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RESEARCH ARTICLE

The impact of article title on the interpretation of scientific research: a randomized trial

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Aims: Interpretation and comprehension of the available health information may be a difficult task for the public, since previous studies have shown that understanding scientific articles can be difficult for lay people. This study aimed to determine whether title incongruence with the conclusions of the study affects readers' interpretation and understanding of the read content.

Methods: We conducted a randomized trial via an online survey using abbreviated summaries of two scientific articles (named "Breakfast" and "Music" trial groups), each of which had a title congruent or incongruent with the conclusion. The participants were adults (n=283), women (81.6%), aged over 30 (53.7%) and with higher education (77.4%); 149 participants took part in the "Breakfast" group, and 134 participants took part in the "Music" group. The primary outcome was text comprehension measured by a correct answer to the question about the conclusion in the summaries.

Results: In both trial groups, we found no differences in answer to the questions about whether the title was congruent or incongruent with the conclusion of the summaries. In the "Breakfast" group, an essential predictor factor for a correct answer was a higher score on knowledge dimensions, while in the "Music" group correct answer predictors, except higher scores on knowledge dimensions, were family physician and search of domestic health websites as sources of health information. Finally, the knowledge score was the only predictor in the overall logistic regression model, where data from both groups was merged (Cox & Snell R^2=0.32).

Conclusion: The title does not affect making of conclusions based on scientific information, which means that people rely on the read article content or some other part of the article other than the title itself.

Trial registration: https://osf.io/4f6se

Keywords: health literacy; health information; information translation; randomized trial; research articles; scientific literacy

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Introduction

The availability of health information on the Internet and online literacy have made it possible, not only for doctors but also for patients to become an essential part of public health and take part in health decision-making [1, 2]. Ease of use, usefulness, and credibility are important predictive factors that will condition the acceptance of health information sites depending on consumers' knowledge about health [3]. At the same time, the quality of available resources on the Internet could be questionable while social media takes a leading role in disseminating health information, and searching for information on the Internet influences the patient's decision-making [4, 5]. Scientific websites, which offer substantial, evidence-based information, are rarely visited by lay audiences since most articles require a university degree level to read a scientific paper, due to the difficulty of understanding and interpreting the presented results [6, 7]. The reading strategy and scientific skills processing develop slowly throughout an academic career [8]. Previous studies point out that greater comprehension of health information by consumers is achieved by avoiding complicated graphics [9, 10]. The title is the primary way to spark readers' interest in an article in a digital environment informing the reader of the article composition itself [11, 12]. Titles can be descriptive or indicative, without detailed disclosure of the main result of a research paper; declarative, containing article conclusions; or interrogative, in a form of a research question [13]. The length and the structure of the title enable better understanding and conveyance of the article content to the reader [14, 15]. However, declarative titles sometimes do not reflect the context of the whole text and incongruent and misleading titles which fail to state the main findings in an understandable and meaningful way, are also found among scientific articles [16]. The efficacy of Internet use for public health is still generally insufficiently researched and there are a lot of knowledge gaps, especially about trust and credibility related to internet-based health-related information and utilization of that information [17]. A previous study showed that common errors in lay comprehension of medical documents are inaccurate interpretation of findings and misunderstanding of the purpose of the trial [18]. Therefore, evidence comprehension plays an important part in decision-making among lay population.

We investigated whether lay readers could correctly interpret information about the results of scientific research based on the congruency between the article title and the article summary. Our hypothesis was that misleading titles would lead readers to incorrect conclusions about the contents of the article.

Participants and methods

Study design

We conducted a randomized controlled trial (RCT) using an online survey system in which we used two scientific article summaries that contained information on topics relevant to a wide range of consumer audiences [19, 20]. The initial scientific abstracts were modified as follows; translated into Croatian, and written in a form of a brief description of a scientific article under 400 words, consisting of four paragraphs on the second page: "What is

this about?", "What did researchers do?", "What are the results of the research?", "What does this mean and what is the conclusion?". The abstracts were written in plain language without technical scientific terms so that they would be understandable to general population.

Participants

Data collection was performed from July to September 2021. Participants were adults ≥18 years of age collected through the list of Patient Associations in Croatia (http://193.198.242.10/dataset/popis-udruga-pacijenata) who completed an online survey. The email invitation containing the survey link was sent by one of the authors (MB), to each patient association individually. The recipients were kindly asked to forward the invitation to their members.

Interventions

Upon opening the survey link, the participants were instructed that they will be presented with a text about scientific research and that they should read it carefully since they will be asked about the content. They were also instructed that, after they read the article, they will not have the option to go back to read it again. On the next page, one abstract with one of the two topics was randomly assigned to each respondent. However, each of abstracts had two forms; where the title is congruent with the conclusion of the abstract and the form in which the title is incongruent to compare them with each other as we tried to condition the understanding of the read content with the incongruent title, resulting in four possible trial arms. The content, demographic data, and questions about summaries were on separate pages, and on each page was only the "next page" button, without going back to the "previous page" button to avoid participants re-reading the content. Each arm within trial group had the same concept of the abstract, and the differences were in the compatibility of the title with the conclusion and knowledge and conclusion questions depending on the topic of the text whether it was a "Breakfast" group or "Music" group. The reason for conducting multiple groups on the same topic was to determine the presence and reproducibility of the effect (if it exists) across different contexts, which would pose greater evidence for the conclusion.

Group 1: Breakfast

Title congruent with the conclusion: Eating a healthy breakfast is associated with a higher quality of life compared to skipping breakfast: a survey.

Title incongruent with the conclusion: Eating any kind of breakfast is associated with a higher quality of life compared to skipping breakfast: a survey.

Group 2: Music

Title congruent with the conclusion: Learning with music does not increase the number of learned words compared to learning without music: experimental research.

Title incongruent with the conclusion: Learning with music does increase the number of learned words compared to learning without music: experimental research.

Randomization

This was a four-arm double-blinded trial, and, as summaries were submitted in the form of an online survey, the participants were randomized when opening the survey by SurveyMonkey program (Momentive, Dublin, Ireland). In this manner, each respondent got one version of an abstract and was answering the questions about their own assigned topic (Breakfast of Music) of abbreviated articles in Croatian. The sample was distributed randomly when opening the survey since the survey program was evenly distributing the participants so that in each of the four arms there was an equal number of participants with minimal deviations.

Primary outcome measures

The primary outcome was the accuracy of interpretation of the article conclusion, which was measured by a single question at the end of the questionnaire, on which a participant could answer correctly or not (binary variable). To "mask" this question, at the end of the survey, we asked participants two additional questions about the content of the text, one before and one after the conclusion question. Those two questions served as distractors.

Secondary outcome measures

The questionnaire had three parts – abstract, demographic data, and knowledge questions about the summaries. Each of the summaries had congruent and incongruent title forms, and knowledge and concluding questions about the content of the text.

Knowledge score was formed as a sum of correct answers to the technical questions of the article. For each summary there were three questions, do the participants' score could range from 0 (all incorrect) to 3 (all correct).

Demographic characteristics of the participants

We also examined demographic data using questions about their gender, age, education level, the primary source of health information, and internet sources to determine where and how they find health information. These questions were identical for all four groups of questionnaires:

1) Gender;
2) Age in years;
3) Education: Elementary, High school, currently enrolled in university, College graduate, University graduate, doctoral degree;
4) The primary source of health information: Internet, family and friends, books, family doctor;

5) Internet sources: First page provided by an Internet search engine, forums, hospital websites, local specialized websites, international specialized websites (e.g., Cochrane), scientific articles in a database (e.g., PubMed), emails to physicians on Internet websites.

Blinding

Participants were asked to participate in a survey about their way of searching for health information and inferences about scientific research. The participants were blinded to this study design because questionnaires were randomly assigned to the participants during the entry into the ques tionnaire via the survey link (https://help.surveymonkey.com/articles/en_US/kb/Block-Randomization) and they were unaware that there were two different topics with the congruent and incongruent title.

Sample size

Based on the data from the previous study [6] we expected that the proportion of participants who will have a correct conclusion in the congruent (control) title arm will be 0.75 and that in the incongruent group, the proportion will be 0.45. With the alpha error of 0.05 and 80% power, we calculated that we would need 48 participants per arm.

Data analysis

Categorical data are presented as the frequencies and percentages and numerical data are presented as the medians (Md) with interquartile range (IQR). The differences between arms within the same group were tested using the chi-squared test for categorical variables and Mann Whitney test for numerical variables. In the second part of the analysis, we performed three logistic regressions (one for each group, and one where we merged the data from the two groups) to assess which characteristics predict that the person would give a correct conclusion of the article summary. The results of the logistic regression are presented as the odds ratios (ORs) and the regression coefficient is expressed as Cox and Snell R^2. The level of statistical significance was set at 0.05 (5%). All analyses were performed using JASP v.0.15.0.0 (JASP Team, 2021). The full dataset available in the **Appendix**.

Results

In total, 149 participants (81.2% women) took part in the “Breakfast” group, and 134 participants (82.1% women) took part in the “Music” group, and the proportion of women was similar across arms (**Figure 1**, **Table 1**).

The age distributions were similar across arms, except for the Congruent title in the “Breakfast” group, where the median age of participants was below 30 years (**Table 1**). The proportion of highly educated participants, if students were included, was around 70% across arms (**Table 1**). In general, participants stated they were searching for information via websites in their mother tongue: hospital websites and local specialized websites (**Table 1**).

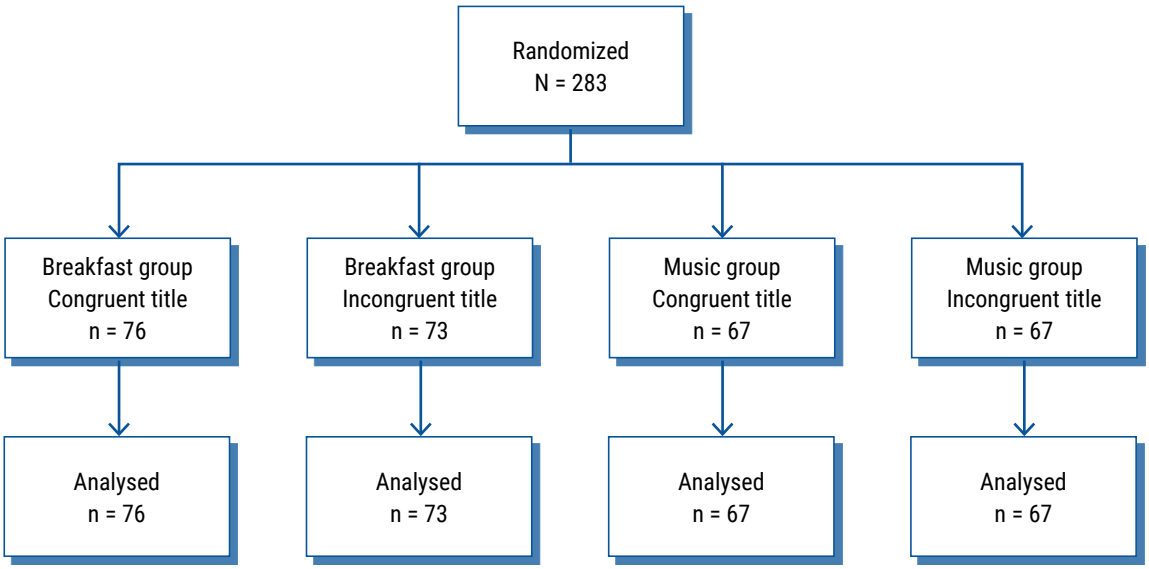

Figure 1. Flowchart of the participants in groups "Eating a healthy breakfast is associated with a higher quality of life compared to skipping breakfast: a survey" and "Learning with music does not increase the number of learned words compared to learning without music: experimental research" across titles congruent and incongruent with the content of the group summary; resulting in four arms.

Table 1. Demographic characteristics of the participants in groups Breakfast ("Eating a healthy breakfast is associated with a higher quality of life compared to skipping breakfast: a survey") and Music ("Learning with music does not increase the number of learned words compared to learning without music: experimental research")*

Scenarios / Variables	Group: Breakfast		Group: Music	
	Incongruent title (n=73)	Congruent title (n=76)	Incongruent title (n=67)	Congruent title (n=67)
Women (%):	63 (86.3)	58 (76.3)	56 (83.5)	54 (80.6)
Age (Md, IQR):	38 (27 to 49)	28 (22 to 47)	36 (25 to 47)	35 (24 to 53)
Education (%):				
Elementary	3 (4.1)	2 (2.6)	1 (1.5)	0 (0.0)
High school	18 (24.7)	16 (21.1)	15 (22.4)	21 (31.3)
Currently enrolled in university	8 (11.0)	22 (28.9)	13 (19.4)	16 (23.9)
College graduate	8 (11.0)	2 (2.6)	10 (19.4)	5 (7.5)
University graduate	34 (46.6)	33(43.4)	26 (38.8)	23 (34.3)
Doctoral degree	2 (2.7)	1 (1.3)	2 (3.0)	2 (3.0)
The primary source of health information (%):†				
Internet	62 (84.9)	63 (82.9)	44 (65.7)	55 (82.1)
Family and friends	35 (47.9)	30 (39.5)	16 (23.9)	23 (34.3)
Books	29 (39.7)	27 (35.5)	21 (31.3)	34 (50.7)
Family doctor	43 (58.9)	41 (53.9)	48 (71.6)	47 (70.1)
Internet sources (%):†				
The first page is provided by Internet search engine	18 (24.7)	24 (31.6)	18 (26.9)	25 (37.3)
Forums	22 (30.1)	30 (39.5)	19 (28.4)	27 (40.3)
Hospital websites	28 (38.4)	29 (38.2)	12 (17.9)	27 (40.3)
Local specialized websites	28 (38.4)	37 (48.7)	22 (32.8)	24 (35.8)
International specialized articles	26 (35.6)	20 (26.3)	13 (19.4)	18 (26.9)
Scientific articles	27 (37.0)	19 (25.0)	21 (31.3)	14 (20.9)
Email to physicians on Internet websites	7 (9.6)	0 (0.0)	0 (0.0)	1 (1.5)

*Md – median, IQR – interquartile range.
†Multiple entries allowed.

We found no difference between groups in either of the groups in knowledge about the content of the summaries or questions related to the conclusions of the text (**Table 2**). However, additional analysis showed what were the predictors of the correct conclusions in the text.

Table 2. Comparison of knowledge scores and conclusion answers in the groups Breakfast ("Eating a healthy breakfast is associated with a higher quality of life compared to skipping breakfast: a survey"" and Music ("Learning with music does not increase the number of learned words compared to learning without music: experimental research") between the arm where the title was congruent with the conclusion and the arm where the title was incongruent

Variables	Group: Breakfast (n, %)		*P**
	Congruent title (n=51)	Incongruent title (n=48)	
Conclusion question: Eating any breakfast is healthier than skipping breakfast (correct answer False, n (%) of correct answers)†	21 (43.8)	27 (52.9)	0.360
Correctly answered knowledge questions:			
0	6 (11.3)	5 (8.9)	0.540
1	15 (28.3)	10 (17.9)	
2	11 (20.8)	15 (28.8)	
3	21 (39.6)	26 (46.4)	
Distractor questions:			
The research findings are valid for adolescents but not for other age groups (correct answer true, n (%) of correct answers)†	29 (64.4)	37 (72.5)	0.393
The research shows that healthy eating habits have a direct effect on stress and depression symptoms (Correct answer False, n (%) of correct answers)†	1 (2.0)	5 (9.8)	0.102
Variables	**Group: Music**		***P****
	Congruent title (n=44)	**Incongruent title (n=40)**	
Conclusion question: Participants remembered greater amounts of words when learning with music compared to without music (False, n (%) of correct answers).‡	27 (65.8)	23 (60.5)	0.624
Correctly answered knowledge questions:			
0	4 (9.1)	5 (12.5)	0.965
1	12 (27.3)	11 (27.5)	
2	14 (31.8)	12 (30.0)	
3	14 (31.8)	12 (30.0)	
Distractor questions:			
Participants liked learning in a situation with music compared to the situation without music (correct answer False, n (%) of correct answers)‡	23 (56.1)	14 (36.8)	0.087
By the information in the text, participants could choose which music they wanted to listen to. (Correct answer False, n (%) of correct answers)‡	27 (68.9)	26 (68.4)	0.808

* Chi-squared test for categorical variables.
† 3 answers missing.
‡ 7 answers missing.

In the assessment of the participants who answered correctly the questions related to breakfast, the only significant predictor was the knowledge scores about the article (OR=3.85, 95% 1.92 to 7.56, P<0.001). Overall, the model explained 35% of the variance of the results (R^2=0.35, P<0.001) and is presented in **Table 3**.

Table 3. Logistic regression model for predicting whether participants answer correctly on the conclusion about the abstract describing the importance of healthy breakfast

Variables	Odds ratio	95% confidence interval		*P*
		Lower	Upper	
Intercept:	**0.00**	**0.00**	**0.53**	**0.026**
Female gender:	2.92	0.52	16.32	0.221
Age:	1.02	0.97	1.06	0.644
Education (reference: Elementary school):				
High school	0.38	0.02	6.50	0.503
Currently enrolled in university	3.33	0.12	92.43	0.478
College graduate	0.71	0.03	15.44	0.828
University graduate	0.98	0.06	15.56	0.988
PhD	0.20	0.00	11.69	0.436
Primary source of health information:				
Internet	2.23	0.37	13.45	0.382
Family and friends	1.29	0.29	5.71	0.738
Books	2.25	0.67	7.50	0.187
Family doctor	1.18	0.34	4.07	0.791
Internet sources:				
First page provided by Internet search engine	0.56	0.13	2.47	0.443
Forums	0.27	0.07	1.07	0.062
Hospital websites	0.91	0.28	3.00	0.878
Local specialized websites	0.84	0.24	2.87	0.778
International specialized articles	1.39	0.34	5.61	0.648
Scientific articles	0.29	0.06	1.46	0.133
Email to physicians on Internet websites	5.31	0.17	164.65	0.340
Knowledge score:	**3.85**	**1.92**	**7.56**	**<0.001**

In the assessment of the participants who answered correctly to the question about conclusion related to music significant predictors were lesser reliance on family doctor (OR=0.01, 95% CI 0.00 to 0.23, P=0.005), more frequent search of domestic websites specialized for health (OR=100.24, 95% CI 3.11 to 3228.50, P=0.009) and higher scores on knowledge dimension (OR=5.79, 95% CI 1.28 to 26.23, P=0.023). The model explained around 40% of the variance (R^2=0.42, P<0.001) and is presented in **Table 4**.

Table 4. Logistic regression model for predicting whether participants answer correctly on the conclusion about the abstract about music and learning.

Variables	Odds ratio	95% confidence interval		*P*
		Lower	Upper	
Intercept:	**0.61**	**0.00**	**265.3**	**0.872**
Female gender:	1.01	0.04	23.8	0.994
Age:	0.99	0.90	1.10	0.953
Education (reference: High school):				
Currently enrolled in university	9.76	0.28	344.33	0.210
College graduate	4.66	0.09	238.04	0.443
University graduate	0.86	0.04	19.54	0.924
PhD	6.03[8]	0.00	Infinite	0.993
Primary source of health information:				
Internet	0.54	0.01	23.3	0.747
Family and friends	1.95	0.17	22.6	0.595
Books	0.32	0.04	2.62	0.285
Family doctor	**0.01**	**0.00**	**0.23**	**0.005**
Internet sources:*				
First page provided by Internet search engine	1.80	0.14	23.14	0.652
Forums	0.05	0.00	1.47	0.083
Hospital websites	18.08	0.72	451.46	0.078
Local specialized websites	**100.24**	**3.11**	**3,228.5**	**0.009**
International specialized articles	22.46	0.02	30,683.05	0.398
Scientific articles	42.16	0.49	3.625.60	0.100
Knowledge score:	**5.79**	**1.28**	**26.23**	**0.023**

CI – confidence interval.
*Email to physicians was excluded from the analysis because variance was 0.

In the overall model, where we merged data from both groups to determine the overall predictors of correct conclusions about the abstract, the only significant predictor was knowledge score (OR=2.25, 95% CI 1.47 to 3.45, P<0.001) which explained abound 30% or the variance of the results (R^2=0.32, P<0.001). The model is presented in **Table 5**.

Table 5. Joint logistic regression model for predicting whether participants answer correctly on the conclusion question

Variables	Odds ratio	95% confidence interval		*P*
		Lower	Upper	
Intercept:	0.04	0.00	1.09	0.057
Female gender:	1.70	0.64	4.53	0.288
Age:	1.01	0.98	1.03	0.648
Education (reference: Elementary school):				
High school	0.32	0.03	3.88	0.369
Currently enrolled in university	1.44	0.10	20.24	0.789
College graduate	0.71	0.05	9.85	0.795
University graduate	1.32	0.11	15.42	0.825
PhD	0.82	0.04	17.83	0.900
Primary source of health information:				
Internet	2.31	0.63	8.48	0.208
Family and friends	1.02	0.43	2.40	0.974
Books	1.41	0.63	3.15	0.401
Family doctor	0.84	0.38	1.87	0.666
Internet sources:				
First page provided by Internet search engine	0.60	0.24	1.48	0.272
Forums	0.58	0.24	1.36	0.211
Hospital websites	1.15	0.48	2.76	0.745
Local specialized websites	1.15	0.49	2.69	0.751
International specialized articles	1.98	0.77	5.09	0.155
Scientific articles	0.47	0.17	1.28	0.142
Email to physicians on Internet websites	1.65	0.11	24.13	0.715
Knowledge score:	2.25	1.47	3.44	**<0.001**

Discussion

Our study showed no significant differences in the frequency of incorrect conclusions about the content of a study summary depending on whether the title was congruent or incongruent with the content. This means that the uptake of the take-home message of the read content was not affected by a misleading title. This is the first study to compare the impact of the article title and the understanding of the content, and it elaborates upon the previous study that compared readers' comprehension and preferences for different presentations of finding, framing, and numerical data [21].

Even in the context of our well-educated sample, the proportion of correct answers did not exceed 70% in any of the trial arms, and the knowledge score was the only significant predictor of the correct conclusion. This finding may indicate that people do not give sufficient attention to the overall text, but are probably skim readers, processing information superficially, which could potentially lead to incorrect conclusions. These

findings could be interpreted in terms of the clickbait phenomenon of headlines in an online environment and significant impact on the performance of a headline to provoke readers intention but will not condition the comprehension of the text [11]. Our findings also revealed that the Internet is the most frequently used source of medical information for participants and family doctor takes second place. Earlier studies have shown that a physician's opinion is the most reliable source of information, despite nowadays Internet availability [22]. Information on the Internet may influence the consultation with doctors because people will find information on the Internet useful and avoid consulting a doctor if they are satisfied with the found information [23]. Another possible reason why the Internet takes first place is that searching for information on the Internet allows patients to be better informed and can influence more efficient physician-patient communication because they can comment on the found information with their doctor [24]. Local specialized websites and forums were reported as the most used sources while international specialized articles (Cochrane) and scientific articles (PubMed) with high-quality health information were reported as rarely used. The complexity of scientific articles (written in technical jargon) makes it difficult for laymen to understand the content [9]. That is why laymen prefer reading other people's posts on for forums which provide users with virtual support and a sense of empathy through sharing stories [25]. The incentive to search for health information varies among people depending on their interests which should condition the development of websites to adapt to the needs of the audience [26]. Study participants who searched for information on the Internet using local websites specialized in health performed better by answering conclusion questions, but that effect was found only for Music trial arm, so it cannot be understood as strong evidence. Consumers who seek health information online are more familiar with the online environment and presentation of health information online [27-29]. Because the Internet is still the most popular source for health information, further efforts should be made to bring evidence-based medicine, with high-quality health information, closer to readers.

There are several imitations of this study. The median age of the participants in this study was below 40 years. The results could have been different if the larger proportion of older people (e.g., over 60 years) had been included in the study. The elderly prefer other sources of information such as friends and family members over the internet [30, 31]. Furthermore, by disabling the "previous page" button, it may seem that we made our study more artificial. However, we wanted to simulate a situation in a real world where people read articles superficially and then make conclusions. We did not want people to understand the content by re-reading the same article multiple times, but to form the conclusions based on the information they remember. That is why the proportion of correct answers is lower than in similar studies [6]. In future studies researchers may decide to allow participants to re-read the article. On top of that, we may hypothesize that if the topic was very interesting or important to participants, they would pay more attention, and then the proportion of correct answers would be bigger. However, we took neutral and everyday topics, which would be relevant to participants, to resemble newspaper articles available to large groups of people. In future studies, text with greater emotional valence can be used. Our study's sample was composed of predominantly women (80%) and highly educated participants (around 70%). Highly educated participants are more likely to better

understand what they read than low educated participants, so our results might be more applicable to highly educated individuals. Understanding of health information depends on educational status, those who have completed only primary school usually have a poorer understanding of information compared to those with higher education status [31]. However, in the overall logistic regression model, education was not a significant predictor of accurate conclusion, but only knowledge about the content of the summary. This can be explained by the fact that most of the participants in our study were highly educated individuals. Therefore, we propose that in future studies researchers employ educationally more diverse sample, to control for this finding. Finally, the summaries were modified to be more comprehensible to the lay audience, since we would expect that laymen do not read scientific articles but take information from other sources, with simpler expressions, which is later confirmed when asked about their preferred sources of information.

The congruency of the title does not seem to affect the making of conclusions based on the summary read by the laymen. Future research should explore which part of the text readers rely on the most when reading a scientific article.

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