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Meta-analytic review of the effects of suggestion on children's memory: Implications for testimony

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Título: Revisión meta-analítica de los efectos de la sugestión en la memoria de niños y niñas: Implicaciones para el testimonio.

Resumen: *Antecedentes/objetivo:* La implantación de información engañosa en la memoria es un tópico de gran relevancia dadas las implicaciones que tiene para la evaluación de la memoria de los testigos. La sugestión ha sido el medio de implantación más estudiado. Por ello, se ha diseñado un estudio meta-analítico para estimar el tamaño del efecto de la sugestión en la implantación de información engañosa en el testimonio y las memorias, y los moderadores de tal efecto. *Método:* Se seleccionaron un total de 17 estudios diseñados para la evaluación de la implantación de memorias sugestionadas o la mera aceptación de información capciosa. Se ejecutaron meta-análisis de experimentos bare-bones. *Resultados:* Los resultados mostraron un tamaño del efecto promedio global (d = 1.68, IC 95% [1.47, 1.89]) significativo, positivo, generalizable entre los estudios y de una magnitud más que grande para la implantación de información engañosa debida a la sugestión. Convertido el efecto en probabilidades, la probabilidad estimada de implantación de cualquier información externa sugestionada fue del 31.3%. Asimismo, los resultados evidenciaron un tamaño del efecto promedio significativo, positivo, generalizable y más que grande para los moderadores grado de sugestión (d = 1.60, IC 95% [1.10, 2.10]), probabilidad de sugestión (d = 1.68, IC 95% [1.48, 1.88]), participación directa en el evento (d = 1.31, IC 95% [1.13, 1.49]), participación indirecta en el evento (d = 2.00, IC 95% [1.77, 2.23]), sugestión mediante el paradigma de diferencias individuales (d = 1.44, IC 95% [1.23, 1.65]) y sugestión mediante el paradigma de desinformación (d = 2.03, IC 95% [1.82, 2.24]). *Conclusiones:* Se discuten las implicaciones de los resultados para la evaluación de la fiabilidad del testimonio infantil.

Palabras clave: Paradigma de desinformación. Paradigma de diferencias individuales. Testimonio. Sugestión interrogativa. Sugestión investigativa. Testimonio infantil.

Abstract: *Background/Objective:* The implantation of misleading information in memory is a highly relevant topic due to its implications for the evaluation of witness memory. Suggestion has been the most studied means of implantation. Therefore, a meta-analytical study was designed to estimate the effect size of suggestion in the implantation of misleading information in testimonies and memories, and the moderators of such effect. *Method:* A total of 17 studies designed to evaluate the implantation of suggested memories or the mere acceptance of misleading information were selected. Bare-bones meta-analyses of experiments were performed. *Results:* The results showed a significantly positive, generalizable across studies, and more than large overall mean effect size (d = 1.68 95% CI [1.47, 1.89]) for the implantation of misleading information due to suggestion. When converted to probabilities, the estimated likelihood of implanting any externally suggested information was 31.3%. Likewise, the results evidenced a significant, positive, generalizable among studies, and more than large average effect size for the moderators: degree of suggestion (d = 1.60, 95% CI [1.47, 1.89]), likelihood of suggestion (d = 1.68, 95% CI [1.48, 1.88]), direct participation in the event (d = 1.31, 95%CI [1.13, 1.49]), indirect participation in the event (d = 2.00, 95% CI [1.77, 2.23]), suggestion through the individual differences paradigm (d = 1.44, 95% CI [1.23, 1.65]), and suggestion through the misinformation paradigm (d = 2.03, 95% CI[1.82, 2.24]). *Conclusions:* The implications of the results for the evaluation of the reliability of child testimony are discussed.

Keywords: Misinformation paradigm. Individual differences paradigm. Interrogative suggestibility. Investigative suggestibility. Child testimony.

Introduction

Suggestion: an approach to the concept

The publication in 1900 of the book 'La Suggestibilité' by Alfred Binet has been established as the starting point for the study of the effects of suggestion on memory and, more specifically, of false memories (Cunningham, 1988). Instead of considering suggestion as a sign of psychological weakness, Binet interpreted it as a common cognitive and social process (Nicolas et al., 2011). Since then, the term suggestion has been used ambiguously and overly broadly, being associated with phenomena such as persuasion, obedience, social influence, and conformity. At the same time, the study of suggestion has been structured around two types of definitions. On the one hand, the intentional definition, which refers to a type of communicative influence in which people tend to accept a proposition, generally expressed in formal language, although it can also be informal (McDougall, 2001). On the other hand, a definition focused on effectiveness, which is linked to individual differences (suggestibility trait) in the response to the effects of suggestion, especially in relation to witness memory (Ridley, 2013). However, and again, there is no uniformity in the operationalization of the concept of suggestion. Thus, for Otgaar et al. (2020), suggestion is the tendency to incorporate misleading information into memory; for Cunningham (1988), it is errors in identifying the source of an experience, derived from the suggestibility index of misleading information; and, for Eisen et al. (2001), the individual's difficulty in discerning between real and suggested events.

In a similar vein, the American Psychological Association (n.d.) establishes two meanings for suggestion. In the first (intentional definition), it defines suggestion as an inclination to readily and uncritically adopt the ideas, beliefs, attitudes, or actions of others. And in the second (effective definition), it takes Eysenck's personality model to establish three types

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of suggestion: 1) primary suggestion, resulting from direct and evident influence such as hypnotic suggestion; 2) secondary suggestion, linked to an indirect or hidden influence where its objective is not clear; and 3) tertiary suggestion, which implies the uncritical acceptance of information from another person motivated by interpersonal factors such as social pressure or the prestige/authority of the source (Ridley, 2013).

Revisiting Binet's ideas, suggestion should not be considered as a qualitative measure, but as a continuum on which an individual can be situated at different points depending on (Cunningham, 1988; Mastroberardino & Marucci, 2013; McDougall, 2001):

a) Individual factors: age, intelligence, personality variables, abnormal mental states, assertiveness, locus of control, the individual's original disposition (e.g., their expectations about whether or not to answer each question); a low level of knowledge, little conviction and/or poor organization of information on the subject to suggestion, among others.

b) Situational factors: the source from which the proposition is suggested (not only should phenomena such as conformity and obedience to authority be considered, but also the suggestible person's expectations about the other's intentions); and, the style of questioning (it is relevant whether explicit warnings are provided before or after the introduction of misleading information, as well as the presence or absence of negative feedback in the interviewer's behavior).

In relation to the set of factors affecting suggestion, two scientific research currents stand out, encompassing much of the literature on this topic. According to Diges et al. (2010), one of them emphasizes suggestion as a trait, while the other considers it the result of situational factors that can be experimentally manipulated. In any case, both currents treat the phenomenon from the perspective of its impact on the accuracy of information obtained during criminal investigation (Ridley, 2013).

Study paradigms

The two aforementioned currents are linked to the two most common paradigms for studying suggestion (Gudjonsson, 2013):

a) Misinformation paradigm: This focuses on the manipulation of both the temporal variable (e.g., the time elapsed since the observation of the main event) and the nature of the questions asked (specifically, whether they contain misleading information introduced in a post-event narrative).
b) Individual differences paradigm: This understands suggestion as a potential individual vulnerability, assessing a person's propensity to yield to leading questions and pressure in an interrogation context.

Depending on the approach or study paradigm, the literature classifies suggestion as investigative (experimental approach) and interrogative (individual differences approach).

Misinformation Paradigm

As early as the late 19th century, psychology warned of the potential distortion that investigative interviews could exert on witness statements (Bartol & Bartol, 1999). However, it was not until the 1970s that the study of the effects of interrogations on witness memory was resumed (Chrobak & Zaragoza, 2013). Specifically, the work of Loftus et al. (1978), inspired by Binet's experiments on suggestion in visual memory, is considered the beginning of the study of investigative suggestion (Nicolas et al., 2011).

The structure of the task devised by Loftus, Burns, and Miller, known as the Classic 3-Phase Paradigm, Misinformation Paradigm, or Standard Test, unfolds in 3 phases (Eisen et al., 2013; Mastroberardino & Marucci, 2013): 1) in the first phase, participants read, listen to, or observe an event; 2) in the second, misinformation is introduced (i.e., false and/or misleading details incidentally after a few minutes, days, or weeks after presenting the event); and, 3) in the third phase, where the time interval can also be manipulated, participants are questioned about their memory of the event presented in the first phase using a forced-choice recognition task between the real (true) information and the false (suggested) information. The result of the experimental manipulation is known as the misinformation effect, intentionally defined by Zaragoza et al. (2007) as the result of a process whereby misleading suggestions implanted after an observed event contaminate the testimony of the original event, occasionally resulting (misinformation effect) in memories of false events that did not occur. In the original study by Loftus et al. (1978), while 75% of the control group participants chose the correct answer, less than half of the participants, 41%, in the experimental group chose it.

Initial explanatory theories of the misinformation effect focused on the fate of the original memory. Loftus et al. (1985) synthesized them around two explanatory proposals. The first proposes that exposure to post-event information results in a "destructive updating" of the original memory trace, where the misleading suggestion permanently replaces the original memory. The second posits the possibility that both memories coexist, but that the original becomes inaccessible due to an inhibition or suppression mechanism. Subsequently, McCloskey and Zaragoza (1985) concluded that there is no conclusive evidence that the original memory is impaired by the misinformation effect. In fact, they observed that participants in the control group of Loftus's experiment exhibited lower-than-expected performance on critical items. In other words, participants not subjected to the misinformation effect (control group) chose the incorrect answer (forced choice) more frequently than expected.

To assess whether the original memory had been erased by exposure to misinformation, McCloskey and Zaragoza (1985) designed a new experimental method known as the 'modified test', where the recognition task offers as alternatives the original (true) information and entirely new information. The results of the six experiments included in the

cited work showed that the probability of correct recognition of the original (true) information was equal in participants in the experimental and control groups (72% and 75%, respectively). In conclusion, the presentation of misinformation does not necessarily lead to the erasure of the original memory but rather fills in incomplete information gaps within it (Gathercole, 1998).

Currently, the misinformation effect is explained by the individual's inability to identify the source of the experienced event. This explanation originated in the 'Source Monitoring Framework' (Johnson et al., 1993). According to Johnson (1997), when a person reactivates and retrieves memories, they not only strengthen them but also make them susceptible to modification, especially if new information with characteristics similar to those of the original event is introduced during reactivation. In the particular case of the tasks employed in this paradigm, both the event and the protagonists of the original and misleading events are usually the same, such that there is a large overlap of semantic content (Chrobak & Zaragoza, 2013; Howe et al., 2006).

Although the three-phase structure of the misinformation paradigm has remained intact since its inception, the second phase of the procedure has been modified, giving rise to two new versions of the paradigm: the 'elicited misinformation paradigm' and the 'forced fabrication paradigm'. In both, the experimenter plays a fundamental role, differing in that in the elicited misinformation paradigm, the experimenter explicitly asks the participant to speculate or guess a detail of the event that they did not originally experience or witness, whereas in the forced fabrication paradigm, the interviewer pressures the participant to respond falsely to questions about items or events that, although plausible, they have not experienced or witnessed (Ackil & Zaragoza, 2011; Chrobak & Zaragoza, 2013).

Individual differences paradigm

Studies framed within this paradigm test how the account of an experienced event can be affected by interrogation techniques frequently employed in forensic and police interviews (Eisen et al., 2013). As with the experimental approach, Binet is the precursor to what was termed in the 1980s as interrogative suggestion. Furthermore, his work influenced researchers like Stern, whose experiments are based on demonstrating that misleading questions can distort individuals' responses if they are phrased in a particular way, eliciting a specific response (Gudjonsson, 2013).

Gudjonsson and Clark (1986) defined the concept of interrogative suggestibility as "the extent to which, within a closed social interaction, people come to accept messages communicated during formal questioning, and thereby their subsequent behavioural response is affected" (p. 84). Thus, suggestion depends on the coping strategies used by individuals when faced with two important aspects of the interrogative situation: uncertainty regarding the correct answer and expectations about the need to answer each question. Finally, Gudjonsson and Clark's (1986) model differentiates between two subtypes of interrogative suggestion: 1) the tendency to yield to questions and 2) the tendency to change the answer as a consequence of negative feedback.

As a result of this theoretical formulation, the Gudjonsson Suggestibility Scales (Gudjonsson, 1992) were developed for the measurement of the effects of suggestion. The procedure for implementing this approach is structured in 3 phases (Eisen & Lynn, 2001): in the first, participants read a story; in the second, they are asked questions about the story, 20 questions, of which 15 are highly leading and misleading, with errors recorded on the Yield scale; and, in the third, participants receive negative feedback on their performance and are asked the same block of questions again, with changes recorded on the Shift scale.

Finally, to this variability surrounding the concept of suggestion and its measurement, the immediate or delayed assessment of the effect has been added to research designs (Eisen et al., 2013).

Memory and Childhood

From a legal perspective, it is crucial to understand the functioning and, above all, the reliability of children's memory, given that, in many cases, especially in those of sexual assault, their testimony is the only practicable evidence (Gathercole, 1998). Furthermore, special attention is paid to a specific type of explicit memory: episodic memory. According to Merín et al. (2024), this is defined as "the recall of information associated with a particular time, place, or person that is not necessarily linked with something personally relevant" (p. 1). Consequently, episodic memory, and its assessment, is fundamental in the legal context (Goodman et al., 2014).

Scientific literature has shown that one of the most robust predictors of memory performance is age, with children being particularly susceptible, among other issues, to the effects of misinformation (Howe et al., 2006). Piaget's 'theory of cognitive development' establishes twelve years as the age limit to affirm that an individual has completed their cognitive development and, therefore, leaves behind what is known as childhood (Alessi & Ballard, 2001). Until cognitive development is complete, children present difficulties in: remembering past events in the absence of external help; remembering spontaneously; dating events; organizing experiences logically; attributing motivation and intention to other people; performing mental operations such as conservation and reversibility; and, using hypothetical-deductive reasoning and abstraction, as these are absent (Alessi & Ballard, 2001; Merín et al., 2024; Nurcombe, 1986).

These developmental deficiencies in children under 12 years of age mean that their memory is less detailed and precise compared to the population in which development has been completed (Roebers et al., 2004). Furthermore, it is necessary to consider that information is encoded and stored according to pre-existing schemas. Consequently, the

knowledge previously acquired by the individual will condition the representations of the experienced event (Gathercole, 1998; Ornstein & Haden, 2001).

Finally, memory is influenced by other variables such as: 1) the time elapsed between the event and recall (information obtained immediately after the witnessed event, before any opportunity for contamination, is related to greater accuracy in recall; Chrobak & Zaragoza, 2013); 2) the type of participation in the event (memory of a self-experienced event is more accurate and less subject to suggestion than that of a self-generated or imagined event; Howe et al. 2006); and, 3) attention (memory and attention are two interdependent processes in constructing a robust memory; Ridley, 2013).

Based on the current state of knowledge and research, a meta-analytic review was designed to understand the effects of suggestion in the population of individuals who have not completed cognitive development (< 12 years), identify potential moderators of the effect, and compare the effects between moderator levels. At a hypothetical level, it is expected that the external introduction of misleading information will produce an effect of suggestion on the memory of individuals who have not completed their cognitive development.

Method

Database Search for Studies

The initial search aimed to identify all empirical studies that assessed suggestion in children under 12 years of age through the introduction of false or misleading information regarding a previously experienced event. For this purpose, an exhaustive search was conducted in the international reference scientific databases Web of Science, Scopus, Medline, and PsycInfo, following the guidelines specified in the PRISMA 2020 Statement (Page et al., 2021). The search was carried out between April and July 2024.

The search was not initially restricted by language and was performed with the following terms and commands: child* AND testimony AND suggestibility AND (misinformation OR "interrogative suggestibility" OR "investigative suggestibility" OR "elicit misinformation paradigm" OR "forced fabrication paradigm" OR "inviting speculation" OR mislead*). The initial search in Web of Science returned a total of 120 primary studies, followed by a search in Scopus which identified 17 additional studies, 24 in PsycInfo, and 3 in Medline. To avoid excluding significant studies and grey literature, a review of the reference lists of the selected studies according to these databases was conducted, adding another 10 additional primary studies.

Inclusion and Exclusion Criteria

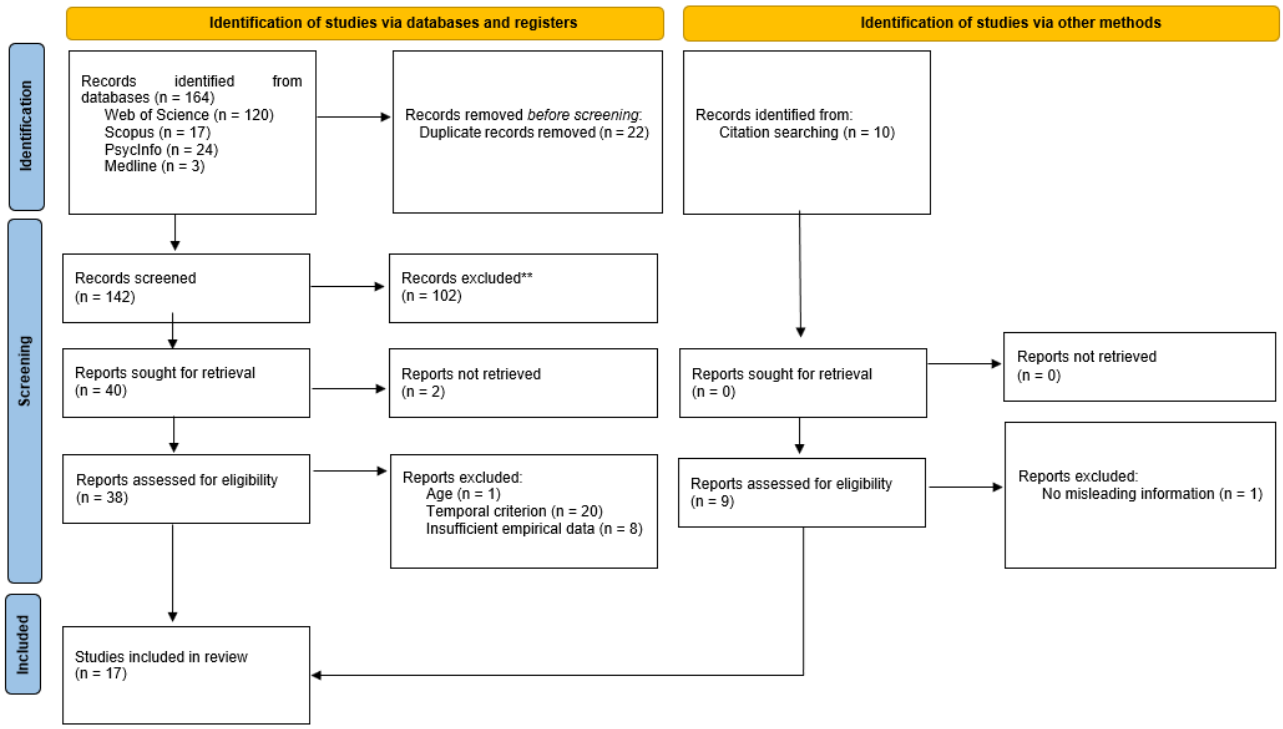
When evaluating the searches obtained from both databases and other sources, compliance with the following inclusion criteria was considered: 1) primary experimental studies whose research topic was suggestion in a population younger than 12 years; 2) the effects of suggestion were tested, either through the misinformation paradigm or the individual differences paradigm; 3) the measurement of the effects of suggestion was taken immediately, with this temporal criterion seeking to analyze whether the child becomes immunized against the immediate acceptance and/or retention of false information; and, 4) the research reported the effect size of suggestion, or provided the data for its computation. The exclusion criteria employed were: 1) systematic reviews, doctoral theses, single-case studies, and/or meta-analyses; 2) experimental studies whose objective was to test the effectiveness of techniques and/or interviews for the prevention of suggestion; and, 3) studies in which the misinformation paradigm is used to assess the accuracy of testimony.

After applying the described criteria, 17 primary studies out of the total of 174 identified in the initial search were included for the meta-analysis. Figure 1 presents a flowchart describing the selection process step by step.

Coding of primary studies

For the present work, the following data from the studies were recorded: 1) reference of the primary study; 2) characteristics of the sample (i.e., age, size); 3) characteristics of the procedure followed for the suggestion of participants (brief description of the event to be remembered, format of participation in the event, research paradigm applied, type of memory task, number of misleading questions, and approximate duration of the experiment); and, 4) data necessary to calculate the effect size due to suggestion (means and standard deviations, proportions, or statistics from which it could be derived). Additionally, coders had an "other" category in which they noted any other condition that could be a moderator to add to the coding

Figure 1
Flow diagram of the meta-analysis



system. By this method, the measure of the effect of suggestion was identified as a moderator: degree vs. probability. Annex 1 of this work includes the relevant data for this work from each of the primary studies.

Based on these coding categories, two coders reviewed all studies separately, subsequently cross-checking for exact correspondence in coding, estimating the concordance with true kappa, which corrects by verifying the exact correspondence in coding ($\bar{k}$; Fariña et al., 2002). The results reported total concordance ($\bar{k}$; = 1).

Data analysis

The objective of this meta-analysis was to determine the degree or probability of suggestion in children under 12 years of age following the introduction of false information about an experienced event. For this purpose, and due to the nature of the data from the primary studies, effect sizes were calculated using Cohen's *h* (probability of suggestion) and Cohen's *d* (Cohen's formula when $N_1 = N_2$; Hedges' g, when $N_1 \neq N_2$; and Glass's, with heterogeneity of variance).

Once the effect sizes were calculated, and since it was not possible to correct the average effect size beyond sampling error, bare-bones random-effects meta-analyses were performed following the procedure of Schmidt and Hunter (2015). For this, the software created by Schmidt and Le (2014) was used, yielding the following results: the sample-size-weighted mean effect size (d_w); the sample-size-weighted observed variance of the *d* values (S^2_{obs}); the standard deviation of the *d* values after removing sampling error variance (SD_{obs}); the variance attributed to sampling error variance (S^2_{em}); the variance of the *d* values after removing sampling error (S^2_{res}); the standard deviation of the *d* values after removing sampling error (S^2_{res}); the percentage of observed variance attributed to sampling error (%Var); the 95% confidence interval for the *d* values (95% CI_d); and the 80% credibility values (80% CV).

Hunter, Schmidt and Jackson found that sampling error, measurement error, and range restriction explain, on average, about 72% of the variance, leading to the 75% rule to establish that unexplained variance is not systematic, i.e., the studies belong to the same population. The variance explained by sampling error is around 60%, so the 75% rule becomes 60% when correcting only for sampling error (Sagie & Koslowsky, 1993).

The magnitude of the effect size was interpreted qualitatively as small (d = 0.20), moderate (d = 0.50), large (d = 0.80), and larger than large (d > 1.20) (Arce et al., 2015; Cohen, 1988; Ferguson, 2009; Sullivan & Feinn, 2012), and quantitatively with the Probability of Superiority of the Effect Size (PS_{ES}; Arias et al., 2020). The PS_{ES} consists of the conversion and interpretation of the effect size as a percentile. The significance of the meta-analytic results (mean effect size) were tested with zeta and the comparisons of the effects between moderators with q_s (Arce et al., 2023; Cohen, 1988).

Results

Study of outliers

The exploratory study of the distribution of primary data showed that there were no effect sizes with extreme values (± 3 * IQR) or outliers (± 1.5 * IQR). Furthermore, the data showed a normal distribution, W(10) = 0.938, *ns*.

Overall effects of suggestion on the implantation of information in memory

The results of the overall meta-analysis (see Table 1) of suggestion in children who have not completed their cognitive development (< 12 years) showed an overall mean effect size (d = 1.68) that was significant, Z = 15.51, p < .001, larger than large (d > 1.20), and greater than 88.3% of effect sizes, PS_{ES} = .830; and positive (implantation of suggested information in the memories of children who have not completed cognitive development). Likewise, this result is generalizable (the credibility interval does not contain 0) to 90% of the studies with a minimum effect of 1.00 (lower limit of the credibility interval). In terms of probability of suggestion, the estimated probability of implantation of any externally suggested information is 31.3% (d = 1.68 = p = .313). These results confirm the hypothesis: the external introduction of misleading information produces an effect of suggestion on the memory of individuals who have not completed their cognitive development. However, sampling error explains 4.04% of the variance (%Var < 60), meaning the data are heterogeneous. Consequently, the unexplained variance is due to the effect of moderators.

Table 1
Overall meta-analysis of suggestion

k	*N*	d_w	S^2_{obs}	SD_{obs}	S^2_{se}	%Var	S^2_{res}	SD_{res}	95% CI_d	80% CV
17	7868	1.68	0.2897	0.5382	0.0117	4.04	0.2780	0.5273	1.47, 1.89	1.00, 2.36

Study of moderators

From the analysis of the experimental designs and manipulations of the primary studies, the measurement variable (degree of suggestion and probability of suggestion), the type of participation in the event (direct and indirect), and the suggestion paradigm (individual differences paradigm and misinformation paradigm) were identified as potential moderators.

Table 2
Meta-analysis of suggestion for the moderator measurement variable

k	*N*	d_w	S^2_{obs}	SD_{obs}	S^2_{se}	%Var	S^2_{res}	SD_{res}	95% CI_d	80% CV
Measurement variable: Degree of suggestion										
3	250	1.60	0.6227	0.7891	0.0637	10.22	0.5590	0.7477	1.10, 2.10	0.64, 2.56
Measurement variable: Likelihood of suggestion										
14	7618	1.68	0.2786	0.5278	0.0100	3.59	0.2686	0.5183	1.48, 1.88	1.02, 2.34

Note. k = number of effect sizes; N: total sample size; d_w = sample size weighted mean effect size; S^2_{obs}: sample size weighted observed variance of d-values; SD_{obs}: sample size weighted observed standard deviation of d-values; S^2_{se}: variance attributed to sampling error variance; %Var = percent of observed variance accounted by sampling error variance; S^2_{res}: variance of d-values after removing sampling error variance; SD_{res}: Standard deviation of d-values after removing sampling error variance; *;* 95% CI_d = 95% confidence interval for d; 80% CV = 80% credibility values interval.

For the degree of suggestion, the results of the meta-analysis (see Table 2) revealed an average effect size (d = 1.60) that was significant, Z = 6.27, p<.001, larger than large (d > 1.20), and greater than 87.1% of effect sizes, PS_{ES} = .871; and positive (implantation of suggested information in the memories of children who have not completed their cognitive development). This result is generalizable (the credibility interval does not include 0) to 90% of studies with a minimum effect of 0.64. However, the effect is explained by the presence of moderators: sampling error explains 10.22% of the variance (%Var < 60). The effect of moderators could not be studied because k (< 3) or N (< 300) were insufficient. For the probability of suggestion, the results of the meta-analysis (see Table 2) showed a significant average effect, Z=16.81, p < .001, larger than large (d > 1.20), and greater than 88.3% of effect sizes, PS_{ES} = .830; and positive (implantation of suggested information in the memories of children who have not completed their cognitive development). In turn, the result is generalizable (the credibility interval does not include 0) to 90% of studies, with a minimum effect of 1.02 (lower limit of the credibility interval), but subject to moderators (%Var = 3.59) that could not be studied because k or N were insufficient.

Table 3
Meta-analysis of suggestion for the moderator type of participation in the event

k	*N*	d_w	S^2_{obs}	SD_{obs}	S^2_{se}	%Var	S^2_{res}	SD_{res}	95% CI_d	80% CV
Participation in the event: Direct										
6	3318	1.31	0.2991	0.5469	0.0088	2.94	0.2903	0.5388	1.13, 1.49	0.62, 2.00
Participation in the event: Indirect										
10	4230	2.00	0.0697	0.2640	0.0143	20.52	0.0554	0.2354	1.77, 2.23	1.70, 2.30

Note. k = number of effect sizes; *N*: total sample size; d_w = sample size weighted mean effect size; S^2_{obs}: sample size weighted observed variance of *d*-values; SD_{obs}: sample size weighted observed standard deviation of *d*-values; S^2_{se}: variance attributed to sampling error variance; %Var = percent of observed variance accounted by sampling error variance; S^2_{res}: variance of *d*-values after removing sampling error variance; SD_{res}: Standard deviation of *d*-values after removing sampling error variance; *;* 95% CI_d = 95% confidence interval for *d*; 80% CV = 80% credibility values interval.

For the moderator type of participation in the event, two modes were recorded in the primary studies: direct participation (self-experienced events, corresponding in the forensic field to a victim-witness) and indirect participation (observed/narrated event, corresponding to the clinical criterion of a witnessed event or one known about, and in the forensic field to an eyewitness). For direct participation in the event, the results of the meta-analysis (see Table 3) revealed an effect size (d = 1.31) that was significant, Z = 13.95, p < .001, larger than large (d > 1.20), and greater than 82.4% of effect sizes, PS_{ES} = .824; and positive (implantation of suggested information) in the suggestion of children who have not completed their cognitive development. Consequently, from the effect size attributable to direct participation in the event (d = 1.31), the probability of direct suggestion is obtained as 20.0% (p = .200). The result is generalizable to 90% of studies, with the minimum expected effect being 0.62 (lower limit of the credibility interval). However, sampling error only explains 2.94% (%Var = 2.94) of the variance, so the data are heterogeneous and, therefore, subject to moderators. Nevertheless, moderators could not be studied because k or N were insufficient. For indirect participation in the event, the results of the meta-analysis (see Table 3) revealed an effect size (d = 2.00) that was significant, Z = 16.75, p < .001, larger than large (d > 1.20), and greater than 92.1% of effect sizes, PS_{ES} = .921; and positive (implantation of suggested information) in the suggestion of children who have not completed their cognitive development. From the observed effect size (d = 2.00), it is derived that the success probability of indirect suggestion is 42.2% (p = .422). This result is generalizable to 90% of studies, with the minimum expected effect being 1.70 (lower limit of the credibility interval). However, sampling error only explains 20.52% (%Var < 60%), so the unexplained variance is due to moderators, which could not be studied because k or N were insufficient. The comparison of the effect between direct and indirect participation in the event showed a significantly larger effect, $q_s(N' = 3719) = 0.266$, Z = 11.47, p < .001, for indirect participation in the event (d = 2.00 vs. 1.31 for indirect and direct participation in the event, respectively).

In the moderator suggestion paradigm used, two procedures for implanting suggestion were recorded: the misinformation paradigm (investigative suggestion) and the individual differences paradigm (interrogative suggestion).

The results of the meta-analysis of studies under the individual differences paradigm (see Table 4) exhibited an average effect size (d = 1.44) that was significant, Z = 13.27, p < .001, larger than large (d > 1.20), and greater than 84.6% of effect sizes, PS_{ES} = .846; and positive (implantation of suggested information). The probability of suggestion under the individual differences paradigm (d = 1.44) was 23.8% (p = .238). Furthermore, the results are generalizable (the credibility interval does not include 0) to 90% of studies with a minimum effect of 0.72, although subject to moderators (%Var < 60%) which could not be studied because k or N were insufficient. Likewise, the results of the meta-analysis of the effects of the misinformation paradigm (see Table 4) yielded an average effect size (d = 2.03) that was significant, Z = 18.81, p < .001, larger than large (d > 1.20), and greater than 92.5% of effect sizes, PS_{ES} = .925; and positive (implantation of suggested information). The observed effect size for the implantation of suggested information using the misinformation paradigm (d = 2.03) resulted in an implantation rate of 43.3% (p = .433). This result is generalizable across studies with a minimum effect of 1.94 (lower limit of the credibility interval) and not subject to moderators (%Var = 70.30).

Comparatively, the effect of implanting suggested information using the misinformation paradigm is significantly larger, $q_s(N' = 3756) = 0.223$, Z = 9.66, p < .001, than the effect due to the individual difference's paradigm.

Table 4
Meta-analysis of suggestion for the moderator suggestion paradigm

k	*N*	d_w	S^2_{obs}	SD_{obs}	S^2_{se}	%Var	S^2_{res}	SD_{res}	95% CI_d	80% CV
Individual differences paradigm										
11	4735	1.44	0.3325	0.5766	0.0117	3.52	0.3208	0.5664	1.23, 1.65	0.72, 2.16
Misinformation paradigm										
6	3133	2.03	0.0165	0.1285	0.0116	70.30	0.0048	0.0693	1.82, 2.24	1.94, 2.12

Note. k = number of effect sizes; *N*: total sample size; d_w = sample size weighted mean effect size; S^2_{obs}: sample size weighted observed variance of *d*-values; SD_{obs}: sample size weighted observed standard deviation of *d*-values; S^2_{se}: variance attributed to sampling error variance; %Var = percent of observed variance accounted by sampling error variance; S^2_{res}: variance of *d*-values after removing sampling error variance; SD_{res}: Standard deviation of *d*-values after removing sampling error variance; *;* 95% CI_d = 95% confidence interval for *d*; 80% CV = 80% credibility values interval.

Discussion

This meta-analytic review confirmed the repeatedly proposed hypothesis (e.g., Johnstone et al., 2023; Rocha et al., 2012; Volpini et al., 2016) that individuals who have not completed their cognitive development are especially vulnerable to suggestion. In turn, it has been observed that the probability of implantation of any external suggestive information is around 31%, a very high value, especially because the measured effects of suggestion were immediate. Furthermore, the strength of the results is such that it can be concluded that the implantation of information into the memory of individuals who have not completed cognitive development moves from being a hypothesis to a fact: implantation is generalizable across all studies and moderators, and no inconvenient results have been found (no study reported implantation failure).

These results have direct implications for the psychology of testimony: the memory of witnesses who have not completed cognitive development can be easily modified by external influence. For forensic practice, these results imply that forensic techniques for testimony assessment must discriminate between suggestive and uncontaminated memories, and not classify memories contaminated by suggestion as memories of self-experienced events. Likewise, and for forensic practice, the results limit the use of questions by experts to witnesses, given that these can have suggestive effects on their memory (the contamination of the evidence, memory, judicially invalidates it).

Given that memory for facts and events tends to become less accessible over time, as reflected in the Ebbinghaus' forgetting curve (Sala et al., 2024; Schacter, 1999), the effects of implanted suggestion may be greater than those observed if delayed recall is studied versus immediate recall. In fact, scientific literature has found that the accuracy in recalling an event decreases when it is reactivated after a week or more, compared to immediate reactivation (Dilevski et al., 2022). Therefore, more studies are needed to understand the effects of suggestion over time on recall, as research generally focuses exclusively on the delayed recall of misleading information. Nor has the relevance of the quality of the implanted information for assessment been studied, i.e., central or peripheral information of the event. Research findings in the psychology of testimony have found that central information of an event is fully persistent in honest testimonies, but peripheral information is not (Montes et al., 2024), and that non-experienced information, such as suggested information, is encoded differently from experienced information (Sanmarco et al., 2023). Consequently, theoretical explanations for the findings are limited. In general, as mentioned in the introduction of this work, the idea of semantic content overlap between the original and misleading events is resorted to as an argument for the observed phenomenon (Chrobak & Zaragoza, 2013; Klemfuss & Olaguez, 2018). Even so, Gobbo (2000) proposes an additional explanation: both memory accuracy and resistance to suggestion are related to the memory trace strength of the false items. Specifically, she finds that it is easier to distort the memory of a peripheral detail of the event than to implant a completely new one.

Regarding the type of participation in an event, there is multiple evidence showing how participation in an event, compared to other indirect forms of experiencing it, increases the quality of recall, making it more accessible during attempts to retrieve information. This is due to multiple reasons, among which the amount of perceptual details and contextual information encoded by the subjects stands out (Baker-Ward et al., 1990; Bates et al., 1999; Murachver et al., 1996; Tobey & Goodman, 1992). However, this meta-analysis finds that not only do children who have observed and/or listened the original event incorporate misleading information, but also those who experienced it directly. These findings match with the limited scientific literature examining the effects of event participation on suggestion. Roebers et al. (2004) warned that the fact that memory performance levels can be affected by the way information is experienced does not presuppose that phenomena linked to this cognitive process, such as suggestion, are affected in the same way. In fact, although experimental studies conducted to date found the effect of suggestion regardless of the type of participation in the event, the results are contradictory regarding the existence of differences between direct and indirect participation and which of the two can truly minimize suggestion levels (Dijkstra & Moerman, 2012; Gobbo et al. 2002; Roebers et al, 2004; Rudy & Goodman, 1991). In this meta-analysis, differences between both modalities have been found. The suggestion effect is significantly greater if the event is experienced indirectly compared to experiencing it directly. On one hand, this difference indicates that it is not possible to generalize the results of 'indirectly' experienced events to real-life situations (Bates et al., 1999). This represents a clear methodological disadvantage in the research field. On the other hand, and linked to the legal-forensic area, the differences in the suggestion effects on witnesses will vary depending on whether the person played the role of a victim or a spectator of the criminal act (Roebers et al., 2004). The implications of the results of these studies are of great relevance for providing evidentiary value to testimonies obtained in police and judicial interrogations.

In relation to the paradigms for studying the phenomenon of suggestion, it is necessary to keep in mind the methodological differences that can lead to variations in the results. In this regard, Lee (2004) highlights two key aspects: the format and the timing of the administration of misleading information. Thus, in the misinformation paradigm, erroneous data are usually introduced both through questions and through a brief summary of the original event. This occurs between the initial exposure to the event and the final recognition test. For its part, in the interrogative suggestion paradigm, false information is administered directly in the test itself through misleading questions and along with critical feedback. Given the differences, the psychological mech-

anisms and moderators linked to both approaches may vary (Dudek & Polzcyk, 2024). Nevertheless, the phenomenon of suggestion occurs in both, as can be verified by the effect sizes obtained in this work. Finally, it is important to note that significant differences have been found when comparing the effects of suggestion depending on the paradigm used. Thus, the hypothesis can be confirmed that, depending on the methodology applied when implementing suggested information, different psychological processes are set in motion (Bruck & Melnyk, 2004). In fact, indications have been found of the existence of moderators of the suggestion phenomenon applicable only to interrogative suggestion, such as age, anxiety, the use of coping strategies based on avoidance and distraction, and the ability to cope with social pressure exerted by peers or adults (Gudjonsson et al., 2016; Maiorano & Vagni, 2020; Saraiva & Albuquerque, 2015).

In recent years, a consensus had been reached on the cause of suggestion in people, regardless of the paradigm used. This rested on the failure of a fundamental cognitive mechanism known as 'discrepancy detection' located within the source monitoring framework (Gudjonsson et al., 2016; Johnson et al., 1993). This failure can be interpreted in two ways: 1) the individual is unaware of the discrepancy between the original and post-event information; and 2) the individual is aware of the difference but is unable to identify the corresponding source for each (Dudek & Polczyk, 2024; Howe et al., 2006; Holliday et al., 2022). The study of retractions of abuse victimization testimonies provided support for this explanatory model by finding that witnesses who retracted their testimony based on the appearance of evidence contradicting their testimony modified their assessment of their memory's accuracy (Li et al., 2024). However, results from recent studies contradict this stance by observing suggestion even when individuals can detect the discrepancy (Dudek & Polczyk, 2024; Polczyk et al., 2024).

These contradictory results imply that, beyond theoretical proposals concerning memory, it is necessary to introduce new explanatory variables that may influence the incorporation of misleading information into testimony, such as conformity to information provided by adults perceived as a source of authority and trust (influence process by obedience). Klemfuss and Olaguez (2018) reviewed all experimental studies focused on the impact of psychosocial variables on child suggestion published since 2004, and concluded that self-concept, self-efficacy, the parent-child relationship, and maternal attachment are the most promising, i.e., they predict the appearance of suggestion if they are not present in a positive sense in the individual. In sum, suggestion seems to be influenced by multiple factors (Rudy & Goodman, 1991).

Limitations

The results of this work are subject to a series of limitations that must be taken into account. Firstly, the results corroborate the existence of suggestion, but with effect sizes so high that it is very likely they are overestimated. This overestimation may have been facilitated by the very design of the included studies. Although all followed a fixed structure determined by the selected evaluation paradigms, each addressed one of the multiple moderating variables of suggestion (e.g., perceived social support, intellectual disability, type of source providing misleading information). Secondly, the primary studies are all laboratory experiments and mostly with low-fidelity designs, which also contribute to an artificial increase in effect sizes.

Finally, caution must be exercised when generalizing the results to the field of legal-forensic psychology. Some of the reasons are set out below. On one hand, in the field of witness memory experiments, due to ethical considerations, the events tested are usually emotionally neutral and non-threatening, especially in children (Bates et al., 1999). However, in real life, events subject to evaluation in criminal proceedings usually have a negative emotional charge and are highly personally relevant. On the other hand, the suggestion conditions typically evaluated consist of an interview about a specific event and in the absence of motivation to falsify testimony (Rudy & Goodman, 1991). Conversely, the judicial process and its preliminary stages are filled with a high number of interviews with victims and witnesses; and, in the particular case of minors and sexual abuse, we are dealing with a crime that is usually continuous over time. For this reason, the results of experimental and field studies in the field of testimony psychology are qualitatively consistent but quantitatively different (Amado et al., 2015, 2016; Fariña et al., 1993).

Complementary information

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Annex 1

Data from primary studies.

Study reference	*N*	Moderator	h/d[95% CI]
Akehurst, L. et al. (2009)	105	Loftus P.[1] Observed/narrated E.[2]	2.06[1.96, 2.16]
Brady, M. et al. (1999)	112	Gudjonsson P.[3] Observed/narrated E.	1.60[1.52,1.68]
Carter, C. et al. (1996)	660	Gudjonsson P. Direct E.[4]	0.95[0.93, 0.97]
Chan, L., & Okamoto, Y. (2006)	420	Gudjonsson P. Observed/narrated E.	2.05[2.00, 2.10]
Davis, S., & Bottoms, B. (2002)	1360	Gudjonsson P. Direct E.	0.90[0.88, 0.92]
Gobbo, C. et al. (2002)	320	Gudjonsson P. Direct E.	1.18[1.14, 1.22]
Goodman, G. et al. (1995)	680	Gudjonsson P. Direct E.	1.56[1.53, 1.59]
Jackson, S., & Crockenberg, S. (1998)	81	Gudjonsson P. Observed/narrated E.	0.47[0.37, 0.47]
Lindberg, M. et al. (2001)	172	Gudjonsson P. Observed/narrated E.	1.86[1.79, 1.93]
Ma, L., & Ganea, P. (2010)	60	Gudjonsson P. Direct E.	1.84[1.72, 1.96]
McDonald, K., & Ma, L. (2016)	96	Loftus P. Direct E.	2.70[2.61, 2.79]
Nida, R. (2018)	462	Gudjonsson P. Direct E.	2.29[2.24, 2.34]
Paz-Alonso, P., & Goodman, G. (2008)	1140	Loftus P. Observed/narrated E.	1.99[1.96, 2.02]
Pezdek, K., & Roe, C. (1994)	1440	Loftus P. Observed/narrated E.	1.99[1.96, 2.02]
Pezdek, K., & Roe, C. (1997)	288	Loftus P. Observed/narrated E.	2.13[2.07, 2.19]
Ridley, M. et al. (2002)	64	Loftus P. Observed/narrated E.	2.32[2.18, 2.46]
Vrij, A., & Bush, N. (2000)	388	Gudjonsson P. Observed/narrated E.	2.43[2.38, 2.48]

Note. *N* = Number of subjects/attempts of suggestion. *h*/*d*[95% CI]= Cohen's *d* or *h* effect size [95% Confidence Interval for *d* or *h*].[1]Misinformation Paradigm. [2]The participant observes and/or listens to the event. [3]Individual Differences Paradigm. [4] The participant directly experiences the event.