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The role of perceptual and cognitive load on inattentional blindness: a systematic review and three meta-analyses.

Jérémy Matias[1*], Clément Belletier[1], Marie Izaute[1], Matthieu Lutz[2] & Laetitia Silvert[1]

[1]Université Clermont Auvergne, CNRS, LAPSCO, F-63000 Clermont-Ferrand, France
[2]Michelin Recherche et Développement, Innovation Procédés Industriels, 23 place des Carmes, 63040 Clermont-Ferrand, France

*corresponding author: jeremy.matias@uca.fr (ORCID number: 0000-0001-6347-3399), Laboratoire de Psychologie Sociale et Cognitive (LAPSCO), 34 Avenue Carnot, 63 000 Clermont-Ferrand cedex 1.

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Abstract

The inattentional blindness phenomenon refers to situations where a visible but unexpected stimulus remains consciously unnoticed by observers. This phenomenon is classically explained as the consequence of insufficient attention, because attentional resources are already engaged elsewhere or vary between individuals. However, this attentional-resources view is broad and often imprecise regarding the variety of attentional models, the different pools of resources that can be involved in attentional tasks and the heterogeneity of the experimental paradigms. Our aim was to investigate whether a classic theoretical model of attention, namely the Load Theory, could account for a large range of empirical findings in this field by distinguishing the role of perceptual and cognitive resources in attentional selection and attentional capture by irrelevant stimuli. Since this model has been mostly built on implicit measures of distractor interference, it is unclear whether its predictions also hold when explicit and subjective awareness of an unexpected stimulus is concerned. Therefore, we conducted a systematic review and meta-analyses of inattentional blindness studies investigating the role of perceptual and/or cognitive resources. The results reveal that, in line with the perceptual account of the Load Theory, inattentional blindness significantly increases with the perceptual load of the task. However, the cognitive account of this theory is not clearly supported by the empirical findings analyzed here. Furthermore, the interaction between perceptual and cognitive load on inattentional blindness remains understudied. Theoretical implications for the Load Theory are discussed, notably regarding the difference between attentional capture and subjective awareness paradigms, and further research directions are provided.

Keywords

Inattentional blindness; Load Theory; resources; capacities; working memory

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Declaration of interest

The authors declare that there is no conflict of interest.

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Author's contribution

The reviewing process and the meta-analyses were performed by Jeremy Matias. The first draft of the manuscript was written by Jeremy Matias and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Data statement

All material is available in the manuscript, tables and supplementary files.

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1. INTRODUCTION

1.1. Inattentional blindness and resource-limited attention

Inattentional blindness (IB) is a well-known phenomenon in cognitive psychology referring to situations in which an observer fails to consciously perceive a *clearly visible* but *unexpected* stimulus (Mack & Rock, 1998). The phenomenon was reported for the first time by Neisser and Becklen (1975), but the terms "inattentional blindness" were coined by Mack and Rock (1998). Afterwards, IB has been popularized by the famous study of Simons and Chabris (1999) in which a woman dressed as a gorilla remained largely unnoticed by participants asked to count the passes made by a basket-ball team.

Since then, numerous studies have tried to decipher the factors relating to the task settings (e.g., Most et al., 2001; Newby & Rock, 1998) and/or the individual differences (e.g., Simons & Jensen, 2009; Swettenham et al., 2014) influencing the occurrence of IB. These experiments are very diverse, ranging from traditional computer-based tasks (for a short overview see Jensen et al., 2011) to real-life scenarios that strengthen the external validity of this phenomenon (e.g., Chabris et al., 2011; Ma et al., 2019; Simons & Schlosser, 2017). Hence, many paradigms have been developed, with important variations regarding the primary task employed or the unexpected stimuli used, which can notably be either static or dynamic (see Jensen et al., 2011; Wright et al., 2018). But classically, the observers have to perform a primary task which requires focused attention (e.g., an object-tracking task) when the unexpected stimulus (e.g., a red cross) suddenly appears during one critical trial, and remains visible for several seconds. At the end of the trial, the observers are asked some questions to determine whether they consciously detected the unexpected stimulus or not. Generally, the observers also perform some "control trials", usually named "divided-attention trial" and "full-attention trial" (see White et al., 2018), to ensure that the lack of perception of the unexpected event was really due to inattention rather than to a perceptual deficit.

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Despite the heterogeneity of the experimental protocols, and as quite explicitly suggested by the name of the phenomenon, IB is generally explained as the consequence of *insufficient attention* (Mack, 2003; Mack & Rock, 1998). More precisely, the rationale is that our attentional resources being limited, they do not allow the simultaneous processing of all the stimuli in our environment. Therefore, when attentional resources are already engaged to process some relevant information in a primary task, an unexpected stimulus might go unnoticed due to the lack of available resources at the time of its appearance. However, "attentional resources" is a broad and imprecise umbrella term in the face of the diversity of resources-based models of attention (e.g., Kahneman, 1973; Lavie, 2010; Norman & Bobrow, 1975; Pashler, 1998; Wickens, 2008; see also Desimone & Duncan, 1995). Moreover, attentional resources manipulations have been achieved through so many different paradigms in IB studies (e.g., Beanland & Pammer, 2010; Horwood & Beanland, 2016; Légal et al., 2017; Richards et al., 2014; Todd et al., 2005) that one could wonder whether those studies actually manipulated similar or different kinds (or pools) of resources (e.g., Lavie, 2010; Wickens, 2008) and whether their results could be understood within a common theoretical framework.

In view of these considerations, our aim was to conduct a systematic review and a meta-analysis of studies investigating the role of attentional "resources", "capacities" or "demands" in IB, in the light of the Load Theory of attention (Lavie, 1995, 2010; Lavie & Tsal, 1994). Indeed, by distinguishing the perceptual and cognitive loads of a task (Lavie & Dalton, 2014), this theory delineates a clear theoretical framework for contemplating the results of these studies together. Besides, it provides distinguishable predictions as to how these two types of load may influence the *allocation of attentional resources* to a task-irrelevant stimulus. However, since the allocation of attentional resources to a stimulus may not always be sufficient to bring it to awareness (e.g., Chica & Bartolomeo, 2012), the applicability of these predictions

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regarding the *conscious perception* of task-irrelevant stimuli in IB paradigms remains uncertain.

1.2. A dual-resource model for attentional selection: the Load Theory

The extent to which people can focus attention in the face of irrelevant distractors is one of the most enduring issue in the study of attention. The Load Theory is rooted in the framework of attention as a limited resource or capacity (Broadbent, 1958; Kahneman, 1973; Lavie & Tsal, 1994; Navon, 1989; Shiffrin & Schneider, 1977) and specifies two mechanisms – a perceptual one and cognitive one – for attentional selection (for reviews see Lavie, 2005, 2010; Murphy et al., 2016). As it will be explained below, the Load Theory originally proposed that the *perceptual load* of the task is a crucial factor for efficient selection (Lavie, 1995). It was later extended to include the *cognitive load* imposed by the task on individuals (de Fockert et al., 2001), thus integrating the role played by central resources in determining the level of processing of an irrelevant stimulus (Lavie et al., 2004). Although this theory has been criticized on particular methodological or theoretical flaws (e.g., Eltiti et al., 2005; Tsal & Benoni, 2010), calling for some model adjustments (Fitousi & Wenger, 2011; Neokleous et al., 2016), perceptual and cognitive loads remain *some* of the major determinants of selective attention (Bruckmaier et al., 2020; Murphy et al., 2016). Moreover, this framework continues to offer valuable perspectives to investigate attentional failures such as distraction into ecological scenarios (e.g., Marciano & Yeshurun, 2012, 2015).

Perceptual load and the processing of distractors

The perceptual load reflects the task demands that affect the availability of perceptual processing capacities (Fitousi & Wenger, 2011; Lavie, 1995). Because of the limited perceptual resources (Lavie, 1995; Lavie & Tsal, 1994) stimuli are in competition to gain access to those

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resources (Desimone & Duncan, 1995). In this way, the perceptual load represents the degree of competition between stimuli that has to be resolved by attention mechanism to bias competition in favor of a relevant information (Bruckmaier et al., 2020; Scalf et al., 2013; Torralbo et al., 2016; Torralbo & Beck, 2008). When perceptual load is low, few perceptual resources are needed to process the relevant information. Spare resources would then "spills over" to irrelevant stimuli, leading to attentional capture and distractor interference (e.g., Cosman & Vecera, 2010; Forster & Lavie, 2008). Conversely, high perceptual load requires a strong top-down bias (Scalf et al., 2013) to give relevant stimuli a privileged access to perceptual resources, and inhibit irrelevant stimuli processing (Bruckmaier et al., 2020; Culham et al., 2001; Rorden et al., 2008; Torralbo et al., 2016). As a result, attentional capture and interferences produced by irrelevant stimuli are significantly reduced under high perceptual load (e.g., Cosman & Vecera, 2010; Forster & Lavie, 2008). It is important to note that a perceptual load effect is expected to be observed when all the perceptual capacities are consumed. In other words, any residual extra capacities would allow task-irrelevant processing (Lavie & Cox, 1997). Consequently, when multiple levels of load (e.g., low, moderate and high) are incremented, the absence of significant differences between low and moderate load conditions does not necessary contradict the theory.

Typically, four types of perceptual load paradigms are distinguished in the literature (Chen & Cave, 2016; Lavie, 1995; Murphy et al., 2016). First, load can be manipulated by varying the number of items (i.e., set-size) on the display (e.g., Exp.1 in Lavie, 1995). The rationale beyond this manipulation is that since only a limited amount of stimuli can be simultaneously perceived (Broadbent, 1958; Carrasco, 2011), more attention is needed to manage perceptual resources at larger set-size. Second, perceptual load can also be adjusted via the similarity between the target and the non-targets and/or the similarity within the non-targets (e.g., Lavie & Cox, 1997). Because visual search is more efficient when the similarity among

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the non-targets increases and/or the similarity between the target and the non-targets decreases (Duncan & Humphreys, 1989, 1992), perceptual load is expected to be larger in condition of non-targets dissimilarity or target/non-targets similarity, than in condition of non-targets similarity or target/non-targets dissimilarity. In the third paradigm, perceptual load is manipulated by making the target perception more difficult, that is, by increasing the similarity between the target features that participants are required to discriminate (e.g., Handy & Mangun, 2000). Finally, the fourth manipulation of load was adapted from the feature integration theory (Treisman & Gelade, 1980; Treisman & Sato, 1990). According to this theory, perception of simple features is load free but their conjunction requires the focusing of attention and therefore imposes perceptual load (e.g., Chen & Cave, 2016; Exp.2 in Lavie, 1995). Following the theoretical framework offered by the Load Theory, increasing the perceptual load of a task should prevent attentional capture by, and perceptual processing of the unexpected stimuli and thus, should *increase* IB for this stimulus (e.g., Cartwright-Finch & Lavie, 2007).

Cognitive load and the processing of distractors

The cognitive load is related to the central resources responsible for executive processes (Baddeley, 1996; Engle, 2002), and more precisely, to the working memory (WM) capacities that have to be engaged to maintain an efficient top-down priority between relevant and irrelevant information for attentional selection (de Fockert, 2013; de Fockert et al., 2001, 2004; Lavie et al., 2004). Typically, WM is loaded when individuals have to switch back and forth between different tasks, or have to maintain and/or manipulate some task-unrelated stimuli in WM during task performance (Lavie, 2010). When the task requires few WM resources, the cognitive load is low and the priority between relevant and irrelevant information can be maintained in an efficient way. Attentional selection is thus more prone to be driven by goal-relevant factor and irrelevant information are more likely to be ignored (Fukuda & Vogel, 2009;

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Kelley & Lavie, 2011). Conversely, when the availability of the WM resources is constrained (e.g., in dual-task situations but also in individuals with low WM capacities), the cognitive load is high and less WM resources can be engaged to maintain attentional priorities. Therefore, selective attention will be less focused on the relevant task and an irrelevant stimulus will be more likely to capture attention (de Fockert, 2013; de Fockert et al., 2001, 2004; Lavie et al., 2004).

If IB is indeed directly dependent on the availability of attentional resources, since the ability to focus attention on the task deteriorates under conditions of high cognitive load, an unexpected irrelevant stimulus would be more likely to be consciously perceived under high cognitive load. Conversely, under low cognitive load, efficient active maintenance of priority should prevent attentional capture and thus conscious perception of unexpected stimuli. In other words, increasing cognitive load should *decrease* IB (i.e., increase awareness) for an unexpected stimulus (e.g., de Fockert & Bremner, 2011). However, this view is to be regarded as the strongest interpretation of the effect of cognitive load on IB. Indeed, it has been argued that cognitive load hampers attentional priority between relevant and irrelevant stimuli only for distractors that strongly compete for attentional selection (Carmel et al., 2012; Lavie et al., 2004). Therefore, the effect of cognitive load on IB might depend on whether the unexpected stimulus is actually in competition with other stimuli for attentional selection (see also de Fockert & Bremner, 2011; Lavie & de Fockert, 2005). In the absence of competition, it could be argued that cognitive load would increase IB given that WM resources are also implicated in conscious perception (Baars, 1988; Dehaene et al., 2006).

Interaction between perceptual and cognitive load

Finally, how the potential interaction between perceptual and cognitive load can affect attention remains a matter of debate (Caparos & Linnell, 2010; Lavie et al., 2004; Linnell & Caparos, 2011). On the one hand, the authors behind the Load Theory assumed a strict

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independence between perceptual selection and cognitive control mechanisms as both rely on dissociable resources (Lavie et al., 2004). And indeed, in a study where perceptual and cognitive load were manipulated orthogonally, they failed to show any statistically significant interaction effect of those two factors on distractor interference (Exp. 3 in Lavie et al., 2004). On the other hand, others have shown that both types of load influence spatial attentional selection in an interactive way (Caparos & Linnell, 2010; Linnell & Caparos, 2011). More precisely, increasing the perceptual load focused the attention (i.e., reduced distraction) only when the cognitive load was low (Linnell & Caparos, 2011), suggesting that perceptual load exerts its effect through the involvement of cognitive resources. Conversely, increasing the cognitive load defocused attention when perceptual load was high rather than low (Linnell & Caparos, 2011). Accordingly, cognitive resources are deployed to manage the priority between relevant and irrelevant information particularly when the stimuli encourage this, that is, when perceptual load is high (see also Theeuwes et al., 2004). Regarding IB, those results would mean that increasing perceptual load should enhance IB particularly when the cognitive load is low. Additionally, under high but not low perceptual load, increasing the cognitive load should reduce IB of the unexpected event. Therefore, at this point, it remains unclear whether perceptual and cognitive load would interact to determine IB as only few works have been conducted on this topic (see Murphy et al., 2016).

Attentional capture vs subjective awareness

Importantly, supports to the Load Theory mainly come from studies using implicit measures of attentional capture (for reviews see Lavie, 2005, 2010; Murphy et al., 2016). In those studies, attentional shifts to irrelevant stimuli are typically inferred from implicit measures of distractor interference such as reaction times (e.g., Cosman & Vecera, 2010; Forster & Lavie, 2008; Lavie, 1995; Lavie & Cox, 1997), neuroimaging data (e.g., Handy et al., 2001; Rees et al., 1997; Rorden et al., 2008; Silvert et al., 2007) or cellular metabolism

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(Bruckmaier et al., 2020). In contrast, IB paradigms usually rely on direct measures of subjective awareness of the unexpected stimulus, the participants being explicitly asked whether or not they noticed this stimulus (Most et al., 2005; Simons, 2000). Yet, even if attention is considered as a necessary condition for conscious perception, it is not always sufficient (Chica & Bartolomeo, 2012; Cohen et al., 2012). Therefore, stimuli for which implicit attentional capture has been observed might nonetheless remain consciously unnoticed. And indeed, there have been several reports of stimuli affecting behavioral responses without people becoming aware of them (e.g., Moore & Egeth, 1997; see also Posner, 1980). Moreover, in IB paradigms, eye movements toward the unexpected stimulus do not predict awareness of this event (Beanland & Pammer, 2010; Richards et al., 2012). Finally, the same factors that influence the allocation of an observer's attention in attention capture studies do not predict what reaches conscious awareness in IB studies (Wright et al., 2018). Hence, attentional capture is clearly not perfectly related to the noticing of an unexpected stimulus.

Note that rather than revealing a real dissociation between attention and awareness, those divergences might also be due to a major methodological difference between the paradigms used to assess attentional capture by distractors and conscious awareness in IB paradigms (see Simons, 2000). While the distractor is clearly irrelevant but expected - because usually present in many trials - in the former, it is completely unexpected – and thus potentially relevant – in the latter. Therefore, after several trials in attentional capture paradigms, observers might develop an attentional set that distinguish between relevant and irrelevant features (Folk et al., 1992, 1994), in order to suppress attentional capture by the distractors (Gaspar & McDonald, 2014; Gaspelin et al., 2015; Gaspelin & Luck, 2018; Kiss & Eimer, 2011). In contrast, observers could not develop such attentional set in IB paradigm, as the irrelevant distractor is totally unexpected and encountered for the first time when awareness is assessed.

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Despite those critical differences across attentional capture and IB paradigms, the processing of a task-irrelevant stimulus in both is typically assumed to be related and determined by similar attentional processes (Most et al., 2005; Simons, 2000). Nonetheless, for all the reasons mentioned above, predictions derived from the Load Theory regarding the allocation of attentional resources to irrelevant stimuli under various perceptual and cognitive load conditions may not fully account for the perception of irrelevant stimuli in IB paradigms.

1.3. Rationale and objectives

To sum up, since seminal papers on IB (Mack & Rock, 1998; Simons & Chabris, 1999), several studies have been conducted to investigate the attentional limited-resource view underlying the IB phenomenon, using various paradigms. Given the link between attention and consciousness, one could expect that the attentional model provide by the Load Theory would be useful to understand the role of "attentional resources" involved in conscious perception. However, it is worth noting that the Load Theory has been mainly built on implicit measure of attention and thus might not be efficient to predict IB as an explicit measure of awareness. Therefore, our aim was to provide qualitative and quantitative analyses of the studies investigating the role of attentional resources or capacities, sometimes referred to as general "task demands", in the IB phenomenon in order to evaluate whether those studies could be included and understood within the scope of the Load Theory. To this end, we first conducted a systematic review of the studies dealing with the effect of perceptual load and/or cognitive load on IB. Then, we carried out three distinct meta-analyses regarding 1) the effect of perceptual load, 2) the effect of cognitive load when manipulated across subjects and 3) the effect of cognitive load when measured through WM tests at an individual level.

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2. QUALITATIVE ANALYSIS

2.1. Method

This systematic review was conducted and reported in line with the PRISMA statement (Moher et al., 2009), and identified all studies investigating the role of attentional resources[1] on IB rates, from studies conducted into controlled lab settings to studies accomplished into more ecological situations (e.g., real-world scenario).

2.1.1. Eligibility criteria

Inclusion criteria

As the term "inattentional blindness" was coined and popularized in the late nineties (Mack & Rock, 1998; Simons & Chabris, 1999), we decided to include only studies from 2000 onwards. Moreover, all experimental studies included were written in English and published in peer-reviewed scientific journals. Participants in the studies could be any age, gender, or nationality. We selected only studies in which IB was assessed for a *visual* stimulus, and made no restriction for the IB paradigms used (e.g., static or dynamic, see Jensen et al., 2011; White et al., 2018) as long as the unexpected stimulus was truly unexpected.

We included studies investigating the effect of attentional resources availability on IB even without explicit reference to the Load Theory framework. It should be noted that perceptual load is more defined by paradigms than by explicit, process-based definitions (Benoni & Tsal, 2013; but for reasoned criticisms and powerful tests of perceptual load see Fitousi & Wenger, 2011; Roper et al., 2013). Therefore, we decided to cover all the classic perceptual load paradigms described in the introduction section (i.e., varying set-size, similarity between target and/or non-target stimuli or the perceptual difficulty of the task). Additionally,

[1] With understanding that "resources" could be replaced by "capacities" and the fewer resources available, the greater the load (or task demands).

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in dynamic IB paradigms, the perceptual task demand is classically increased with the speed of the items in multiple-objects tracking tasks (e.g., Simons & Jensen, 2009). Thus, we also considered speed variation in this paradigm as a perceptual load manipulation (see Tombu & Seiffert, 2008). Regarding the cognitive load, we included the studies that directly manipulated the amount of WM resources available when the unexpected stimulus was displayed (e.g., maintaining one versus six digits for subsequent recall). We did not restrict our selection to a specific modality for the WM task (e.g., visual or auditory material). Additionally, we included studies that measured individual differences for WM capacities through specific tests (e.g., AOSPAN: Unsworth et al., 2005) and looked whether they could predict IB rates. The rationale beyond that decision was that a same task could generate different cognitive loads at the individual level, depending on whether the participant has a low or high WM capacity (resulting respectively in a relatively high or low cognitive load at the individual level). However we did not include studies investigating more general abilities that did not rely exclusively on, or only correlate with, WM capacities (e.g., fluid intelligence through Raven's matrices test, see Unsworth & Engle, 2005).

Exclusion criteria

We excluded all commentaries, reviews, abstract conferences and proceedings, or studies published in books. Moreover, the present review does not include phenomenon related to but different from IB, namely inattentional amnesia (Rees et al., 1999; Wolfe, 1999) and change blindness (Jensen et al., 2011). Finally, some studies might confound the manipulation of perceptual and cognitive loads because the main purpose of the study was elsewhere. In such studies, the authors manipulated a general "attentional load" that relied on increasing both loads simultaneously. Consequently, it was not possible to determine which factor drove the effect observed on IB. Therefore, those studies have been excluded from our review (but are nonetheless mentioned in the online Supplementary Material).

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2.1.2. Information sources, search and study selection

Electronic sources included PubMed, ScienceDirect and APA PsycNET, which are major databases in cognitive psychology. Those databases have been consulted on 22nd April 2020. We successively searched[2] in Title, Keywords or Abstract for the terms "`inattention* blind* AND`":

- `Load*`
- `Task* demand*`
- `Resource* OR capacit*`
- `Working memory`

The search conducted in each databases successively yielded 205 entries in total (Figure 1). After the removal of duplicates (n = 89), the 116 remaining studies were screened for eligibility by reading the abstracts. According to the inclusion/exclusion criteria, 62 studies were removed at this step and 54 were full-text assessed for eligibility. Subsequently, 23 papers were discarded (see the online Supplementary Material) and 31 studies have been included in the present review. Finally, during the full-text reading phase, we identified five new studies cited in the selected papers, manipulating the perceptual or cognitive resources availability on an IB paradigm (see Tables 1 and 2). Typically, perceptual and cognitive load effects were not the main purpose in those studies, but some experimental conditions fitted well with our inclusion criteria and classic perceptual (e.g., varying the number of distractors) or cognitive load (e.g., dual-task) manipulations. Therefore, those studies have been included in our review. At this step, the 36 studies included were categorized according to the type of load investigated (i.e.,

[2] The authors also checked entries found with a long search query including all the search terms. However, this method is not recommended when using multiple truncations (see https://www.nlm.nih.gov/bsd/disted/pubmedtutorial/020_460.html). And indeed, the long search query led to less (relevant) entries than successive searches with different keywords.

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perceptual, cognitive or both). Note that several studies included multiple experiment and/or experimental conditions, each with a different sample. In those cases, we describe each experiment and/or condition in a separate line (Tables 1, 2 and 3).

--- Insert Figure 1 about here ---

2.1.3. Qualitative data analysis

We first conducted a qualitative analysis of the selected studies. More precisely, we described whether the effects of perceptual load and/or cognitive load (including measures of WM capacities, thus the cognitive load at the individual level) observed in each paper are in accordance with the Load Theory predictions ("Consistent" being then reported in Tables 1, 2 and 3). Alternatively, the Load Theory could fit partially with the results, when typical perceptual and/cognitive load effects are significant in some but not all conditions (corresponding to "Partially Consistent " in the tables) or the studies could report null results in all conditions (corresponding to "No Effect" in the tables). Otherwise, the studies could reveal results that are significant but opposite to the Load Theory expectations in all ("Inconsistent" is then reported in the tables) or only in some conditions (corresponding to "Partially Inconsistent" in the tables).

Additionally, we reported in Tables 1, 2 and 3 the main statistical information of each experiments or conditions we have identified (when possible) in order to provide the most exhaustive representation of IB under the scope of the Load Theory. However, note that all experiments or conditions could not be included in the following meta-analyses presented in the Quantitative analysis section (e.g., due to insufficient data or because they relied on the same sample) and that all statistics used in the meta-analyses appear in Figures 2, 4 and 6.

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2.1.4. Risk of bias

As mentioned earlier, our studies selection was not strictly restricted to a specific IB or (perceptual or cognitive) load paradigm. Therefore, the pool of studies included here might suffer from methodological heterogeneity, which is an inherent and common bias among systematic review and meta-analysis (Higgins, 2008). On the one hand, if the effects are systematically observed among different paradigms, it could strengthen their reliability and consistency beyond methodological considerations. On the other hand, discrepant findings could be explained by methodological heterogeneity instead of alternative theoretical interpretations, undermining conclusions about perceptual and cognitive/WM resources on IB. Additionally, a publication bias might exist with, for instance, null results not being published (see Sterne et al., 2011).

2.2. Results

To begin with, the studies included in our review are described according to the paradigms used for perceptual and cognitive load investigation (including measures of WM capacities for the latter). Then, in a second step, we report the effect of those investigations on IB and we assess whether those results were qualitatively consistent (or not) with the Load Theory predictions.

2.2.1. Studies characteristics

Perceptual load

Sixteen studies (Table 1) were considered as falling within the scope of perceptual load manipulation (Beanland & Pammer, 2010; Cartwright-Finch & Lavie, 2007; Dixon et al., 2013;

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Ericson et al., 2017; Horwood & Beanland, 2016; Koivisto & Revonsuo, 2008, 2009; Lathrop et al., 2011; Lin & Yeh, 2014; Marcus et al., 2015; Murphy & Greene, 2016, 2017; Remington et al., 2014; Simons & Jensen, 2009; Swettenham et al., 2014; White & Davies, 2008). As a reminder, four main types of paradigms have been identified, sometimes adapted into more applied studies.

--- Insert Table 1 about here ---

In one study, the perceptual load manipulation was achieved by increasing the number of (relevant) stimuli that had to be processed during the primary visual search task (White & Davies, 2008)[3]. More precisely, one target-letter was displayed in the low load condition (Exp.3a), two in the moderate load (Exp.1) and three in the high load condition (Exp.3b). Two studies conducted during a surgery training (Dixon et al., 2013; Marcus et al., 2015) used the same kind of manipulation. Here, the authors investigated IB for an unexpected event like a foreign body (e.g., a screw) in surgeons using either a classic view (i.e., camera) or an additional image guidance view (i.e., camera + augmented reality view adding relevant information about body anatomy) during an endoscopy. Therefore, less relevant information were displayed for the classic view, considered as low perceptual load condition, than for the additional image guidance view, considered as high perceptual load condition.

In some other studies, the number of irrelevant (i.e., non-target) stimuli was increased between low and high perceptual load while participants performed an object-tracking task of multiple targets (Horwood & Beanland, 2016; Exp.4 in Koivisto & Revonsuo, 2008). Increasing

[3] One could argue that this manipulation could be view as cognitive load because participants needed to store more target-letters in working memory. However, in our viewpoint, this manipulation should not be considered as cognitive load because participants did not store information in working memory at the time of stimuli appearance, and thus when the unexpected stimulus was displayed. In typical cognitive load scenario, some information are stored in working memory before the unexpected stimulus appearance.

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the number of irrelevant stimuli was also employed while observers performed a visual search task for a target-picture (Koivisto & Revonsuo, 2009), a target-word (Lin & Yeh, 2014) or a target-letter (Exp.2 and 4 in Cartwright-Finch & Lavie, 2007) among non-target stimuli. Similarly, in one driving simulator study (Ericson et al., 2017), the visual complexity of the driving environment was increased by displaying more irrelevant information (e.g., trees or buildings) in the high perceptual load condition than in the low perceptual load condition.

A more complex perceptual judgement task was also used in three studies to manipulate the perceptual load (Exp.1 and 3 in Cartwright-Finch & Lavie, 2007; Lathrop et al., 2011; Remington et al., 2014; Swettenham et al., 2014). Typically, participants had to make a perceptual judgment about a cross (e.g., which arm, horizontal or vertical, is longer) but the difficulty varied between conditions (e.g., smaller difference between arms in high- rather than low-load). The perceptual judgment task was adapted in two simulated driving studies, in which the task required either a more or less difficult gap-size estimation between two parked vehicles (Murphy & Greene, 2016) or the search for a target-car defined by a simple feature (e.g., the unique red car) or features conjunction (e.g., the unique red Mercedes car; see Murphy & Greene, 2017).

Finally, perceptual load manipulation was achieved by increasing targets speed in an object-tracking task in two studies (Beanland & Pammer, 2010; Simons & Jensen, 2009).

Cognitive load and WM capacities

Sixteen studies (Table 2) were considered as investigating cognitive load (Beanland & Chan, 2016; Bredemeier & Simons, 2012; de Fockert & Bremner, 2011; Fougnie & Marois, 2007; Hannon & Richards, 2010; Harvey et al., 2018; Kreitz et al., 2015; Kreitz, Furley, Memmert, et al., 2016; Kreitz, Furley, Simons, et al., 2016; Légal et al., 2017; Matsuyoshi et al., 2010; Pizzighello & Bressan, 2008; Richards et al., 2010, 2014; Seegmiller et al., 2011; Todd et al., 2005). It should be noted that those studies were all computer-based experiments,

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none of them being conducted into a more ecological context (e.g., driving simulator). Two main paradigms were identified as investigating the role of cognitive resources in IB: through a direct manipulation of WM load, or through measures of individual differences in WM capacities.

--- Insert Table 2 about here ---

In the first type of paradigms, cognitive resources were manipulated *directly* through a WM task that engaged more or less WM resources depending on the cognitive load condition. The rationale is that the more items are stored in WM, the higher the cognitive load. It is worth noting that the WM task either took place along with an additional attentional task (i.e., dual-task paradigms: de Fockert & Bremner, 2011; Harvey et al., 2018; Légal et al., 2017; Pizzighello & Bressan, 2008) or stood on its own (i.e., single-task paradigms: Fougnie & Marois, 2007; Matsuyoshi et al., 2010; Todd et al., 2005). In the former case, observers performed both the WM task and an attentional task; the unexpected stimulus appeared along with other stimuli that were part of the attentional task (e.g., target and non-target letters in the objet-tracking task). In the latter, observers only performed the WM task. The unexpected stimulus was displayed alone on the screen during the "maintenance" phase, that is, during the time between the presentation of the to-be-memorized stimuli in WM and their recall or recognition at the end of the trial. In others words, the unexpected stimulus either appeared in competition with other stimuli or appeared alone with no concurrent stimuli. Besides, regarding cognitive resources manipulations, observers had to maintain less stimuli in WM in the low rather than in the high cognitive load condition (digits: de Fockert & Bremner, 2011; shapes: Matsuyoshi et al., 2010; a short story or words: Pizzighello & Bressan, 2008; spatial locations: Todd et al., 2005). Similarly, observers had to count the passes made by a basket-ball team (Harvey et al., 2018; Légal et al., 2017), but they had to count either the total number of passes (i.e., single count - low cognitive load) or the number of both aerial and bounce passes

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separately (i.e., double count – high cognitive load). Finally, instead of relying on the quantity of information that had to be stored, the cognitive load manipulation could rely on a qualitatively more complex operation for the high cognitive load condition (i.e., rearrange the string of consonants by alphabetic order) than for the low cognitive load condition (i.e., maintain a string of consonants in memory; Fougnie & Marois, 2007).

A second type of paradigms relied on a different approach in which WM capacities were measured *independently* of the IB task. The aim here was to investigate whether individual differences in WM capacities would predict the awareness of the unexpected stimulus. According to this approach, authors investigated whether WM capacities differed between individuals who perceived the unexpected stimulus and those who did not, or conversely whether IB rates differed between individuals with low or high WM capacities. Our review revealed that the OSPAN task (or its automated version – AOSPAN; Unsworth et al., 2005) was used in all the studies to measure WM capacities (Beanland & Chan, 2016; Bredemeier & Simons, 2012; Hannon & Richards, 2010; Kreitz et al., 2015; Kreitz, Furley, Memmert, et al., 2016; Kreitz, Furley, Simons, et al., 2016; Richards et al., 2010, 2014; Seegmiller et al., 2011). Along with the (A)OSPAN task, additional measures of WM capacities were sometimes investigated as predictor of IB, such as spatial or verbal n-back tasks (Beanland & Chan, 2016; Bredemeier & Simons, 2012; Kreitz et al., 2015; Kreitz, Furley, Simons, et al., 2016) or performances on an independent visual WM task (Hannon & Richards, 2010).

Investigation of both perceptual and cognitive resources

We found four studies that simultaneously investigated the role of perceptive and cognitive resources on IB (Beanland et al., 2011; Calvillo & Jackson, 2014; Hughes-Hallett et al., 2015; Richards et al., 2012) with one study conducted into a real-world scenario (Table 3).

--- Insert Table 3 about here ---

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The manipulation of the perceptual load was achieved by increasing the targets speed in an object-tracking task (Beanland et al., 2011), by adding irrelevant stimuli in a visual search task (Calvillo & Jackson, 2014), or by adding relevant information in a surgical training task (i.e., surgeons used a classic camera view alone or with an additional image guidance view: Hughes-Hallett et al., 2015). In addition, one study varied the number of both relevant and irrelevant stimuli as well as the target speed to manipulate the perceptual load (Richards et al., 2012).

The cognitive load was manipulated directly on a dual-task paradigm with a concurrent audio WM task (Beanland et al., 2011) or with a concurrent counting task (Hughes-Hallett et al., 2015). Additionally, individual WM capacities were measured independently through an AOPSAN task (Calvillo & Jackson, 2014; Richards et al., 2012).

2.2.2. Qualitative results

IB and perceptual load

For recall, the Load Theory predicts that increasing the perceptual load should lead to larger IB rates (Lavie, 2006). We considered a strong interpretation of this claim, that is, that it should hold in any situation. Therefore, if perceptual load effect is replicated but modulated by additional factors in some conditions (e.g., due to particular clinical traits or to the nature of the unexpected stimulus) the study would then be labelled as "Partially consistent" with the theory. However, it is important to note that those modulating factors do not necessary disprove, in a strong sense, the Load Theory but rather might be helpful to expand its original framework and encompass a broader range of situations. Additionally, perceptual load effect is expected to be observed when all perceptual capacities are loaded, that is, between low and high load but not necessary between low and moderate levels of load (Lavie & Cox, 1997).

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For studies investigating the role of perceptual load only (Table 1), we found ten out of sixteen studies reporting consistently more IB under higher rather than lower perceptual load, thus, in line with the Load Theory (Beanland & Pammer, 2010; Cartwright-Finch & Lavie, 2007; Dixon et al., 2013; Koivisto & Revonsuo, 2008, 2009; Marcus et al., 2015; Murphy & Greene, 2016, 2017; Remington et al., 2014; Simons & Jensen, 2009). In four studies, the results fit partially with the Load Theory, with a significantly larger IB rates in at least one but not all conditions of higher perceptual load (Horwood & Beanland, 2016; Lin & Yeh, 2014; Swettenham et al., 2014; White & Davies, 2008). In those cases, the effect of perceptual load was modulated by an additional factor (e.g., the category of the unexpected event) leading to a non-significant difference in some conditions. Finally, two studies reported null results regarding the perceptual load effect on IB in all conditions (Ericson et al., 2017; Lathrop et al., 2011).

In the four studies where both loads were investigated, the Load Theory fits with the main effect of perceptual resources manipulation in two studies (Beanland et al., 2011; Calvillo & Jackson, 2014). However, two other studies found non-significant effect of perceptual load on IB (Hughes-Hallett et al., 2015; Richards et al., 2012).

In sum, most of the studies (16/20; see Tables 1 and 3) reported significant results that are (at least partially) in line with the Load Theory, with more IB under high rather than low perceptual load. Therefore, even if some factors might modulate the influence of the perceptual load, it appears to be one of the main determinants of the IB phenomenon. The few null results may be explained by inefficient perceptual load manipulations or by a lack of statistical power instead of an alternative theoretical framework and would be discussed further in the General Discussion section. Importantly, none of the included studies showed significant results that contradict the predictions of the Load Theory (i.e., less IB under high rather than low perceptual load) and expected perceptual load effects were also replicated in applied studies (i.e., driving

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simulator and surgery training) which strengthens the external validity of the perceptual account of the Load Theory.

IB and cognitive load

Considering cognitive load and WM resources, the Load Theory predicts that IB rates should decrease under high load or for individuals with low level of WM resources. More precisely, this should be observed when relevant and irrelevant stimuli are in competition for attentional selection (Carmel et al., 2012; de Fockert & Bremner, 2011; Lavie et al., 2004). Therefore, when the reverse is observed (i.e., larger IB rates under high cognitive load or for individuals with low level of WM resources) but under situation where the unexpected stimulus appeared alone (i.e., without competition), the study would be labelled as "consistent" with the theory because it does not stand against the original claim.

In sharp contrast, the results of the studies in which the role of cognitive load only was investigated offer a picture that is rather in contradiction with the predictions of the Load Theory. Indeed, seven (out of 16) studies reported significant results in opposition (or partially in opposition) with those predictions (Table 2). More precisely, two studies showed greater IB rates in high rather than in low cognitive load (dual-task paradigms) when the unexpected stimulus competed with other stimuli (Légal et al., 2017; Pizzighello & Bressan, 2008). Moreover, five studies revealed that low WM capacities (i.e., high cognitive load) measured through (A)OSPAN tests are associated with larger IB rates when the unexpected stimulus and other stimuli were in competition (Hannon & Richards, 2010; Kreitz et al., 2015; Richards et al., 2010, 2014; Seegmiller et al., 2011). To be precise, Seegmiller et al. (2011) have found that individuals with low WM capacities (i.e., low AOSPAN scores, similar to high cognitive load) exhibit more IB than individuals with high WM capacities (i.e., high AOSPAN scores, low cognitive load). Studies using direct comparisons between WM tests scores have shown that individuals who did not exhibit IB had greater WM capacities than the individuals who

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exhibited IB (Hannon & Richards, 2010; Richards et al., 2010, 2014). Finally, Kreitz et al. (2015) established a negative correlation between WM capacities and IB such as greater WM scores were linked to less IB (i.e., a higher awareness of the unexpected stimulus). In other words, the likelihood of suffering from IB appears larger when the WM capacities are lower. Those seven studies all reported results opposite to the Load theory predictions in at least one experimental condition. However, even if the results were non-significant in some conditions (i.e., neither supporting nor contradicting the Load Theory) none has reported significant findings consistent with the Load Theory predictions.

Next, the results of five studies were all non-significant (Beanland & Chan, 2016; Bredemeier & Simons, 2012; Harvey et al., 2018; Kreitz, Furley, Memmert, et al., 2016; Kreitz, Furley, Simons, et al., 2016). Consequently, they do not strictly support nor contradict the Load Theory. It should be noted that one of these studies (Kreitz, Furley, Memmert, et al., 2016) reported effect-size estimates (95% CIs) rather than conducting null-hypothesis significance tests on correlation analyses. However, according to the authors, all WM scores they measured showed little or no association with IB.

Finally, the results of four studies fit with the Load Theory framework (de Fockert & Bremner, 2011; Fougnie & Marois, 2007; Matsuyoshi et al., 2010; Todd et al., 2005). In three of them (Fougnie & Marois, 2007; Matsuyoshi et al., 2010; Todd et al., 2005) the authors found that high cognitive load increased IB in tasks where the unexpected stimulus did not compete with other stimuli, which is consistent with the Load Theory. Conversely, de Fockert & Bremner (2011)[4] revealed higher IB rates in the low rather than in the high cognitive load

[4] The authors have also observed a non-significant effect of cognitive load [IB: HL (33%) > LL (23%), $\chi^2(1, N=25) = .33$, $p > .5$] but in a condition where IB was assessed for an *expected* stimulus. Therefore, this condition was not eligible for the present review.

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condition when the unexpected stimulus was in competition with other stimuli, as claimed by the theory.

Concerning the studies investigating both loads, the main effect of cognitive load was in line with the Load Theory in one study (Beanland et al., 2011) involving a dual-task paradigm (i.e. the unexpected visual stimuli competed with auditory stimuli for perceptual processing) and showing larger IB rates in the low load condition. However, the results of two studies appeared to be in the opposite direction of Load Theory's predictions (Hughes-Hallett et al., 2015; Richards et al., 2012). Indeed, Richards et al. (2012) found that low WM capacities (AOSPAN scores) were associated with larger IB in a situation of perceptual competition between stimuli and Hughes-Hallett et al., (2015) have observed more IB when individuals were engaged into a more demanding dual-task paradigm, with the unexpected stimulus also in competition for attentional selection. Finally, a non-significant main effect was observed in the study by Calvillo and Jackson (2014).

In sum, the results of almost half of the studies (9/20; Tables 2 and 3) are in opposite or partially opposite direction with the Load Theory predictions. Five studies reported significant results in accordance with this framework, with only two involving a situation where the unexpected stimulus competed with others. Theoretical and methodological implications are discussed further in the General Discussion section.

IB and interaction between perceptual and cognitive loads

Regarding the potential interaction between perceptual and cognitive loads, we have chosen not to label the Load Theory's consistency with the studies reviewed as this issue is still debated in the literature

Three (out of four) studies did not directly investigated the potential interaction between perceptual and cognitive load on IB, as both effects were analyzed separately. In the remaining

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study (Calvillo & Jackson, 2014), the results showed higher WM capacities for individuals that perceived the unexpected stimulus but only in a high perceptual load condition. Thus, cognitive resources were more likely to predict IB when the task involved a high rather than a low perceptual load, as previously observed (Linnell & Caparos, 2011). However, the link between WM capacities and IB was in contradiction with Load Theory predictions for an unexpected stimulus that competed with others items. Importantly, the authors decomposed the interaction and compared AOSPAN scores for individuals who perceived the unexpected stimulus and those who did not, but they did not use IB rates as a dependent variable. It is therefore not possible to decide whether the perceptual load effect on IB was different for low (i.e., individuals with high AOSPAN scores) versus high cognitive load (i.e., individuals with low AOSPAN scores).

In sum, the potential interaction between perceptual and cognitive load effects on IB remains largely under-investigated, opening a new route for future research.

2.3. Discussion

Our systematic review showed that the perceptual load effect on IB seems consistent across the studies included here, even if some factors might modulate its occurrence. It is worth noting that no study revealed significant results in opposite direction to the Load Theory predictions. Therefore, at this point, it would be interesting to evaluate more precisely the effect size of the perceptual load influence on IB and to quantify to what extent greater perceptual load increases the risk of suffering from IB. This analysis might be also particularly helpful for future studies in this field to determine their sample size.

In contrast, our systematic review revealed mixed-results for the cognitive load effect on IB. First, studies manipulating the cognitive load found results in opposite direction, with

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sometimes more IB under high load (e.g., Pizzighello & Bressan, 2008) but a decrease of IB with load for others (e.g., de Fockert & Bremner, 2011). Secondly, several studies that investigated cognitive load at an individual level, that is, through the measure of WM capacities (e.g., AOSPAN), are in opposition with the theory: individuals with more WM capacities are more prone to perceive the unexpected stimulus. Nevertheless, this correlational effect was not supported in all studies, notably in those that relied on large sample sizes (e.g., Bredemeier & Simons, 2012; Kreitz et al., 2015). Indeed, studies that found no link between IB and WM (though WM tests) are based on almost twice more volunteers than those that did. Therefore, even if the absence of significant results did not constitute a convincing evidence to discard a potential effect, those studies cast some doubts on the link between WM capacities and IB. Accordingly, IB appears to be driven more by situational and task factors, or even by chance, than by individual differences in WM capacities (Kreitz et al., 2015). Consequently, a quantitative approach might be particularly fruitful to sketch more finely the potential link between cognitive resources and IB or to assert its non-existence. To this end, we performed two separate meta-analyses regarding the effect of cognitive load when manipulated and when measured at an individual level (because of the different nature of the outcome in those studies, i.e., dichotomous IB rates for the former and continuous WM test scores for the later).

3. QUANTITATIVE ANALYSES

Those meta-analyses have been conducted and reported in line with the PRISMA statement (Moher et al., 2009). They are based on experiments or conditions that satisfied our eligibility criteria and found in the aforementioned 36 studies included in the systematic review (Figure 1).

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3.1. Method

3.1.1. Eligibility criteria

Inclusion and exclusion criteria

The meta-analyses on perceptual load and cognitive load manipulations (i.e., not including measure of WM capacities) were restricted to experiments or conditions (i.e., entries) manipulating perceptual or cognitive load in a between-group design (as needed for meta-analysis on dichotomous outcome like IB; Higgins et al., 2021). We excluded entries that provided a within-subject comparisons regarding perceptual or cognitive load effect on IB, even if the unexpected stimulus was truly unexpected in each load condition, because the overall meta-analytic effect would suffer from sample bias and measure's dependency (Becker, 2000). Moreover, only entries for which sufficient data were provided, or could be computed, to fill in the 2 (low *versus* high load) x 2 (individuals who perceived the unexpected stimulus *versus* those who did not) contingency table were included. Additionally, we conducted a third meta-analysis on studies that investigated IB in the light of individual differences in WM capacities, measured through WM tests (e.g., AOSPAN, OSPAN, n-back tasks, etc). To this end, we included entries where WM tests scores were compared between subjects that suffered from IB and those who perceived the unexpected stimulus, and again, for which sufficient data were provided, or could be computed, to fulfil the requirement for meta-analysis on continuous outcome (Higgins et al., 2021). For each experiment or condition, the reason for exclusion from the meta-analyses could be found in Tables 1, 2 and 3.

3.1.2. Quantitative data analyses

We conducted three separate meta-analyses that distinguished between the effect of perceptual load, cognitive load and individual differences in WM capacities on IB. Since

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several studies included multiple experiments and/or experimental conditions, each with a different sample, we computed separate effect sizes for each experiment or condition. Statistical analyses have been performed on RevMan 5.4 (The Cochrane Collaboration, 2020) for meta-analytic effect sizes and measures of heterogeneity, whereas publication bias has been analyzed with Meta-Essentials tool (Suurmond et al., 2017).

For the two first meta-analyses (i.e., perceptual and cognitive load manipulations), we estimated the meta-analytic effect size by comparisons of IB between low and high load groups. It is important to note that "low" and "high" load groups in our meta-analyses are labelled according to their *relative* difference. Indeed, those load levels have no absolute value nor meaning so that a "high" load condition in one study might be considered as a "moderate" load in another. Nevertheless, our aim was to provide the overall meta-analytic effect sizes reflecting the effect of *higher* level of perceptual and cognitive load on IB, in the way those loads are manipulated in the literature. To this end, we conducted a random-effect analysis on the effect sizes found in the included studies. We expressed the studies' and meta-analytic effect sizes in terms of Risk Ratio (RR), with its 95% confidence intervals (CIs), as it might be more comprehensible and less difficult to interpret than Odd Ratio (Deeks et al., 2021; Higgins et al., 2021; Ranganathan et al., 2015; Sinclair & Bracken, 1994). For each meta-analysis, we coded the low perceptual or cognitive load condition as "control group" so that a RR > 1 means that there is an increased risk of suffering from IB in, respectively, the high perceptual or cognitive load condition. Conversely, a RR < 1 means that the risk of suffering from IB is decreased in the high perceptual or cognitive load groups. Finally, a RR not significantly different from one means that there is no significant difference on IB between groups.

For the third meta-analysis (i.e., individual differences in WM capacities), we estimated the meta-analytic effect size, and its 95% CIs, by comparing the WM test scores between individuals who suffered from IB (individuals blinded, "ind-IB") and those who perceived the

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unexpected stimulus (individuals not blinded, "ind-NIB"). As different tests, and thus absolute measures, could be used across studies to evaluate WM capacities, we expressed the meta-analytic effect size as a Standardized Mean Difference (SMD; Murad et al., 2019; Takeshima et al., 2014). We compute SMD from the group's mean, standard deviation and the number of subjects in each group (i.e., ind-IB and ind-NIB). Individuals who suffered from IB were coded as the control group[5]. In this way, a positive SMD means that individuals who perceived the unexpected stimulus have higher WM capacities than those who suffered from IB. Conversely, a negative SMD indicates that individuals who exhibited IB have more WM capacities than those who perceive the stimulus. Importantly, multiple WM tests are sometimes reported for the same sample (typically AOSPAN *and* n-back tasks). Therefore, taking into account all the different effect sizes provided by different outcomes on the same sample would lead to a meta-analytic effect suffering from a sample bias and measure's dependency (Becker, 2000). Therefore, when multiple WM tests were used for the same sample, we have chosen to focus on AOSPAN or OPSAN over other tests (e.g., n-back task) as this choice led to more eligible entries for our meta-analysis[6].

For each of the three meta-analyses, we also investigated effect size heterogeneity by using the standard Cochran Q test (Deeks et al., 2021) and we reported both I^2 and τ^2 to grade heterogeneity (Higgins, 2008; Higgins et al., 2003). Importantly, the low statistical power of tests for subgroup differences is commonly assumed (Burke et al., 2015; Deeks et al., 2021) and thus, a p-value of .1 should be sued to determine statistical significance. When significant, we explored heterogeneity by conducting subgroup analysis. Regarding studies on perceptual load, it could be argued that some manipulations might involve, at least partially, concurrent

[5] This coding allowed for a quick visual comparison between forest plots as the right (resp. left) side of forest plots reflects an increase (resp. decrease) of IB rates in high perceptual and cognitive load conditions, or for individuals with less WM capacities (i.e., similar to high cognitive load).
[6] Notably because no study that relied exclusively on another WM task (such as n-back task) was eligible for the meta-analysis (e.g., insufficient data provided).

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mechanisms (e.g., dilution, Tsal & Benoni, 2010; but see Lavie & Torralbo, 2010) so heterogeneity could be driven by the perceptual load paradigm employed. For cognitive load manipulations and measures of WM capacities, their influence on IB might depend on the presence/absence of irrelevant stimuli that compete for attentional selection (Carmel et al., 2012; de Fockert & Bremner, 2011; Lavie et al., 2004). Therefore, we investigated whether the unexpected stimulus appearing alone or in competition with other stimuli might explained such heterogeneity. We also evaluated whether the use of AOSPAN versus OSPAN test might result in heterogeneity because those two tests might not precisely measure the exact same WM capacities (the former being less dependent on language abilities; Richards et al., 2010; Unsworth et al., 2005). Moreover, for each meta-analysis, it could be argued that the experimental context could drive some heterogeneity in effect sizes. Indeed, computerized tasks are part of standardized procedures, whereas real-world scenario take place in less controlled settings. Therefore, those latter are more prone than computerized tasks to variability among effect sizes observed.

Finally, the potential publication bias that might arise from small-study bias (i.e., the smaller a study, the larger the effect necessary for the results to be statistically significant) was assessed through funnel plot and Egger's regression test (Ioannidis & Trikalinos, 2007; Sterne et al., 2000).

3.1.3. Risk of bias

Same as qualitative analysis (see 2.1.4)

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3.2. Results

IB and perceptual load

A random-effect analysis (inverse variance) of the perceptual load effect on IB was performed on the 37 entries (i.e., experiments/conditions) which rely on 940 and 841 participants in, respectively, the high and low perceptual load conditions. The meta-analytic effect was significant ($Z = 7.22$, $p < .001$) showing a significant increase of IB under conditions of high perceptual load (RR = 1.67; 95% CIs [1.46, 1.93]; Figure 2). In other words, compared with participants in the low perceptual load conditions, participants in the high perceptual load conditions have 1.67 times the risk of suffering from IB, that is, they have a 67% increase of risk to experience IB. The analysis of heterogeneity between effect-sizes was also significant ($Q(36) = 72.98$, $\tau^2 = 0.07$, $p < .001$) and revealed a moderate[7] heterogeneity ($I^2 = 51\%$). Nevertheless, our subgroup analyses showed that heterogeneity was not influenced by the type of perceptual load paradigm (i.e., load increased by requiring a more complex perceptual judgement, by adding more stimuli or by increasing their speed; $\chi^2(2) = 1.52$, $p = .47$) nor by the experimental context (computer-based tasks versus real-world scenario; $\chi^2(1) = 0.13$, $p = .72$).

--- Insert Figure 2 about here ---

To evaluate the potential presence of a publication bias, we computed a funnel plot (Figure 3) which shows each effect size (i.e., logRR) against its standard error. The Egger's regression test was significant ($t(36) = 4.56$, $p < .001$), indicative of a publication bias. However, the presence of a publication bias might be taken with caution when heterogeneity among effect sizes is observed, as heterogeneity can actually drive the publication bias (see Ioannidis & Trikalinos, 2007; Lin et al., 2018). To further explore this asymmetry, we used the

[7] The percentage of heterogeneity is labelled as "not important, moderate, substantial or considerable" according to Deeks et al., (2021) but threshold are arbitrary (Higgins et al., 2003).

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trim-and-fill method (Duval & Tweedie, 2000) and the analysis showed 10 missing studies on the left side of the funnel plot. Therefore, the meta-analytic effect size of perceptual load on IB appeared to be biased toward studies showing an increase of IB under high perceptual load. Nevertheless, after adjusting for missing studies, the meta-analytic effect was still significant (adjusted RR = 1.51; 95% CIs [1.26, 1.8]; $p < .001$) with an increase of IB rates under high perceptual load.

--- *Insert Figure 3 about here* ---

IB and cognitive load

A random-effect analysis (inverse variance) of the cognitive load effect on IB was performed on the 11 entries which rely on 312 and 301 subjects in, respectively, the high and low cognitive load conditions. The random-effect analysis of the cognitive load effect on IB was not significant ($Z = 1.09$, $p = .28$). The meta-analytic effect size (RR = 1.21, 95% CIs [0.86, 1.71]; Figure 4) revealed a non-significant 21% increase of risk to suffer from IB under high cognitive load.

--- *Insert Figure 4 about here* ---

The analysis of heterogeneity between studies was significant ($Q(10) = 36.72$, $\tau^2 = 0.23$, $p < .001$) and represented a substantial heterogeneity ($I^2 = 73\%$). Our test for subgroup difference reached significance level ($\chi^2(1) = 5.49$, $p = .02$), revealing that cognitive load significantly increased IB under conditions where the unexpected stimulus appeared alone, without any task to be performed during its appearance (i.e., without concurrent stimuli; $Z = 3.53$, $p < .001$; RR = 1.82, 95% CIs [1.31, 2.54]) but not when the unexpected stimulus was displayed during a concurrent attentional task (i.e., in competition with other stimuli; $Z = 0.5$, $p = .62$; RR = 0.88, 95% CIs [0.53, 1.46]). However, the subgroup analysis revealed no significant effect of experimental context (i.e., computerized task or ecological scenario; $\chi^2(1)$

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= 0.44, p = .51). In sum, the effect of cognitive load on IB was significantly influenced by the type of cognitive load paradigm, that is, by the presence or absence of concurrent stimuli when the unexpected stimulus was displayed.

To evaluate the presence of a publication bias, we computed a funnel plot (Figure 5) but the Egger's regression test revealed no significant publication bias ($t(10) = 0.82$, p = .431).

--- Insert Figure 5 about here ---

IB and WM resources

A random-effect analysis (inverse variance) of the effect of WM capacities on IB was performed on the 10 entries, which rely on 909 subjects. The meta-analytic effect size of WM resources on IB was significant ($Z = 2.18$, p = .03) with low WM resources associated with more IB (SDM = 0.3; 95% CIs [0.03, 0.57]; Figure 6).

--- Insert Figure 6 about here ---

The analysis of heterogeneity was also significant ($Q(9) = 29.79$, $\tau^2 = 0.12$, p < .001) showing a substantial heterogeneity between studies' effect sizes ($I^2 = 70\%$). The following subgroup analyses revealed no significant difference between AOSPAN or OSPAN tests ($\chi^2(1) = 2.42$, p = .12). Only one study used a paradigm where the unexpected stimulus appeared alone, without competitive stimuli for attentional selection (Kreitz, Furley, Simons, et al., 2016). However, the subgroup analyze was also non-significant ($\chi^2(1) = 0.65$, p = .42). All studies used computerized tasks and none has been conducted into more ecological settings thus we did not perform a subgroup analysis regarding experimental context.

Finally, the publication bias analyses through Egger's test was not significant ($t(9) = 1.04$, p = .33; Figure 7).

--- Insert Figure 7 about here ---

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4. GENERAL DISCUSSION

The present work focused on the role played by perceptual and cognitive resources, as well as their interaction, in determining the occurrence of the IB phenomenon. Our aim was to investigate, qualitatively and quantitatively, whether the Load Theory (Lavie, 1995, 2005, 2010) can provide a comprehensive framework in this field and account for the results of a large range of IB studies. Many studies have already provided empirical support for the Load Theory but most of them relied on attentional capture paradigms and implicit measures of attentional shifts. However, since allocation of attention is a necessary but not sufficient condition for conscious perception (Cohen et al., 2012), it was unclear whether this framework could also predict the perception of unexpected stimuli in IB paradigms. Thirty-six studies have been included in our systematic review, leading to 58 entries in the three following meta-analyses. We found that the empirical validation of the Load Theory largely depends on the type of load considered.

4.1. Perceptual load as a main determinant of IB

Most of the studies included in the systematic review have provided results in line with the Load Theory concerning the perceptual load effect (Tables 1 and 3). Those results have been obtained in several computer-based and real-world scenario experiments, supporting the internal and external validity of the theory. Increasing the perceptual load of a task imposes a strong bias to prevent the perceptual processing of irrelevant stimuli (Culham et al., 2001; Scalf et al., 2013; Torralbo et al., 2016). Accordingly, IB for the unexpected stimulus was larger under high rather than low perceptual load in most of the studies that we reviewed and this observation was statistically confirmed in the subsequent meta-analysis (Figure 2). Therefore,

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it seems that the perceptual account of the Load Theory holds for the attentional capture by a task-irrelevant – but expected – stimulus as well as for the conscious perception of a task-irrelevant – but unexpected – stimulus.

However, our review revealed several studies in which a higher perceptual load did not lead to increased IB rates in any situations (Ericson et al., 2017; Hughes-Hallett et al., 2015; Lathrop et al., 2011; Richards et al., 2012). First, it should be noted that the results in Richards et al., (2012) were *numerically* in line with the Load Theory and the difference in IB rates between low and high perceptual load was close to significance threshold (p = .065). The authors therefore argued that their perceptual load manipulation was probably not strong enough. Alternatively, the lack of significance could be due to sample variability because studies using very similar design have reported significant results (e.g., Horwood & Beanland, 2016; Simons & Jensen, 2009). Second, the study published by Ericson et al. (2017) was conducted on a driving simulator and *all* the observers in each load conditions detected the unexpected pedestrian crossing the road. According to the authors, in order to maintain their operating speed, drivers would have collided the pedestrian, making its detection almost unavoidable and leading to the ceiling effect observed. Third, Hughes-Hallett et al. (2015) observed no significant effect of perceptual load on surgeons' awareness for an unexpected event. However, two related studies conducted in analogous surgical contexts have shown significant effects of perceptual load on IB (Dixon et al., 2013; Marcus et al., 2015). Because the main outcome (blindness/awareness) is assessed on a single experimental trial, IB studies require a large sample size to reach sufficient statistical power. In applied studies conducted in very specific contexts like surgery, low sample size group (here, 73 observers distributed in six groups) might lower the statistical power. Consequently, discrepant results could be due to sample heterogeneity and/or individual differences (e.g., expertise) that hampered the results' replicability. Finally, the remaining study reporting null results (Lathrop et al., 2011) employed

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a quite unusual load manipulation (i.e., a variant of the cross-task), and in the absence of other decisive measures, one could question whether it has been efficient to produce a significant variation of the perceptual load (Benoni & Tsal, 2013; Roper et al., 2013).

It is worth mentioning that perceptual load was not the *only* determinant of the IB phenomenon in the present studies. Indeed, in several studies, the perception of the unexpected stimulus was modulated by additional factors such as its congruency with the observer's attentional set (Horwood & Beanland, 2016; Koivisto & Revonsuo, 2009; White & Davies, 2008), its semantic category and spatial location (Lin & Yeh, 2014), or by individuals clinical traits (Swettenham et al., 2014). However, those modulations of perceptual load effects should not be considered as surprising, nor specific to IB paradigms. For instance, the observer's attentional set (Theeuwes et al., 2004) or the distractor spatial location (Chen & Cave, 2016) are known to interact with perceptual load in visual search tasks. Those factors are also known to influence the rates of IB (for the influence of the attentional set see Most, 2013; Most et al., 2005; for the influence of spatial location see Most et al., 2000; Newby & Rock, 1998). Therefore, as for implicit measures of attentional shifts, the perceptual load of the task should be considered as one of the main (but not the only) determinant of awareness (Murphy et al., 2016).

The perceptual load account seems to accommodate with a well-known model about the interaction between attention and consciousness, namely the Global Neuronal Workspace hypothesis (Dehaene et al., 2006; Dehaene & Naccache, 2001) which extends Baars' (1988) cognitive theory of consciousness. Accordingly, although attention and consciousness are different, they are inextricably intertwined because attention serves as a gateway to consciousness (see also Chica & Bartolomeo, 2012; Cohen et al., 2012). Attentional mechanisms could be triggered by bottom-up activation and/or top-down amplification for a stimulus, in order to reach the threshold for conscious perception (see also Kouider & Dehaene,

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2007). In IB tasks, the observer's attention is already engaged in a demanding attentional task. Moreover, high perceptual load prevents the unexpected stimulus to gain sufficient access to perceptual resources because of the top-down inhibition of irrelevant stimuli (Culham et al., 2001; Torralbo et al., 2016). On this basis, it is unsurprising that observers remained largely unaware of the unexpected stimuli under high perceptual load condition because it did not receive enough bottom-up activation (nor top-down amplification) to capture attention and thus consciousness. This framework could also accommodate with results showing modulations of the perceptual load effect by additional factors (see above). Indeed, an unexpected stimulus that is congruent with the observer's attentional set is more likely to benefit from top-down bias and to receive attention (for integration between bottom-up and top-down activations see Fecteau & Munoz, 2006; Zelinsky & Bisley, 2015). Therefore, unexpected stimuli that are congruent with the current attentional set are more likely to be noticed, lowering the IB rates observed (Horwood & Beanland, 2016; Koivisto & Revonsuo, 2009; White & Davies, 2008).

4.2. The impact of cognitive load on IB

Regarding the influence of cognitive load on IB, our review revealed a picture that is rather in contradiction with the Load Theory (see Tables 2 and 3 and Figures 4 and 6), at least with the strong interpretation of its cognitive load account. Accordingly, the theory predicts that WM load will increase the processing of irrelevant information that *compete* for attention with relevant stimuli (Lavie et al., 2004). When WM resources are depleted they could not be engaged to prioritize relevant processing and to actively guard against distraction (both processes relying on WM resources). Consecutively, the unexpected stimulus should be more likely to receive attention and gain consciousness access under high load (i.e., IB should decrease under high load). However, only two studies manipulating the cognitive load, with an

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unexpected stimuli appearing among others stimuli, have reported such observation (Beanland et al., 2011; de Fockert & Bremner, 2011). Moreover, the following subgroup test in the meta-analysis confirmed the doubts surrounding this prediction, with a non-significant effect size for studies displaying the unexpected stimulus in a "competitive" condition. Additionally, evidence contradicting the Load Theory came from studies that measured WM capacities (i.e., AOSPAN and OSPAN), and looked whether it predicted IB in an independent attentional task. The qualitative and quantitative analyses revealed that individual who were blinded to the unexpected stimulus had lower WM capacities than those we perceived it. Those results were observed even in situation where the unexpected stimulus appeared in competition with other stimuli. Thereafter, contrary to the Load Theory prediction, those studies support the proposal that WM resources are rather mobilized to process the unexpected stimulus, even when it competes for attentional selection.

Regarding experimental conditions where the unexpected stimulus appeared alone (i.e., without competition), the results also confirmed that WM load increases IB. In that case, one could argue that when no concurrent stimuli had to be processed, observers' attention is disengaged from the screen and focused "internally" on information stored in WM, because memory traces decay as soon as attention is switched away (Barrouillet et al., 2011; Barrouillet & Camos, 2020). According to this view, the more information has to be maintained, the less attention is paid to the screen and thus the more IB should occur.

Globally, the discrepancy between studies reporting greater distractor interferences under high cognitive load (e.g., de Fockert et al., 2001; Lavie et al., 2004; Lavie & de Fockert, 2005) and our meta-analyses showing "paradoxically" more IB for an irrelevant stimulus under similar condition (i.e., competition), raised important questions that deserve to be explored in further research. In our view, one way to reconcile those discrepant results would be to take into consideration the *status* of the irrelevant stimulus between attentional capture and

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subjective awareness paradigms. Indeed, in attentional capture paradigms, the distractor is clearly irrelevant but expected, because it is usually present in many trials and participants received explicit instruction to ignore it. Consequently, observers might develop an attentional set that relies on WM resources to suppress specifically irrelevant information. Thus, the depletion of WM resources by a concurrent task would weaken the attentional settings and the distractor would be more likely to capture attention, producing larger interferences under high load. Conversely, in subjective awareness paradigms, the "distractor" is clearly unexpected and no distractor's features are represented into the observer's attentional set. Therefore, under low cognitive load, some WM resources are still available to process the unexpected event, which is, at the time of its (first) apparition neither relevant nor irrelevant. As a result, the unexpected stimulus is likely to gain access to consciousness. However, under high cognitive load, most of WM resources are already engaged to process relevant information. In this way, the unexpected event does not received access to WM and would be more likely to go consciously unnoticed, increasing IB rates. In other words, the status of the distractor and the resulting observer's attentional set would determine whether the cognitive load would increase or decrease the effect of an irrelevant stimulus.

In sum, the cognitive load account of the Load Theory did not find a large support in the studies included in our systematic review, as confirmed by our meta-analyses. Therefore, we could not discard the possibility that the only two studies supporting the Load Theory prediction for stimuli that compete for attention have found a positive result due to a sample bias or to extremely specific experimental settings.

4.3. Implications for the Load Theory and future research directions

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According to the studies included in this present review, the perceptual load effect described in the Load Theory has a reliable influence on the IB phenomenon. In other words, the influence of perceptual load on implicit attentional capture is similar to its influence on explicit subjective awareness. In that sense, the Load Theory provides a comprehensive framework that could be extended to conscious perception. However, regarding the influence of the cognitive load on IB, evidence in favor of the Load Theory is scarce, particularly for situations where stimuli are in competition for attentional selection.

Rather than throwing the baby out with the bathwater, a reframing of Load Theory might accommodate with the discrepancy observed for the cognitive load account. On the one hand, those findings could converge on the idea that WM resources underlying explicit processing of an unexpected object *fundamentally* differ from those involved in the implicit processing of expected distractors (for a discussion see Hassin et al., 2009). In that sense, we could hypothesize that WM capacities would be useful to inhibit expected irrelevant information at an implicit attentional level, so that high cognitive load leads to increase distractor processing (e.g., Lavie & de Fockert, 2005). Conversely, (others) WM capacities could be necessary for explicit awareness access, playing a role for top-down amplification in attention-consciousness models (Baars & Franklin, 2003; Dehaene et al., 2006; Gayet et al., 2013; Halgren et al., 2002) so that high cognitive load leads to increased IB (e.g., Fougnie & Marois, 2007; Légal et al., 2017). Therefore, the Load Theory should reframe to distinguish between implicit or explicit processing levels, as it would reverse the effect of cognitive load (see also Konstantinou et al., 2014; Konstantinou & Lavie, 2013). However, this alternative interpretation of the Load Theory is merely *additive* to the existing model. On the other hand, a more parsimonious view would be to consider that the same WM load would produce the same effect at both implicit and explicit levels. As we argued above, the processing of irrelevant stimuli could be increased or decreased under high cognitive load, depending on *how* WM resources are actually involved in

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a given experimental context (e.g., distractor expected or unexpected) rather than the (implicit or explicit) measurement level (see also Luna et al., 2020). In that sense, we could imagine that in attentional capture paradigms, the distractor taps on WM resources on early trials but, progressively, the observers develop an attentional set that prevents attentional capture and decreases distractor interference (see De Tommaso & Turatto, 2019). Turning into subjective awareness, it means that observers would be particularly aware of the distractor on early trials, but the distractor would be less likely to reach consciousness on the later trials. Therefore, the Load Theory could evolve to take into consideration how WM resources are used to perform a task in a given context. This point also echoes recent findings showing that individuals could develop different strategies on WM tasks and thus did not use WM resources in the same extent (Logie et al., 2020). Interestingly, this view might be in line with neurobiological models of selective attention (Corbetta & Shulman, 2002; Petersen & Posner, 2012). Classically, a dorsal attentional network (DAN) and a ventral attentional network (VAN) interact to determine the orienting and reorienting of attention. Whereas the DAN is involved in top–down control processes and the cognitive selection of information that are relevant to current goals, the VAN is generally activated when an unexpected event occurs (Corbetta et al., 2008). In that sense, the key function of the VAN is to trigger shifts of attention toward stimuli outside of the current focus, and is referred to as the circuit breaking section of the two attention networks (Shulman et al., 2002). Therefore, one could imagine that the status of the distractor (i.e., expected or unexpected) might have different implication regarding the DAN and VAN interactions, with the latter being implicated in attention reorienting toward the unexpected stimulus in IB paradigms. Further research is thus needed to determine more precisely the different strategic utilizations of WM resources that could be achieved by individuals and their implications at a neuronal level.

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Moving to another point, some criticisms toward the Load Theory have concerned the potential confound between perceptual load manipulation and the increase in general task difficulty (Benoni & Tsal, 2012; see Murphy et al., 2016). Indeed, the greater difficulty and the general slowing of response associated with higher load might be compensated for by applying more attention and thus, the decrease of distractor interference under high load might be attributed to the task difficulty rather than being a specific effect of load on perceptual resources. However, the contrast between perceptual and cognitive load effects on distractor interference has ruled out the general task difficulty as an alternative account (Lavie et al., 2004). Although both loads increase task difficulty, they clearly have opposite effect on distractor interference. Moreover, increasing the task difficulty in a manner that could not be compensated by applying more attention (i.e., sensory degradation) did not reduce distractor interference (Lavie & de Fockert, 2003). This debate about load and task difficulty relied on implicit measures of distractor processing but our review and meta-analyses revealed that the pattern is still not clear when explicit measures and distractor awareness are considered. Both perceptual and cognitive load increase the difficulty of the primary task in the studies included (e.g., Cartwright-Finch & Lavie, 2007; Fougnie & Marois, 2007; Légal et al., 2017; Simons & Jensen, 2009), irrespectively of whether the unexpected stimulus appears alone or in competition. Whereas the perceptual load meta-analytic effect size revealed larger IB rates under high load, this was not the case for the global meta-analytic effect size of cognitive load (i.e., larger IB rates only significant when stimuli were not in competition). Additionally, investigations of IB in the light of WM capacities did not show any significant differences in primary task difficulty between individuals who were blinded and those who were not (e.g., Hannon & Richards, 2010; Richards et al., 2010, 2012, 2014). Therefore, similarly to implicit measures of distractor interference, the general task difficulty account does not seem to fully

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explain the pattern of IB observed in the included studies here, but more investigations are needed to settle this point.

Finally, our review revealed a lack of investigations on the potential interactive effect of perceptual and cognitive load on IB. Both effects have been considered independently (Beanland et al., 2011; Hughes-Hallett et al., 2015; Richards et al., 2012) or the dependent variable concerned AOSPAN scores instead of IB rates (Calvillo & Jackson, 2014). Therefore, a promising research direction would be to assess whether both factors actually interact to determine IB. This would give an opportunity to evaluate more deeply the Load Theory framework for explicit awareness capture and should be considered as a useful perspective on its own to understand and predict IB under a larger range of situations. An important step would be also to invest applied research in a more extensive way, notably regarding the role of WM resources for which only one study (Hughes-Hallett et al., 2015) took place into a real-world scenario. Besides, as underlined in the present review, some studies have investigated the impact of augmented reality systems on IB (Dixon et al., 2013; Hughes-Hallett et al., 2015; Marcus et al., 2015). We suggest that all the fields concerned by the emergence of augmented reality would benefit from the efforts made to disentangle the (separate and/or combined) effects of perceptual and cognitive load on IB. Indeed, the purpose of this new technology is precisely to reduce the individuals' cognitive load (e.g., Braly et al., 2019; Jetter et al., 2018) by displaying virtual perceptual information superimposed on the real world, thereby increasing their perceptual load (Azuma et al., 2001; Bottani & Vignali, 2019). Nonetheless, while many studies have already highlighted the advantages provided by augmented reality systems into the "Industry 4.0" (e.g., Braly et al., 2019; Fiorentino et al., 2014; Vignali et al., 2018), the potential impact of those systems on the IB experienced by users and, as a consequence, on their safety, remains largely unexplored (see Kim & Gabbard, 2019; Lewis & Neider, 2016).

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5. CONCLUSIONS

The present review gives strength to the perceptual account of the Load Theory, beyond distractor interference at implicit levels, and highlights a reliable effect of perceptual load among many experimental situations. However, the cognitive load account of this framework only received poor support. It could suggest that the Load Theory has to distinguish more finely how WM is involved in a given experimental context. Evaluating the interaction between both loads as well as conducting applied research would be beneficial to provide a more comprehensive framework about how perceptual and cognitive load would determine IB in our daily activities.

6. SUPPLEMENTARY MATERIAL

The Supplementary Material is available at: qjep.sagepub.com

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8. FIGURE CAPTIONS

Figure 1: The PRISMA flow diagram (adapted from Moher et al., 2009) representing the number of studies included and excluded at each step of the qualitative and quantitative analysis. For the final step, we informed about the number of studies included in each of the three meta-analysis: the perceptual load (PL) or cognitive load (CL) effect on IB, with the latter investigated through direct manipulation or measured through working memory (WM) tests (e.g., OSPAN). However, note that the number of studies included in the meta-analysis was different (i.e., lower) than the number of entries (experiments and/or conditions) on which the meta-analysis relied on.

Figure 2: Forest plot of the effect sizes (Risk Ratio, RR) for studies included in the meta-analysis regarding perceptual load effect on inattentional blindness (IB). A positive RR indicates larger IB rates under high rather than low perceptual load. Studies are ordered according to their effect size. Error bars represent 95% confidence interval (CI) of the effect size. IV = inverse variance.

Figure 3: The funnel plot showing effect size (log Risk Ratio, logRR) against its standard error for each individual entries (blue dots) included in the meta-analysis of the perceptual load effect on inattentional blindness. The trim-and-fill method (Duval & Tweedie, 2000) revealed ten missing studies (orange open circles) indicative of a publication bias. The logRR of the meta-analytic effect size (green dot) and the adjusted effect size (black dot) are also represented with their 95% confidence interval. Red diagonal lines indicate the triangular region within which 95% of studies are expected to lie in the absence of publication biases and heterogeneity.

Figure 4: Forest plot of the effect sizes (Risk Ratio, RR) for studies included in the meta-analysis regarding cognitive load manipulation and its effect on inattentional blindness (IB). A positive RR indicates larger IB rates under high rather than low perceptual load. Studies are ordered according their effect size. Error bars represent 95% confidence interval (CI) of the effect size. IV = inverse variance.

Figure 5: The funnel plot showing effect size (log Risk Ration, logRR) against its standard error for each individual entries (blue dots) included in the meta-analysis of the cognitive load effect, when manipulated, on inattentional blindness. The logRR of the meta-analytic effect size (green dot) is also represented with its 95% confidence interval. Red diagonal lines indicate the triangular region within which 95% of studies are expected to lie in the absence of publication biases and heterogeneity.

Figure 6: Forest plot of the effect sizes (Standard Mean Difference, SDM) for studies included in the meta-analysis regarding working memory (WM) capacities measured through OSPAN and AOSPAN tests, and their effect on inattentional blindness (IB). A positive SDM indicates that individuals who perceived the unexpected stimulus (ind-NIB) have larger WM capacities than those who suffered from IB (ind-IB). Studies are ordered according their effect size. Error bars represent 95% confidence interval (CI) of the effect size. SD = standard deviation; IV = inverse variance.

Figure 7: The funnel plot showing effect size (Standard Mean Difference) against its standard error for each individual entries (blue dots) included in the meta-analysis of the cognitive load effect, when measured through working memory tests (OSPAN and AOSPAN), on inattentional blindness. The meta-analytic effect size (green dot) is also represented with its 95% confidence interval. Red diagonal lines indicate the triangular region within which 95% of studies are expected to lie in the absence of publication biases and heterogeneity.

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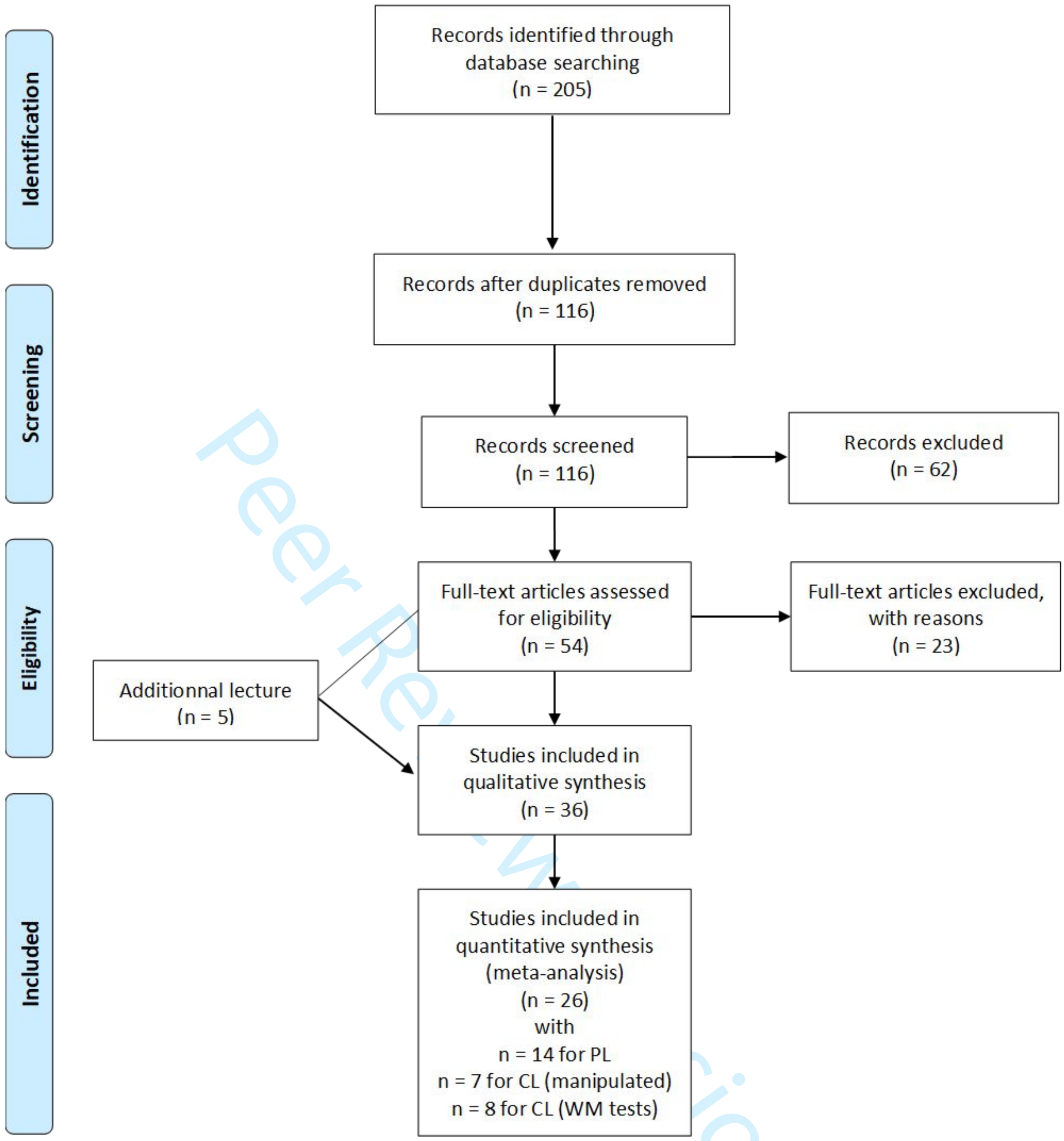

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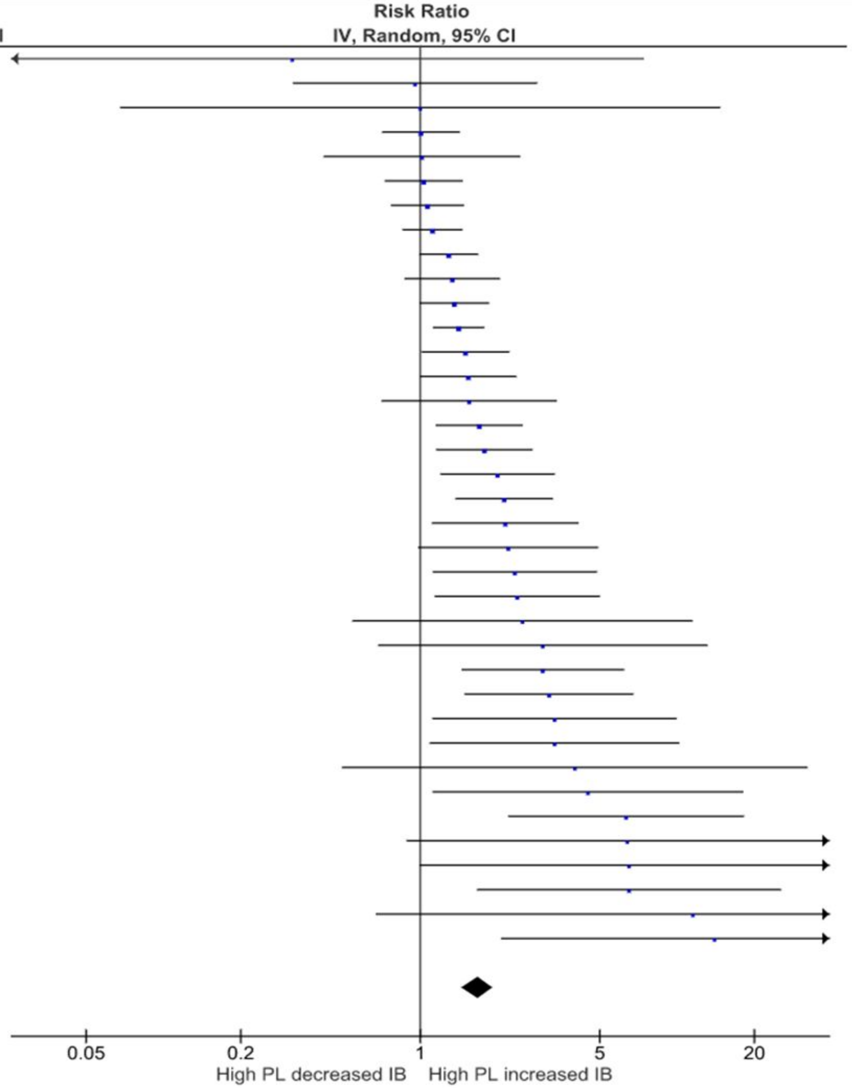
Study or Subgroup	High PL Events	High PL Total	Low PL Events	Low PL Total	Weight	Risk Ratio IV, Random, 95% CI
Horwood & Beanland (2016), Match-young	0	20	1	19	0.2%	0.32 [0.01, 7.35]
Lin & Yeh (2014), other name center	5	22	5	21	1.4%	0.95 [0.32, 2.83]
Remington et al. (2014), Exp.2, adults	1	16	1	16	0.3%	1.00 [0.07, 14.64]
Lathrop et al. (2011)	29	53	31	57	5.1%	1.01 [0.72, 1.42]
Swettenham et al. (2014), ASD children	6	13	5	11	1.9%	1.02 [0.42, 2.43]
Lin & Yeh (2014), own name center	17	22	15	20	5.1%	1.03 [0.73, 1.45]
Remington et al. (2014), Exp.1, 9-10 yo	16	20	18	24	5.3%	1.07 [0.78, 1.47]
Hughes-Hallett et al. (2015), swab periph.	41	49	18	24	5.8%	1.12 [0.86, 1.45]
Calvillo & Jackson (2014), Inanimate	40	50	31	50	5.9%	1.29 [1.00, 1.67]
Lin & Yeh (2014), own name periph.	16	20	12	20	4.4%	1.33 [0.88, 2.03]
Remington et al. (2014), Exp.1, 7-8 yo	19	20	14	20	5.5%	1.36 [1.00, 1.84]
Beanland & Pammer (2010)	65	72	32	50	6.2%	1.41 [1.13, 1.76]
Remington et al. (2014), Exp.2, 7-8 yo	18	20	12	20	4.7%	1.50 [1.02, 2.21]
Beanland et al. (2011), Exp.1	20	25	13	25	4.4%	1.54 [1.01, 2.35]
Hughes-Hallett et al. (2015), suture center	19	49	6	24	2.2%	1.55 [0.71, 3.37]
Swettenham et al. (2014), controls	20	20	11	19	4.7%	1.70 [1.16, 2.49]
Calvillo & Jackson (2014), Animate	32	50	18	50	4.4%	1.78 [1.16, 2.72]
Cartwright-Finch & Lavie (2007) Exp.1	18	20	9	20	3.7%	2.00 [1.21, 3.32]
Remington et al. (2014), Exp.2, 9-10 yo	20	20	11	24	4.3%	2.12 [1.38, 3.26]
White & Davies (2008) valid expectation	15	20	7	20	2.8%	2.14 [1.12, 4.10]
Remington et al. (2014), Exp.1, 13-14 yo	11	16	5	16	2.2%	2.20 [0.99, 4.89]
Remington et al. (2014), Exp.1, 11-12 yo	14	20	6	20	2.5%	2.33 [1.13, 4.83]
Simons & Jensen (2009)	15	22	6	21	2.4%	2.39 [1.15, 4.97]
White & Davies (2008) invalid expectation	5	20	2	20	0.8%	2.50 [0.55, 11.41]
Horwood & Beanland (2016), Match-older	6	19	2	19	0.8%	3.00 [0.69, 13.03]
Lin & Yeh (2014), other name periph.	18	23	6	23	2.5%	3.00 [1.46, 6.17]
Dixon et al. (2013)	14	15	5	17	2.4%	3.17 [1.50, 6.71]
Cartwright-Finch & Lavie (2007) Exp.3	10	16	3	16	1.3%	3.33 [1.12, 9.90]
Cartwright-Finch & Lavie (2007) Exp.4	10	18	3	18	1.3%	3.33 [1.10, 10.14]
Remington et al. (2014), Exp.1, adults	4	16	1	16	0.4%	4.00 [0.50, 31.98]
Cartwright-Finch & Lavie (2007) Exp.2	9	18	2	18	0.9%	4.50 [1.13, 17.99]
Horwood & Beanland (2016), Mismatch-older	19	20	3	20	1.4%	6.33 [2.22, 18.06]
Remington et al. (2014), Exp.2, 13-14 yo	8	20	1	16	0.5%	6.40 [0.89, 45.99]
Marcus et al. (2015)	26	40	1	10	0.5%	6.50 [1.00, 42.31]
Remington et al. (2014), Exp.2, 11-12 yo	13	20	2	20	0.9%	6.50 [1.68, 25.16]
Horwood & Beanland (2016), Mismatch-young	5	20	0	21	0.2%	11.52 [0.68, 195.79]
Remington et al. (2014), Exp.3	14	16	1	16	0.5%	14.00 [2.08, 94.24]
Total (95% CI)		**940**		**841**	**100.0%**	**1.67 [1.46, 1.93]**
Total events	618		319			

Heterogeneity: Tau² = 0.07; Chi² = 72.98, df = 36 (P = 0.0003); I² = 51%
Test for overall effect: Z = 7.22 (P < 0.00001)



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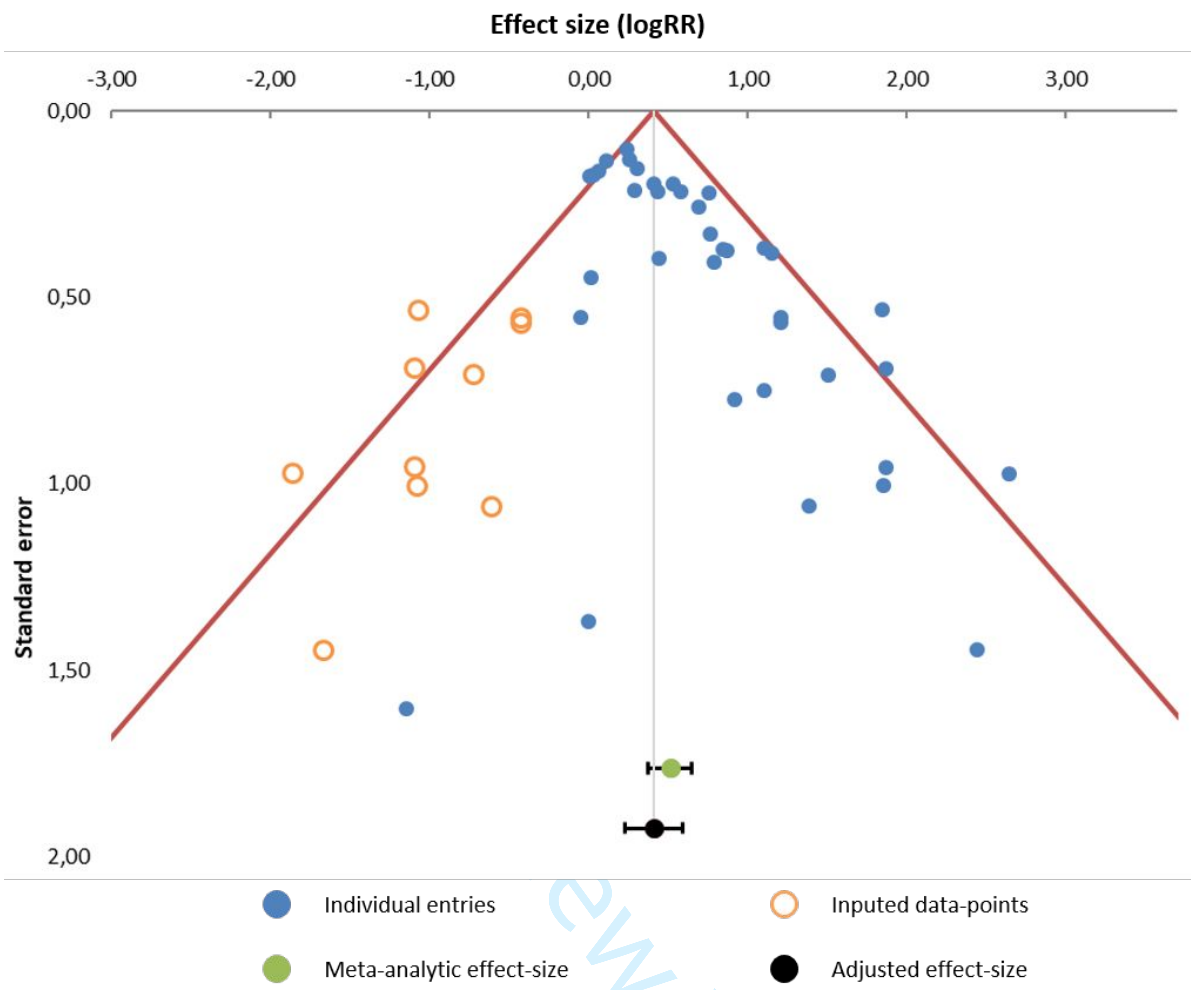

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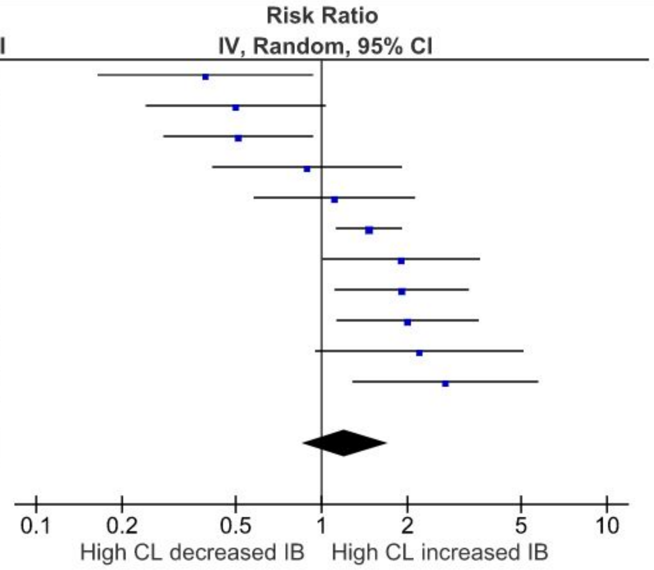
Study or Subgroup	High CL Events	High CL Total	Low CL Events	Low CL Total	Weight	Risk Ratio IV, Random, 95% CI
de Fockert & Bremner (2011), Exp.1	4	13	11	14	7.3%	0.39 [0.17, 0.93]
Beanland et al. (2011), Exp.1	7	25	14	25	8.5%	0.50 [0.24, 1.03]
de Fockert & Bremner (2011), Exp.2, unexpected	7	16	12	14	9.6%	0.51 [0.28, 0.93]
Fougnie & Marois (2007), Exp.2	8	23	9	23	8.1%	0.89 [0.42, 1.89]
Hughes-Hallett et al. (2015), suture center	14	39	11	34	9.1%	1.11 [0.58, 2.11]
Hughes-Hallett et al. (2015), swab periph.	37	39	22	34	12.4%	1.47 [1.13, 1.90]
Matsuyoshi et al. (2010), Exp.2	19	40	10	40	9.3%	1.90 [1.01, 3.56]
Fougnie & Marois (2007), Exp.1	21	31	11	31	10.1%	1.91 [1.12, 3.25]
Pizzighello & Bressan (2008), Exp.1, visual load	20	30	10	30	9.8%	2.00 [1.14, 3.52]
Fougnie & Marois (2007), Exp.3	11	18	5	18	7.5%	2.20 [0.96, 5.05]
Todd et al. (2005), Exp.5	19	38	7	38	8.3%	2.71 [1.29, 5.69]
Total (95% CI)		**312**		**301**	**100.0%**	**1.21 [0.86, 1.71]**
Total events	167		122			

Heterogeneity: Tau² = 0.23; Chi² = 36.72, df = 10 (P < 0.0001); I² = 73%
Test for overall effect: Z = 1.09 (P = 0.28)



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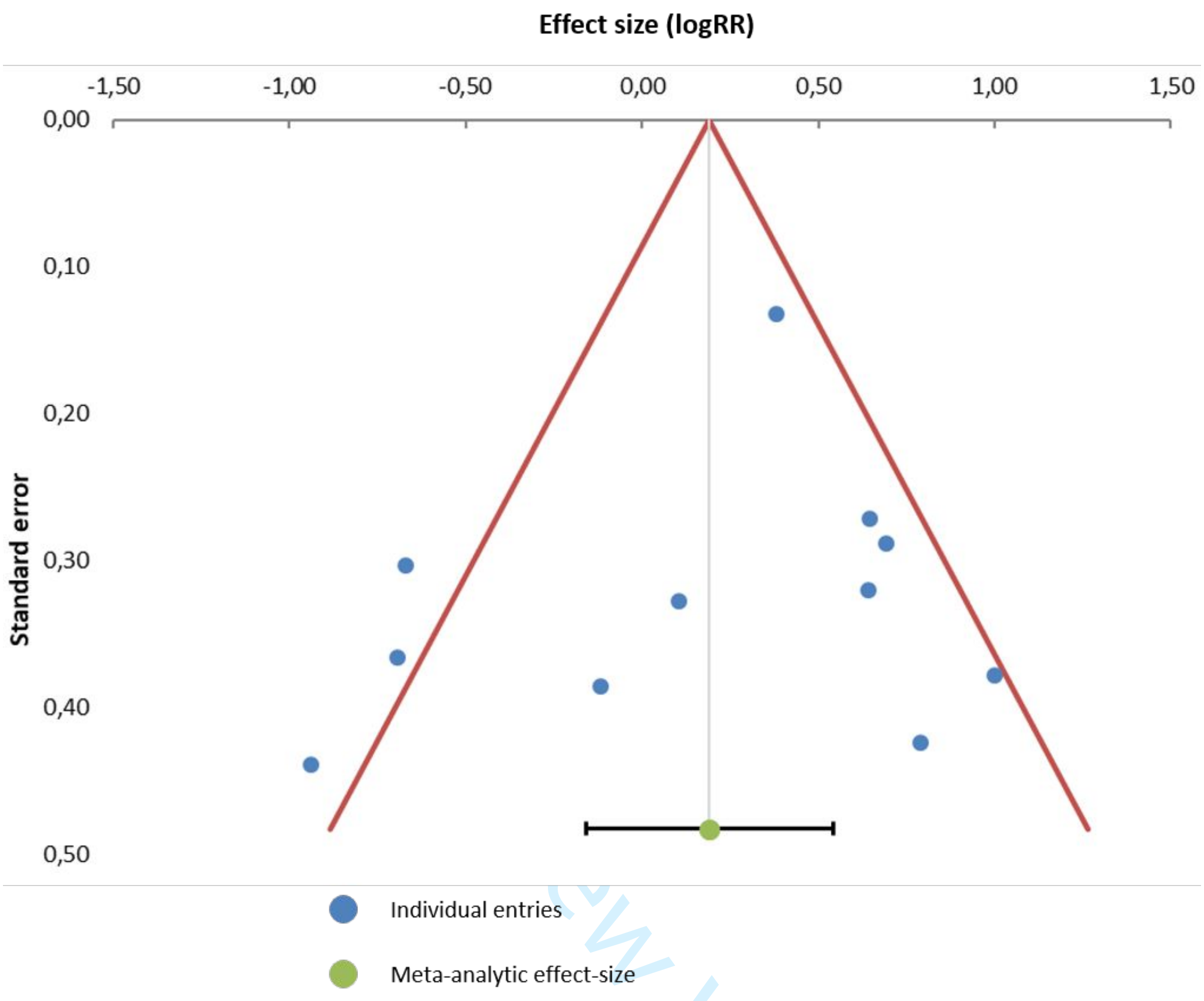

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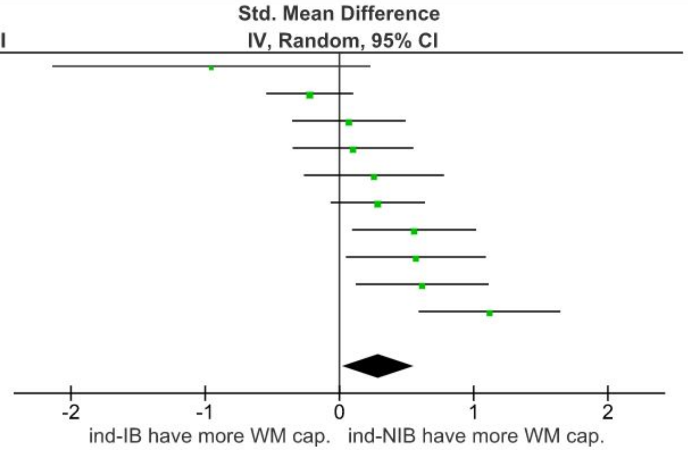
Study or Subgroup	ind-NIB Mean	ind-NIB SD	ind-NIB Total	ind-IB Mean	ind-IB SD	ind-IB Total	Weight	Std. Mean Difference IV, Random, 95% CI
Kreitz, F., M., et al. (2016), Match, AOSPAN	34	15.45	53	49	16.77	3	3.9%	-0.95 [-2.13, 0.22]
Bredemeier & Simons (2012), Exp.2, AOSPAN	39.5	18.2	53	43.3	16.69	142	12.5%	-0.22 [-0.54, 0.10]
Calvillo & Jackson (2014), Low PL, AOSPAN	54.57	13.55	49	53.61	13.6	41	11.1%	0.07 [-0.34, 0.49]
Kreitz, F., S., et al. (2016), Exp.2, AOSPAN	38.7	18.81	30	36.96	16.1	57	10.7%	0.10 [-0.34, 0.54]
Kreitz, F., M., et al. (2016), Mismatch, AOSPAN	43	16.21	27	39	14.59	32	9.7%	0.26 [-0.26, 0.77]
Richards et al. (2012), AOSPAN	43.46	17.77	69	38.36	17.77	62	12.1%	0.29 [-0.06, 0.63]
Hannon & Richards (2010), OSPAN	19.18	8.31	39	14.68	7.67	38	10.5%	0.56 [0.10, 1.01]
Calvillo & Jackson (2014), High PL, AOSPAN	59.8	9.65	20	51.47	15.72	60	9.7%	0.57 [0.06, 1.08]
Richards et al. (2010), Exp.1, OSPAN	19.56	7.69	32	15.11	6.62	36	10.1%	0.62 [0.13, 1.10]
Richards et al. (2014), Exp.2, AOSPAN	52.03	11.67	34	39.5	10.39	32	9.6%	1.12 [0.60, 1.64]
Total (95% CI)			**406**			**503**	**100.0%**	**0.30 [0.03, 0.57]**

Heterogeneity: $Tau^2 = 0.12$; $Chi^2 = 29.79$, df = 9 (P = 0.0005); $I^2 = 70\%$
Test for overall effect: Z = 2.18 (P = 0.03)



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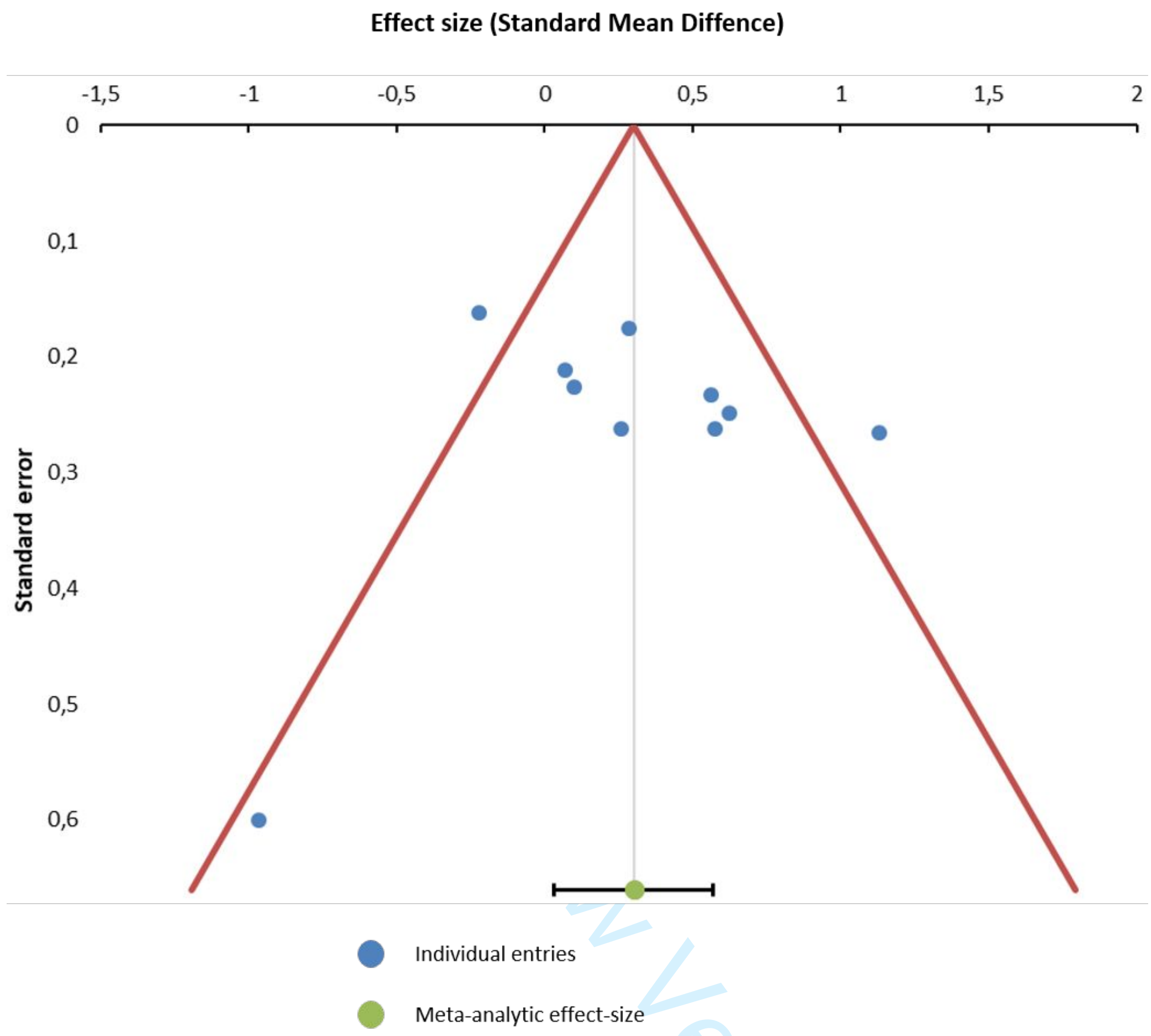

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Table 1: *Studies considered for perceptual load investigation only.*
The global experimental context, the perceptual load and inattentional blindness paradigms used, the statistical comparison between load levels and fit regarding the Load Theory framework are presented. P-values that reached significance (α < .05) are highlighted in bold. When possible, we computed the statistical information (e.g., degrees of freedom, chi-square test, etc.) not found in original papers. Note that the labels for load level (low, moderate or high) are those used by the authors in original studies. For each entry (experiment or condition), its inclusion or exclusion (with reasons) from the meta-analysis is stated.
IB = inattentional blindness; LL = low-load; ML = moderate-load; HL = high-load; ns = non-significant; US = unexpected stimulus.
† additional studies identified during the full-text eligibility phase.

Reference	Experimental context	Perceptual load	IB paradigm	Results	Comparison with Load Theory prediction	Inclusion / exclusion in the meta-analysis
(Beanland & Pammer, 2010)	Computer-based	Tracking with increased targets speed	Dynamic	Exp.2 (only for first US) IB: HL (81%) > LL (54%), $\chi^2(1, N=122) = 7.18$, ***p* = .007**	Consistent	*Included*
(Cartwright-Finch & Lavie, 2007)	Computer-based	Cross task requiring more complex perceptual judgment (Exp.1 and 3) Visual search with more non-target stimuli (Exp.2 and 4)	Static	Exp.1 IB: HL (90%) > LL (45%), $\chi^2(1, N=40) = 9.23$, ***p* < .002** Exp.2 IB: HL (50%) > LL (11.1%), $\chi^2(1, N=36) = 6.42$, ***p* < .01** Exp.3 IB: HL (62.5%) > LL (18.8%), $\chi^2(1, N=32) = 6.35$, ***p* < .01** Exp.4 IB: HL (55.6%) > LL (16.7%), $\chi^2(1, N=36) = 5.90$, ***p* < .02**	Consistent	*Included* *Included* *Included* *Included*
(Dixon et al., 2013)†	Real-world (surgical endoscopy)	Visual search with more relevant stimuli (Standard view vs. Standard + Augmented reality views)	Static	IB: HL (93.3%) > LL (29.4%), ***p* < .001** (Fisher's exact test)	Consistent	*Included*
(Ericson et al., 2017)†	Driving simulator	Visual clutter complexity	Dynamic	Clutter complexity results (not the tracking vehicle task) IB: 0% in HL and LL	No Effect	*Not included (insufficient data)*
(Horwood & Beanland, 2016)	Computer-based	Tracking with more non-target stimuli	Dynamic	Attentional set match IB overall: HL (15%) > LL (8%), $\chi^2(1, N=77) = 1.05$, *p* = .48 Young IB: HL (0%) < LL (5%), *p = .49* (Fisher's exact test) Older	Partially Consistent	 *Included*

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				IB: HL (32%) > LL (11%), *p = .23* (Fisher's exact test)		*Included*
				Attentional set mismatch IB overall: HL (60%) > LL (7%), χ^2(1, N=81) = 25.3, ***p* < .001**		
				Young IB: HL (25%) > LL (0%), ***p* = .021** (Fisher's exact test)		*Included*
				Older IB: HL (95%) > LL (15%), ***p* <.001** (Fisher's exact test)		*Included*
(Koivisto & Revonsuo, 2008)†	Computer-based	Tracking with more non-target stimuli	Dynamic	Exp.4 IB: HL (52%) > LL (21.7%), χ^2(1) = 4.68, ***p* < .05** IB: HL < ML (53.8%), χ^2(1) = .02, *p* < .9, ns IB: ML > LL, χ^2(1) = 5.30, ***p* < .05**	Consistent	*None included (insufficient data)*
(Koivisto & Revonsuo, 2009)	Computer-based	Visual search with more non-target stimuli	Static	Incongruent stimulus IB: HL (93%) > LL (79%), χ^2(1, N=57) = 5.22, ***p* = .025** Congruent stimulus IB: HL (18%) > LL (9%), χ^2(1, N=68) = 1.37, ns But initially the load*congruency interaction was non-significant [*Z*(1,125) = 0.81, *p* = .442]	Consistent (because the interaction was initially non-significant)	*None included (insufficient data)*
(Lathrop et al., 2011)	Computer-based	Cross task requiring more complex perceptual judgment	Static	IB: HL (54%) = LL (54%), χ^2(1, N=110) = .027, *p* > .05	No Effect	*Included*
(Lin & Yeh, 2014)	Computer-based	Visual search with more non-target stimuli	Static	Free-recall results (not recognition) Own-name periph. IB: HL (78%) > LL (26%), χ^2(1, N=46) = 25.55, ***p* < .001**	Partially Consistent	*Included*
				Own-name center IB: HL (23%) < LL (24%), χ^2(1, N=43), *p* > .16		*Included*
				Other periph. IB: HL (80%) > LL (60%), χ^2(1, N=40), *p* > .16		*Included*
				Other center IB: HL (77%) > LL (75%), χ^2(1, N=42), *p* > .16		*Included*

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(Marcus et al., 2015)	Real-world (surgical endoscopy)	Visual search with more relevant stimuli (Standard view vs. Standard + Image guidance views)	Static	IB: HL (65%) > LL (10%), ***p* = .025** (Fisher's exact test)	Consistent	*Included*
(Murphy & Greene, 2016)†	Driving simulator	Vehicle gap size estimation requiring more complex perceptual judgment	Dynamic	IB: HL (82.9%) > LL (46.3%), $\chi^2(1, N=41) = 17.78$, ***p* < .001**	Consistent	*Not included (within-subject comparison)*
(Murphy & Greene, 2017)	Driving simulator	Visual search requiring more complex perceptual judgment (feature vs. conjunction search)	Dynamic	IB: HL (70%) > LL (7.5%), $t(19) = 4.45$, ***p* < .001**	Consistent	*Not included (within-subject comparison)*
(Remington et al., 2014)	Computer-based	Cross task requiring more complex perceptual judgment	Static	Exp.1 IB overall: ML (69.6%) > LL (45.8%), $\chi^2(1, N=188) = 10.82$, ***p* < .001**	Consistent	
				IB 7-8 years old: ML (95%) > LL (70%), $\chi^2(1, N=40) = 4.33$, ***p* = .037**		*Included*
				IB 9-10 yo: ML (80%) > LL 75(%), $\chi^2(1, N=44) = .02$, $p = .69$		*Included*
				IB 11-12 yo: ML (70%) > LL (30%), $\chi^2(1, N=40) = 6.4$, ***p* = .01**		*Included*
				IB 13-14 yo: ML (68.75%) > LL (31.25%), $\chi^2(1, N=32) = 4.5$, ***p* = .034**		*Included*
				IB adults: ML (25%) > LL (6.25%), $\chi^2(1, N=32) = 2.1$, $p = .14$		*Included*
				Exp.2 IB overall: ML %(62.5) > LL (28.12%), $\chi^2(1, N=192) = 22.89$, ***p* < .001**		
				IB 7-8 yo: ML (90%) > LL (60%), $\chi^2(1, N=40) = 4.8$, ***p* = .03**		*Included*
						Included

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				IB 9-10 yo: ML (100%) > LL (45.83%), $\chi^2(1, N=44) = 15.38$, ***p* < .001**		*Included*
				IB 11-12 yo: ML (65%) > LL (10%), $\chi^2(1, N=40) = 12.91$, ***p* < .001**		*Included*
				IB 13-14 yo: ML (40%) > LL (6.25%), $\chi^2(1, N=36) = 5.4$, ***p* = .02**		*Included*
				IB adults: ML (6.25%) = LL (6.25%), $\chi^2(1, N=32)$, ns		
				Exp3. IB adults: HL (87.5%) > LL (6.25%), $\chi^2(1, n=32) = 21.20$, **p < .01**		*Included*
(Simons & Jensen, 2009)	Computer-based	Tracking with increased targets speed	Dynamic	Exp.1 IB: HL (68.2%) > LL (28.6%), $\chi^2(1, N=43) = 6.747$, ***p* = .0094**	Consistent	*Included*
(Swettenham et al., 2014)	Computer-based	Cross task requiring more complex perceptual judgment	Static	Control group IB: HL (100%) > LL (57.9%), $\chi^2(1, N=39) = 13.72$, ***p* < .001**	Partially Consistent	*Included*
				Children with Autism Spectrum Disorders IB: HL (46.2%) > LL (45.5%), $\chi^2(1, N=24) = .001$, *p* = .97		*Included*
(White & Davies, 2008)	Computer-based	Visual search with more relevant stimuli (Exp.3a/b for low- and high-load; Exp.1 for moderate-load)	Static	Exp.3 (HL, LL) and Exp.1 (ML)	Partially Consistent	
				For valid-expectation: $\chi^2(2, N=60) = 7.13$, ***p* = .03** IB: HL (75%) > LL (35%), $\chi^2(1, N=40) = 6.47$, ***p* = .01**		*Included*
				IB: HL (75%) > ML, $\chi^2(1, N=40) = .48$, *p* =.49, ns		*Not included (same sample for HL group and the comparison between HL and LL is more relevant)*
				For invalid-expectation: *p*= .47 (Fisher's exact test) IB: HL (25%) > LL (10%), $\chi^2(1, N=40) = 1.56$, *p* =.21, ns		*Included*

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Table 2: *Studies considered for cognitive load investigation only.*
The global experimental context, the perceptual load and inattentional blindness paradigms used, the statistical comparison between load levels and fit regarding the Load Theory framework are presented. P-values that reached significance (α < .05) are highlighted in bold. When possible, we computed the statistical information (e.g., degrees of freedom, chi-square test, etc.) not found in original papers. Note that the labels for load level (low, moderate or high) are those used by the authors in original studies. For each entry (experiment or condition), its inclusion or exclusion (with reasons) from the meta-analysis is stated.
M = mean; SD = standard deviation; ACC = accuracy; IB = inattentional blindness; ind-IB = individual suffering from IB; ind-NIB = individual not suffering from IB; LL = low-load; ML = moderate-load; HL = high-load; ns = non-significant; US = unexpected stimulus; WM = working memory.
† additional studies identified during the full-text eligibility phase.
° Studies where the US appeared alone (i.e., no competition with others stimuli).

Reference	Experimental context	Cognitive load	IB paradigm	Cognitive demands effect	Comparison with Load Theory prediction	Inclusion / exclusion in the meta-analysis
(Beanland & Chan, 2016)	Computer-based	AOPSAN and n-back tasks	Dynamic	Exp.1 AOSPAN score: ind-IB (41.1) > ind-NIB (37.9), W = 1.01, p > .05 N-back corrected score: ind-IB (.66) > ind-NIB (.65), W = .08, p > .05 Exp.2 AOSPAN score: W = 1.67, p > .05	No Effect	*None included (insufficient data)*
(Bredemeier & Simons, 2012)	Computer-based	AOPSAN and n-back tasks	Dynamic	Exp.1 n-back task (verbal) ACC: ind-IB (86.4) > ind-NIB (84.8), W = .65, p = .42 n-back task (spatial) ACC: ind-IB (84.7) > ind-NIB (82.9), W = .67, p = 41 Exp.2 AOSPAN score: ind-IB (43.3) > ind-NIB (39.5), W = 1.91, p = .17 n-back task (verbal) ACC: ind-IB (88.1) > ind-NIB (87.9), W = .01, p = .94 n-back task (spatial) ACC: ind-IB (85.8) < ind-NIB (87), W = .75, p = .39	No Effect	*None included (insufficient data)* *Included* *None included (insufficient data and same sample than AOSPAN)*
(de Fockert & Bremner, 2011)	Computer-based	WM task	Static	Exp.1 IB: HL (31%) < LL (79%), $\chi^2(1, N=27) = 7.46$, ***p* < .01** Exp.2 Unexpected condition IB: HL (44%) < LL (86%), $\chi^2(1, N=30) = 5.66$, ***p* < .025**	Consistent	*Included* *Included*
(Fougnie & Marois, 2007)	Computer-based	WM task	Static°	Exp.1 IB: HL (68%) > LL (35%), ***p* < .05** (Fisher's exact test)	Consistent	*Included*

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				Exp.2 IB: HL (34%) < LL (39%), *p* = 1 (Fisher's exact test) Exp.3 IB: HL (61%) > LL (28%), ***p* < .05** (Fisher's exact test)		*Included* *Included*
(Hannon & Richards, 2010)	Computer-based	OSPAN and visual WM task (vWM)	Dynamic	Correlation IB-OSPAN: *r* = .274, ***p* = .016** OSPAN score: ind-IB (*M* = 14.68) < ind-NIB (*M* = 19.18), *t*(75) = 2.47, ***p* = .016** Correlation IB-vWM: *r* = .124, ns vWM ACC (all set sizes): ind-IB (*M* = 25.45; *SD* = 3.5) < ind-NIB (*M* = 25.93; *SD* = 3.52), *F* < 0.74, ns	Inconsistent	*Included* *Not included (same sample than OSPAN)*
(Harvey et al., 2018)	Computer-based	WM task	Dynamic	IB (for 3 US): HL (2.55) > LL (2.42), *F*(1, 96) = 1.335, *p* = .251	No Effect	*Not included (insufficient data)*
(Kreitz et al., 2015)	Computer-based	AOPSAN and n-back tasks	Static or dynamic	Exp.1 (Static IB paradigm) Near-condition IB-AOSPAN: *r* = .26, ***p* < .05** (with positive r means greater scores for ind-NIB than ind-IB) IB – n-back task (verbal): *r* = .23, *p* > .05 IB – n-back task (spatial): *r* = .04, *p* > .05 Far-condition IB-AOSPAN: *r* = -.16, *p* > .05 IB – n-back task (verbal): *r* = -.13, *p* > .05 IB – n-back task (spatial): *r* = .06, *p* > .05 Exp.2 Static IB paradigm Near-condition IB-AOSPAN: *r* = .30, ***p* < .05** IB – n-back task (verbal): *r* = .01, *p* > .05 IB – n-back task (spatial): *r* = .26, ***p* < .05** Far-condition IB-AOSPAN: *r* = .14, *p* > .05 IB – n-back task (verbal): *r* = .11, *p* > .05 IB – n-back task (spatial): *r* = .08, *p* > .05 Dynamic IB paradigm Near-condition IB-AOSPAN: *r* = .05, *p* > .05	Partially inconsistent	*None included (insufficient data)* *None included (insufficient data)* *None included (insufficient data)*

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				IB – n-back task (verbal): *r* = -.04 , *p* > .05 IB – n-back task (spatial): *r* = -.08, *p* > .05 Far-condition IB-AOSPAN: *r* = -.18, *p* > .05 IB – n-back task (verbal): *r* = -.09, *p* > .05 IB – n-back task (spatial): *r* = -.07, *p* > .05		
(Kreitz, Furley, Memmert, et al., 2016)	Computer-based	AOPSAN and n-back tasks	Dynamic	Authors reported 95% Confidence Intervals instead of p-values. Mismatch condition IB-AOSPAN: *r* = .12, [95%CI: -.14, .37] IB – n-back (verbal): *r* = .02, [-.24, .28] IB – n-back task (spatial): *r* = -.23, [-.46, .03] Match condition IB-AOSPAN: *r* = -.21, [-.45, .06] IB – n-back (verbal): *r* = -.12, [-.37, .15] IB – n-back task (spatial): *r* = -.09, [-.35, .18] Overall for all scores: ind-IB > ind-NIB, *ps* > .05	No Effect	*Included (data retrieved from repository)* *None included (same sample than AOSPAN)* *Included (data retrieved from repository)* *None included (same sample than AOSPAN)*
(Kreitz, Furley, Simons, et al., 2016)	Computer-based	AOPSAN and n-back tasks	Static°	Exp.2 IB-AOSPAN: *r* = .11, *p* > .05 IB – n-back (verbal): *r* = .14, *p* > .05 IB – n-back task (spatial): *r* = .03, *p* > .05	No Effect	*Included (data retrieved from repository)* *None included (same sample than AOSPAN)*
(Légal et al., 2017)	Computer-based	WM task	Dynamic	IB: HL (81%) > LL (36.1%), Wald $\chi^2(1)$ = 27.73, ***p* < .001**	Inconsistent	*Not included (insufficient data)*
(Matsuyoshi et al., 2010)	Computer-based	WM task	Static°	Exp.2 IB: HL (4 targets, 47.5%) > LL (2 targets, 25%), $\chi^2(1, N=80)$ = 4.38, ***p* < .05**	Consistent	*Included*
(Pizzighello & Bressan, 2008)†	Computer-based	WM task	Dynamic	Exp.1 IB: HL (66%) > visual task LL (33%), $\chi^2(1, N=60)$ = 5.55, ***p* = .018** IB: HL > auditory task LL (60%), $\chi^2(1, N=60)$ < 1, ns	Inconsistent	*Included*

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						Not included (same sample and no incentives to watch the screen where the US was displayed)
				Exp.2 IB: HL (Exp1., 66%) > auditory + (simple) visual task LL (27%), $\chi^2(1, N=60) = 11.28$, ***p* = .001**		*Not included (same sample for HL group)*
(Richards et al., 2010)	Computer-based	(A)OSPAN	Dynamic	Exp.1 OSPAN score: ind-IB (M = 15.11) < ind-NIB (M = 19.56), $t(66) = 2.57$, ***p* = .013**	Inconsistent	*Included*
				Exp.2 AOSPAN score: ind-IB (M = 44.68) < ind-NIB (M =55.41), $F(1, 76) = 6.06$, ***p* = .016**, $\eta_p^2 = .074$		*Not included (insufficient data)*
(Richards et al., 2014)	Computer-based	AOPSAN	Dynamic	Exp.2 AOSPAN score: ind-IB (39.5) < ind-NIB (52.03), $t(64) = 4.6$, ***p* < .001**	Inconsistent	*Included*
(Seegmiller et al., 2011)	Computer-based	AOSPAN	Dynamic	Primary task ACC > 80% IB: WM low-span (64%) > WM high-span (33%), $\chi^2(1) = 3.85$, ***p* < .05** Primary task ACC < 80% IB: High-span (36%) > low-span (29%), $\chi^2(1) = .31$, $p = .58$	Partially inconsistent	*None included (insufficient data)*
(Todd et al., 2005)	Computer-based	WM task	Static°	Exp.5 IB: HL (50%) > LL (18%), ***p* < .01** (Fisher's exact test)	Consistent	*Included*

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Table 3: *Studies considered for both perceptual and cognitive load investigations.*

The global experimental context, the perceptual/cognitive load and inattentional blindness paradigms used, the statistical comparison between load levels and fit regarding the Load Theory framework are presented. P-values that reached significance (α < .05) are highlighted in bold. When possible, we computed the statistical information (e.g., degrees of freedom, chi-square test, etc.) not found in original papers. Note that the labels for load level (low, moderate or high) are those used by the authors in original studies. For each entry (experiment or condition), its inclusion or exclusion (with reasons) from the meta-analysis is stated.

IB = inattentional blindness; LL = low-load; HL = high-load; PL/CL = perceptual/cognitive load; ns = non-significant; US = unexpected stimulus; WM = working memory.

Reference	Experimental context	Perceptual load	Cognitive load	IB paradigm	PL effect and comparison with Load Theory prediction	CL effect and comparison with Load Theory prediction	Interaction between PL and CL	Inclusion / exclusion in the meta-analysis
(Beanland et al., 2011)	Computer-based	Tracking with increased targets speed	WM task	Dynamic	Exp.1 IB: HL (80%) > LL (52%), $\chi^2(1, N=50) = 7.85$, ***p* = .005** Consistent	Exp.1 IB: HL (28%) < LL (52%), $\chi^2(1, N=50) = 4.02$, ***p* = .045** Consistent	Not tested because loads not manipulated orthogonally (i.e., no perceptual HL – cognitive HL)	*Included for PL and CL results*
(Calvillo & Jackson, 2014)	Computer-based	Visual search with more non-target stimuli	AOSPAN	Static	IB overall: HL (72%) > LL (49%), $\chi^2(1, N=200) = 11.07$, ***p* = .001** US animate IB: HL (64%) > LL (36%), $\chi^2(1, N=100) = 7.84$, ***p* < .01** US inanimate IB: HL (80%) > LL (62%), $\chi^2(1, N=100) = 3.93$, ***p* = .047** Consistent	AOSPAN score: ind-IB (52.34) < ind-NIB (56.09), $t(168) = 1.71$, *p* = .089 No Effect	Perceptual LL AOSPAN score: ind-IB (53.61) < ind-NIB (54.57), $t(88) = .34$, *p* = .739 Perceptual HL AOSPAN score: ind-IB (51.47) < ind-NIB (59.8), $t(78) = 2.23$, ***p* = .029**	*Included for both PL conditions (animate and inanimate) and for both CL conditions (i.e., comparisons of AOSPAN scores in low PL and high PL, see "interaction" column)*
(Hughes-Hallett et al., 2015)	Real-world (surgical endoscopy)	Visual search with more relevant stimuli (Standard view vs. Standard + Augmented	WM task	Static	Unprompted attention US swab (periphery) IB: HL (84%) > LL (75%), Fisher's exact test, *p* = .528 US suture (center) IB: HL (39%) > LL (25%), Fisher's exact test, *p* = .3	Unprompted attention US swab (periphery) IB: HL (95%) > LL (68%), Fisher's exact test, ***p* = .002** US suture (center) IB: HL (36%) > LL (32%), Fisher's exact test, *p* = .808	Not tested	*Included for both PL and CL conditions (periphery and center)*

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		reality views)			No Effect	Partially inconsistent		
(Richards et al., 2012)	Computer-based	More stimuli with increased target speed	AOSPAN	Dynamic	IB: HL (54%) > LL (38%), $\chi^2(1, N=131) = 3.41$, $p = .065$ No Effect	AOSPAN score: ind-IB (38.36) < ind-NIB (43.46), $t(129) = 1.64$, $\boldsymbol{p = .05}$ Inconsistent	Not tested	*Not included for PL (insufficient data) but included for CL.*

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