CHEMICAL VS. NATURAL: COMMON MISCONCEPTIONS

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Abstract

In the era of universal and compulsory education, in which attention is paid to the ability to think scientifically, there should be no room for unscientific views. However, unscientific theories often appear in the media, and they find numerous supporters. Therefore, it was decided to investigate which of the common beliefs about the "chemical vs. natural" pair are believed by Poles. And whether belief in unscientific myths depends on gender, age, level of education or its type. Checking these relationships will allow, inter alia, to evaluate the effectiveness of science education in Poland. Within 4 years, the beliefs of 2,473 people were examined. The obtained results show that the universality of education does not prevent misconceptions. There was also no correlation between the correctness of the answers to the questions on age, gender, education level or its type. It seems that the way science is taught should be completely modified in such a way that students can distinguish truth from myth.
Keywords: *science misconceptions, common beliefs, fake news*

Introduction

Today, in many countries, compulsory education is considered a right for every citizen. It aims to level out the educational differences between citizens and to provide a minimum level of knowledge for all citizens (Universal Declaration of Human Rights art. 26, Convention on the Rights of the Child art. 28). The main goal of the Europe 2020 strategy was also to increase the level of education of Europeans (increasing the proportion of people aged 30-34 with tertiary education in Europe to at least 40%). Recommendation of the European Parliament and the Council of the European Union on Key Competences for Lifelong Learning (2006, 2018) describes in detail what competences Europeans should possess upon leaving school.

One of them is the so-called scientific competence. They refer to the ability and willingness to use existing knowledge and methodology to explain the natural world, formulate questions and draw evidence-based conclusions. In the case of the natural and exact sciences, the necessary knowledge covers the main principles governing the natural world, basic scientific concepts, theories, principles and methods, as well as an understanding of the impact of science and human activity on the natural world. These competences should enable individuals to better understand the benefits, limitations and risks of scientific theories and applications in societies in general (linked to decision making, values, moral issues, culture, etc.). Skills include understanding science as a process of studying nature through controlled experimentation, the ability to use technological tools

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and devices and scientific data to achieve a goal or make a decision, or draw a conclusion based on evidence, and a willingness to give up one's own beliefs if they contradict new scientific discoveries. Individuals should also be able to recognize the necessary features of scientific conduct and be able to express the conclusions and reasoning that led to them. Competences in this area include attitudes of critical understanding and curiosity, respect for ethical issues and promoting both environmental safety and sustainability, in particular with regard to scientific and technological progress in the context of the individual, his family and community, and global issues.

It, therefore, seems that educated people should not believe in unscientific theories. However, despite the fact that in Poland the percentage of people with higher education is 45.7% (for the population aged 30-34) and 21% (for the group of people aged 25-64), many Poles believe in non-scientific, and many of them allow ads to deceive themselves.

International studies on the correlation between scientific knowledge and non-scientific beliefs most often concern the relationship between science and religion. So, i.a. belief in creationism or Darwinism (Allmon 2011; Bishop, 2007; Branch, 2008; Cornish-Bowden & Cárdenas, 2007; Brown, 2010; Plutzer & Berkman, 2008; Williams, 2009) or belief in the origin of the universe (De Carvalho, 2013; Fisher, 2006; Gleiser, 2005). Other non-scientific approaches are studied less frequently - one of them is chemical vs natural opposition (Rozin, et al. 2004; Li & Chapman, 2012; Chouakea & Friedman, 2012). And this problem is very common in everyday life. In colloquial conversations and publicity or ad, we meet the opposition: chemical or natural. However, is this opposition scientifically justified? From a scientific point of view, there is no difference between “natural” and “synthetic” versions of a chemical. Very often people think that “synthetic” chemicals (it means - chemicals made in a lab) are not as good for them as their “natural” equivalent. This is a complete misunderstanding of the basics of chemistry. Chemical molecules have the same properties, whether they were created in a laboratory or in a living organism. It seems strange that after 5 years or more of studying chemistry in school, misconceptions of this type can appear in people's minds. Therefore, it was decided to study the beliefs of ordinary people. It was decided to investigate whether belief in unscientific theories is common among Poles. And whether it depends on the level and type of education, age and gender of the respondents.

The main aim of the study was to check the effectiveness of science education in Poland. It was hypothesized that younger, better-educated people would not believe in unscientific myths. It was also assumed that people with natural science education would choose the correct answers more often than other people.

Research Methodology

To investigate the common beliefs of people about 'natural and chemical': drugs, cosmetics, food preservatives, etc., the research was conducted for a period of 4 years from March 2016 to February 2020.

The attitude of the respondents to 19 common beliefs - myths that often appear in the media was examined. People with secondary education should have no problem separating truth from falsehood. (In Poland, education is compulsory up to the age of 18.)

This article describes only the results of 7 myths about the conceptual opposition:

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chemical - natural. These are the myths:

- All natural substances are healthy,
- Herbs are safer than medicines,
- Brown (cane) sugar is healthier than white sugar,
- Vitamin C helps with colds,
- The homeopathic remedies work,
- All chemicals are harmful,
- You can eat vitamins unlimitedly.

These questions were separated from each other by questions of a different type. The research was carried out in Krakow at the Pedagogical University. The study was attended by participants of open lectures (undergraduate, graduate and doctoral students, participants of 2nd and 3rd age universities, children participating in educational projects at our university), and people associated with them (e.g., family). A study of 2,473 people was conducted.

A questionnaire was used as a research tool. The respondents' task was to find out how much they agree with a given myth. The Likert scale was used as the measurement strategy. Because thanks to it you can get knowledge about the degree of acceptance of given views by the respondents. The survey had five answers: I fully agree, I agree, I have no opinion, I don't agree, I completely disagree.

The surveyed sample reflected the percentage of society in Poland. 62.8% of the respondents were women (which is consistent with the statistical data in Poland, women constitute 58% of students, and at universities of the 2nd and 3rd age they constitute as much as 86%). Most of the respondents were undergraduate (53.0%) and graduate students (28.5%). 12.1% were PhD students. 38.3% of respondents had a humanistic education, 37.3% strict education or technical and 13.5% natural science education.

Research Results

Table 1 summarizes the results of answering the questions. The analysis of the obtained data showed that in three (out of seven questions) the respondents answered incorrectly. And in one question they have no opinion. However, even in the questions where the majority of the respondents give the correct answer, the percentage of wrong and "undecided" answers is high.

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Table 1
Percentage of Answers to Selected Questions (Concerning the chemical / natural opposition).

Investigated myths	Responses of the study participants				
	I fully agree	I agree	I have no opinion	I don't agree	I completely disagree
All natural substances are healthy	11.73	26.20	9.14	35.30	17.63
Herbs are safer than medicines	13.30	34.86	20.30	25.03	6.51
Brown (cane) sugar is healthier than white sugar	22.12	44.36	19.17	9.70	4.65
Vitamin C helps with colds	32.15	49.09	9.83	7.04	1.90
The homeopathic remedies work	5.05	15.00	56.41	12.58	10.96
All chemicals are harmful	4.89	14.56	19.69	41.57	19.29
You can eat vitamins unlimitedly	4.08	9.38	12.05	39.06	35.42

Note: Responses considered correct are shown in bold. The most common answer appears on a grey background.

The most correct answers were given to the question: “You can eat vitamins unlimitedly”. However, even in this case, the percentage of people who disagreed with this opinion is around 25%. The second question with the highest number of correct answers was: “All chemicals are harmful”. However, in this case, as many as 39% of respondents did not indicate the correct answer. The attitude of people who "agree" to people who "strongly agree" is also different (for the vitamin C question it is 1.1 and for the question of the chemicals 2.2). The third question with a greater percentage of correct answers than the others is: “All natural substances are healthy”. However, in this case, the percentage of people not choosing the correct answer is very high (about 47%). In this case, the ratio of people who "disagree" and "strongly disagree" is 2.0. Among the three questions that most of the respondents answered incorrectly, the question "Vitamin C helps with colds" had the most incorrect answers.

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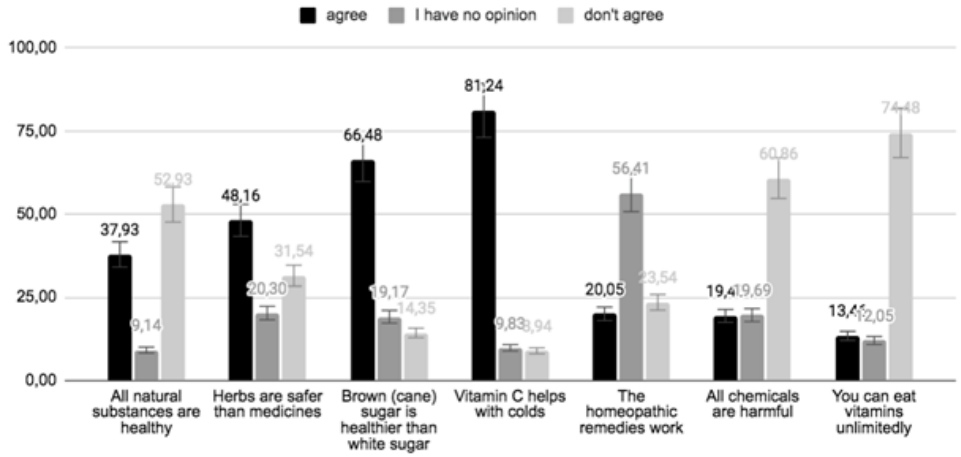
Figure 1

Percentage of Grouped Answers to Particular Questions



Note: (answers "I agree" and "I strongly agree" were grouped with the answers "I agree" and answers "I disagree" and "I strongly disagree" were grouped with the answers "I disagree").

The Spearman coefficient was calculated for the obtained data. In the part concerning the respondents, a moderate, positive relationship between the age of the respondents and their education (r_s = .53) and a weak relationship between sex and the type of education (r_s = .27) were obtained. In none of the seven questions, a correlation was found between the type of answer to the question and gender, age, education, and type of education. It was found moderate dependencies between the answers to the questions:

- All chemicals are harmful: You can eat vitamins unlimitedly (r_s=.46);
- All natural substances are healthy: All chemicals are harmful (r_s=.44);
- All natural substances are healthy: Herbs are safer than medicines (r_s=.41).

Weak relationships were found between the answers to the questions:

- All natural substances are healthy: You can eat vitamins unlimitedly (r_s=.34);
- Brown (cane) sugar is healthier than white sugar: Herbs are safer than medicines (r_s=.26);
- Brown (cane) sugar is healthier than white sugar: Vitamin C helps with colds (r_s=.26);
- All chemicals are harmful: Herbs are safer than medicines (r_s=.26).

No correlation was found between the answers to the remaining questions (Table 2).

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Table 2
Spearman's Coefficient for Individual Pairs of Questions

	All natural substances are healthy	Herbs are safer than medicines	Brown (cane) sugar is healthier than white sugar	Vitamin C helps with colds	The homeopathic remedies work	All chemicals are harmful	You can eat vitamins unlimitedly
All natural substances are healthy		**.41**	.18	.08	.14	.44	.34
Herbs are safer than medicines	.41		***.26***	.17	.19	***.26***	.17
Brown (cane) sugar is healthier than white sugar	.18	.26		***.26***	.14	.11	.04
Vitamin C helps with colds	.08	.17	***.26***		.13	.03	-.05
The homeopathic remedies work	.14	.19	.14	.13		.16	.14
All chemicals are harmful	**.44**	***.26***	.11	.03	.16		.46
You can eat vitamins unlimitedly	***.34***	.17	.04	-.05	.14	**.46**	

Discussion

The results obtained show that, in the opinion of the general public, there is a belief that natural substances are superior to synthetic (chemical) substances in terms of effectiveness and safety in human health matters, although this is not true. Toplis (2002) obtained similar results to those obtained in these studies. It seems that the influence of the media promoting products containing the so-called natural substances as pro-health products have a great influence here. For example, Valkenburg et al. (2016) write about the power of the media on human attitudes and beliefs.

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However, no influence of the degree of education or its type on the beliefs of the research participants was noticed. Similar results, i.e., the lack of influence of the level of education on people's attitudes (in this case, regarding climate change), describe Funk (2017) in the article *How much does science knowledge influence people's views on climate change and energy issues?* Similar research results were obtained by Impey et al. (2012). It seems that the summary of the considerations in the article "Belief, Knowledge, and Science Education" (2001, p. 349) still remains valid: "... we must shed light on this subject from a variety of sources — theoretical and empirical, philosophical and psychological — to advance our understanding of knowledge and beliefs and their influence on science learning".

Perhaps the explanation of the facts of belief in unscientific myths, despite the acquired scientific knowledge, can be found in the laws of Jost (1897). Although these laws were made a long time ago, it seems they are still valid today.

The first law states: *As time goes on, the power of associations of the elders weakens more slowly.* So, after many years, a person remembers the original associations associated with a given concept. So, for example, non-scientific explanations of parents or grandparents or information from advertising. That is why it is so important that the first explanation that a child meets in the process of environmental education is correct.

The second law states: *If two associations are of equal strength but one is older than the other, then the repetition will favour the older association more*.

This law also indicates the importance of the first connotations associated with a given concept. As the first associations with natural phenomena remain in memory for the longest time, their improper shaping may lead to a negative transfer at later stages of education and misconceptions in adulthood.

Conclusions and Implications

The obtained results indicate that a large percentage of the society does not have basic knowledge about the health properties (or harmfulness) of natural and synthetic substances. Despite the fact that in the Polish core curriculum for Nature, Biology and Chemistry, we can find many topics related to this issue. For example: In the core curriculum for elementary school for the subject Nature there is an entry: the student describes the effects of substances harmful to health, recognizes poisonous plants and poisonous animals. The core curriculum for Biology includes the entire section on "Chemistry of life", where attention is drawn to the lack of distinction between substances of natural origin and synthetic substances - obtained in a laboratory. And in the section "Digestive system and nutrition" is discussed, inter alia, digesting sugars and using vitamins. In the core curriculum in Chemistry, in the section "Chemical substances of biological importance", the properties of the substances that are the main components of everyday products are described. And in the section "Water and water solutions", the student performs calculations using, among others, concepts: solubility, percentage concentration. Therefore, it seems that after completing primary school education, the student should acquire knowledge that would allow him to correctly answer the questions asked in the questionnaire. However, as the results show, this is not the case.

The obtained results are a big challenge for people responsible for education, including teachers. The results show that non-scientific ideas are widespread among peo-

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ple and resistant to standard teaching methods. The question then arises: How and what to teach students to become informed citizens who vote / choose wisely on science and technology?

There seems to be some action to be taken to combat unscientific myths and to ensure that scientific thinking is at the heart of our teaching. Policy makers and curriculum developers must ensure science education as early as possible in kindergartens or primary education. False, unscientific perceptions instilled by the media or parents and naturally occurring in younger children will be very difficult, if not impossible, to correct at a later date. Curriculum makers and policymakers should also introduce a discussion and explanation of the most damaging anti-science myths into curricula.

Children in kindergartens and schools should be taught the 'scientific reasoning', for example by making extensive use of the IBSE or learning to discuss and argue. Teachers should be given the tools to combat unscientific theories, as well as a way to deal with those who hold such views. Scientists should be more involved in educating the public. They should avoid inappropriate and imprecise language; they should react when unscientific myths appear in the media. Working together can help prevent science misconceptions.

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