# Can Media Literacy Intervention Improve Fake News Credibility Assessment? A Meta-Analysis

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The analysis scripts have been made publicly available via the Open Science Framework (OSF) and can be accessed at: https://osf.io/a3fch/.

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## Abstract

Fake news impacts individuals' behavior and decision-making while also disrupting political processes, perceptions of medical advice, and societal trends. Improving individuals' ability to accurately assess fake news can reduce its harmful effects. However, previous research on media literacy interventions designed for improving fake news credibility assessments has yielded inconsistent results. We systematically collected 33 independent studies and performed a meta-analysis to examine the effects of media literacy interventions on assessing fake news credibility (n=36,256). The results showed that media literacy interventions significantly improved fake news credibility assessments (Hedges' $g$=0.53, 95%CI [0.29, 0.78], $p$<.001). Gaming interventions were the most effective intervention form. Conversely, the intervention channel, outcome measurement, and subject characteristics (age, gender, and country development level) did not influence the intervention effects.


*Keywords:* Media Literacy; Intervention; Fake News; Meta-Analysis

## Introduction

Globally, the internet is an important source of information. The Pew Research Center survey conducted in 2021 found that 67% of Americans acquire news from social media.[1] Further, the "post-truth" era has arrived, in which people no longer care about the truth and only want to see what they want,[2] leading to the explosive growth of fake news, particularly surrounding the US Elections[3] and COVID-19.[4] This phenomenon is also considered an "infodemic."[5] In addition, the spread of fake news can result in the loss of credibility for public institutions and increased mass panic, violent tendencies, and other adverse outcomes.[6–8] Even after correcting the misinformation, the consequences of fake news continue to influence individuals' perceptions and actions.[9]

### Overview of Fake News

*Fake news* is fabricated content that mimics traditional news and is spread consciously to serve the interests of specific entities or people.[10,11] A common strategy for measuring the credibility of fake news is to present participants with a series of real or fake news items and ask them how credible each item is. Studies have analyzed fake news using measures of the attitude and credibility of fake news materials.[12,13] Since individuals' misconceptions about fake news may lead to more serious consequences, this study focused on the ability to assess the credibility of fake news using a fake news credibility assessment.

Various factors may influence individuals' assessment of the credibility of fake news, which can be categorized as personal, informational, and environmental. Personal factors, including cognitive ability,[14] emotions,[15] personal traits,[16,17] and political identity,[8,19] can significantly affect individuals' beliefs in fake news. In terms of informational factors, the fluency of information,[20] importance of information,[21] and source of information[22] influence individuals' beliefs about fake news. Regarding environmental factors, the echo chamber effect and social media filter bubbles are the main influences on individuals' acceptance of and belief

in fake news.[23–25]

Current approaches to combat fake news include debunking, increasing government regulation, improving social media structures, and enhancing individual capacity. Studies on debunking have focused on improving the effectiveness of rebuttals by emphasizing the benefits to the information's recipients[26] and providing alternative explanations.[9] Regarding increasing government regulations, some countries have enacted legislation to address fake news.[27] Improving the social media structure is primarily focused on improving detection algorithms,[28] adding warnings,[29] and crowdsourced judgments.[30] However, social media improvements have not effectively addressed the changing forms of fake news. More consideration has been given to enhancing individuals' capacity to respond to fake news, and media literacy interventions have gained attention as particularly successful measures.[31,32]

**Media Literacy and Fake News Credibility Assessment**

*Media literacy* is the active inquiry and critical thinking about the messages received and created[33] and is not limited to a single medium, rather representing skills essential for working, living, and participating in society.[34] For some time, the concept of media literacy has been acknowledged as a beneficial strategy for effectively navigating the current era of media ubiquity.[35]

Social cognitive theory can explain how media literacy improves the ability to assess fake news. According to this theory, individuals' knowledge, beliefs, attitudes, and values can influence how they receive and interpret media information.[36,37] By improving their media literacy, individuals can better understand and interpret media information and improve their ability to assess fake news.

Another relevant theoretical perspective is an audience's acts on the authentication model.[38] According to the model, individuals initially encountering suspicious news on social media first develop "internal authentication behaviors," which involve using personal

judgment and experience to consider the source and its credibility along with characteristics of the news content, key indicators of media literacy, implying that increased media literacy will improve the ability to assess fake news.[39]

Furthermore, selective exposure, relevant in the context of media literacy and fake news,[40] suggests that individuals tend to seek information that aligns with their existing beliefs and attitudes, potentially reinforcing confirmation bias.[41] Media literacy can help individuals recognize their own biases and actively seek diverse perspectives, challenging their preconceived notions. By consciously exposing themselves to various viewpoints and critically analyzing information from different sources, individuals can mitigate the impact of selective exposure and enhance their ability to assess fake news.

*Media literacy intervention* is the process of developing media literacy skills and aims to promote awareness of the influence of media and develop an active attitude toward both the consumption and production of media.[42] Motivated and analytic reasoning are two widely accepted influences on an individual's belief in fake news.[43,44] Media literacy interventions are more effective through analytical reasoning. Individuals with a higher level of media literacy are more capable of analyzing, critiquing, and responding to information,[45] so they are likely to experience lower costs associated with analytical reasoning. Their ability to discern the truth more efficiently reduces the time and effort required. When the cost of analytical reasoning is minimal, individuals can accurately assess fake news, even if it aligns with their pre-existing beliefs. This finding underscores the importance of media literacy in mitigating the negative effects of fake news.[46] For instance, McGrew aimed to teach 11th-grade students three strategies with eight courses: Who is behind this information? What is the evidence? What do other sources say? The students' ability to discover reliable sources improved in the posttest.[47] The "Bad News" game designed by van der Linden et al. let users take on the role of a fake news producer and learn techniques commonly used in producing fake news.[12] After this 10-

minute intervention, participants showed increased awareness of fake news. However, the relationship between media literacy and fake news credibility assessment remains unclear.[48,49] The effects of media literacy interventions may even be counterproductive by making one question their ability to assess the facts.[50] Additional evidence is required to evaluate whether media literacy interventions effectively improve the assessment of fake news credibility.

**Potential Moderators**

Many study characteristics influence intervention effects and can be measured across three levels. The first level comprised intervention characteristics, including the intervention form, time, and channel. The form of intervention, currently including course,[47] games,[12] video,[51] and graphic interventions,[52] may impact the effects of media literacy interventions. The courses were structured educational programs for teaching specific knowledge or skills, games were interactive activities for entertainment or educational purposes, videos were visual and audio media presenting information or entertainment, and graphics combined text and images to convey information or ideas. Game interventions have been found to achieve better intervention effects than other forms of interventions in a relatively short period through increased cognitive engagement.[53,54] They provide personalized learning experiences that accommodate diverse learning styles and preferences in the realm of media literacy.[55,56] By integrating elements such as decision-making, problem-solving, and critical thinking within the gaming context, participants are more than passive recipients of information but active contributors to their learning process.[57,58] This participatory aspect is particularly relevant for fostering a deep understanding of media literacy concepts and instilling a sense of empowerment in individuals to navigate complex media landscapes. Generally, intervention effects improved as interventions increased in time,[59] although short interventions have shown promising results.[29,60] Therefore, this study analyzed the differences in effect sizes across intervention time, classified as short or long (i.e., short < 1 h, long ≥1 h). The intervention

channel influences the intervention effects. Previous studies have indicated that online interventions are better than offline interventions.[61] Therefore, this study analyzed differences in intervention effects based on the channel of delivery. Additionally, most current interventions lead to a decay in their effects over time.[62] Therefore, we analyzed whether the intervention effect decreased over time.

The second level of moderators was the individual characteristics of participants. Age may lead to differences in intervention effect. For example, older adults are more susceptible to fake news,[63] while intervention effects may be inversely associated with age. Therefore, this study analyzed age differences in intervention effects. Some demographic backgrounds also influence intervention effects, including gender and country.[64,65] This study analyzed differences in intervention effects by gender and national development levels (HDI). We referred to the Human Development Report 2021–22,[66] which divided countries into low, medium, high, and very high levels based on their level of human development.

The final level of moderators was the study design. The current measurements of fake news credibility assessment lack criteria[67] and primarily include the assessment of the credibility of true and false information and the attitude of information-related knowledge.[60,68] Different outcome measurements could result in differences in intervention effects. Therefore, this study compared differences in the intervention effects between credibility and attitude assessment. Studies assessing the credibility of true and false information were classified as credibility assessments, whereas those evaluating attitudes toward information-related knowledge were classified as attitude assessments.

**The Present Study**

Researchers have conducted meta-analyses of media literacy. Jeong et al. analyzed the effects of media literacy interventions on various behaviors;[69] Vahedi et al.[70] and Zuair and Sopory[71] examined the impact of media literacy interventions on adolescents' risky health

behaviors. Additionally, Xie et al. analyzed the effect of media literacy interventions on individuals' deviant behavior,[72] focusing on a specific population (e.g., adolescents) and behavior (e.g., deviant behaviors). As fake news has become a more prominent problem, improving an individual's ability to assess fake news could reduce the occurrence of negative events. Therefore, this meta-analysis focused on whether media literacy interventions improved fake news credibility assessments.

## Materials and Methods

### Literature Search

The studies included in the meta-analysis were conducted using three methods. First, we searched for articles on the Web of Science, EBSCO (PsycArticles and PsycINFO), ProQuest, and PubMed. Two search strings were combined using Boolean search terms in title, abstract, and keywords: ("media literacy" OR "news literacy" OR "media evaluation" OR "media education") AND ("misinformation" OR "disinformation" OR "conspiracy theor*" OR "fake news" OR "rumor" OR "false information"). Second, we systematically searched using Chinese translations of keywords from the CNKI (China National Knowledge Infrastructure). Third, we examined the reference lists of each publication after full-text screening to identify potential studies that were not originally identified through the search terms. The literature search included articles published before December 31, 2022. Ultimately, we retrieved 3,888 articles from different databases, with 3,444 being excluded after screening their titles and abstracts and 61 being excluded after the full-text screening (Figure 1). Finally, 29 articles comprising 33 studies were included in the meta-analysis.

### Inclusion Criteria

The criteria for the inclusion of meta-analyses in this study were:

a) were quantitative in design and peer-reviewed to ensure the article quality;

b) subject content linked to fake news, as we were concerned with fake or incorrect news,

whether intentionally or unintentionally spread;

c) included at least one media literacy intervention, meaning that individuals were taught to identify the meaning, message, source, intended audience, and implications of media images;

d) reported quantitative outcomes of fake news credibility assessment;

e) only included the final measurement if the study included multiple assessment points;

f) included data for an intervention and control group or appropriate statistics (e.g., t-values or Hedges' g).

The exclusion criteria included:

a) review, theoretical, and qualitative studies;

b) lacking a control group for comparison;

c) using previously reported datasets;

d) being written in neither English nor Chinese.

**Coding**

Articles included in the meta-analysis were coded as follows: article information (first author name and publication year), size, country, HDI (low, medium, high, and very high), gender, age, intervention form (course, video, game, and graphic), intervention time (short and long), intervention channel (offline and online), outcome measurement (credibility assessment and attitude assessment), measuring time (immediate and follow-up), effect size, and standard deviation for the effect sizes. Table 1 lists the details of the included studies.

One effect size was coded per independent study. If multiple independent samples were reported simultaneously in one article, they were coded separately to produce various unique effect sizes. The data were extracted independently by two coders. When discrepancies arose, corrections were made for coding inconsistencies after reviewing the original article and discussion. The inter-rater consistency was 95% (Cohen's Kappa = .92).

**Data Analysis**

All analyses were conducted using Comprehensive Meta Analysis 3.0 (CMA 3.0) software.[73] Given that the intervention effects were examined by comparing the standardized difference between the intervention and control groups, the standardized mean deviation Hedges' *g* was used as an effect size to test the effectiveness.[74] Hedges' *g* is the standardized mean difference between the two group means and provides a more accurate estimate of the effect size than Cohen's *d*.[75] Through CMA 3.0, determine the Hedges' *g* by entering the intervention and control groups' sample sizes, means, and standard deviations. If the mean or standard deviation was not published in the article, it was determined by converting the $\chi^2$, *t*, or *F* value. Hedges' $g = 0.2$, 0.5, and 0.8 often indicate small, intermediate, and large effect sizes, respectively.

Owing to the potential discrepancies between the many studies included in this meta-analysis, a random-effects model was used. *Q* statistic and $I^2$ statistic were used to estimate the heterogeneity,[76] with $p < .05$ being considered significant. We used a sensitivity analysis by sequentially excluding single studies to further test the robustness of the findings.[77]

The risk of bias owing to poor study quality was evaluated at the study level using the Cochrane risk-of-bias tool,[78] which assesses the bias risk due to the randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of reported results. Three approaches were used to investigate publication bias—the funnel plot, Rosenthal's classic fail-safe N test, and Egger's regression test.

We analyzed the moderating effects to examine the effects of different subgroup variables on intervention effects to further explore the possible sources of research heterogeneity.[79] Intervention form, intervention time, intervention channel, age, and measurement time were the primary moderating variables.

## Results

### Study Characteristics

The literature search yielded 3,888 studies, and 33 studies from 29 articles were included in the meta-analysis. Among 36,256 participants of the eligible studies, most were young adults (97%, with a mean age of approximately 33 years), over three-quarters had an intervention time of less than one hour (85%), 47% of participants were women, and almost half were graphic interventions (45%). Figure S1 shows the geographical distribution of the studies. Most were conducted in the US (33%) and the UK (18%), followed by Germany (9%) and India (9%).

**Sensitivity Analysis**

Owing to the substantial heterogeneity, a sensitivity analysis was required, and the effect sizes were recalculated by leave-one-out analysis (Figure 2). The effect sizes ranged from $g$ = 0.47 (95% CI [0.22, 0.71], $p < .001$) to $g$ = 0 .55 (95% CI [0.30, 0.81], $p < .001$), indicating that excluding a single study did not significantly affect the main effect size, highlighting the stability and validity of the meta-analysis's results.

**Main Effects Test**

The heterogeneity test for the effects of media literacy interventions, $z = 4.20$, $p <. 001$, $I^2$ = 99.13%, indicated significant heterogeneity that should be analyzed using a random-effects model. After calculating the effect sizes, Figure 3 presents a forest plot showing the effect of media literacy interventions on fake news credibility assessment, indicating a significant and positive intervention effect on fake news media literacy ($g$ = 0.53, 95% CI [0.29, 0.78], $p <$ 0.001, $k$ = 33).

**Moderator Analysis**

Through subgroup testing, this study further examined the effects of several moderators on the media literacy interventions—intervention form, intervention time, intervention channel, HDI, outcome measurement, measurement time, age, and gender (Table 2). We excluded moderators for measuring time because subgroups containing too few studies (k = 1) were

excluded from the analysis.[80]

The form of intervention significantly influenced the effect of media literacy interventions ($Q$=22.53, $p$<.001). The Bonferroni post-hoc test demonstrated that gaming interventions had better effects than graphic interventions ($p$ < .001). HDI significantly influenced the intervention effects ($Q$ = 19.88, $p$ < .001). The Bonferroni post-hoc test found that interventions conducted in very high ($p$=.001) and high ($p$=.004) HDI countries had better intervention effects than those conducted in medium HDI countries. Intervention time ($Q$ = 0.50, $p$ = .478), intervention channel ($Q$ = 0.25, $p$ = .619), and outcome measurement ($Q$ = 0.06, $p$ = .810) did not significantly influence the intervention effects. Meta-regression analyses examined the influence of gender (percentage female) and mean age, suggesting that no continuous moderators significantly explained the between-study heterogeneity.

**Publication Bias**

Funnel plots were used to examine publication bias. The included studies were evenly distributed on both sides of the total effect size and concentrated above the center, indicating no significant publication bias (Figure 4). Table 3 presents the results of the Classic Fail-safe N and Egger tests. The fail-safe factor for the intervention effect was 1021, indicating that an additional 1021 research publications were required to negate the effect of media literacy interventions on fake news credibility assessment. Additionally, the Egger's test was not significant ($p$ = .31), demonstrating no publication bias.

## Discussion

This study aimed to evaluate the effect of media literacy interventions on fake news credibility. After screening 3,888 retrieved articles, 33 independent studies from 30 articles were included in this study. The overall effect was positive and significant ($g$ = 0.53, 95% CI [0.29, 0.78]), representing an intermediate effect size ($g$ = 0.5 – 0.8) and indicating that the interventions were effective in enhancing fake news credibility assessment, especially since

the finding was robust for the subject characteristics (gender and age), intervention characteristic (intervention time and location), and intervention design (outcome measurement). Media literacy interventions improve individuals' ability to think critically about the information and evaluate the information sources.[72] Relevant theoretical frameworks (social cognitive theory, audiences' acts of authentication model, and selective exposure) explained how media literacy interventions improved individuals' abilities to assess fake news credibility. Thus, when exposed to media literacy interventions, individuals become more capable of evaluating information, recognizing their own biases, and understanding how to discover sources.

Notably, the intervention effects differed according to form. Game interventions were more effective than graphic interventions because game interventions were more interactive than graphic interventions.[53] Games typically require active engagement, problem-solving, and decision-making, fostering an immersive and participatory environment for users.[81,82] This heightened level of interaction may have increase the impact on targeted outcomes. The cognitive engagement and stimulation provided by game interventions may enhance the learning or behavioral change process compared with static graphic interventions. This study also found large variations in the effects of video interventions (effect size: 0.14–2.69). Videos with high interactivity, such as simulations or branching scenarios, may be particularly effective in eliciting the desired responses from participants.[83,84] Conversely, videos with limited interactivity may not effectively engage participants, resulting in a wide spectrum of observed effects.

Researchers usually assume that different measurements lead to differences in results,[67] but previous fake news studies found small differences. We observed moderate intervention effects for media literacy interventions for both credibility and attitude assessments. This implies that different outcome measures may have a minimal impact on the effectiveness of

the intervention.

Intervention time was not statistically significant, meaning that interventions addressing fake news can achieve a decent effect in a short period, which is important for the social media context. Thus, prolonged interventions may not be as effective as expected, and in some studies, the effects of prolonged interventions were small even when conducted.[85,86] The intervention channel was not significantly different, meaning that the media literacy intervention did not result in changes in the intervention context. The online implementation of media literacy interventions may not diminish their effectiveness.

A country's level of development also influenced effect size. Most media literacy interventions have been concentrated in developed countries, and most countries with higher development levels achieve better intervention effects. This may be because individuals with higher standards of living have better basic digital skills, allowing them to quickly learn how to identify fake news.[87] At the same time, current media literacy interventions in countries with low development levels had lower effects, except for the Zhang et al. study, which yielded a large effect size.[88] Thus, the results suggest that current media literacy interventions for less developed countries are inadequate and require further improvement to effectively deal with fake news.

Neither age nor gender significantly moderated the intervention effects, indicating that media literacy interventions for fake news were effective for all ages and genders. The participants in the included studies were similar in terms of gender ratios and age distribution predominantly adults and gender-balanced potentially weakening the effects of these moderator analyses. Therefore, targeted interventions for different groups are necessary. For example, Moore and Hancock designed a media literacy intervention for older adults that achieved greater intervention effects.[89]

This study is significant for existing fake news response efforts. Media literacy

interventions are effective in helping individuals assess fake news. Public health organizations and stakeholders can respond to fake news by improving their media literacy. Additionally, shorter-duration media literacy interventions that can be deployed in online settings should be applied to help more individuals respond to fake news and maintain a satisfactory effect.

This study has theoretical and practical implications for media literacy interventions. Regarding practical implications, this study underscores the effectiveness of media literacy interventions in enhancing fake news credibility assessments. Incorporating interactive elements, particularly through gaming experiences, is recommended for increased effectiveness. The findings also advocate short, focused interventions, highlighting their viability in a fast-paced online environment. Moreover, this study supports the use of online platforms for media literacy interventions and emphasizes the importance of targeted programs tailored to diverse demographic groups. Addressing global disparities, particularly in less developed countries, requires refined approaches to improve the interventions' effectiveness.

Regarding the theoretical implications, this study provides a solid foundation for understanding how media literacy interventions enhance fake news assessments. Contrary to expectations, this study challenges the assumption that different measurements significantly impact the results in fake news studies, emphasizing consistency in intervention effects. These theoretical and methodological insights contribute to developing effective strategies for media literacy research and intervention designs.

This study has several limitations. First, we included additional databases (e.g., CNKI); most studies were from developed countries (e.g., the UK and US) to increase global representation. However, future research should broaden the generalizability of the intervention effects across cultures. Second, the focus of our study was the credibility assessment of fake news. The dissemination process of fake news includes accepting, sharing, and correcting.[90] For example, the continuous influence of fake news can severely affect

individuals. Future research should investigate the enhancement of individuals' abilities throughout the dissemination process after improving their media literacy. Third, real news must be assessed. Recent studies have found that interventions against fake news may reduce trust in real news.[52,60] Therefore, focusing solely on improving the credibility of fake news assessments when evaluating the effects of interventions may be insufficient. Future research should focus on both fake and real news credibility assessments and use more comprehensive indicators, such as accuracy and sensitivity.[67,91] Fourth, we only included peer-reviewed studies to ensure the quality of the articles; thus, unpublished articles could have been overlooked, increasing the risk of publication bias. Finally, this study lacks attention to specific groups. For example, older adults are more susceptible to fake news because most lack digital skills and are more easily driven by social and emotional factors.[92] Improving older adults' ability to cope with fake news is important and should receive more attention in future research. Developing focused media literacy interventions for different age groups, such as offline courses for older adults and online games for adolescents,[89,93] is critical.

## Conclusions

This study found that media literacy interventions positively and significantly enhanced fake news credibility assessment. Notably, game interventions outperformed graphics, and intervention effectiveness is unaffected by duration or channel. This study emphasized the importance of media literacy in countering fake news.

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Fig.1

*PRISMA Flowchart for the Included Studies*

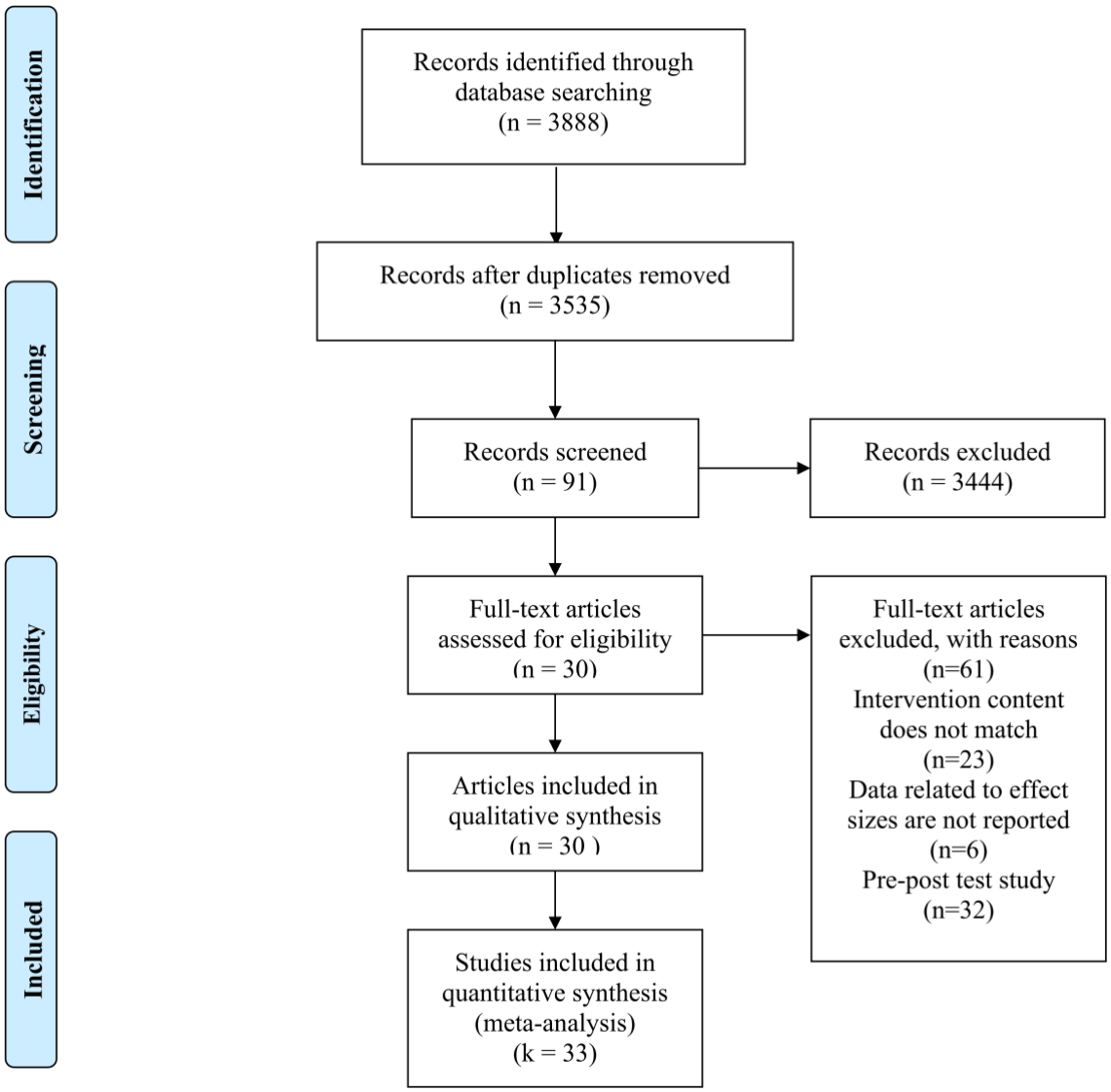

**Figure 2**

*Sensitivity Analysis Excluding Single Study*

| Study name | Point | Lower limit | Upper limit | Z-Value | p-Value |
|---|---|---|---|---|---|
| Lewandowsky 2021 | 0.465 | 0.223 | 0.708 | 3.763 | 0.000 |
| Vandormael 2021 | 0.490 | 0.353 | 0.626 | 7.040 | 0.000 |
| Belova 2022 | 0.495 | 0.243 | 0.746 | 3.858 | 0.000 |
| Maertens 2021 a | 0.519 | 0.266 | 0.772 | 4.024 | 0.000 |
| Moore 2022 | 0.522 | 0.268 | 0.776 | 4.031 | 0.000 |
| Zhang 2022 | 0.526 | 0.272 | 0.781 | 4.053 | 0.000 |
| Saleh 2021 | 0.528 | 0.274 | 0.781 | 4.075 | 0.000 |
| Hwang 2021 | 0.528 | 0.274 | 0.781 | 4.082 | 0.000 |
| Domgaard 2021 | 0.528 | 0.275 | 0.780 | 4.093 | 0.000 |
| Basol 2020 | 0.531 | 0.278 | 0.784 | 4.109 | 0.000 |
| Basol 2021 | 0.532 | 0.274 | 0.790 | 4.043 | 0.000 |
| Roozenbeek 2020 | 0.533 | 0.277 | 0.789 | 4.087 | 0.000 |
| Yang 2021 | 0.534 | 0.281 | 0.787 | 4.138 | 0.000 |
| Vraga 2021 | 0.534 | 0.277 | 0.791 | 4.079 | 0.000 |
| Mingoia 2019 | 0.535 | 0.281 | 0.788 | 4.138 | 0.000 |
| Qian 2022 | 0.537 | 0.282 | 0.792 | 4.123 | 0.000 |
| Soetekouw 2022 | 0.538 | 0.283 | 0.792 | 4.145 | 0.000 |
| Thomas 2021 | 0.539 | 0.285 | 0.793 | 4.158 | 0.000 |
| Maertens 2021 b | 0.539 | 0.286 | 0.791 | 4.177 | 0.000 |
| Murrock 2018 | 0.540 | 0.288 | 0.793 | 4.192 | 0.000 |
| Tully 2020 a | 0.541 | 0.287 | 0.794 | 4.178 | 0.000 |
| Roozenbeek 2019 | 0.543 | 0.290 | 0.795 | 4.212 | 0.000 |
| Merpert 2018 | 0.543 | 0.285 | 0.801 | 4.120 | 0.000 |
| Guess 2020 a | 0.544 | 0.278 | 0.810 | 4.011 | 0.000 |
| Hameleers 2022 | 0.545 | 0.289 | 0.801 | 4.178 | 0.000 |
| Guan 2021 | 0.545 | 0.292 | 0.798 | 4.224 | 0.000 |
| Tully 2020 b | 0.545 | 0.293 | 0.798 | 4.228 | 0.000 |
| Lutzke 2019 | 0.546 | 0.288 | 0.803 | 4.154 | 0.000 |
| Ali 2021 | 0.547 | 0.293 | 0.800 | 4.223 | 0.000 |
| Guess 2020 c | 0.547 | 0.287 | 0.806 | 4.132 | 0.000 |
| Gichangi 2022 | 0.549 | 0.296 | 0.802 | 4.251 | 0.000 |
| Badrinathan2 021 | 0.550 | 0.297 | 0.803 | 4.261 | 0.000 |
| Guess 2020 b | 0.550 | 0.295 | 0.806 | 4.223 | 0.000 |
| | 0.533 | 0.285 | 0.782 | 4.204 | 0.000 |

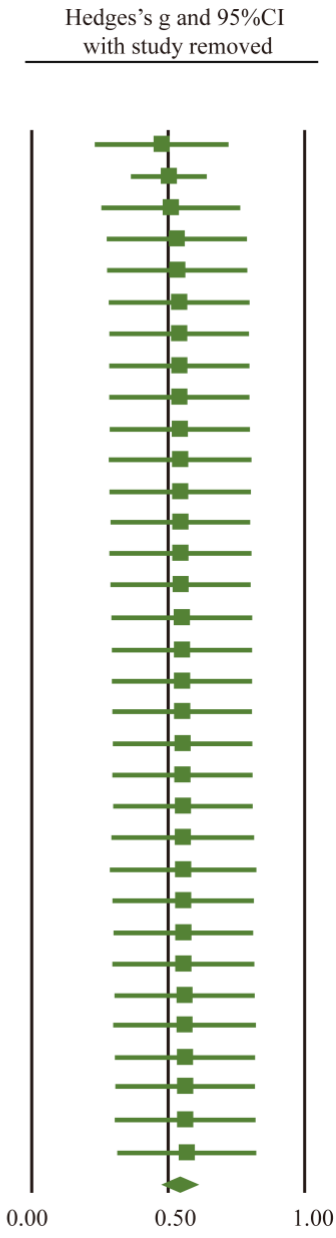

**Figure 3**

*Forest Plot of the Intervention Effect*

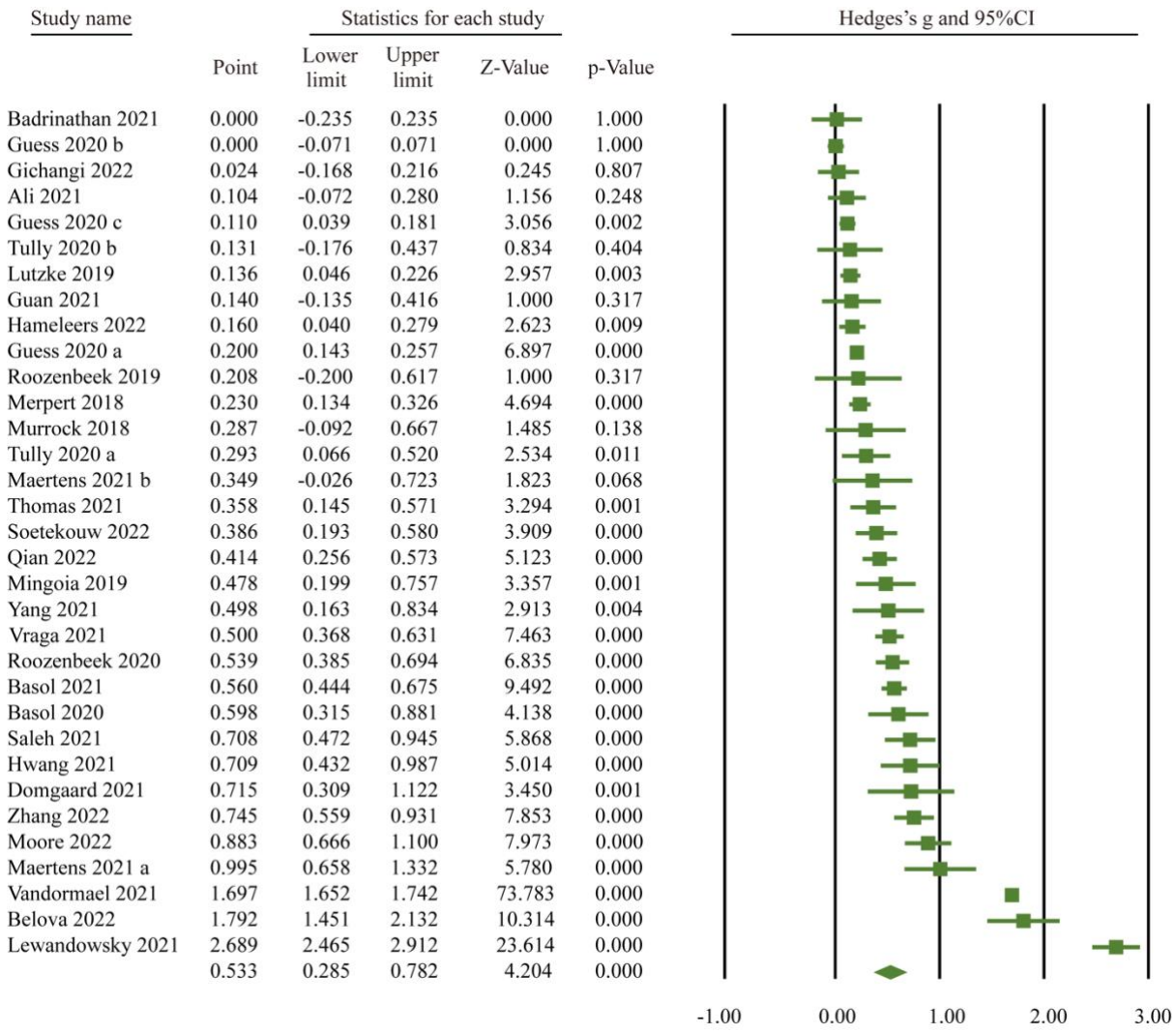

**Figure 4**

*Funnel Plot of Publication Bias*

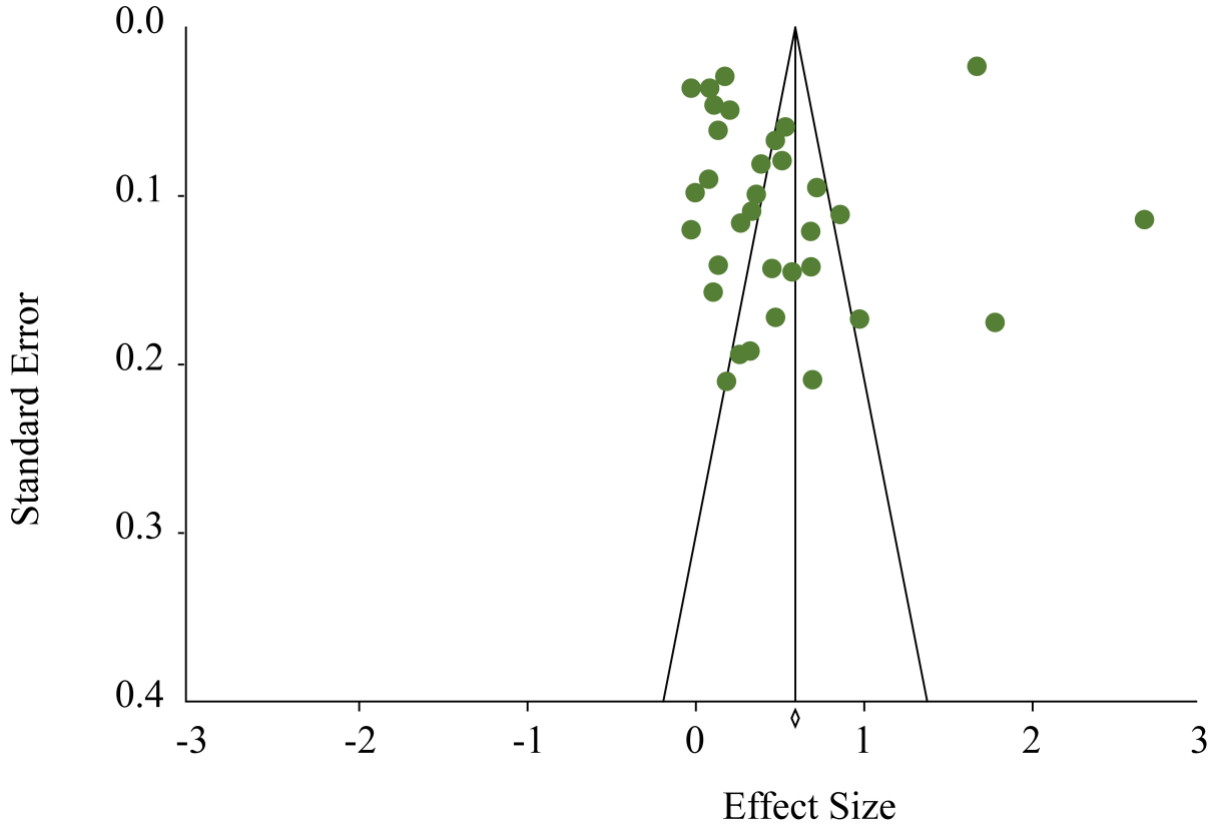

**Table 1**

*Characteristics of Studies Included In the Meta-Analysis*

| Study | Sample size | Country (HDI) | Sex composition (% male) | Age | Intervention form | Intervention time | Intervention channel | Outcome | Measuring Time |
|---|---|---|---|---|---|---|---|---|---|
| Ali 2021 | 500 | Pakistan[a] | 50.9 | 29 | Video | 3min | Offline | CA | Immediately |
| Badrinathan 2021 | 1224 | India[b] | 8.9 | 26 | Course | 1h | Offline | CA | Immediately |
| Basol 2020 | 198 | U.K.[d] | 42.0 | 18-24 | Game | 5min | Online | CA | Immediately |
| Basol 2021 | 1185 | U.K., France, Germany[d] | 49.6 | 34 | Game | 5min | Online | CA | Immediately |
| Belova 2022 | 186 | Germany[d] | N/A | 16-18 | Course | 3h | Offline | CA | Immediately |
| Domgaard 2021 | 98 | U.S.[d] | 41.2 | 43 | Graphic | Immediate | Online | AA | Immediately |
| Gichangi 2022 | 417 | Kenya[b] | 46.9 | 18-24 | Graphic | 7week | Online | AA | Immediately |
| Guan 2021 | 203 | U.S.[d] | 40.0 | 34 | Video | Not provided | Online | AA | Immediately |
| Guess 2020 a | 4907 | U.S.[d] | 54.6 | 50 | Graphic | Immediate | Online | CA | Immediately |
| Guess 2020 b | 3140 | India[b] | 36.3 | 37 | Graphic | Immediate | Offline | CA | Immediately |
| Guess 2020 c | 3160 | India[b] | 28.3 | 30 | Graphic | Immediate | Online | CA | Immediately |
| Hameleers 2022 | 1091 | Netherlands, U.S.[d] | 45.9 | 44 | Graphic | Immediate | Online | CA | Immediately |
| Hwang 2021 | 212 | Korea[d] | 49.1 | 39 | Graphic | 7min | Online | CA | Immediately |
| Lewandowsky 2021 | 591 | U.K.[d] | 62.4 | 36 | Video | 5min | Online | CA | Immediately |
| Lutzke 2019 | 1860 | U.S.[d] | 50.0 | 44 | Graphic | Immediate | Online | CA | Immediately |
| Maertens 2021 a | 151 | ① | 52.0 | 28 | Game | 30min | Online | CA | Immediately |
| Maertens 2021 b | 110 | ① | 43.0 | 18-24 | Game | 30min | Online | CA | 9-week follow-up |
| Merpert 2018 | 1725 | Argentina[d] | 34.0 | <45 | Graphic | 15min | Online | CA | Immediately |
| Mingoia 2019 | 200 | Australi [d] | 100.0 | 22 | Graphic | 2week | Online | AA | Immediately |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Moore 2022 | 381 | U.S.[d] | 64.7 | 67 | Course | 1h | Online | CA | Immediately |
| Murrock 2018 | 412 | Ukraine[c] | N/A | ① | Course | 8h | offline | CA | Immediately |
| Qian 2022 | 621 | U.S.[d] | 49.6 | 45 | Graphic | Immediate | Online | CA | Immediately |
| Roozenbeek 2019 | 95 | Netherlands[d] | 41.0 | 16 | Game | 30min | offline | CA | Immediately |
| Roozenbeek 2020 | 681 | ① | 43.2 | 18-24 | Game | 10min | Online | CA | Immediately |
| Saleh 2021 | 291 | U.K.[d] | 57.0 | 25-34 | Game | 15min | Online | CA | Immediately |
| Soetekouw 2022 | 417 | U.K.[d] | 38.4 | 18-34 | Graphic | Immediate | Online | CA | Immediately |
| Thomas 2021 | 309 | Indonesia[c] | 50.0 | ① | Video | 5min | Online | CA | Immediately |
| Tully 2020 a | 306 | U.S.[d] | 50.0 | 37 | Graphic | Immediate | Online | CA | Immediately |
| Tully 2020 b | 165 | U.S.[d] | 54.0 | 36 | Graphic | Immediate | Online | CA | Immediately |
| Vandormael 2021 | 9894 | Germany, U.S., Spain, Mexico, U.K.[d] | 54.7 | 18-59 | Video | 2min | Online | AA | Immediately |
| Vraga 2021 | 916 | U.S.[d] | 46.0 | 36 | Graphic | Immediate | Online | CA | Immediately |
| Yang 2021 | 140 | Korea[d] | 50.0 | 26 | Game | 10min | Online | CA | Immediately |
| Zhang 2022 | 470 | Nigeria[a] | 56.0 | 18-35 | Course | 8week | offline | CA | Immediately |

*Note*. The same authors and years are distinguished by indicating a, b, and c in the Study column; N/A means study not reported relevant information; ① represents a larger coverage of countries and ages in the study. U.S.: The United States; U.K.: The United Kingdom; CA: credibility assessment, AA: attitude assessment. [a] low national development level, [b] medium national development level, [c] high national development level, [d] very high national development level.

**Table 2**

*Moderator Analysis of Intervention Effects*

| Variable | *g* | *k* | N | LL | UL | *Q* | $I^2$(%) | *p* |
|---|---|---|---|---|---|---|---|---|
| Main effect | 0.53 | 33 | 36256 | 0.29 | 0.78 | 3679.84 | 99.13 | <.001 |
| **Intervention form** | | | | | | 22.53 | | <.001 |
| Course | 0.74 | 5 | 2673 | 0.23 | 1.25 | | 95.06 | |
| Video | 1.00 | 5 | 11497 | 0.11 | 1.89 | | 99.36 | |
| Graphic | 0.26 | 15 | 19235 | 0.18 | 0.35 | | 85.35 | |
| Game | 0.57 | 8 | 2851 | 0.46 | 0.69 | | 44.41 | |
| **Intervention time** | | | | | | 0.50 | | .478 |
| Short | 0.55 | 29 | 34757 | 0.28 | 0.82 | | 99.31 | |
| Long | 0.39 | 4 | 1499 | 0.01 | 0.76 | | 89.52 | |
| **Intervention channel** | | | | | | 0.25 | | .619 |
| Online | 0.56 | 26 | 30229 | 0.27 | 0.85 | | 99.23 | |
| Offline | 0.44 | 7 | 6027 | 0.07 | 0.81 | | 95.96 | |
| **HDI** | | | | | | 19.88 | | <.001 |
| Low | 0.42 | 2 | 970 | -0.21 | 1.05 | | 95.85 | |
| Medium | 0.05 | 4 | 7941 | -0.02 | 0.12 | | 39.39 | |
| High | 0.34 | 2 | 721 | 0.16 | 0.53 | | 0.00 | |
| Very High | 0.64 | 22 | 25682 | 0.31 | 0.97 | | 99.27 | |
| **Outcome** | | | | | | 0.06 | | .810 |
| Credibility Assessment | 0.61 | 28 | 25444 | -0.30 | 1.53 | | 96.84 | |
| Attitude Assessment | 0.50 | 5 | 10812 | 0.34 | 0.66 | | 99.13 | |
| **Mean Age** | 0.0007 | 33 | 36256 | -0.03 | 0.03 | 0.00 | 99.24 | .961 |
| **Percent Female** | 0.01 | 33 | 36256 | -0.003 | 0.03 | 2.79 | 98.96 | .095 |

*Note*. L.L. and U.L. represent the lower and upper limits of the 95% CI of Hedges' g, K means the number of independent effect values.

**Table 3**

*Publication Bias Test Result*

| Result | *k* | Classic Fail-safe N | Egger's Intercept | SE | LL | UL | *p* |
|---|---|---|---|---|---|---|---|
| Intervention effect | 33 | 1021 | -3.64 | 3.53 | -10.87 | 3.58 | .311 |

*Note*. K means the number of independent effect values; S.E. is the standard error; L.L., U.L. denotes the lower limit of the 95% confidence interval of Egger's regression Intercept and upper limit of the 95% confidence interval of Egger's regression Intercept.