthful data and citing the original publication, and using everyday language. Students were asked to make an oral presentation in which they should present a sketch of their dissemination article. Professors would correct and/or guide their work. After corrections, students should present the final project, a template that reproduces the structure of a newspaper article: title, entry, body of the article and photograph, which could be taken from the original publication. Study 2 ended with the administration of post questionnaire, which included also questions about their participation in the project and their level of satisfaction (score: lowest satisfaction 0 to highest satisfaction 10).

Data analysis

Data were analyzed using SigmaPlot 12.5. In Study 1 we analyzed data using a two-way repeated measures ANOVA. Intervention measure (two levels: pre/post) and reliability (three levels: low/medium/high) were considered as within-subjects and between-subjects factors, respectively. Post hoc comparisons were done when significant differences were found using the Holm-Sidak method.

In Study 2 we performed repeated measures ANOVA to examine knowledge of the features of each article across pre and post-intervention measures. Average score on each questionnaire (pre/post) was the main factor. When statistical differences were found, Holm-Sidak method was used as a multiple comparison procedure. Student's *t*-tests were used to assess differences between articles in the score obtained by the students in each intervention measure (pre/post). We used Mann-Whitney Rank Sum Test when normality test failed. Results were considered statistically significant when p<0.05.

Results

Study 1

Regarding the percentage of students who show knowledge of each source of information (dissemination article or scientific article), the two-way RM ANOVA revealed significant effect of the intervention ($F_{(1,16)}$ = 8.549, p=0.010). The reliability ($F_{(2,16)}$ = 3.439, p=0.057) and the interaction between both factors (Reliability x Intervention) were not significant ($F_{(2,16)}$ = 1.606, p=0.231). The post hoc Holm-Sidak method revealed that there were differences between pre and post-intervention measures in the sources assigned to high reliability (t= 2.741, p=0.015) but not in the sources assigned to medium (t= 3.957, p=0.432) and low reliability (t= 1.214, p=0.242). Furthermore, in post-intervention measures, we found differences in students' knowledge of the sources assigned to high and medium reliability (t= 2.950, p=0.025). No differences were found in students' knowledge of the high and low reliability sources (t= 2.218, p=0.078), neither of the medium and low (t= 0.948, p=0.356) (Fig. 1)

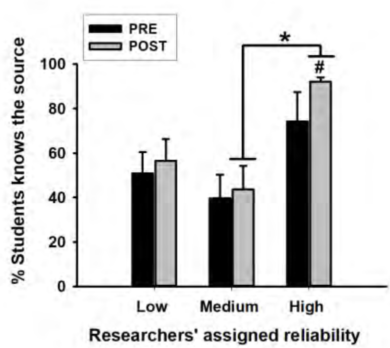

Figure 1. Percentage of students who knows the information source (Mean ± S.E.M). The *x*-axis shows the three levels of reliability assigned by researchers to each

source. Students showed higher knowledge of the sources classified as high reliability in the post-intervention measure compared to the pre-intervention measure (# p =0.015). In the post-intervention, we found differences in students' knowledge of the sources assigned to high and medium reliability (* p=0.025).

Regarding perceived reliability of sources of information (average score), the two-way RM ANOVA revealed significant effect of the assigned reliability ($F_{(2,16)}$ = 14. 198, p<0.001) and intervention ($F_{(1,16)}$ = 8.052, p=0.012). The interaction between both factors (Assigned reliability x Intervention measures) was not significant ($F_{(2,16)}$ = 0.443, p=0.650). Pairwise comparisons with Holm-Sidak method showed that students perceived as with higher reliability the high reliability sources compared with medium (t= 4.634, p<0.001) and low (t= 5.015, p<0.001). There were no differences in the perceived reliability between medium and low reliability sources (t= 0.322, p=0.752), neither between pre and post-intervention measure of each reliability: low (t= 1.233, p=0.236); medium (t= 1.575, p=0.135) and high (t= 2.022, p=0.060) (Fig. 2)

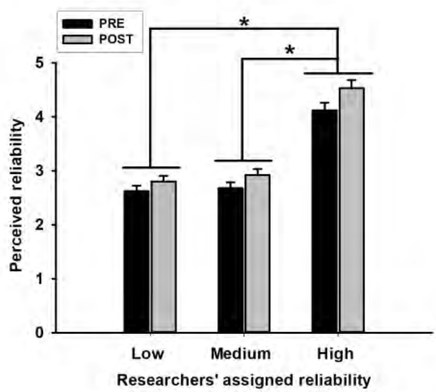

Figure 2. Perceived reliability mean score of sources of information (Mean ± S.E.M). The *x*-axis shows the three levels of reliability assigned by researchers to each source. Students perceived as with higher reliability sources classified as high reliability (* p <0.001).

We decided to look more deeply into the effects of our intervention and explore students' knowledge about a high-reliability source on which we have focused our intervention, Pubmed, and also on one source with low reliability, a TV program. Pre-intervention, 35.185% of our students knew Pubmed while 90.740% of our students knew the TV program. Post-intervention, 87.671% of the students showed knowledge of Pubmed, while the TV program maintained its popularity (93.150%).

Finally, we examined student's level of satisfaction with the intervention. From a total of 67 students who received the intervention, their satisfaction mean was 8.636 with a standard deviation of 1.076 and a standard error of 0.131 (Fig. 3)

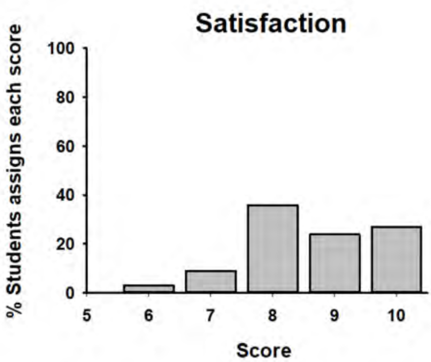

Figure 3. Percentage of students by level of satisfaction with the intervention (score 0: lowest satisfaction, score 10: highest satisfaction). Students showed scores above 6 in their level of satisfaction with the intervention.

Study 2

We examined knowledge of the features of each article across pre and post-intervention measures. Regarding the percentage of correct scores given by the students to the features of scientific and dissemination articles, we found statistically significant differences between the two types of articles in the pre-intervention (t_{179}= 2.343, p=0.020) and in the post-intervention measure (U= 958.500, n_1=67, n_2=67, p< 0.001). Comparisons between pre and post-intervention measures revealed differences in percentage of correct scores for dissemination articles ($F_{(1,65)}$=19.470, $p<0.001$), but not for scientific articles ($F_{(1,66)} = 2.593$, $p=0.112$) (Fig. 4a). When we analysed percentage of incorrect scores given by the students to the features of the questionnaire, we also found differences between the two types of articles in the pre-intervention (U= 2475.000, n_1=90, n_2 =91, $p<$ 0.001) and in the post-intervention (U= 1524.500, n_1=67, n_2=67 p=0.001). Comparisons between pre and post-intervention measures revealed lower percentage of incorrect scores given by the students for scientific articles ($F_{(1,66)} = 31.416$, $p<0.001$) and dissemination articles ($F_{(1,65)} = 84.368$, $p<0.001$) after intervention (Fig. 4b)

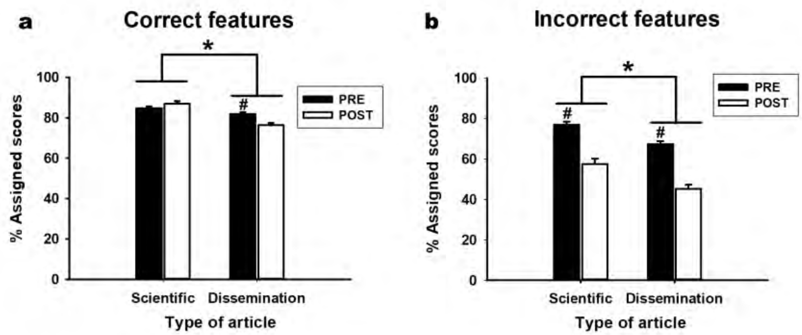

Figure 4. Percentage of scores classified as correct and incorrect given by the students to each type of article in the pre and post-intervention (Mean ± S.E.M). The *x*-axis shows the two types of articles: scientific and dissemination articles. **a.** Percentage of scores given to the correct features of each article. Comparing pre- and post-intervention, there were differences between the two types of articles (* $p<0.05$). Correct scores for the dissemination articles were lower in the post-intervention than in the pre-intervention (# $p<0.001$). **b.** Percentage of scores given to the incorrect features of each article. There were differences between the two types of articles in the pre-intervention and the post-intervention measure (* $p<0.05$). Comparisons between pre and post-intervention measures revealed lower percentage of incorrect scores given by the students for scientific and dissemination articles (# $p<0.001$).

Finally, we examined student's level of satisfaction with the intervention. From a total of 67 students who received intervention, their satisfaction mean was 8.014 with a standard deviation of 1.638 and a standard error of 0.200. 97 % of the students presented a level of satisfaction greater than 6 (Fig. 5)

Figure 5. Percentage of students by level of satisfaction with the intervention (score 0: lowest satisfaction, score 10: highest satisfaction).

Discussion

The aim of the present study was to improve first-year university student's knowledge about scientific studies and its dissemination. Our intervention aimed to enhance their knowledge about original scientific sources, in addition, to encourage critical analysis of scientific research portrayed in the mass media.

In Study 1, we developed a theoretical-practical intervention targeted to first-year university students in which we provided theoretical information about reliable sources of information and how to use scientific database, i.e., Pubmed. Then, first-year university students had to apply the theoretical content to perform the work. In particular, they were asked to select a dissemination article. Then, they needed to find its original scientific source. They should compare information and language used by dissemination and scientific articles. Finally, they participated in a final debate over rigor of scientific dissemination. Moreover, first-year university students were asked to make an oral presentation, in which they had to summarize their work and answer the questions.

The results from Study 1 reveal that our theoretical-practical intervention resulted in enhanced knowledge of high reliable sources of information. We did not find any difference in medium and low reliability sources. Indeed, first-year university students present similar knowledge about these information sources, regardless the degree of reliability, without any specific formation about the scientific and non-scientific sources of information (pre-intervention). Post-intervention, students display a higher knowledge about high reliability sources than medium reliability sources. Moreover, we explored the student's perceived reliability of different sources of information, scientific and dissemination. Our results show that students perceive as higher reliability those sources derived from original scientific resources and consequently classified by researches as "high scientific reliability", such as Pubmed articles or conference in scientific congresses, in comparison with "medium scientific reliability" sources, such as dissemination made by scientists on the Internet or podcasts, and "low scientific reliability" sources, web pages with non-rigorous information or TV programs. These differences in their perception were obtained before and after intervention. In consequence, our theoretical-practise intervention had a positive impact on knowledge about scientific sources of information, but we do not reach an enhancement of the perceived reliability of high reliable sources of information, probably because our sample already presented accurate perceived reliability of scientific and dissemination field.

Some studies address to examine and/or promote accurate discern about reliable and unreliable sources of information, focusing on an accurate use of internet resources (Julien & Barker, 2009; Sanchez et al., 2006). Specifically, it has been reported that secondary schoolers are confused when selecting and using information from internet-based sources in order to solve academic tasks (Julien & Barker, 2009). Indeed, they seem to be unaware of how search sources work and they give low importance to the process of finding information (Julien & Barker, 2009). However, as far as we know, there is no literature that collects precise information about student's knowledge of scientific and non-scientific sources of information in response to specific related training.

University students show high rates of recognition of high reliability sources of information, as some of them use scientific sources for academic purposes (Romanov & Aarnio, 2006). Specifically, in health science university education, searching information from MEDLINE is common at least twice a month for study purposes (Romanov & Aarnio, 2006). Therefore, an accurate perceived reliability of high scientific sources is an academic skill developed during university studies. However, it is important to outline that the knowledge of those scientific sources of information does not guarantee its accurate use (Romanov & Aarnio, 2006). The development of searching skills across high reliability sources has a positive impact not only on the student's scientist career but also in his/her daily life, leading to a better understanding of science (Julien & Barker, 2009). For this reason, it is necessary to include these seeking skills in the student's academic curriculum (Barranoik, 2001; Julien & Barker, 2009; Romanov & Aarnio, 2006). The objective might be not only to inform about the availability of certain high reliability sources of information but also to promote their accurate management. This could be done by including particular training in recognizing and using scientific sources of information, which could also have a positive impact on the student's learning abilities (Sanchez et al., 2006).

Moreover, in Study 1, we aimed to examine two sources of information, one with high reliability, PubMed, and another with low reliability, a Spanish TV program. After the intervention, Pubmed was known better by the students, meanwhile, the Spanish TV program was similarly known. Thus, we can assume that our theoretical-practise intervention resulted in increased knowledge about Pubmed scientific database, which use is highly recommended for future academic and professional purposes. From our point of view, there are several reasons to encourage the development of specific scientific seeking skills through academic studies: there is a large extent of pseudoscientific beliefs related to neuroscience in nowadays societies (Davidson, 2017; Dekker et al., 2012; Düvel et al., 2017; Ferrero et al., 2016; Howard-Jones, 2014); scientific dissemination sources are not accurate and rigorous enough, showing, for example, excessive optimistic conclusions (O'Connor et al., 2012; Racine et al., 2010) or not scientific-based results explanation (O'Connor & Joffe, 2014); and university students are not able to accurately interpret scientific data from mass media (Norris et al., 2003). We are in accordance with several authors that also suggest the need for improving student's abilities of seeking information (Barranoik, 2001; Julien & Barker, 2009; Romanov & Aarnio, 2006). This could have a positive impact on discrediting false beliefs, which is extremely necessary (Majima, 2015), and generating a better understanding of science (Julien & Barker, 2009).

In our intervention, first-year university students were subjected to carry out practical activities –select the dissemination source, find the original source, compare both and elaborate an oral presentation–, being this type of learning known to be positive across a wide range of areas of knowledge, as it is able to encourage student's critical thinking (Cone et al., 2016; Foster & Lemus, 2015; Holmes et al., 2015; Ngai, 2007; Yazici, 2004). As students were asked to perform an oral presentation, they worked on their oral language expression, and more specifically, formal language (Aguilar-tablada, 2001; Villagrán & Harris, 2009). Moreover, as the oral presentation was time-limited, students improved their synthesis abilities, focusing on relevant points, an intrinsic desirable characteristic of scientist communication (Aguilar-tablada, 2001; Villagrán & Harris, 2009). Likewise, as all original scientific articles were written in English, students need to face with this language (Di Bitetti & Ferreras, 2017). Finally, except for the theoretical content teaches gave at the beginning of the project and the clarification of specific doubts, performance of work was autonomous. As a consequence, the intervention could have improved not only their ability to know, locate, understand, synthesize and use information from reliable scientific sources, but also to enhance their understanding of science and to develop their group work skills and autonomous work. However, we cannot ensure these specific effects because we did not include an assessment of the above-mentioned skills.

In Study 2, we also developed a theoretical-practical intervention targeted to first-year university students, but, as a difference, we focused on the development of accurate scientific dissemination abilities. For this purpose, after providing theoretical information about discrimination between scientific and dissemination content, in addition to empathizing on how to maintain rigor and accuracy when transforming scientific information into disseminative, students had to read a neuroscientist article written in English and generate an accurate and rigorous journalistic article.

Our results showed that first-year university students recognize correct features of scientific articles independently of our intervention. However, they made more mistakes when attributing incorrect features to scientific articles when compared to dissemination ones. Therefore, first-year university students recognize better those features that are essential within scientific articles, but they show greater trouble when identifying incorrect features linked to scientific articles in comparison with dissemination content. Similarly, it has been shown that university students may show from average to moderate levels of knowledge, meanwhile, they do not display a lack of misconceptions, that is, wrong ideas about science (Fraim, 2012). Moreover, teachers present false beliefs (Dekker et al., 2012; Düvel et al., 2017; Ferrero et al., 2016; Kaltakçi & Didiç, 2007; Macdonald et al., 2017b), and high rates of scientific knowledge can be also accompanied by misconceptions (Kaltakçi & Didiç, 2007).

Our theoretical-practical intervention did succeed in reducing the number of incorrect features linked to both scientific and dissemination articles post-intervention. This suggests that any academic intervention should pay attention to misconceptions. It has been shown that students may achieve a correct understanding about science but also misconceptions in the same field of knowledge (Nehm & Reilly, 2007). Thus, interventions focused on decreasing misconceptions seem to be essential. Some of them, taken on neurosciences courses, have shown to be beneficial in dispelling brain misunderstandings (Macdonald et al., 2017b). Others have improved neuroscience literacy but have not reduced belief in neuromyths (Im et al., 2018). In accordance with our results, it has been reported that there are not only misunderstandings about how to disseminate science (Guenther et al., 2017b; O'Connor et al., 2012; Racine et al., 2010; Saguy & Almeling, 2008), but also in writing some scientist articles. Thus, it can be interesting to improve students' incorrect understanding of writing science (Downs & Wardle, 2007).

First-year university students were asked to perform a time-limited oral presentation after transforming a scientific article into a dissemination one, with the final aim of writing an accurate and rigorous journalistic article. Thus, our intervention could have improved student's oral and written language abilities and competence in reading manuscripts written in English. In addition, our intervention might have developed group work skills and autonomous work. However, as in study 1, the lack of specific assessment of these skills make impossible to probe their real improvement.

Finally, 84.55% and 70.00% of the students participated in study 1 and study 2, respectively. Students' satisfaction with both activities was very high. Hence, considering that these activities were not mandatory, we achieved high student's engagement. This could result in an enhanced engagement in scientific research, as it was already demonstrated in previous studies after application of courses linked to science (Rowe et al., 2015).

Conclusion

In the first theoretical-practical intervention, focused on scientific and non-scientific sources of information, our results showed improvement of students' knowledge of high reliable sources of information. Our intervention had a positive impact on knowledge about scientific information sources, particularly Pubmed. In the second theoretical-practical intervention, aimed to generate better discrimination between scientific and dissemination articles, students showed knowledge of correct features of scientific articles, independently of our intervention. However, they made more mistakes when attributing incorrect features to scientific articles when compared to dissemination ones. The intervention did succeed in reducing the number of incorrect features linked to both scientific and dissemination articles. This suggests the importance of interventions focused on misconceptions. Participation and satisfaction of first-year university students were very high, which lead us to be positive about further interventions.

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