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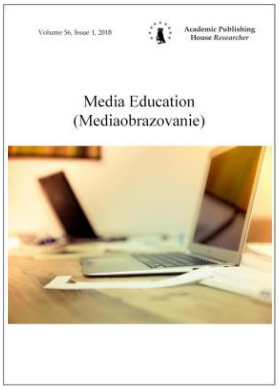

Assessment of the Level of Students' Scientific Literacy in Ukraine in the Media Literacy Context

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Abstract

This paper focuses on the students' media use for the search of scientific information. Theoretical methods were used in the work: generalization and analysis of scientific sources. To study the students' scientific literacy, the survey was used (n = 678 students). Its results were interpreted with the methods of analysis, specification, and classification. The study found out that the media have a powerful and contradictory influence on students' scientific literacy. The level of trust of Ukrainian students to science and its sources was revealed. The sources of scientific information (YouTube channels, including popular science channels; blogs; Wikipedia; popular science books and journals; Facebook and other social networks; popular science programs on TV; mass remote online courses; news sites; peer-reviewed scientific journals; websites of scientific organizations and universities; popular science radio programs) were identified and the disparities in understanding and trust to different information sources have been highlighted. By testing the level of students' trust in pseudoscientific statements, the general level of their scientific literacy has been described. The article reveals difficulties in the perception of scientific information, the reasons for the search for scientific data, the topics of scientific research that are most of interest for students. The results of students' self-assessment of the level of their scientific literacy were also recorded.

Keywords: scientific literacy, scientific community, scientific information, pseudoscience, source of information, media literacy.

1. Introduction

In 1985, the British Royal Society published a report "Public Understanding of Science" to show the relationship between science and the public. This report and subsequent research (Eurobarometer, 1991; Miller, 1991) confirmed that, although scientific content was important for solving all social problems, scientific literacy was insufficient: the public was not interested in science, had no knowledges of it and was skeptical about research (Miller, 1996). Therefore, to promote science, the program "Public Understanding of Science" was launched. In this program, scientific communication with the public was given a key role, and the "popularization" of science was to take place through the diffusion of information from the researchers to the public. This information had to deliver scientific literacy to a wide audience (Gregory, Miller, 1998).

The scientific community (a system of scientific teams, organizations and institutions that interact with each other and are communicatively connected both with each other and with the economy, education, politics, culture, etc.) is responsible for creating a scientifically literate society. Nowadays, media researchers have focused on tools, channels, and techniques for scientific

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communication, such as media relations (Serong et al., 2017), online communication (Metag, Schäfer, 2017). Press releases have been found to be a key tool in university media orientation (Serong et al., 2017). At the same time, the opportunities for dialogue with the public provided by social media are insufficiently used; instead, according to some scholars, the information strategies with almost no feedback predominate (Schäfer et al., 2019).

Scientific literacy plays a significant role in the social and educational context of society. General education, science education, and scientific literacy are associated with greater political and religious polarization (Drummond, Fischhoff, 2017). It is extremely important to understand that scientific literacy includes an assessment of the role of science; understanding its scope and significance; trust in science. Scientific literacy is not just an individual asset, but a public resource that predetermines the solution of global and local socio-economic, cultural, demographic, environmental and other problems. Scientifically literate people are interested in science and can consciously talk, listen, write, and read about science, interpret scientific information; follow instructions; state a purpose for scientific search; put forward persuasive arguments, explanations, formulate clear descriptions and definitions. It allows to draw argumentative conclusions, make decisions, follow, and participate in public discussion of controversial issues of science and technology. Such people are also able to formulate a public request for scientific research. It has also been proved that scientific literacy and economic growth have been working together (Hanushek, Woessman, 2016). In addition, scientific literacy is an understanding of the difference between scientific findings and personal subjective opinion. But scientific literacy requires continuous updating and confirmation, as the rate of new knowledge increases rapidly.

In today's world scientific information pours continuously from social media, TV, books, and from the growing number of new devices. Social media give access to scientific information and provide greater public engagement with science. Online video-sharing has created great opportunities for professional and amateur authors to reach large and diverse audiences. The media play significant role in scientific literacy formation, considering the main requests of the modern mass audience to scientific information:

- entertainment: dynamic multimedia series, high-quality web modeling technologies, etc.;
- emotionality: unexpected comparisons, metaphors and examples, humor, spontaneous and even eccentric remarks;
- emphasis on personalities: in the focus of their life stories and successes;
- interactivity: active interaction between the translator and the consumer of information (Emelyanova, 2018: 136).

The lack of scientific and media literacy leads to the dissemination of pseudoscience – misinformation that its proponents present as scientific, but it is not, and the uncritical use of questionable or erroneous data. Pseudoscience does not meet the standards of science (criticality, reliability, reproducibility). Meanwhile, information overload can harm society too, even if the information is evidential, especially when the content of such information is highly specialized, and it is not intended for a wide audience that cannot adequately interpret it.

The aim of this article is to discuss:

1) the concept of scientific literacy, as well as its manifestation it in the social group of students;

2) the degree of students' interest in science;

3) the main sources of scientific information and how scientific literacy relates to the students' media use.

2. Materials and methods

At first theoretical method of generalization of scientific sources was used in the work. To study the students' scientific literacy, the survey was used. Its results were interpreted with the methods of analysis, specification, and classification.

Procedure. From November 2020 to February 2021, we surveyed Ukrainian students on their interest, trust to science and media use for their access to scientific information. The survey was tested on the Printing and Publishing Institute of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" before launch. The google-form was distributed to students of 8 Ukrainian universities by their lecturers, found in Facebook groups "Ukrainian Scientists Worldwide", "Education. Science. Technology. Innovations", "Higher School and Science of Ukraine: Disintegration or Blossoming?" The online survey was accessed by respondents using various devices.

A total of 678 respondents took part in the survey. The survey contained 19 questions, including open-ended ones. Most questions had ready-made answers, of which for 10 questions respondents could choose more than one answer (multiple choice questions).

Students of 1–6 courses took part in the survey: 1st year – 141, 2nd year – 125, 3rd year – 123, 4th year – 101, 5th year – 99, 6th year – 89. The students of following specialties were involved: 03 "Humanities", 05 "Social and Behavioral Sciences", 06 "Journalism", 07 "Management and Administration", 10 "Natural Sciences", 12 "Information Technologies", 15 "Automation and Instrumentation", 18 "Production and Technology", 22 "Health care", 29 "International Relations".

The students of 8 Ukrainian universities participated in the survey: National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv National Economic University named after Vadym Hetman, Bogomolets National Medical University (Kyiv), Zhytomyr Ivan Franko State University, National Aviation University of Ukraine (Kyiv), Pirogov National Medical University of Vinnytsia, Taras Shevchenko National University of Kyiv, Chernivtsi National University named after Yuriy Fedkovych.

3. Discussion

There is an extensive literature about scientific literacy and on the importance of its improving. The term "scientific literacy" was coined by P. Hard, a professor at Stanford University, who saw in it the unity of the following components: understanding the essence of science and knowledge of its basic concepts; awareness of the need for ethical regulation in science; interaction between science, technology, and society (Hurd, 2000). R. Bybee and B. Mccrae defined scientific literacy as the skill to use scientific knowledge, identify scientific issues and use scientific evidence in daily life (Bybee, Mccrae, 2006). Scientific literacy involves "understanding of scientific terminology and concepts; scientific enquiry and practice; and the interactions of science, technology, and society" (Jarman, McClune, 2007: 3).

In general definitions proposed by scientists can be conditionally divided into three groups: a) definitions that emphasize the need to master scientific knowledge for everyday activities; b) definitions where scientific knowledge is prioritized to achieve personal, professional, and social success; c) definitions that emphasize the popularization of science.

We understand scientific literacy as the ability to analyze, interpret, construct, and critique texts within the discourse of science. Our results are consistent with prior research (Pearson et al., 2010), and prove that scientific literacy helps people to be more competent and confident in dealing with everyday issues, such as healthcare. So, it is important to have both scientific and media literacy skills (the ability to critically analyze the content of various media for accuracy and reliability).

Some people consider science as abstract and distant from daily life. But this imaginary "distance" can be a barrier to engagement and involvement in science. S. Norris and L. Phillips have identified four main components associated with scientific literacy. They are following: 1) knowing what science is and how science differs from non-science, 2) knowledge needed for participating in science-related social issues, 3) awareness of risks and benefits of science, and 4) critical thinking about science (Norris, Phillips, 2003). Every individual is demanded to have scientific literacy including scientific knowledge, scientific process skill, and scientific attitude (Fakhriyah et al., 2017). The connection between the old and new information, together with new conclusions as the consequences of intellectual activity, improve scientific literacy (Bellová et al., 2017).

R. Laugksch differentiates the micro and macro views of scientific literacy. The micro view is related to the immediate benefits for people, the macro view includes the benefits of scientific literacy for the whole society (Laugksch, 2000). At the micro-level, scientifically literate people have the skills and confidence to make science-related decisions, which often involves interpreting scientific information in the media (Nordheim, et al., 2019). Scientifically literate people may be more supportive of science and, importantly, engaged with democratic decision-making about science-based issues (Yacoubian, 2018). At the macro-level, a scientifically literate society can provide the supply for individuals with skills needed for scientific research.

On one hand, scientifically literate individuals feel confident and competent to deal with everyday science- and technology-related issues; they are in a favorable position for new job opportunities; and enjoy the intellectual and moral benefits that scientific literacy gives

(Yacoubian, 2017). On the other hand, scientifically literate public can contribute to the economic well-being, provide support for science domains, have realistic expectations from science, contribute to democratic decision-making, and benefit society in the context of interaction between science with culture (Laugksch, 2000). So, developing scientific literacy is "not solely an individual process, but one that is situated in various social contexts" (Washburn, Cavagnetto, 2013: 128).

Scientific literacy depends on trust to science. Prior research confirms the thesis that popular online information sources may poorly separate facts from opinions (Brossard, 2013), perhaps due to a lack of gatekeepers (Shapiro, Park, 2015). The main aspects of trust in science include trust in the scientific knowledge itself (accumulated scientific knowledge); trust in the actions of scientists (conscientiousness, self-criticism, validity, logic); trust in the scientific methodology (learning procedure); trust in scientific institutions (universities, institutes, expert teams, etc.) (Shtompka, 2015). The problem of trust in science is closely related to the researcher – the subject of scientific activity, with his ideas about the ethics of scientific work and the desire to follow the accepted norms, which, according to R. Merton, include universalism, communism, disinterestedness, organized skepticism (Merton, 1973).

Universities now play a central role in the creation and dissemination of scientific knowledge in the world. However, a study of corporate sites of five Ukrainian universities, included in the ranking of QS World University (Kharkiv National University named after Karazin, Kyiv National University named after Taras Shevchenko, National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kharkiv Polytechnic Institute, Sumy State University), confirmed that their information content lacks a holistic picture about science. The chronological period of monitoring covered 2016–2017. It was found that out of 2289 news items, only 335 publications (14.6 %) talked about scientific discoveries and informed about activities related to scientific topics.

There were mainly reports from meetings of scientific councils, presentations of scientific publications, stories about the participation of students, and teachers in various scientific events. Of the news content, extracurricular topics predominated (854 publications out of 2289). Most news was about amateur art competitions, sports competitions, visits to university officials, the activities of volunteers, etc., but not about science (Sadovnychy, 2017).

Students understand science (issue, concept, theory etc.) only if they see how a constellation of facts relevant to the subject are related to one another (causally, explanatorily, etc.). As a result, "the object of understanding is always a body and never a single piece of information" (Huxster, 2017: 4). Students need not only facts, but also methods of cognition. That is why it is important to implement independent work, investigation, and observation in the educational process, not just a passive perception of information (Veselovský, Gnoth, 2001).

It is crucial for the formation of scientific literacy of students to create scientific media texts. Writing about science gives opportunities to propose, promote, and revise knowledge and to practice in different genres (forms/functions) of writing. Integrating science, writing, and reading results in a more engaging, purposeful, reflective, efficient, and effective approach, which improves comprehension, understanding, and academic writing (Yore, 2012).

In students' communities, scientific literacy is not only equal to the amount of knowledge of members of this community, but is complemented and enriched or, on the contrary, limited by the exchange of information between members of this community.

4. Results

At first, we asked respondents to choose answers from a linear set of responses that increase or decrease in intensity or strength. In this way we received answers to four questions: "Are you looking for scientific information purposefully?", "Do you agree that there can be no restrictions on what scientists are investigating?", "Do we need scientific research, the results of which cannot be immediately put into practice?", "Should scientists listen more to the public about needs for scientific research" (Table 1). This Likert scale has five choices that start at one end with "strongly agree" and end at the other with "strongly disagree," with neutral answer in the middle of all points.

The answers to the next question "Do you read scientific articles from your specialty?" were distributed as follows: yes, Ukrainian and foreign authors, including articles in English – 45.1 %; yes, but only Ukrainian authors' articles – 17.7 %; I do not read, because I do not need it and I am not interested – 14.2 %; yes, but only Ukrainian and Russian authors' articles – 9.7 %; I do not read because I have no time – 8.8 %; I do not read, because I do not know how and where to find articles – 4.5 %.

Reading scientific articles from their specialty, students faced the following problems (respondents could choose more than one answer): lack of open access articles – 69.6 %; insecurity of information, complex vocabulary – 40.3 %; not sufficient level of their English – 36.3 %; outdated lists of literature to articles – 32.5 %; questionable scientific value – 30.4 %; inconsistency of article content and its headline – 19.6 %; illogical presentation – 16.7 %; I do not want to read, but teachers require –20,5 %. Only 2.9 % of respondents have not faced any problems. 4th, 5 th and 6 th year students also noted that they do not trust scientific information if the list of literature at the end of the scientific article contains only Ukrainian-language resources, if non-fiction books predominate among sources, if the authors use ideas without specifying the source.

Table 1. Distribution of the Likert scale responses, %

Question	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Are you looking for scientific information purposefully?	9.7	20.4	46.9	21.2	1.8
Do you agree that there can be no restrictions on what scientists are investigating?	36.3	37.2	15.9	10.6	0
Do we need scientific research, the results of which cannot be immediately put into practice?	18.6	65.2	14.2	2.1	0
Should scientists listen more to the public about the needs for scientific research?	15.9	49.6	16.8	17.7	0

The students answered that they understand information best from the following sources (respondents could choose more than one answer): YouTube channels, including popular science channels – 77,0 %; their teachers' lectures – 65.2 %; textbooks – 51.3 %; blogs – 46,9 %; Wikipedia – 45.1 %; popular science books and journals – 45.1 %; Facebook and other social networks – 44.0 %; popular science programs on TV – 41.6 %; mass remote online courses – 38.1 %; news sites – 37.2 %; visiting museums, exhibitions, zoos, national parks, reserves, etc. – 37.2 %; peer-reviewed scientific journals – 32.5 %; websites of scientific organizations and universities – 24.8 %; scientific events (conferences, scientific seminars, etc.) – 23.9 %; popular scientific events (science days, scientific picnics, etc.) – 10.6 %; popular science radio programs – 6.2 %. It is consistent with the results of S. Ferraro et al., who proved that the visual experience of videos is a powerful tool for science education and engagement (Ferraro et al., 2019).

Among the popular science sites and groups on Facebook students named AIN.ua, Alpha Centauri, Archaeology. News, Antonov, Astronomy in ua, BBC. Science, Bank of Lectures, Batrachos, Aroundbotany, Damn Rationalist, Kunsht, Microbe and I, Interesting Science, etc. The respondents also noted benefits of popular scientific events, such as the Festival "Arsenal of Ideas", telegram channels (AlphaCentauri – about the Universe, The Damn Rationalist – about critical thinking and refutation of fakes, Laboratory mouse – about science in Ukraine and the world, MedGoblin – about fakes in medicine), etc. The effects of popular science sources on audience result in participation in scientific discourse (Shapiro, Park, 2015) and more positive perceptions of scientists (Brewer, Ley, 2017).

When asked which sources students trust the most, the following answers were received (respondents could choose more than one answer): peer-reviewed scientific journals – 57.0 %; textbooks – 55.8 %; popular science books and journals – 49.6 %; their teachers' lectures – 44.0 %; visiting museums, exhibitions, zoos, national parks, reserves, etc. – 31.9 %; YouTube channels, including popular science channels – 30.1 %; scientific events (conferences, scientific seminars, etc.) – 26.5 %; websites of scientific organizations and universities – 24.8 %; Wikipedia – 20.4 %; mass remote online courses – 12.7 %; popular scientific events (science days, scientific picnics, etc.) – 12.7 %; popular science programs on TV – 7.8 %; news sites – 7.1 %; Facebook and other social networks – 6.2 %; blogs – 5.3 %; popular science radio programs – 1.8 %. Some students noted in comments that media environment creates mass consumer of media information with fragmentary and uncritical perception of content. So, they need books that personify science: fictionalized biographies of scientists, allowing to show the social psychological, ethical problems that accompany scientific research, the relationship between science, practice and education.

Table 2 shows disparities in understanding and trust to different sources of scientific information. The largest disparities are between the level of understanding and trust for the online popular science sources: YouTube channels (77.0 % and 30.1 %, respectively); blogs (46.9 % and 5.3 %); Wikipedia (45.1 % and 20.4 %); social networks (44.0 % and 6.2 %); popular science programs on TV (41.6 % and 7.8 %); mass remote online courses (38.1 % and 12.7 %); news sites (37.2 % and 7.1 %).

Table 2. Comparative table of understanding and trust to the sources of scientific information, %

Source	Understanding	Trust
YouTube channels, including popular science channels	77.0	30.1
Teachers' lectures	65.2	44.0
Textbooks	51.3	55.8
Blogs	46.9	53.0
Wikipedia	45.1	20.4
Popular science books and journals	45.1	49.6
Facebook and other social networks	44.0	6.2
Popular science programs on TV	41.6	7.8
Mass remote online courses	38.1	12.7
News cites	37.2	7.1
Visiting museums, exhibitions, zoos, national parks, reserves, etc.	37.2	31.9
Peer-reviewed scientific journals	32.5	57.0
Websites of scientific organizations and universities	24.8	24.8
Scientific events (conferences, scientific seminars, etc.)	23.9	26.5
Popular scientific events (science days, scientific picnics, etc.)	10.6	12.7
Popular science radio programs	6.2	1.8

Among the reasons why students are looking for scientific content, the students named the following (respondents could choose more than one answer): to check the facts – 68.1 %; because of my curiosity – 65.2 %; for studying, on the recommendation of teachers – 55.8 %; for studying, when required by teachers – 46.9 %; for writing my own scientific papers – 30.1 %; to solve everyday problems – 28.3 %; scientific content finds me alone – 23.9 %.

The survey showed that students are interested in the following topics: information technologies – 51.3 %, sociological research – 46.9 %, history – 46.9 %, space exploration – 45.1 %, medicine – 44.2 %, ocean – 40.3 %, fauna and flora – 36.3 %, psychology – 34,1 %, art – 33.6 %, climate changes – 32.5 %, technologies – 31.9 %, specialty – 31.0 %, nanotechnology – 21.2 %, geography – 16.7 %, literature – 15.9 %, ethnology – 12.7 %, philosophy – 10.6 %. Among the most interesting scientific information that students have encountered recently, they named the results of scientific research on coronavirus, genetics, astrophysics, biochemistry, nuclear energy, vaccination, ornithology, art studies, gender studies, neuromarketing, microbiology, computer simulation of physical phenomena, artificial intelligence etc.

Students' scientific literacy skill was measured by the test. The test instrument consisted of false sentences about science that were used to measure aspects of scientific knowledge and competence. To find out the approximate level of scientific literacy of students, we selected pseudoscientific statements for which students had to express their point of view. 51.3 % of students responded that none of these statements are true. Instead, 23.9 % believe that the mite is an insect, 20.4 % – that antibiotics treat viral infections, 16.7 % trust homeopathy, 10.6 % trust horoscopes and astrologers, 6.2 % strongly oppose vaccination, 2.1 % believe that electrons are larger than atoms. Senior students (4–6 years of studying) have shown a higher level of scientific literacy than students of 1–6 courses. If more than 60 % of the respondents believe in the truth of pseudoscience among the students of 1–3 courses, then for senior students the percentage decreases to 29 %.

Students who do not consider any of the pseudoscientific theses to be true have demonstrated a high level of trust in science and trust primarily peer-reviewed scientific content. Their understanding of science may help them to participate in ongoing debates about science.

When asked what helps students understand scientific information, the following answers were received (respondents could choose more than one answer): breaking information into small semantic fragments (86.7 %), video format (69.9 %), infographics (57.5 %), interesting examples (51.6 %), emotional statements, dialogue (49.6 %), storytelling (43.8 %), audio format (23,0 %), interesting headlines (19.5 %), comic book genre (18.6 %). 77,0 % of respondents can understand sketches, diagrams, models, tables, charts, maps, pictures, and graphs to reveal relationships between the concepts and data and can evaluate them.

As the main criteria of the reliability of scientific information the students identified the following: the source of information (87.6 %), argumentation of theses and conclusions (81.4 %), peer-reviewing (57.5 %), availability of statistical data (54.0 %), critical assessment of the data (49.6 %), "fresh" scientific data (46.5 %), logical presentation of the material (41.6 %), citation of authoritative scientists (40.7 %), the conciseness (26.5 %), compliance with the language norm (14,2 %), presence of formulas and calculations (13.3 %), refutation of generally accepted scientific statements (8.8 %), sensationality of information (6.2 %), a large number of concepts (1.8 %).

Engagement with science can lead to information overload and difficulties for some students in finding reliable sources. This is partly because anyone can create media content and get direct access to potentially large audiences.

Answering the question about the mission of science in society, students mentioned the following aspects: to ensure social well-being and progress (90.3 %), to warn about the risks (61.9 %), to refute pseudoscience theses (54.9 %), to raise the intellectual and cultural level (44.0 %).

The last question made it possible to collect information on students' self-assessment of the level of their scientific literacy. 77.0 % of the respondents do not share dubious content; 69.9 % are able to separate scientific information from subjective points of view, prejudice, advertising, manipulation; 65.2 % verify dubious scientific information; 59.3% are interested in and understand popular science content; 54.9 % use to compare previously known information with new scientific achievements; 50.4 % can participate in conversations about science; 38.1 % know where to look for reliable information; 19.5 % teach others to choose scientific content. At the same time, 13.3 % do not distinguish which sources of scientific information are reliable and do not even try to identify them.

5. Conclusion

Scientific literacy creates the perceptions of the world, form conditions for perception and understanding of innovation; provides the basis for effective, scientifically, and socially justified management decisions about the prospects for the development of all areas of public life; ensures the economic growth; promotes socialization; influences the choice of communication strategies; helps to motivate young people to do research. Scientifically literate people understand the essence and importance of scientific achievements for their personal and professional lives.

Scientifically literate students can identify a valid scientific argument, evaluate sources of information, the use and misuse of scientific information, understand research methodology and find out how it impacts scientific findings. Science representation is also important because models, analogies, graphs, figures, students' projects improve understanding.

Our results prove that young people enter the universities with certain experiences and stereotypes. Meanwhile the fact that senior students show a higher level of scientific literacy proves that professional education can change stereotypes and misunderstanding scientific facts, incorporated into mindset. So, the education system, libraries, museums, media are responsible for improving the scientific literacy. The survey shown that among the reasons that reduce the level of scientific literacy of students, lack of time, educational overload, lack of motivation.

The set of scientific literacy skills includes ability to formulate questions, to think analytically, to visualize and report summary data, to be able to collect data from different sources and evaluate them, to inform and persuade others about science ideas, and to participate in the public debate about science.

There is a synergy between the interest in scientific information and professional learning. So purposeful integration science education with media use results in a complementary understanding of both science beyond the scope and within the scope of future specialty. A special and important role should be played by YouTube channels, including popular science channels; blogs; popular science books and journals; Facebook and other social networks; popular science programs on TV; mass remote online courses; news sites; websites of scientific organizations and universities; popular science radio programs. Extremely important for increasing scientific literacy are peer-reviewed scientific journals as a source of reliable scientific information.

The examination of the scientific literacy level of university students indicated that the focus should be directed toward the ability to identify reliable scientific information and interactive participation from educational perspectives. From the popular scientific content students expect novelty, originality, accessibility, and at the same time scientific convincing. It is also important not to contrast the availability of information for perception and its scientific value and validity.

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