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Effect of external distractors on text comprehension: a meta-analysis

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Abstract

Distractions are common in reading environments and can negatively affect comprehension. This meta-analysis explores the effect of distractors on reading comprehension and examines moderating factors, including the type of distractor (interference vs. interruption) and mode of presentation (visual vs. auditory). Seven studies, comprising 16 effect sizes, were analyzed. The combined effect size was moderate and statistically significant (g = 0.45, 95% *CI* [0.29, 0.60], p < .001), indicating a detrimental impact of distractors on reading comprehension. Moderation analysis revealed that interruptions (b = 0.68, p < .001) were more disruptive than interferences (b = 0.36, p < .001), as they require a shift in attention. Additionally, visual distractors (e.g., on-screen) showed a greater impact (b = 0.62, p < .001) compared to auditory distractors (b = 0.37, p = .001), likely due to shared cognitive resources for visual processing. Despite including these moderators, significant residual heterogeneity remained (τ^2 = 0.04–0.05; I^2 = 47–56%). These findings emphasize the importance of reducing distractions in educational and work settings to enhance reading performance. Future research should examine additional moderators, such as text complexity and reader characteristics, to better understand the underlying mechanisms and extend these findings to diverse contexts.

Keywords: Reading comprehension; cognitive processes; attention control; visual stimuli; auditory stimuli.

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Efecto de distractores externos en la comprensión de textos: un metaanálisis

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Resumen

Las distracciones son comunes en los entornos de lectura y pueden afectar la comprensión de textos. Se analiza el efecto de los distractores en la comprensión lectora y explora factores moderadores como el tipo de distractor (interferencia vs. interrupción) y su forma de presentación (visual vs. auditiva). Se incluyeron 7 estudios con 16 tamaños de efecto. El tamaño de efecto combinado fue moderado y significativo (g = 0.45, *IC* 95% [0.29, 0.60], p < .001), indicando un impacto negativo de los distractores en la comprensión. El análisis de moderadores mostró que las interrupciones (b = 0.68, p < .001) son más perjudiciales que las interferencias (b = 0.36, p < .001), ya que requieren cambios de atención. Los distractores visuales (e.g., en pantalla) mostraron un mayor impacto (b = 0.62, p < .001) en comparación con los auditivos (b = 0.37, p = .001), probablemente debido a la competencia por recursos cognitivos visuales. Sin embargo, quedó heterogeneidad residual significativa (τ^2 = 0.04–0.05; I^2 = 47–56%). Estos resultados destacan la necesidad de minimizar las distracciones en entornos educativos y laborales. Futuros estudios deberían explorar moderadores adicionales y evaluar la aplicabilidad en distintos contextos y poblaciones.

Palabras clave: Comprensión lectora; procesos cognitivos; control de atención; estímulos visuales; estímulos auditivos.

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INTRODUCTION

Text comprehension is a complex cognitive process that involves the interpretation, analysis, and construction of meaning from a text (Kintsch, 1998; Kintsch & van Dijk, 1978). This process entails the activation of mental processes that enable individuals to integrate new information with prior knowledge, extract relevant information, infer relationships and implicit meanings, and construct a coherent and comprehensive mental representation of the text's content (Kintsch & van Dijk, 1978). Most empirical research on reading comprehension has been conducted in controlled settings, with readers focused on the reading task (e.g., Cain, 2009; Cutting et al., 2009; Kendeou et al., 2012). However, although it is possible to decode a text without directing attention to it, successful comprehension is difficult to achieve when attention is not focused on the task at hand (Reichle et al., 2010; Steindorf & Rummel, 2020). Nevertheless, reading often takes place in distraction-rich environments (Luke & Jensen, 2022), which place additional demands on attentional control mechanisms. Thus, text comprehension depends not only on cognitive abilities but also on the capacity to filter out irrelevant information that competes for attention.

Distractors are stimuli or sources of irrelevant information that compete with the primary task or focus of attention and may interfere with or interrupt cognitive processes. They have the potential to divert attention and hinder concentration on the task being performed (Couffe & Michael, 2017).

In cognitive research, external distractors are frequently used to examine how interferences or interruptions affect performance on a primary task and to investigate individuals' capacity to maintain attentional focus. Previous research has examined how distractors influence attention, memory, and other cognitive processes, as well as how individuals can learn to control or minimise their detrimental effects (Couffe & Michael, 2017). Some studies have also reported potential benefits of interruptions for ongoing tasks, such as faster completion of the primary task through the use of compensatory mechanisms (Burmistrov & Leonova, 2003), although such effects appear to depend on task complexity.

However, not all distractors operate in the same way. Interferences, for example, are concurrent stimuli that compete for cognitive resources without interrupting the primary task, whereas interruptions redirect attention entirely towards a secondary activity and require a subsequent process of task resumption (Couffe & Michael, 2017). Both forms of distraction affect reading comprehension; however, the underlying mechanisms and specific effects may vary according to factors such as frequency, task complexity, and text type.

Interferences are characterised by the presence of irrelevant stimuli that compete for the cognitive resources required to process the primary task without immediately halting its execution (Couffe & Michael, 2017). For example, irrelevant background speech or ambient music may act as sources of interference by generating cognitive overload, thereby hindering sustained attention and the deep processing of text.

By contrast, interruptions are characterised by the suspension of an ongoing activity through the redirection of attention towards a secondary task, such as responding to a text message or answering a telephone call while reading (Stangl & Riedl, 2023). Unlike interferences, interruptions produce a temporary shift in attentional focus, generating cognitive load and requiring a process of reorientation and resumption of the primary task (Burmistrov & Leonova, 2003). Although interruptions may, in certain circumstances, trigger compensatory mechanisms that allow a task to be completed more efficiently, such benefits are more likely to occur in simple tasks than in cognitively demanding activities such as text comprehension (Couffe & Michael, 2017). Interruptions may also be particularly detrimental when they occur frequently or require substantial effort to process the secondary task.

The effect of distractors on text comprehension has been documented. Among the external factors that may affect reading comprehension, auditory distractors have been among the most extensively studied (Luke & Jensen, 2022). Examples of studies reporting such effects include distractors such as exposure to irrelevant speech (Cauchard et al., 2012; Furnham & Strbac, 2002; Murphy et al., 2018; Sörqvist et al., 2010); music or radio broadcasts (Murphy et al., 2018; Perham & Currie, 2014; Souza & Barbosa, 2023; Wong et

al., 2023); television (Armstrong et al., 1991; Cool et al., 1994; Ylias & Heaven, 2003); and siren sounds (Gheewalla et al., 2021). In a meta-analysis conducted by Vasilev et al. (2018) on auditory distraction, background noise, spoken language, and music were found to exert a detrimental effect on reading performance. Similarly, when comparing reading in silence with reading under distraction induced by meaningful speech related to the content, comprehension was poorer in the presence of distraction (Hao & Conway, 2022). More recently, distractions generated by technologies associated with mobile phone use in comprehension tasks have also been investigated, such as receiving a message or experiencing an interruption during a reading task (Chen & Yan, 2016; Luke & Jensen, 2022). In this regard, tasks involving visuo-spatial interference may lead to poorer comprehension performance when compared with auditory or visual interference (Fincher-Kiefer, 2001).

The distinction between interference and interruptions, as well as their effects on comprehension, has not previously been examined exhaustively. In light of the foregoing, the present study aims to synthesise the research agenda concerning the role of distractors in reading comprehension in order to address the following questions:

(1) What is the effect size of distractors on reading comprehension?

(2) Is this effect moderated by text type or by the type of distractor employed?

The present study examines how distractions affect reading comprehension and which factors may moderate these effects. Particular emphasis will be placed on comparing interference and interruptions, as well as analysing how different types of distractors affect text comprehension.

METHOD

In the present meta-analysis, the available empirical evidence regarding the role of distractors in reading comprehension was synthesised.

Literature Search

To summarise the literature, the PRISMA standards were followed (Page et al., 2021). A total of three searches were conducted in the EBSCO Discovery Service, PubMed, and Wiley Online Library databases for articles published between 1 January 2000 and 31 December 2024. Within EBSCO, a search platform that compiles information from all databases accessible through the university, the following primary databases were selected: Academic Search Ultimate, Education Resources Information Center (ERIC), Fuente Académica Plus, MEDLINE, and Psychology and Behavioral Science Collection. Database selection was based on criteria of disciplinary relevance and thematic coverage. In particular, priority was given to repositories commonly used in the fields of cognitive psychology and education, as well as specialised databases providing direct access to full-text articles.

A summary of the literature search process is presented in the flow diagram shown in Figure 1.

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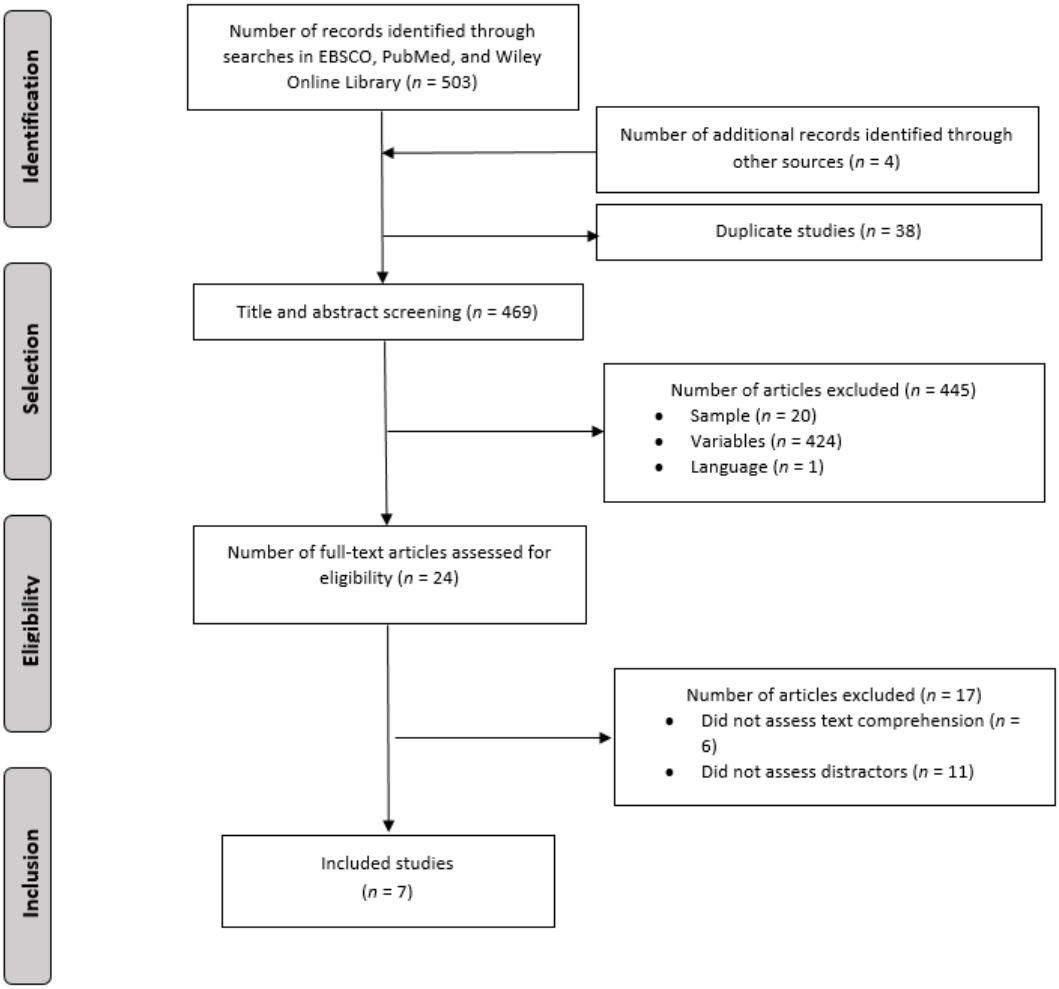
Figure 1

PRISMA flow diagram of the study selection process.



Each database was searched independently using the following comprehensive search terms: ['text comprehension'] OR ['reading comprehension'] AND ['distractions'] OR ['interruptions'] OR ['disruptions'] (n = 503 articles). The same procedure was carried out using combinations of search terms in Spanish (Table 1), and the same search strategy was applied across databases, with the necessary modifications according to each database interface.

Table 1

Search terms used in the systematic review

('text comprehension') OR ('reading comprehension') AND ('distractions') OR ('interruptions') OR ('disruptions') /// ("comprensión de texto" OR "comprensión lectora") AND ("distractores") OR ('interrupciones') OR ('interferencias')

Inclusion and exclusion criteria

To be included in the present meta-analysis, a primary study was required to meet the following criteria:

(1) The sample had to consist of adults without reported developmental, learning, psychiatric, neuropsychological, and/or sensory impairments.

(2) The study had to include an operationally defined measure of interference or interruption.

(3) The study was required to include at least one measure of reading comprehension achievement. Studies that administered only cognitive measures other than reading comprehension achievement measures were excluded.

(4) If a study reported more than one reading comprehension achievement outcome and/or included more than one component of reading comprehension, each outcome and component was treated as a separate effect size.

(5) The results had to include at least one effect size between a measure of reading comprehension ability and a measure of distraction.

(6) Studies were required to employ an experimental or quasi-experimental group design.

Based on these criteria, the selection process was conducted using an initial spreadsheet as a screening tool, in which it was specified whether a study was included and, where applicable, the reason for exclusion.

Following completion of all database searches, duplicate records were removed (n = 38). Subsequently, all non-duplicate articles were screened to determine whether they met the inclusion criteria on the basis of titles and abstracts. When necessary, the methods sections and tables were also reviewed to establish eligibility.

To ensure comprehensive coverage of the literature, supplementary sources of information were employed. Once the final sample of articles had been identified, both backward and forward citation searches, as well as the reference lists of each included study, were examined to verify whether any cited articles had not appeared in the previous searches. Four additional studies were identified from the reference lists of the eligible articles.

A total of 445 articles were excluded following the screening of titles and abstracts: 20 due to sample characteristics, 424 due to the variables examined, and 1 due to language, leaving 24 full-text articles for eligibility assessment. These studies underwent a more detailed analysis involving full-text review. As a result of this evaluation, 17 articles were excluded because they did not include an explicit measure of text comprehension (n = 6) or did not incorporate a distraction manipulation during the reading task (n = 11). The final sample comprised seven studies.

Although the number of studies identified was limited, the analysis was conducted because the methodological literature does not indicate a minimum number of studies required for conducting a meta-analysis (Green & Higgins, 2006).

Coding procedure

To evaluate the role of distractors in reading comprehension, standardised mean differences between the control group and the group exposed to the distractor in each study were used as the effect size measure.

In addition, data on the following variables were collected for each included study: authors, year of publication, total sample size, mean age of the sample, standard deviation of age, text presentation medium

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(paper, screen, or audio), type of text used (narrative or expository), type of distractor employed, and distractor presentation modality.

With regard to distraction factors, distractors were coded according to two main dimensions defined a priori: (a) type of distractor, distinguishing between interference and interruptions, and (b) presentation modality, distinguishing between visual and auditory distractors. Interference was defined as distracting stimuli presented concurrently with reading, without requiring an active response from the reader (e.g., background music, ambient noise, irrelevant speech), whereas interruptions included tasks or stimuli involving the suspension of the reading task in order to perform an activity (e.g., solving mathematical problems or answering questions).

Furthermore, distractor presentation modality was coded as auditory (e.g., music with or without lyrics, ambient sounds) or visual (e.g., visual stimuli presented on screen).

Data analysis

The meta-analysis was conducted using a random-effects model, which allows estimation of the average effect size while accounting for heterogeneity across studies (Borenstein et al., 2010). Heterogeneity was assessed using the I^2 statistic, which estimates the proportion of total variability in effect sizes attributable to between-study heterogeneity rather than sampling error (Higgins & Thompson, 2002). In addition, Cochran's Q test was employed to determine whether the observed heterogeneity was statistically significant.

Publication bias was assessed through funnel plot analysis and Egger's regression test (Sterne & Egger, 2005). In addition, sensitivity analyses were conducted to evaluate the influence of individual studies on the overall effect size and heterogeneity.

All statistical analyses were conducted using R within the RStudio environment, version 3.5.3 (R Core Team, 2020). Data cleaning, dataset construction, and descriptive analyses of the included studies were performed using the *tidyverse* package (Wickham et al., 2019). Meta-analytic models were fitted using the *metafor* package (Viechtbauer, 2010).

RESULTS

Characteristics of the studies

The systematic search yielded seven articles that met the inclusion and exclusion criteria. The characteristics of the studies included in the meta-analysis are presented in Table 2.

Table 2

Characteristics of the studies included in the meta-analysis

Authors	*N*	Text presentation modality	Text type	Distractor presentation modality	Distractor type
Foroughi, et al. (2015)	24	screen	expository	screen	interruption
	24	screen	expository	screen	interruption
	24	screen	expository	screen	interruption
	24	screen	expository	screen	interruption
	24	screen	expository	screen	interruption
	24	screen	expository	screen	interruption
Wong et al. (2023).	70	screen	expository and narrative	audio	interference
	70	screen	expository and narrative	audio	interference
Robison and Unsworth (2015)	241	screen	expository	audio	interference
Pashler, et al. (2013)	82	audio	narrative	screen	interference
Ylias and Heaven (2003)	63	paper	expository	audio	interference
	84	paper	expository	audio	interference
	68	paper	expository	audio	interference
	67	paper	expository	audio	interference
	88	paper	expository	audio	interference
Perham and Currie (2014)	30	paper	expository	audio	interference
	30	paper	expository	audio	interference
Sorqvist et al. (2010)	40	screen	not specified	screen	interference

The included studies were conducted predominantly with samples of university students and involved sample sizes ranging from 24 to 178 participants. All studies employed controlled experimental designs, including both between-subjects and within-subjects approaches.

Studies employing interruptions

In studies employing interruptions, the experimental manipulations consisted of introducing secondary tasks that required an active response from participants while they were reading or listening to texts, such as solving mathematical problems (Foroughi et al., 2015) or responding to opinion questions presented on a screen (Pashler et al., 2013). The texts comprised either standardised academic passages (Foroughi et al., 2015) or passages specifically developed for the purposes of the experiment (Pashler et al., 2013). All texts were presented without time limits, and comprehension was assessed using multiple-choice questions.

In the study conducted by Foroughi et al. (2015), three experiments employing a between-subjects design were carried out. Each experiment involved 24 students, and interruptions were presented visually on screen. Participants read passages modelled on those used in the standardised SAT (Scholastic Aptitude Test; The College Board, 2000), widely used for admission to undergraduate programmes in the United States, Canada, and some European universities, and subsequently answered comprehension questions. The passages were equivalent in both length and difficulty. The interruption task required participants to solve mathematical problems between paragraphs. In the interruption condition, each passage contained

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three interruptions lasting 15 seconds each. No time restrictions were imposed on either reading or question answering. Significant differences were observed between the interruption and no-interruption conditions. In Experiment 2, the design incorporated recognition questions in addition to comprehension questions. The primary task was similar to that employed in Experiment 1. Outcome measures consisted of the number of correct responses to both comprehension and recognition questions. Once again, comprehension performance was poorer under interruption conditions; however, no significant differences between conditions were observed for recognition performance. In Experiment 3, the authors investigated whether a 15-second warning interval prior to an interruption could mitigate its effects on comprehension. The primary task was similar to that employed in Experiment 2, with the addition of warning-interval conditions, resulting in six experimental conditions overall: interruption, no interruption, and warning-interval conditions for both types of questions. Comprehension performance was again significantly poorer under interruption conditions. By contrast, the warning-interval conditions did not produce significant differences in either comprehension or recognition performance.

In the study by Pashler et al. (2013), a design incorporating a visual interruption was employed. Participants (N = 82) listened to two text passages: one under a listening-only condition and the other accompanied by visually presented opinion questions that they were required to answer while listening. After listening to each passage, participants completed comprehension questions related to the text, irrespective of condition. A significant effect of condition was observed, with a medium effect size.

Studies employing interferences

The studies employing interference all involved auditory distractors presented concurrently with the reading task, including music with and without lyrics (Perham & Currie, 2014; Wong et al., 2023), ambient noise (Robison & Unsworth, 2015), irrelevant speech (Sörqvist et al., 2010), and narrative auditory stimuli (Ylias & Heaven, 2003). These studies primarily employed within-subjects or repeated-measures designs involving the reading of narrative or expository passages.

The study conducted by Wong et al. (2023) examined how different musical distraction conditions were associated with reading comprehension performance. Participants were first-year undergraduate students (N = 40). They were required to read six passages and answer multiple-choice questions. A repeated-measures design incorporating three randomised musical conditions was employed. The results revealed no significant differences in reading comprehension across distraction conditions.

Robison and Unsworth (2015) also conducted a study involving auditory interference in which participants (N = 120), under each condition (silent versus noise), read 17 paragraphs at their own pace and answered questions about the text by selecting one of five response options. The paragraphs were extracted from The Challenge of Democracy (Janda et al., 2001). In the silent condition, participants wore headphones to minimise external sounds. In the noise condition, the headphones played a recording of a busy bar or restaurant environment. The authors reported no significant differences in reading comprehension scores between the silent and noise conditions.

In the study by Ylias and Heaven (2003), university students (N = 178) read two passages from the standardised GMAT examination, one under a silent condition and the other under a distraction condition. In the distraction condition, a 15-minute segment of the Australian television drama SeaChange, characterised by relatively low action but extensive dialogue, was played. Each passage contained 480 words followed by eight multiple-choice comprehension questions. The results revealed significant differences favouring the silent condition over the distraction condition in only one participant group.

Perham and Currie (2014) employed a counterbalanced design in which participants (N = 30) were presented with texts extracted from the SAT assessment (College Entrance Examination Board, 2000). Four passages were used: *Silent Film Industry, Diversity of Life, Values and Integrity of Journalism*, and *Emergence of Genetics*. Each passage was approximately 70 lines in length and was accompanied by six multiple-choice comprehension questions. The design comprised four distraction conditions: disliked music with lyrics, liked music with lyrics, liked music without lyrics, and silence. For the disliked-music condition,

the researchers selected heavy/thrash metal songs (*Seemingly Endless Time* and *The Ultra-Violence* by Death Angel), ensuring that participants who enjoyed this genre were excluded. For the liked-music conditions, participants selected music according to their personal preferences. Music was delivered through headphones. The authors found that performance was superior under silent conditions and in the presence of music without lyrics, whereas performance was poorer under music-with-lyrics conditions, irrespective of whether the music was liked or disliked.

Finally, Sörqvist et al. (2010) investigated individual differences in susceptibility to irrelevant speech interference during reading comprehension tasks. A within-subjects design was employed (N = 40), in which participants completed the task under two conditions. Participants read texts and answered related questions under both a silent condition and an irrelevant-speech condition, in which the distractor consisted of a recorded narration presented through headphones. The authors found that irrelevant speech impaired reading comprehension performance.

Characteristics of the sample

A total of 16 effect sizes were extracted from the seven included studies, which were published between 2003 and 2023.

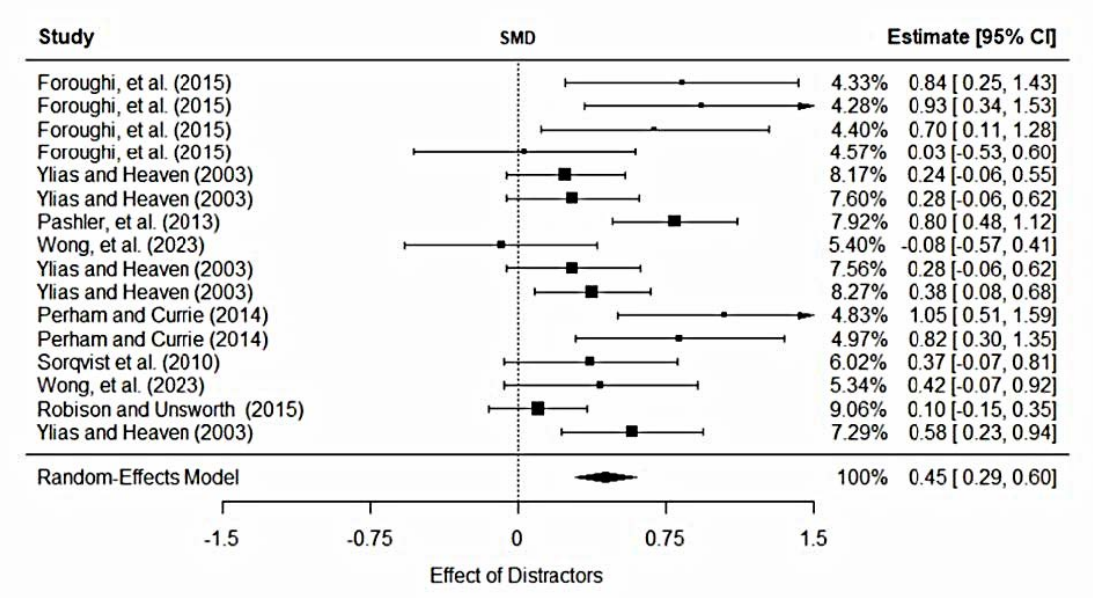
With regard to the mode of text presentation, 50% of the studies employed screen-based texts, 44% used paper-based texts, and 6% presented texts in an auditory format. Concerning text type, 75% of the studies utilised expository texts, 13% employed both expository and narrative texts, 6% used narrative texts exclusively, and the remaining 6% did not specify the text type. Regarding distractor type, 69% of the studies examined interference, whereas the remainder investigated interruptions. In addition, distractors were presented either auditorily (62.5%) or visually via a screen-based format (37.5%).

Effect of distractors on text comprehension

The results obtained are presented in the forest plot (Figure 2).

Figure 2

Forest plot illustrating the effect sizes reported across studies.



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The meta-analysis yielded a pooled effect size of .45 (95% *CI* [.29, .60]), indicating a moderate and statistically significant effect of distractors on text comprehension (z = 5.72, p < .0001). A random-effects model was employed due to the significant heterogeneity across studies.

The analysis also revealed significant between-study heterogeneity (τ^2 = .05; *SE* = .04). The I^2 index indicated that 55.75% of the total observed variability was attributable to heterogeneity, suggesting a moderate degree of heterogeneity. The heterogeneity test ($Q_{(19)}$ = 33.9, p < .003) demonstrated that the observed heterogeneity exceeded that expected by chance, indicating that the effects reported across studies were diverse. Such variability may reflect differences in sample characteristics and/or study design.

Moderator Analyses: Distractor type and distractor presentation

To account for the observed heterogeneity, two additional models were fitted, incorporating distractor type ("interference" vs. "interruption") and distractor presentation modality (auditory vs. screen-based) as moderator variables. All moderators were treated as categorical variables.

The first multilevel analysis, which included distractor type as a moderator, indicated that distractor type significantly explained part of the heterogeneity observed across studies ($Q_{M(2)}$ = 43.47, p < .001). Specifically, interruption-type distractors (b = 0.68, 95% *CI* [0.40, 0.95], p < .001) exerted a greater average effect on text comprehension than interference-type distractors (b = 0.36, 95% *CI* [0.21, 0.52], p < .001). Nevertheless, a substantial proportion of unexplained heterogeneity remained after inclusion of this moderator (τ^2 = 0.03, I^2 = 44.41%), suggesting that additional factors may contribute to the observed variation across studies.

The second moderator analysis showed that distractor presentation modality significantly influenced the magnitude of the observed effect ($Q_{M(2)}$ = 40.15, p < .001). Distractors presented visually on screen produced a significantly larger effect (b = 0.62, 95% CI [0.36, 0.87], p < .001) than those presented auditorily (b = 0.37, 95% *CI* [0.20, 0.55], p = .001). These findings suggest that visual distractors may be more disruptive than auditory distractors in the tasks examined, possibly owing to the predominantly visual nature of the processing demands involved. Although the inclusion of this moderator partially reduced heterogeneity (τ^2 = 0.04; I^2 = 47.89%), a significant proportion of unexplained variability remained ($Q_{E(14)}$ = 26.87, p < .02), indicating the presence of additional uncontrolled factors that may have influenced the results.

However, the limited number of available studies precluded examination of other potentially relevant moderators, such as text presentation format, assessment instruments, or year of publication.

Publication bias and sensitivity analyses

Publication bias was initially assessed using Egger's regression test, which was not statistically significant (b = −0.02, *95% CI* [−0.53, 0.50]; z = 1.80; p = .07), indicating no evidence of funnel plot asymmetry.

For the sensitivity analyses, the original pooled effect size was compared with the effect size obtained after excluding studies with small sample sizes (n < 30). The results indicated a slight reduction in the estimated effect size: whereas the original estimate was g = 0.45, the estimate excluding small-sample studies was g = 0.41. Although modest, this difference suggests that studies with smaller samples may have slightly inflated the initial effect size estimate.

In addition, heterogeneity estimators were explored using three different methods: *DerSimonian–Laird* (DL), *Restricted Maximum Likelihood* (REML), and *Maximum Likelihood* (ML). The heterogeneity estimator results were consistent across methods (g = .45 for all three methods), suggesting that the choice of heterogeneity estimator did not have a significant impact on the meta-analytic results.

Finally, the results were adjusted using the Trim-and-Fill method in order to assess the impact of publication bias. The adjusted effect size was g = .40, representing a modest reduction relative to the original effect size (g = .45).

DISCUSSION

Text comprehension is a cognitive process that has attracted considerable interest within the field of cognitive psychology due to its importance in individuals' everyday and academic lives. Research on text comprehension has largely been conducted under controlled conditions, with readers focused on the reading task (e.g., Cain, 2006; Cutting et al., 2009; Jenkins et al., 2003; Kendeou et al., 2012). However, reading is generally carried out in environments containing numerous distractions. These distractions may take various forms, including ambient noise, related or unrelated conversations, music, or the simultaneous performance of another task.

Previous research has documented the effects of distractions on text comprehension (Foroughi et al., 2015; Hao & Conway, 2022; Perham & Currie, 2014; Robison & Unsworth, 2015; Wong et al., 2023). The aim of the present study was to extend research on the role of distractors in reading comprehension by fitting two theoretically relevant multilevel models within a meta-analytic framework. To this end, specific methodological criteria were established, which limited the number of comparable studies available for inclusion.

The present findings indicate that distractors exert a moderate and statistically significant effect on text comprehension, consistent with previous evidence demonstrating that distractions impair performance on complex cognitive tasks (Denning et al., 2018; Singer-Trakhman et al., 2019). Given the cognitive demands involved in comprehending a text, distractors may exert their effects by interfering with the primary reading and comprehension task, which remains active in working memory, thereby diverting attentional resources away from task-relevant processing (Cowan, 1988, 1999; Cowan et al., 2005). According to Cowan's model, working memory capacity is determined by a limited number of attentional foci available for storing information, which may be occupied by elements such as words, numbers, or images.

Within the study of working memory, capacity-based models (Engle et al., 1999) conceptualise it as a limited-capacity system in which the resources available for task performance vary across individuals. Similarly, Cowan's model (Cowan et al., 2005) conceptualises working memory as a unitary system that temporarily retains information within the focus of attention and supports the storage and processing required for cognitive task performance. Distractions may disrupt ongoing tasks represented in working memory, leading to reductions in processing speed and accuracy (Brumby et al., 2013; Gillie & Broadbent, 1989) as well as increases in cognitive workload (Wickens, 2008). In this regard, several studies have examined the role of working memory in text comprehension under distracting conditions. For example, interruption effects on sentence processing have been shown to affect reading times but not comprehension accuracy (Ledoux & Gordon, 2006). Other studies (Hao & Conway, 2022; Robison & Unsworth, 2015) suggest that individual differences in working memory capacity may contribute to comprehension performance in the presence of distractors.

The exploratory moderator analyses suggest that distractor type ("interference" or "interruption") accounts for part of the variability in effects on reading comprehension. Interruptions produced a greater average impact than interferences, which may be attributable to their more intrusive nature, involving abrupt shifts in attentional focus and the need for cognitive reorientation. From the perspective of Cowan's working memory theory (Cowan et al., 2005), interruptions may consume a larger proportion of the limited attentional resources available, thereby impairing the retention of relevant information in working memory during reading.

Consistent with this interpretation, previous research has shown that unexpected interruptions may result in the loss of actively maintained information (O'Donnell & Wyble, 2023). Interruptions may compromise the stability of working memory representations beyond what can be explained solely

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by task interference, as they appear to disrupt attentional control processes. In this respect, evidence suggests that the impairment produced by interruptions may be attenuated through unexpected cues that reactivate memory traces (Kotyusov et al., 2023). Nevertheless, these differences between distractor types should be interpreted with caution given the limited number of studies that employed interruptions as an experimental manipulation.

Furthermore, distractor presentation modality also emerged as a relevant factor, with visual distractors presented on screen exerting a greater impact than auditory distractors. This finding may reflect direct competition between the visual processing required for reading and the visual distractor itself, both of which draw upon the same sensory and attentional resources (Mandal et al., 2024). This pattern is evident, for example, in studies employing visual on-screen distractors alongside visually presented texts (Foroughi et al., 2015; Sörqvist et al., 2010). However, this explanation does not fully account for the effects observed when the distractor is visual but the text is presented auditorily. In such cases, the findings may be interpreted within the framework of Cognitive Load Theory, which proposes that working memory can become overloaded by increases in extraneous cognitive load generated by task-irrelevant stimuli (Sweller, 2003; Sweller et al., 1998).

These findings also raise new questions regarding the role of auditory distractors in predominantly visual tasks. The observation that visual distractors exerted a more disruptive effect than auditory distractors suggests that tasks relying heavily on visual processing, such as screen-based reading, may benefit from designs that minimise visual interruptions. These findings have practical implications for the design of digital learning environments, where multiple sources of visual information are commonplace. Reducing extraneous cognitive load arising from external distractors, such as notifications from electronic devices, may enhance reading comprehension.

Although constrained by the characteristics of the included studies, the findings of the present meta-analysis have implications for the design of educational environments and learning materials. For example, it may be advisable to minimise visual distractors in complex educational materials by introducing supplementary elements (e.g., graphics, images, and hyperlinks) progressively, once the core content has been processed, thereby reducing competition for attentional resources. Likewise, given that interruptions appear to be particularly detrimental, structuring reading activities into periods protected from interruptions may support the stability of working memory representations. The findings also suggest the value of interventions targeting the reader, particularly those aimed at promoting metacognitive strategies that facilitate the anticipation, regulation, and recovery of attention following interruptions.

The present study has several limitations. The first limitation to consider is the small number of articles identified, which restricts the scope of the analyses and limits conclusions regarding the generalisability of the effects. Furthermore, the residual heterogeneity indicates that unexamined factors may have influenced the results. Future research could expand the available empirical evidence concerning distractions during reading. Access to a broader evidence base would allow exploration of these factors and evaluation of how distractors affect different dimensions of text comprehension (literal, inferential, etc.) in specific populations, such as children or adults. These studies could also examine issues related to differences in text complexity or distractor duration.

Despite the limitations mentioned above, the findings reported in the present study provide evidence for the moderate and significant effect of distractors on reading comprehension. In particular, the moderator analyses suggest that this effect varies according to distractor type and presentation modality. These findings constitute a basis for future research and contribute to the characterisation of the conditions under which distractions may prove detrimental to reading comprehension.

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AUTHOR CONTRIBUTIONS

Sofía-Soledad Ortiz: Project administration; Formal analysis; Conceptualisation; Data curation; Writing – original draft; Writing – review and editing; Investigation; Methodology; Software; Visualisation; Funding acquisition.

Jesica Formoso: Formal analysis; Writing – review and editing; Methodology; Supervision; Validation.

Juan-Pablo Barreyro: Formal analysis; Writing – review and editing; Resources; Supervision; Validation.

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