Retention of visual features in the absence of conscious awareness…? A closer look at the inattentional blindness paradigm

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Abstract

Day to day, as we move throughout our lives, we generally assume we consciously perceive most of what exists around us, yet, evidence suggests otherwise: we may actually perceive very little, including incredibly salient, large, obvious stimuli when our attention is directed elsewhere, in a perceptual phenomenon called “inattentional blindness” (IB). Recently, the existence of IB has been doubted by evidence appearing to demonstrate above-chance performance on feature-discrimination tasks for stimuli participants claim to have not noticed (Nartker et al., 2025). Thus, the long-held core concept of attention being necessary for conscious awareness has been called into question. The current thesis combined the original IB classic cross-line paradigm created by Mack & Rock (1998), signal detection theory analysis and 2-alternative forced choice questions from Nartker et al. (2025), and improved follow-up questioning methods to test whether participants are genuinely sensitive to features of visual stimuli they fail to report seeing. Out of 914 participants run online, 77% did not report noticing the unexpected shape (i.e. “Non-Noticers”) and did not display any significant residual sensitivity to its features, through both traditional accuracy (% correct) and signal detection theory measures of sensitivity (d’) therefore consistent with previous literature on IB. Thus, the current study did not replicate findings displayed in Nartker et al. (2025), therefore validating the existence and prevalence of the phenomenon of IB.

Chapter 1: Introduction

1.1 Our Visual Systems – Rich, or Sparse?

To count boats drifting across a shimmering ocean on the brightest of summer days, to read, to witness the changing form of the moon, to be warmed by a loved one's smile— to *see*. Visual perception provides a bridge between our internal selves and the outside world, where the transmission of knowledge, understanding, and the appreciation of beauty can form. A precious, powerful act, seeing is utilized to navigate and survive, while also reflecting sentiments of awe and purpose that nurture the mind and soul. So— how do all the colors, shapes, shades, lights, edges, and movements from the outside world translate into neural signals that then become meaningful visual information? In each of our eyes, a 2-D image composed of wavelengths of light is taken in from the cornea, reflected onto our retina, and then is transduced into electrical signals by photoreceptor cells ("rods" in low light, "cones" in daylight). These neural signals travel from the eye to the brain through the optic nerve, eventually splitting and decussating (left becoming right and vice versa) at the optic chiasm at the base of the brain. Then, these signals enter the lateral geniculate nucleus (LGN) to be sent further along the processing pathway to our visual cortex. Information from the right side of our visual fields is processed by the left side of the brain, and vice versa (why some forms of brain damage on one side of the brain limit vision on the opposite side; such as "hemianopia" and "hemispatial neglect"). This visual information then makes its way through the visual cortex, bouncing around the primary visual cortex (V1) and higher-level extrastriate areas (V2, V3, V4, etc) for processing. Rather than strictly advancing from low-level to increasingly higher-level areas in one-way hierarchical sequence, *Reverse Hierarchy Theory* instead suggests our brains are engaging in bottom-up and top-down processing in unison, which allows us to get the *gist* of a given scene before observing any of the specific details (Hochstein & Ahissar, 2002).

Our sensory systems are constantly working to guide us in paying attention to relevant information and blurring the rest for the time being. We could not possibly take in *everything* from the environment at once, every miniscule detail, every little crack in the pavement, wrinkle on skin, leaf on a singular tree; we would not be able to function with so much sensory overload. While many of us undoubtedly go through our daily lives believing we consciously perceive everything (or nearly everything) existing in our visual fields, evidence suggests otherwise, and the striking question of how much we truly see has remained an ongoing puzzle in cognitive neuroscience for decades. Though we may not be able to see every single detail of a scene (i.e. every individual tree), we still retain a summary of the picture as a whole (the forest), and, we can capture an impressively large amount of visual information in just a few hundred milliseconds. Our eyes can only focus our attention on one (or at best two) spatial locations at a time, yet we do not see *only* that individual region; information from the periphery still seeps its way into our understanding (coined “ensemble statistics”; Cohen et al., 2016; Jackson-Nielsen, Cohen, & Pitts, 2017). As our retinas can only take in a small amount of detailed information at once, our eyes must dart around an image to see it fully (called “saccades”), with our brains largely filling in the rest. This process is selective: we first look at what is most important to us in the present moment. What determines importance here also remains fuzzy. The visual system is constantly working to process stimuli while other systems in the brain influence what to focus on, once again, through a combination of both top-down and bottom-up processing. Ultimately, ensemble statistics and our brain’s ability to fill-in unattended areas of an image may coax us into believing we have a better grasp on what lies around us than we really do.

One incredible example of our ability to *not* see much of the visual world was found through an experiment that combined eye tracking with virtual reality (VR) headsets (Cohen et al., 2020). In this experiment, observers freely explored interactive, 3-D environments with VR while researchers gradually faded out all of the color in their periphery. In tracking wherever participants’ eyes were momentarily fixated (a good proxy for where visual attention was currently focused), researchers could retain a “color radius” around this central point that followed each of their eye movements while everything else was turned to black-and-white. Amazingly, many observers failed to notice this color change, even when more than 75% of their visual field was changed to monochrome, and were shocked when they were shown the same VR environment a second time, now with their attention cued to detect the change (i.e. "*How could I not have noticed this??*"). Example images of the four critical trial conditions are shown below, along with awareness data for each condition (Figure 1).

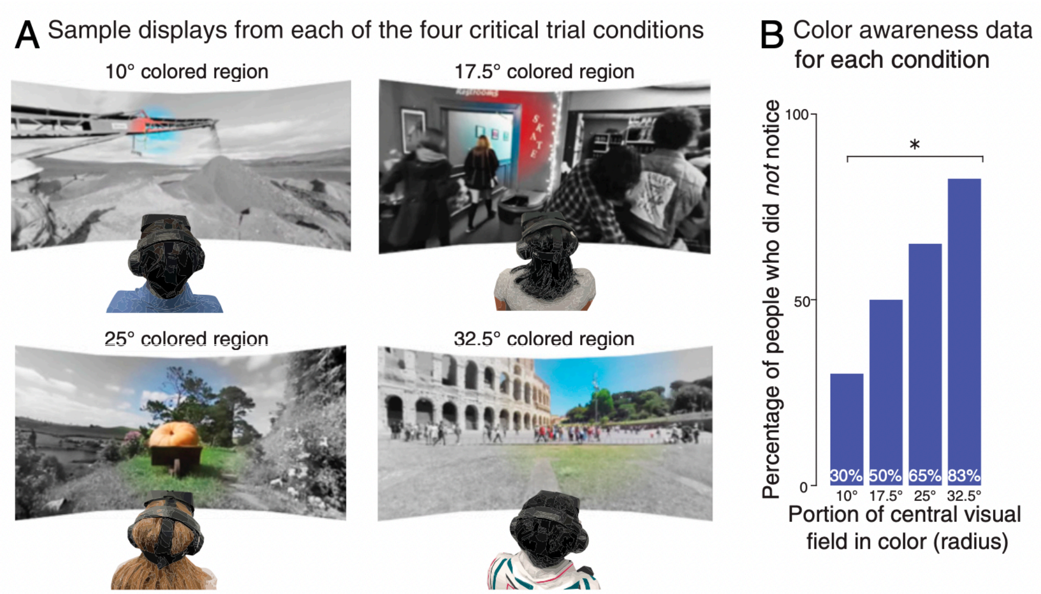

Figure 1. *(A)* Sample displays of the four experimental conditions in Cohen, Botch, and Robertson's 2020 VR paradigm.
Only the area where participants were directly looking remained in color, either including 10, 17.5, 25, or 32.5 degrees from wherever their eyes were presently focused. *(B)* Percentage of participants who failed to notice the black-and-white periphery, per radius degree condition (ex. 50% of participants who only had a radial distance of 17.5 degrees in color noticed that their remaining surroundings were colorless).

Participants who answered that they were totally unaware of any color change on a follow-up question *and* who confirmed they did not notice this change when shown an example of what they had previously seen were included in this "non-noticers" category. So- how could so many participants fail to see this drastic change, when color is such a vivid and vital aspect of our visual sensory experience? This is yet one of many nearly unbelievable studies demonstrating the limitations of our visual systems, due to one essential factor—attention.

1.2 Attention Here, Attention There, Attention (Not) Everywhere

1.2.1 Attention

In reading this, your eyes are currently scanning across the the page, line by line, ignoring other distractions, such as as repeated words… (reread this sentence one more time… but more slowly, specifically attending to any repeated words). When our cognitive toolbox (eyes, brains, ears, neurons, etc.) is intently focused on a specific task, it can be difficult to notice unpredictable, extraneous factors that may lie outside of that attentional pathway. While this ability to focus our attention on solely relevant stimuli alone is essential for correctly performing complex tasks (think of how difficult driving would be if we noticed and clearly read every single word on road signs, billboards, storefronts, license plates, trucks, and also EVERYTHING else), it can also prove to be potentially catastrophic, such as not noticing the motorcycle, cyclist, or pedestrian crossing the street when we are so focused on other vehicles.

Rather than stemming from visual deficits in which unnoticed features are not able to be processed or absorbed by the visual system at all, or possible memory and encoding errors, these unseen stimuli may be quite obvious and easy to see, and the observer’s blindness of them can be solely caused by distracted attention. As mentioned, the visual system works to absorb wavelengths of light (sensation) while the brain selects what to focus on or “decode” first (perception). Attention is the bridge between the two: the selective process by which we devote more mental resources to certain stimuli and less to others, with these selected stimuli progressing further in our cognitive processing pathway than others that may remain outside of our realm of awareness. Attention is how we manage and make sense of the incredibly beautiful, chaotic, overwhelming, and complex world around us. It is in our best interest to allocate mental resources to the most important task at hand and be guided in our daily lives through this process, whether that task is working through a challenging academic article while ignoring the rest of our environment for the time being, or quitting reading that article and jumping into action mode if we hear the sound of a fire alarm or someone calling for help. From as early on as infancy, we pay more attention to things that are novel, out of the ordinary, or unfamiliar (Colombo & Mitchell, 2008), which can help to protect us from strange and potentially dangerous situations. If many people in a crowd direct their attention towards a certain direction or stimulus, it is evolutionarily advantageous for us to follow suit. While attention undoubtedly remains a necessary, incredibly useful tool for navigating the world, it can also limit our ability to see the full picture, causing us to miss vital visual details that may place ourselves and others in harm's way.

1.2.2 Awareness

Awareness can be understood plainly as *having an experience*. Other terms to describe awareness include perception and consciousness; the *precise* definitions of which have remained philosophically debated for centuries. An "experience" could include one that is visual, auditory, or of another sensory modality. Sensation does not always progress to perception. Hence, our eyes "see" things we may not truly be aware of: if you have ever had the experience of sleepily reading a full page of text and then realizing you have no idea what it was about, you understand this well, or perhaps walking straight past a smiling and waving friend when preoccupied in thought. This process of seeing without perceiving happens constantly, and we likely could not accomplish much in our daily lives without it.

In studies of visual perception, measures of awareness have ranged from relatively easy to implement questioning methods to invasive and noninvasive brain monitoring and analysis (Ramsøy & Overgaard, 2004; Overgaard & Sandberg, 2021; Tsuchiya & Koch, 2016; Ferrante et al., 2025). One common measure of neural activity is electroencephalography (EEG), which records activity from external electrodes placed on the scalp (usually in an EEG cap, which appears like a swim cap with many wires attached). While EEG can provide impressively precise timing data, somewhat precise brain location data, and allow for further analyses such as temporal decoding, it can be monetarily costly and immensely time consuming. The most utilized measure of awareness in experimental paradigms has been questioning methods. This can include asking participants whether they noticed anything extra in a scene that was not previously there, asking them to freely describe what they saw, having them select what they saw in a multiple-choice question, rating their confidence in whether they saw something extraneous, or other variations of questions. Participants have generally been considered unaware or *not conscious* of a stimulus if they report not seeing it in initial and follow-up questioning measures. As mentioned above, in Cohen and colleagues' VR paradigm, participants were shown an example of the colorless VR environment they had just experienced and had to verify they did not see it to be included in the non-noticers group. One simple yes/no question of "did you notice x" can be subject to error, and more careful and thorough questioning procedures are often called for (see Foundational Experiments for more on this).

Taking a step back, the larger questions such research on the contents of visual awareness seek to answer include: what is the relationship between attention and awareness? How much can we perceive (if anything) of what we are not attending to? As it turns out, an enormous collection of literature suggests that when our attention is directed elsewhere, we can fail to perceive large, salient, clear stimuli right in our direct field of vision. From simple laboratory experiments to real-world simulations, we can fail to see what lies *right before our eyes*, even if that stimulus is strikingly weird, out of place, comical, and astonishingly, even if our own lives or others' may depend on noticing it. Our potential overconfidence in perceptual abilities may place ourselves and others in harm’s way: this leads us to *inattentional blindness*.

1.3 What is Inattentional Blindness? IB on the Radar

1.3.1 Foundational Experiments

Initially explored as "selective looking" by Ulric Neisser in 1979, the term *inattentional blindness* (IB) was coined by researchers Arien Mack & Irvin Rock in 1998 to describe the visual blindness of some objects or events in the world resulting from attention being focused elsewhere (Neisser, 1979; Bahrick et al., 1981; Neisser & Becklen, 1975; Mack & Rock, 1998). In Neisser and colleagues' original investigation, participants watched two superimposed videos of two teams wearing differently colored shirts passing a basketball (one video of players in white t-shirts passing a ball, layered against one video of players in black t-shirts passing a ball) and were instructed to count the passes of one team while ignoring the other. About 30 seconds into this task, a third video was superimposed amongst the other two, where a woman with an open umbrella walked slowly through the middle of the court. When questioned afterwards, only six out of twenty-eight observers (about 20%) reported noticing the woman with the umbrella.

You may be familiar with a popular replication study of this initial investigation that gained tremendous widespread attention in more recent years (hint: it involved a gorilla). Aimed at exploring Neisser's surprising initial findings and seeing if the results solely occurred due to a "fluke" from superimposed videos, Simons and Chabris (1999) created one live-action video as well as a similar transparent 3-video combination and compared participants' rates of noticing the unexpected event. As well as video type (opaque vs. transparent), they tested two variations of the unexpected event: one where a woman with an umbrella walked through the court to stick as closely as possible to Neisser's procedure they were attempting to replicate; and one where the critical stimulus was instead a person in a full-size gorilla costume walking across the court, beating their chest halfway through (Simons & Chabris, 1999; a common misconception in published papers is that this was a *man* in the gorilla suit, when in fact it was a woman). Out of 192 naïve observers across all four conditions, only about half (54%) noticed the unexpected event. While more observers noticed the unexpected event in the opaque condition (67%) than in the transparent condition (42%), still, a surprising 33% of participants failed to notice the woman or gorilla right in the center of the screen in the single (fully clear) video condition (Figure 2). This incredibly popular replication study has caused gorillas to be the unofficial "mascot" of IB, appearing as the critical stimulus in further extended IB studies (such as "The Invisible gorilla strikes again"; Drew et al., 2013) and as a stuffed animal in the background of a crime video in an IB study on eyewitness accounts (Wulff & Hyman Jr., 2021).

Figure 2. Snapshot from Simons and Chabris’ opaque video procedure, displaying the unexpected gorilla that 33% of subjects failed to notice when their attention was focused on counting basketball passes (Simons & Chabris, 1999)

While the initial "invisible gorilla" study may have garnered immense popular attention, the first actual inattentional blindness experiment that gave the phenomenon its name was a simple computerized task where participants viewed crosses appearing on a screen and judged which arm appeared to be longer (horizontal or vertical; Mack & Rock, 1998). Each cross was presented at the screen's central fixation point for 200ms before participants gave a response. After three trials, on the fourth “critical” trial, a small shape (the critical stimulus) was presented along with the cross within 2.3 degrees of fixation on either the bottom-right or bottom left-side. This critical stimulus similarly lasted for 200ms on the screen. Immediately after, rather than being prompted with the same cross-length question as in previous trials, participants were asked whether they had seen anything besides the cross on the screen ("did you notice anything presented on the last screen besides the cross?". This initial wording is important to keep in mind. Depending on the size and properties of the critical stimulus itself, the presence of a pattern mask that sometimes appeared after the last cross, or flip-flopping the locations of the cross and the critical stimulus, Mack and Rock found rates of IB that ranged from 25% in the most basic of experiments to upwards of 89% (the original simple cross task described here retained 25%-30% IB rate in initial studies, but rates heavily increased depending on the size of the critical stimulus, and whether or not it was fully filled in).

Mack & Rock went on to conduct a plethora of manipulations to further investigate the mechanisms of IB using their highly controlled, innovative cross-line paradigm. They discovered having the critical stimulus range in size from 1.0 degree of visual angle to 0.6 degrees of visual angle was the golden zone for obtaining substantial rates of IB while still guaranteeing that participants *could* see the critical stimulus with attention directed towards it (instead of it just being too hard to see in the first place). These trials in which participants' attention is guided toward noticing the critical stimulus, i.e., "full-attention" trials that are run as controls after the critical unexpected stimulus trial, are essential for validating that IB is the underlying mechanism at play. After all, participants who cannot see the critical stimulus when they are explicitly looking for it cannot be defined as "inattentionally blind" on the critical trial (perhaps the stimulus is just too difficult to see). In another manipulation, changing the critical stimulus from a solid to an outlined shape raised IB rates in one experimental procedure from an initial 23% to 37%. Then, in the sequential full attention trial, all subjects (27) reported being aware of the critical stimulus, 100% correctly reported its location, and 96% correctly reported its shape. Other manipulations repeatedly displayed participants' inattentional blindness time and time again, to stimuli such as faces, names, symbols, words, photographs, dynamic stimuli, jittering stimuli, flickering stimuli, stimuli with masks, growing stimuli, auditory stimuli (in "inattentional deafness"), and even highly emotionally reactive stimuli such as a swastika (which achieved a 26% IB rate. How??). In the words of Mack & Rock (1998), "it is as if attention provides the key that unlocks the door dividing unconscious from conscious perception. Without this key, there is no awareness of the stimulus".

Questioning measures used to assess the contents of perception remain an essential aspect of determining whether IB is in fact present. Some experiments in the literature unfortunately may have unintentionally overestimated IB rates due to asking participants "did you see anything *unusual* on the last trial?" without sufficient additional follow-up questions. While this question using the term "unusual" may be potentially less problematic in lifelike manipulations (a gorilla on a basketball court would likely be considered "unusual" by many people), it can lead to skewed results in more basic experimental paradigms, where a small shape on the computer screen within the context of a visual perception experiment may not be judged as "unusual" for many participants. Thus: they may answer "no, I did not see anything *unusual*" when they did, in fact, clearly see the (quite usual) shape. Improved wording on the primary IB question (such as Mack and Rock's original wording) and follow-up questioning methods can help reduce error.

1.3.2 Extending IB

Beyond the lab, IB has been repeatedly displayed in a wide collection of real-life scenarios. In the actual physical world, many participants who jogged behind an experimenter and counted how many times they touched their head failed to notice a fistfight occurring halfway along their route, right next to the running path (Chabris et al., 2011). Similarly, naïve pedestrians failed to notice money on a tree when talking on the phone (Hyman et al., 2010; Hyman Jr. et al., 2014). In a virtual reality simulation implementing a novel "sustained" IB design (multiple critical stimuli were tested throughout the experiment), when focused on tracking a bumblebee through an urban scene, many participants failed to notice a series of violent and distressing images presented on large billboards, occasionally directly behind the flight of the bumblebee they were intently focused on (Hirschhorn et al., 2024). As mentioned earlier, participants in another VR simulation failed to notice color draining from the periphery when they were navigating various environments (Cohen et al., 2020), and in related studies many participants failed to notice when researchers scrambled all of the objects and textures in the periphery of natural photographs while they were focused on faces in the center (Cohen et al., 2021; Cohen et al., 2011; Mack & Clarke, 2012). Though IB can be amusing, it contains darker implications as well. In a simulation, certified airline pilots failed to notice another airplane blocking the runway and proceeded to attempt to land a plane on top of another when their attention was focused on their windshield display (Haines 1991), only seeing it when it was far too late.

In medicine, failures of awareness due to distracted attention could directly impact patient care and the detection of life-threating conditions. Providers reading vital signs may begin with prior ideas of what condition(s) to search for, which may limit them from noticing other unexpected outcomes. Similarly, in the discipline of radiology, searching for one specific condition in imaging exams may obscure the unexpected (Hults et al., 2024). In one well-known radiology IB study in Boston, both experienced radiologists and untrained observers alike did not notice a gorilla embedded in multiple slices of a lung CT scan when searching for nodules (Drew et al., 2013; Figure 3).

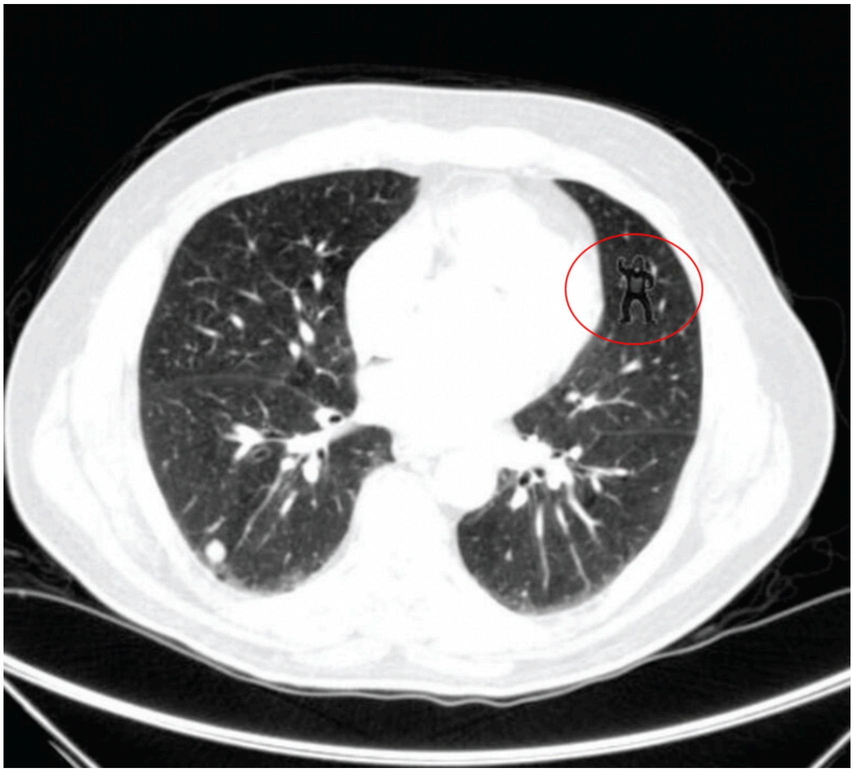

Figure 3. Example CT slide from Drew and colleagues' The Invisible Gorilla Strikes Again: Sustained Inattentional Blindness in Expert Observers. The gorilla is identified here inside the red circle.

This gorilla, our old friend, was 48 times the size of an average nodule. Twenty out of twenty-four (83.3%) radiologists missed the gorilla, as well as all twenty-five (100%) non-medically trained participants. Strikingly, eye tracking was used in this study, and even 12 radiologists and 9 non-trained participants who fixated their gaze directly on the gorilla still failed to see it when it was unexpected. Then, in the full attention control condition (when participants were instructed to keep an eye out for a possible gorilla), 88% of the 49 participants easily spotted the gorilla.

1.4 Complicating Inattentional Blindness

1.4.2 Sensitivity to Visual Features - Nartker et al., 2025

Can participants who are classified as "inattentionally blind" retain visual information of the critical stimulus and then report those properties above-chance in follow up questioning measures? If participants who did not report seeing a critical stimulus due to distracted attention are then able to guess above chance on its specific features (ex. shape, color, location), they may have subconsciously absorbed some of its features through implicit processing, or somehow seen it (briefly, fleetingly, partially) despite reporting otherwise, e.g., due to low confidence and/or a conservative criterion for reporting seeing it. If so, the long-held core concept of attention being necessary for conscious awareness might then be called into question, uprooting decades of research that are grounded in the view that inattentionally blind participants are truly *not aware* of the critical stimulus. Recently, a team of researchers set out to answer this question with an enormous online experiment analyzing residual sensitivity to visual features in IB (Nartker et al., 2025). Results found through this novel, exciting, and controversial study could alter the fields of perceptual science and consciousness research for years to come.

Nartker and colleagues utilized both traditional accuracy measures (% correct on follow-up questions) as well as measures of sensitivity through signal detection theory (d prime; d'). In signal detection theory, an observer's sensitivity (d′) is the distance between the assumed “noise” (stimulus absent, solely environmental/neural noise) and “signal + noise” (stimulus present) distributions. A d′ of zero implies no sensitivity in discriminating the presence of the stimulus apart from noise. Measuring accuracy involved "2-alternative-forced-choice" (2AFC) questions where all participants needed to select one of two options, even if they did not report seeing the critical stimulus (these "inattentionally blind" participants will be called "Non-Noticers" going forward). If Non-Noticers truly did not see the critical stimulus, they should not be able to judge features of the unseen stimulus at levels significantly different from chance (50% correct) on the 2AFCs; in other words, participants should be equally likely to select circle or triangle, red or blue, left or right if they truly failed to see the stimulus. Because each participant completes the critical trial only a single time, measurements of sensitivity involved calculating d' at the group level using 2AFC questions' hit and false alarm rates (further explained in Analysis). So--could Non-Noticers guess above chance on follow-up questions, demonstrating possible retention of visual information? In short, yes, across five experiments, Nartker et al. (2025) found that Non-Noticers, as a group, displayed significantly above-chance rates of 2AFC accuracy (% correct) and sensitivity (d'). These surprising results are potentially very important and are the target of the current thesis experiment.

Experiments 1, 2, and 3 of the Nartker et al. (2025) study utilized the same cross-line distractor task from Mack and Rock (1998), except the cross was presented above the central fixation point and the critical stimulus was presented either directly to the right or directly to the left of fixation on the fourth “critical” trial. The critical stimulus in Experiment 1 was always a solid red line (location was the only factor altered). In Experiment 2, the line was similarly presented to the left or to the right of fixation and was either red or black. Experiment 3 used the same design as Experiment 2, but with added confidence measures to participants' Y/N responses in noticing, as well as to their 2AFC selections. Across all three experiments, on the critical trial, subjects were first prompted with the length judgement question before additional questions were asked about the critical stimulus. The IB question was written as "did you notice anything unusual on the last trial which was not there on previous trials?", i.e., including the potentially problematic framing of the critical stimulus as *unusual*. Subjects then went through a 2AFC question for just location (Experiment 1) or color (Experiments 2-3). Confidence measures in Experiment 3 were nonspecific and written purely as "how confident are you in your answer? (Four-point scale: 0 = Not at all confident, to 3 = Highly confident)" for both the primary noticing question and the 2AFC question. Experiments 4 and 5 implemented a sustained IB task utilizing moving white and black squares from Wood & Simons (2017) where participants tracked one set, ignored the other, and were then presented with an unexpected circle or triangle (black or white in Experiment 4, green or orange in Experiment 5) and asked follow-up noticing and 2AFC questions about color, shape, and location.

In Experiment 1, 28.6% of subjects responded "no" to the primary IB question, placing them in the Non-Noticers category. Out of these Non-Noticers, 63.6% answered the 2AFC location question correctly, significantly above chance (50% correct); 95% CI = [54%, 73%], BF10 = 9.9. Signal detection theory analysis displayed a 2AFC d prime of 0.51, also significantly different from the level of zero sensitivity (in which d' should be 0); 95% CI = [0.16, 0.85].

Experiment 2 resulted in a 27.7% IB rate where these Non-Noticer participants went on to answer the color 2AFC significantly above chance (58.5% correct, 95% CI = [51.95%, 64.93%]; BF10 = 4.54). Similarly, d' was significant, d' = 0.38, 95% CI = [0.03, 0.73].

Experiment 3 (which included 5296 participants in total) explored whether accuracy and sensitivity would change as a function of participants' confidence ratings in their answers. 30.85% of subjects shown an additional stimulus responded “no”, placing them in the Non-Noticer category. Of particular interest were high-confidence Non-Noticers (those who selected "3" on the noticing confidence question). Even this sub-group of highly confident Non-Noticers displayed slight (but still significant) sensitivity on the 2AFC question, d' = 0.34; 95% CI = [0.08, 0.60]; but not above chance accuracy.

In Experiment 4, participants collectively displayed significant residual sensitivity to both color (d' = 0.82, 95% CI = [0.61, 1.04]) and shape (d' = 0.21, 95% CI = [0.01, 0.42]), but not location. The same held true in Experiment 5: sensitivity was displayed for color (d' = 0.12, 95% CI = [0.02, 0.23]) and shape (d' = 0.23, 95% CI = [0.13, 0.33]), but not location. Accuracy (% correct) was not significantly above chance for color, shape, or location in Experiments 4 and 5.

Nartker and colleagues' massive dive into the possibility of residual sensitivity in IB is impressive, yet their results must be replicated several times, by independent laboratories, before the field even considers changing its now standard main-stream views that IB exists and attention is necessary for awareness. Importantly, attempts to replicate Nartker and colleagues’ findings may benefit from a few aspects of improved experimental design that have been implemented in IB experiments from as early on as 1998. These include clearer questioning methods such as a less biased primary IB question (i.e. "did you notice anything presented on the last screen besides the cross" rather than "did you notice anything *unusual*"), additional confidence judgements for specific stimuli being presented, and more precise and specific rating scales for confidence judgements. Nonsensical confidence judgements, as reported in Nartker et al., 2025, could arise when participants first answered "no" to not seeing anything *unusual* and then rated their 2AFC judgement about the location of the unseen stimulus as "highly confident" (e.g., "I didn't see anything *unusual*, but of course I saw that line on the right side! …was that unusual?"). In addition, one essential aspect of IB studies is the inclusion of a "full attention" control trial that acts as a validation check. If a participant cannot clearly identify and report the critical stimulus when their attention is geared towards it, it is unfair to say inattentional blindness is the mechanism at play (maybe it was just too difficult to see). Similarly, due to the nature of online data collection, the full attention condition can help rule out participants who were paying no attention to the instruction, the stimuli, or the questions to begin with and were simply clicking through yet another online survey to earn their payments as online participants. Thus, a full attention (or partial attention) control trial, first introduced by Mack & Rock (1998) in their initial procedure, allows for a more accurate analysis of IB and its implications across the board.

1.5 The Present Study

The present thesis uses the same classic cross-line paradigm as Mack & Rock (1998) along with the forced-choice judgment tasks and signal detection analysis (d') from Nartker et al. (2025), but incorporates improved methods to test whether participants are genuinely sensitive to features of visual stimuli they fail to report seeing. Improved methods include adjustments to the precise wording of the questions, the addition of confidence ratings with more precise scales to all follow-up questions, the inclusion of a “full attention” control trial as a validation-check, and an adjustment to the difficulty of the distracter task in order to achieve initial rates of inattentional blindness that more closely match the majority of studies in the literature (i.e., > 50%, as opposed to the 29% rate reported by Nartker et al., 2024). Signal detection theory analysis using d’ will be performed as well as traditional IB analysis of percent seen. Since Nartker and colleagues' results may call into question the future direction of research on IB, attention, perception, and consciousness, it is essential to verify if they indeed hold true under improved experimental procedures.

Chapter 2: Methods

2.1 Participants

Participants were recruited online through Prolific (www.prolific.com) under the guise of a "visual acuity and length perception" task. Participants were compensated for their time completing the study ($0.67 per the approx. 5 minute study, the equivalent of $8.04 an hour). One thousand participants in total were recruited, two hundred per condition with four IB conditions plus one control condition. Participants could only take the study once.

Participants were limited to English speakers residing in the United States who used a computer to take the experiment (no tablets or smartphones). Personal identifiers such as IP addresses, Prolific IDs, or participants' names were not recorded, so participants remained fully anonymous and stored data did not pose any privacy risks. Each participant was assigned a randomly generated number (that could not be linked back to them personally) in order to tell separate data files apart.

Out of 1,000 total recruited participants, 914 completed the experiment, producing useable data files for analysis. Some of the missing 86 participants did not fully complete the study (answered a few questions, but not all) and some data files were just completely blank (for reasons unknown; explained in greater detail under Stimuli). Incomplete and blank data files were deleted and not used for further analysis.

2.2 Stimuli and Logistics

Experimental procedures, hypotheses, and planned analyses were preregistered on the Open Science Framework (OSF), an open-source project to encourage accessibility and honesty in the science research community (https://osf.io).

The experimental procedure was coded on PsychoPy 2024.2.4 (py3.10, Open Science Tools Ltd). Once finalized, it was linked to run on Prolific and translated from Python code to JavaScript through Pavlovia (Open Science Tools, https://pavlovia.org) in order to run on participants' individual browsers and not require software downloads to take the experiment. Participants were paid through Prolific (the recruitment server) but running them required credits on Pavlovia (the "hosting platform" that made the code useable). Unfortunately, while Prolific was able to exclude participants from being compensated if they did not finish the entire study, one Pavlovia credit was consumed each time the experiment was opened. Thus, even if someone began the study and decided to close the browser before even answering the first consent question, they were not paid on Prolific, but it consumed a Pavlovia credit, and there were exactly 1000 credits total to be consumed. Following the completion of this thesis, which analyzes the 914 usable data files due to time constraints, the missing 86 participants worth of data will be collected and added to the analysis prior to submitting the results for publication.

Since participants were limited to taking the experiment on a computer screen, it was impossible to know for certain the exact measurements of every individual's screen size, refresh rate, and distance from their eyes to the monitor, but any substantial differences should be miniscule among the large quantity of data collected. We assumed an average viewing distance of 57 cm for all visual angle calculations. Consistent with Mack and Rock’s (1998) original procedure, in which cross stimuli ranged from 0.1 to 1.8 degree difference (smaller = more difficult), the first cross composed 1.3 degree difference (H = 150px, V = 60px), the second 0.9 degree difference (H = 70px, V = 135px), the third 0.5 degree difference (H = 110px, V = 80px), and the fourth cross on the critical trial 0.3 degree difference (H = 80px, V = 100px).

The critical (IB) stimuli consisted of either a circle or triangle on either the bottom-left or bottom-right side of the cross, 2.3 degrees from fixation and 0.6 degrees of visual angle in diameter. The shape was outlined in black instead of fully filled in. As Mack & Rock found, the same experimental procedure using an outlined shape as the critical stimulus instead of a fully shaded-in one raised IB rates from 25% to 37% (Mack & Rock, 1998). In the context of the present study, more participants in the IB "non-noticer" category would be advantageous to allow for higher statistical power in analysis, particularly analyses of performance on the 2AFC tasks. The four possible critical stimulus arrangements are shown in Figure 4.

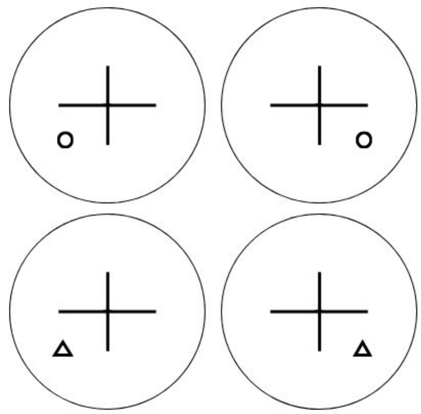

Figure 4. Four critical stimulus conditions implemented in the present study, including Circle Left (CL), Circle Right (CR), Triangle Left (TL), and Triangle Right (TR).

2.3 Procedure

Four experimental (IB) conditions plus one control condition were implemented in the present study. While the task remained the same across conditions, the four experimental conditions contained a critical stimulus, while the control condition did not. The four critical stimulus conditions contained either: a circle on the bottom-left (Circle Left/CL condition), a circle on the bottom-right (Circle Right/CR condition), a triangle on the bottom-left (Triangle Left/TL condition), or a triangle on the bottom-right (Triangle Right/TR condition). After giving consent, participants were told they would be shown crosses appearing on the screen and their job was to judge which arm appeared to be longer (horizontal or vertical). They were also instructed to focus on being as accurate as possible and to not worry about how quickly they responded. On each trial, a fixation point appeared for 1500ms, followed by the cross for 200ms, and then a 500ms delay before questioning.

In the experimental conditions, in the fourth and critical trial, a critical stimulus (the IB stimulus) accompanied the cross; the control condition only displayed the cross on the fourth trial. Participants were prompted to give length judgement responses after the first three trials ("which arm was longer? press H for horizontal or V for vertical") and responses were recorded with "H" and "V" keyboard presses (Figure 5).

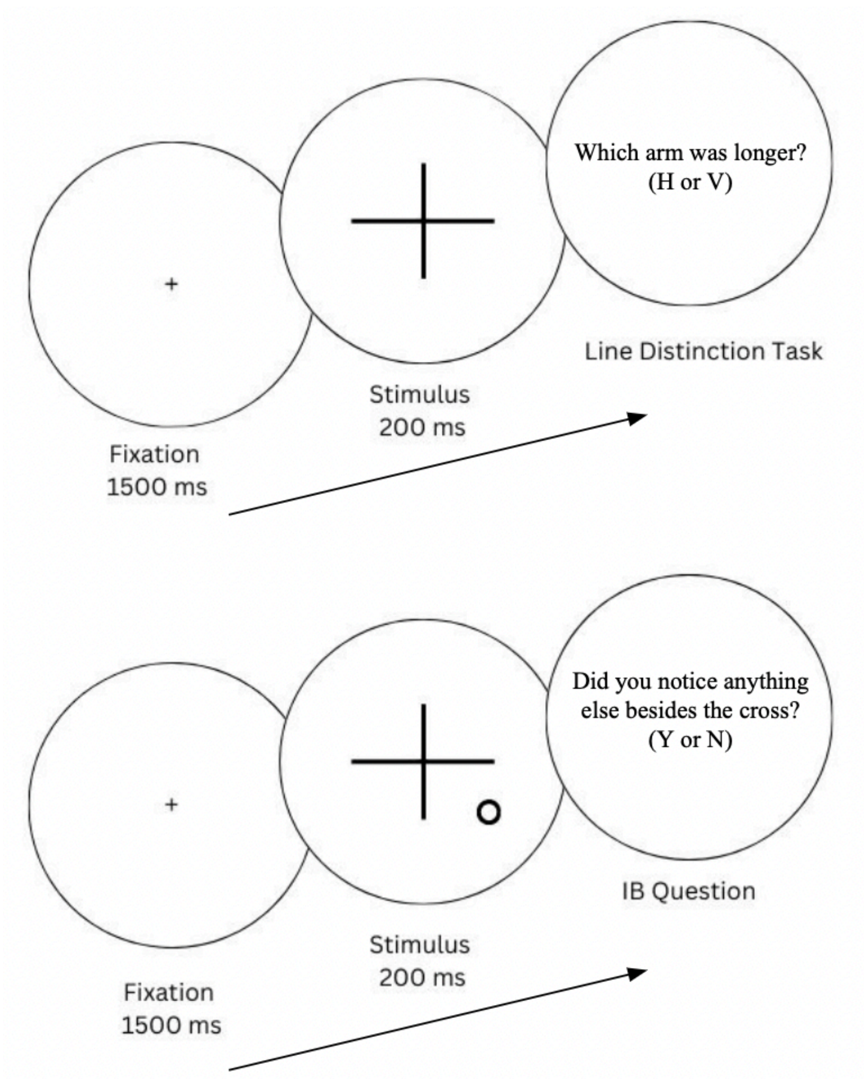

Figure 5. Experimental procedure for the three lead-up trials (top) and critical trial (bottom; one of the four possible critical stimuli is shown here as an example). Responses were recorded with key presses.

Participants were not prompted with the line-length discrimination question on the critical trial, but were asked the IB question right away ("did you notice anything presented on the last screen besides the cross?"). Key responses of "Y" or "N" were recorded. Then, participants rated their confidence in their answer on a clear 5-point scale:

1) I am highly confident I did NOT notice anything else
2) I am somewhat confident I did NOT notice anything else
3) I am unsure
4) I am somewhat confident I saw something else
5) I am highly confident I saw something else

After giving confidence ratings for the first question, the screen displayed *"For some participants who take this experiment, we did present something else on the screen besides the cross, but for other participants, we did not"* followed by two 2-alternative forced choice questions (2AFCs) for the shape and location of the critical stimulus ("*If you had to guess, was there a circle or triangle present on the last screen?*" and "*If you had to guess, was it on the left or the right side of the cross*?"). All participants had to select an option, even if they previously answered "no" they did not notice anything else. Key presses were recorded for each question: "C" for circle, "T" for triangle, "L" for left, "R" for right.

Next, one by one, visual examples of each possible option of the critical IB stimulus were presented on the screen, asking participants to rate their confidence in having seen that exact image on the critical trial ("*how confident are you that this was presented?*") on a similar 5-point scale (Figure 6):

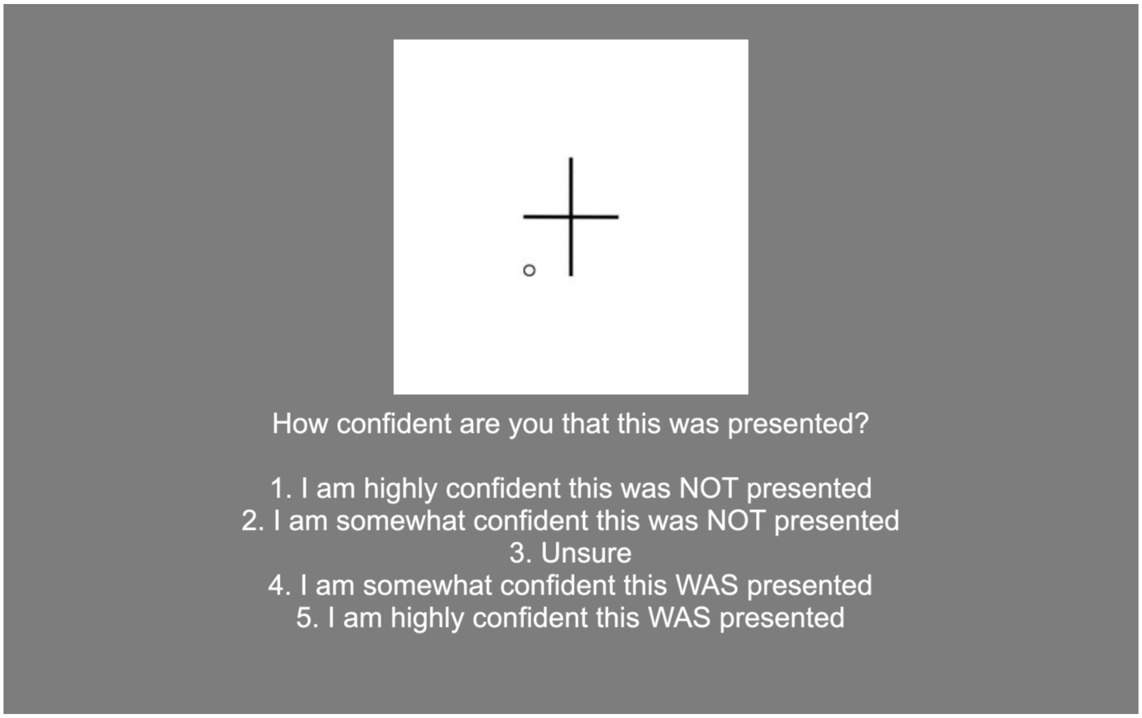

Figure 6. One of the four "presented stimulus confidence rating" questions (CL). This question was repeated four times with each of the possible critical stimulus options (CL, CR, TL, TR). For participants presented a stimulus, one would act as the critical stimulus confidence question (i.e. CL if they were in the CL condition) and the other three would act as foils (i.e. CR, TL, and TR).

Control participants who were presented no critical stimulus still went through the same series of questions to allow for the assessment of a false alarm rate (those who were presented no critical stimulus but still answered "yes" to seeing something besides the cross).

Following this, all participants then completed one more trial, this time being instructed to ignore the cross-task and pay full attention to noticing whether anything else was presented on the screen besides the cross (i.e., the "full-attention" condition). Full attention trial instructions were written as: *"You will now go through one more trial. This time, pay attention and try to notice if anything else is presented on the screen besides the cross."* Each participant's full-attention trial was identical to their previous critical trial, besides the difference in instructions. This helped verify that the unexpected stimulus was able to be easily seen and reported with confidence when participants focused their attention toward it.

After completing the set of trials (lasting ~5min total) participants were thanked for their participation, debriefed on IB, and informed about the true nature of the experiment.

2.4 Hypotheses

Overall, it was predicted that more than half of participants engaged in the cross-line distracter task would answer “no” to the first IB question (“did you notice anything presented on the last screen besides the cross?”), consistent with the phenomenon of inattentional blindness. Participants who answered “yes” would be placed in the “noticer” category and participants who answered “no” would be placed in the “non-noticer” category. This predicted IB rate of >50% was based off Mack and Rock's original demonstration that using an outlined rather than solid shape raised IB rates, as well as the programmed cross-line distinction trials falling on the slightly more difficult range of Mack and Rock's original degree of visual angle calculations.

Then, it was predicted that non-noticers who answered they were "somewhat confident they did NOT notice anything" (2) and "highly confident they did NOT notice anything" (1) (collectively, the "confident non-noticers") would be unable to report the location and shape of the critical stimulus significantly above chance (50% correct on the 2AFCs) and they would not display significant d’ values for shape and location. Also, a gradual increase in accuracy and d’ was expected on the 2AFC tasks as confidence ratings progressed from confident in NOT noticing (1-2), to unsure (3), to confident in noticing (4-5).

A re-run of analyses with the exclusion of participants who failed the full attention trial was also preregistered, i.e., those who answered “no” they did not see anything else presented besides the cross, even when told to focus their attention on detecting the critical shape stimulus, and/or those who incorrectly answered the full attention 2AFCs for location or shape. It was expected that these exclusions would provide a more accurate estimate of overall IB rates, and in turn, would enable a cleaner test of whether participants have sensitivity to visual information during IB.

2.5 Analysis

2.5.1 IB Rate

An unadjusted inattentional blindness rate was assessed from taking the percentage of participants who answered "no" on the primary IB question. Participants who answered "yes" were labeled Noticers and participants who answered "no" were labeled Non-Noticers. Further analysis was split between Noticers and Non-Noticers respectively.

2.5.2 Accuracy (% Correct)

Accuracy was measured through calculating percentage correct on the 2AFC questions. Accuracy was measured for shape and location respectively. At-chance accuracy would imply 50% of participants selecting the correct option (e.g. circle if circle was presented) and 50% selecting the incorrect option (e.g. triangle if circle was presented).

Accuracy was compared to chance using binomial tests in Jeffrey's Amazing Statistical Package (JASP 0.19.3), calculating 95% confidence intervals (CIs) and p-values (as in standard psychology and neuroscience literature, significance implies $p < .05$).

Bayes Factor (BF10) scores were calculated using the BayesFactor package in R Studio, interpreted as follows: < 1, support for the null hypothesis; >1, support for the alternative hypothesis; =1, inconclusive.

2.5.3 Sensitivity (d')

Sensitivity (d') was measured at the group level using signal detection theory calculations of hits (H), false alarms (FA), present trials, absent trials, and then applying the log-linear correction of adding 0.5 to all variables of the decision matrix as described by Hautus (1995; used in Nartker et al., 2025). This would prevent an infinite d' in the unlikely event of variables in the 2x2 matrix being zero. Sensitivity on the 2AFC questions was calculated in the following method (first described by Gourevitch and Galanter, 1967; then re-assessed by Macmillan and Creelman, 2005; and further described in Nartker et al., 2025):

$$d'_{2afc} = \frac{1}{\sqrt{2}}\left[z(H) \; - \; z(FA)\right]$$

In an example for d′ 2AFC location, trials where a stimulus is presented on the right side become "present" trials and those in which a stimulus is presented on the left become "absent" trials (the analysis works the same in both directions, no matter which way present/absent is arbitrarily assigned). Then, the following is assumed, and the above equation can be measured:

1. *N* total subjects where the critical stimulus is presented on the left
    a. Hit rate (H) = % that answer “Left”
2. *N* total participants where the critical stimulus is presented on the right
    a. False Alarm rate (FA) = % that answer “Left”

And similarly for shape.

In order to measure a 95% confidence interval around a value of d', the variance of d' was calculated by the following equations:

$$\phi(H) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2} z(H)^2}$$

$$\phi(FA) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2} z(FA)^2}$$

where ϕ converts z-scores into probabilities. This allowed the calculation of variance using the probability of H and FA rates:

$$\mathrm{var}(d'_{2afc}) = \frac{H(1-H)}{2N_2[\phi(H)]^2} + \frac{FA(1-FA)}{2N_1[\phi(FA)]^2}$$

with N_2 representing the number of present trials, and N_1 representing the number of absent trials (Macmillan and Creelman, 2005; Nartker et al., 2025). Using the calculated variance of d′, confidence intervals could be measured to compare d′ values to zero sensitivity (d′ = 0) assuming the standard significance criterion of alpha = .05 (two-tailed). If a calculated d′ 95% confidence interval (CI) contained zero, such as 95% CI = [-0.23, 0.15], d′ would not be significantly different from zero ($p > .05$) and no residual sensitivity of the critical IB stimulus could be assumed; whereas, if the CI did not contain zero, such as 95% CI = [0.04, 0.17], d′ would be significantly greater than zero ($p < .05$) thus demonstrating residual sensitivity to the critical stimulus.

Chapter 3: Results

3.1 Total Participants

3.1.1 Inattentional Blindness Rate

In total, 914 participants completed the experiment on Prolific, including 730 total participants in the four IB conditions (CL, CR, TL, TR), as well as 184 participants in the control group (no critical stimulus). Out of the 730 total participants who were presented a critical stimulus, 169 answered "yes" to the noticing question, and 561 answered "no", producing a non-adjusted IB rate of 76.9% and a noticing rate of 23.1% (Figure 7).

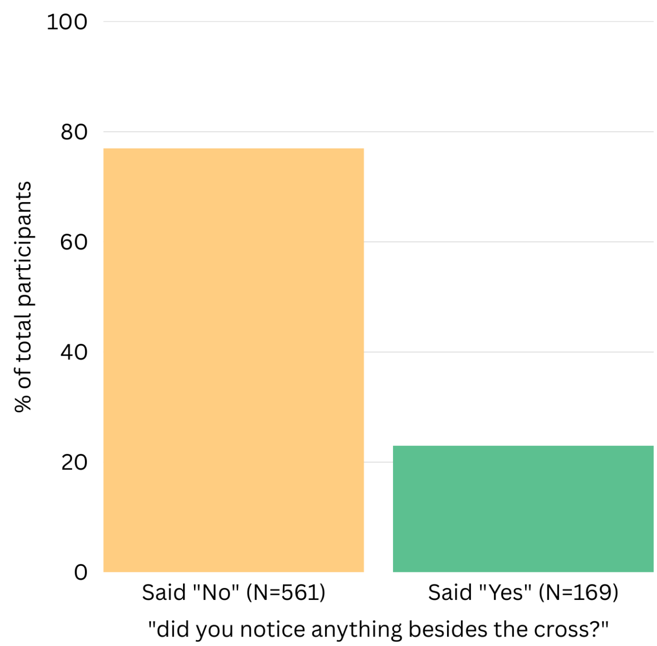

Figure 7. IB and noticing rates for total participants across the four IB conditions.

3.1.2 Total Non-Noticers – Accuracy and Sensitivity

For total Non-Noticers across the four IB conditions, 295 answered the location 2AFC correctly and 266 answered incorrectly, with total accuracy on location being 52.58% correct. A two-tailed binomial test indicated that this level of accuracy was not significantly different from chance (50% correct), 95% CI = [48.4%, 56.8%], p = .237, BF10 = 0.221. Similarly, total Non-Noticers did not answer the shape 2AFC question significantly different from chance, with 49.38% answering correctly, 95% CI = [45.2%, 53.6%], p = .800, BF10 = 0.110. Accuracy rates per condition as well as overall rates across conditions are shown in Table 1.

Condition	Total Non-Noticer participants	Total Correct Location 2AFC	Total % Correct Location	Total Correct Shape 2AFC	Total % Correct Shape
CL	140	97	69.28%	68	48.57%
CR	130	51	39.23%	72	55.38%
TL	141	87	61.70%	60	42.55%
TR	150	60	40.00%	77	51.33%
Total Across Conditions	561	295	52.58%	277	49.38%

Table 1. Total Non-Noticers and % correct split by condition (CL-TR) as well as overall (across conditions).

Collectively, Non-Noticers did not show significant sensitivity for location or shape, i.e., d′ was not statistically greater than zero. For location, d′ = 0.096, 95% CI = [-0.06, 0.25], p = .223 (Figure 8). Similarly, for Non-Noticers' sensitivity to shape, d′ = -0.019, 95% CI = [-0.17, 0.13], p = .80 (not significant).

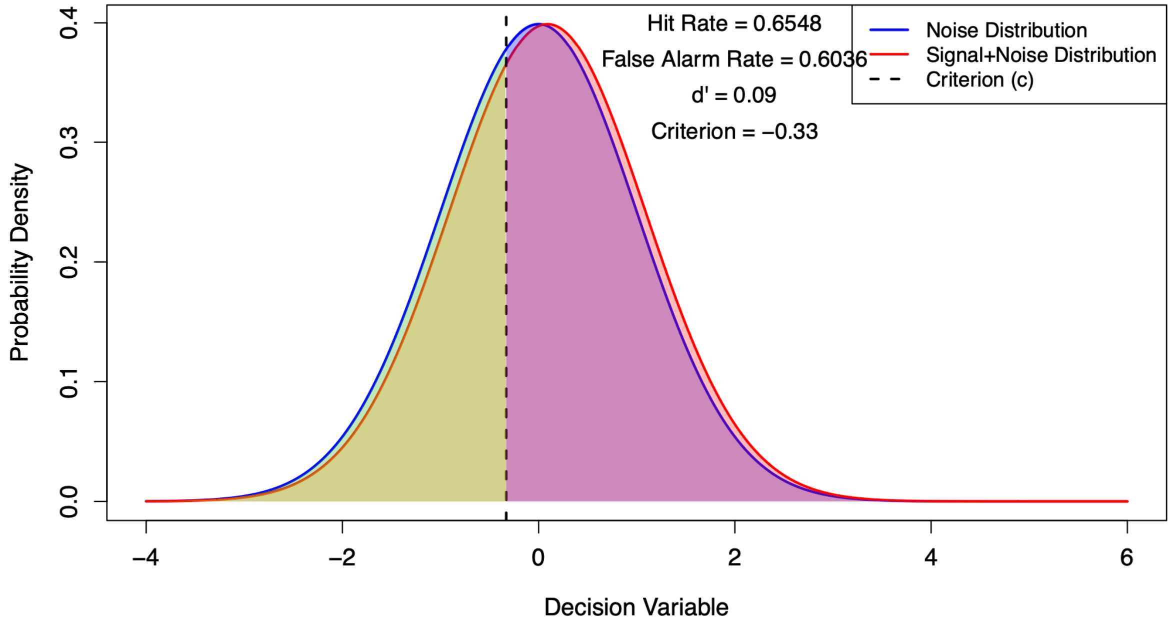

Figure 8. Signal Detection Theory visualization of Non-Noticers' d' for location (distance between the noise and signal + noise distributions), showing no sensitivity to the location of the critical stimulus.
Here, the assumed distributions for noise (plotted in blue) and the signal + noise (plotted in red) are almost entirely on top of each other, implying no sensitivity to detecting the presence of the signal (the location of the critical stimulus). The vertical dotted line, criterion (c), implies that Non-Noticers displayed a *very slight* bias for responding "left" over "right"; c = -0.33. Axes (x = decision variable, y = probability density) are in arbitrary units.

3.1.3 Total Noticers – Accuracy and Sensitivity

Noticers across the four IB conditions (i.e., those answering "yes" to the initial IB question on the critical trial) performed better on the 2AFC question for location compared to shape, though unsurprisingly, were able to judge both visual features at levels far above chance. For location, 74.6% of Noticers answered correctly, 95% CI = [67.3%, 80.9%], $p < .0001$, BF10 = 1.49 x 10^8, and for shape, 68.1% of Noticers answered correctly, 95% CI = [60.4%, 75.0%], $p < .0001$, BF10 = 9527. Accuracy rates per condition and across conditions for Noticers are displayed in Table 2.

Condition	Total Noticer participants	Total Correct Location 2afc	Total % Correct Location	Total Correct Shape 2afc	Total % Correct Shape
CL	43	32	74.42%	24	55.81%
CR	56	40	71.43%	43	76.79%
TL	38	30	78.95%	27	71.05%
TR	32	24	75.00%	21	65.63%
Total Across Conditions	169	126	74.56%	115	68.05%

Table 2. Total Noticers and % correct split by condition (CL-TR) as well as overall (across conditions).

Total Noticers displayed significant sensitivity for location and shape, i.e., d′ was significantly greater than zero; location d'= 0.94, 95% CI = [0.65, 1.23], $p < .0001$; shape , d'= 0.67, 95% CI = [0.39, 0.95], $p < .0001$. Noticers' sensitivity for location is plotted in Figure 9. In a stark contrast to Figure 8 for Non-Noticers' location sensitivity, here, Noticers' noise (blue) vs. signal + noise (red) distributions are separated, implying discrimination sensitivity towards the location of the critical stimulus.

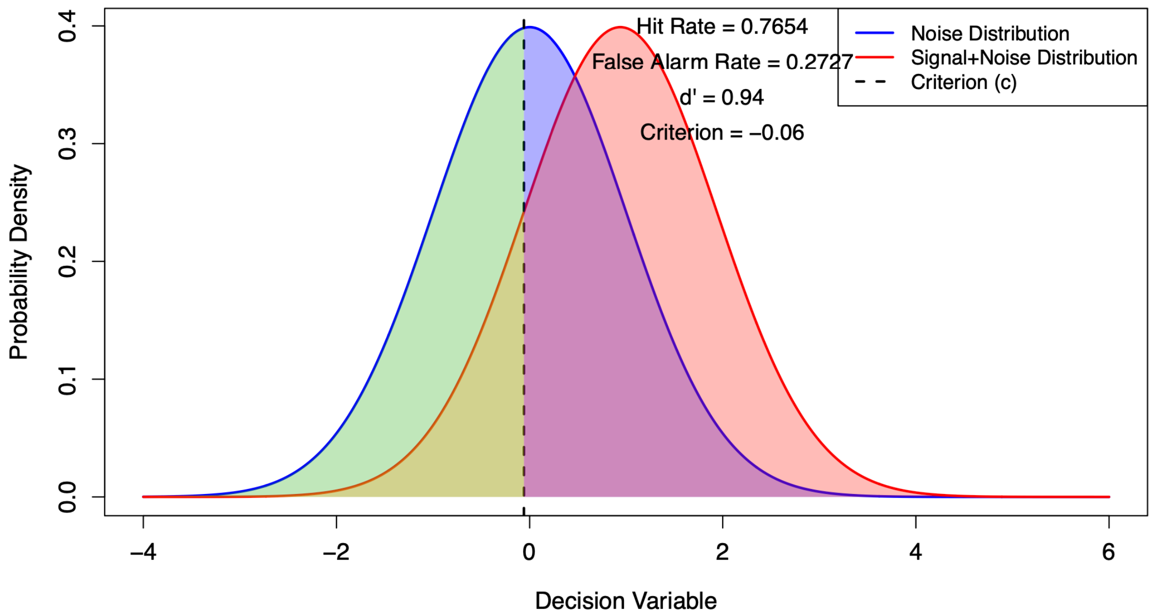

Figure 9. Signal Detection Theory visualization of Noticers' d' for location (distance between the noise and signal + noise distributions), showing sensitivity to the location of the critical stimulus.
Once again, Noticers similarly displayed a *very slight* bias of choosing left rather than right; c = -0.06.

3.2 Split by Confidence Rating

3.2.1 Non-Noticers

Of particular interest were confident Non-Noticers, those that selected either "1 – *I am highly confident I did not notice anything else*" or "2 – *I am somewhat confident I did not notice anything else*" on the IB confidence question (N = 415). Still, as a group, these participants did not perform above chance on accuracy for location (51.3% correct, 95% CI = [46.4%, 56.2%], p = 0.562, BF10 = 0.1408) or shape (48.2% correct, 95% CI = [43.3%, 53.1%], p = 0.531, BF10 = 0.1592). These confident Non-Noticers also did not display significant sensitivity for location (d'= 0.019, 95% CI = [-0.16, 0.20], p = 0.836) or shape (d'= -0.060, 95 % CI = [-0.2316, 0.1114], p = 0.492).

Splitting confident Non-Noticers even more, Non-Noticers who selected "1" (i.e. highly confident Non-Noticers; N = 202) did not perform significantly above chance on 2AFC accuracy for location (51.9% correct, 95% CI = [44.9%, 59.0%], p = .622, BF10 = 0.2019) or shape (45.0% correct, 95% CI = [38.1%, 52.2%], p = .181, BF10 = 0.4519). Significant residual sensitivity was also not found for location (*d′* = 0.051, 95% CI = [-0.20, 0.31], p = .695) or shape (*d′* = -0.18, 95% CI = [-0.42, 0.069], p = .159).

Somewhat confident Non-Noticers, those who selected "2" on the confidence scale (N = 213), similarly did not perform above chance on measures of accuracy for location (50.7% correct, 95% CI = [43.8%, 57.6%], p = .891, BF10 = 0.1723) or shape (51.2% correct, 95% CI = [44.3%, 58.1%], p = .784, BF10 = 0.1787). Likewise, they did not show significant residual sensitivity for location (*d′* = -0.013, 95% CI = [-0.26, 0.24], p = .922) or shape (*d′* = 0.054, 95% CI = [-0.19, 0.30], p = .659).

Next, unsure Non-Noticers were tested, those who selected "3 – *I am unsure*" on the IB confidence question (N = 122). This group of participants did not perform significantly above chance on measures of accuracy for location (54.1% correct, 95% CI = [44.8%, 63.2%], p = 0.415, BF10 = 0.3250) or shape (52.5% correct, 95% CI = [43.2%, 61.6%], p = 0.651, BF10 = 0.2534). Measures for sensitivity were also not significant for location (*d′*= 0.25, 95% CI = [-0.10, 0.59], p = 0.139) or shape (*d′*= 0.081, 95% CI = [-0.24, 0.40], p = 0.617).

Next involved grouping together Non-Noticers who selected "4 – *I am somewhat confident I saw something*" or "5 – *I am highly confident I saw something*" into what will be referred to as the "confused Non-Noticers" (N = 24). Confused Non-Noticers scored greater than chance on location accuracy (66.7% correct), but due to such a small number of participants in this group, it was not significant (95% CI = [44.7%, 84.4%], p = .152, BF10 = 1.31). For shape, 54.2% of confused Non-Noticers were correct on the 2AFC, which was also not significant (95% CI = [32.8%, 74.4%], p = .839, BF10 = 0.4796). Sensitivity for location (*d′*= 0.55, 95% CI = [-0.23, 1.34], p = .168) and shape (*d′*= 0.179, 95% CI = [-0.55, 0.91], p = .630) were not significant. Confused Non-Noticers were not broken down anymore (i.e. testing for differences between ratings 4 and 5) due to such a small sample size.

3.2.2 Noticers

On the other hand, Noticers who selected "4 – *I am somewhat confident I saw something else*" or "5 – *I am highly confident I saw something else*" were jointly considered as the confident Noticers (N = 111), and they did perform significantly above chance on location accuracy (79.3% correct, 95% CI = [70.5%, 86.4%], p < .001, BF10 = 4.82 x 10^7) and shape accuracy (74.7% correct, 95% CI = [65.6%, 82.5%], p < .001, BF10 = 1.58 x 10^5). The same was true for sensitivity for location (*d'*= 1.14, 95% CI = [0.76, 1.51], p < .0001) and shape (*d'*= 1.09, 95% CI = [0.72, 1.46], p < .0001).

To mirror breakdowns in the Non-Noticer group, splitting confident Noticers even more, Noticers who selected "5" (i.e., the highly confident Noticers; N = 65) were significantly above chance on accuracy for location (84.62% correct, 95% CI = [73.5%, 92.4%], p < .0001, BF10 = 1.67 x 10^6) and shape (84.62% correct, same 95% CIs, p-value, and BF10 as location). Highly confident Noticers also displayed significant sensitivity for location (*d'* = 1.41, 95% CI = [0.89, 1.94], p < .0001) and shape (*d'* = 1.45, 95% CI = [0.92, 1.97], p < .0001).

Somewhat confident Noticers, those who selected "4" (N = 46), also had significantly above chance accuracy for location (71.7% correct, 95% CI = [56.5%, 84.0%], p = .005, BF10 = 17.6) but surprisingly not shape (60.9% correct, 95% CI = [45.4%, 74.9%], p = .184, BF10 = 0.895). Sensitivity was significant for both location (*d'* = 0.81, 95% CI = [0.26, 1.35], p = .0037) and shape (*d'* = 0.68, 95% CI = [0.14, 1.22], p = .013).

Since Noticers who were unsure (selected "3") comprised just 9 participants, for fair statistical analysis, they were grouped together with those who selected either "1 – *I am highly confident I did not notice anything*" or "2 – *I am somewhat confident I did not notice anything*" on the IB confidence question. This group (Noticers who selected 1, 2, or 3) were collectively named the non-confident Noticers (N = 59). These participants did score above chance on measures of accuracy for location (64.4% correct, 95% CI = [50.9%, 76.4%], p = .0363, BF10 = 2147) but not shape (54.2% correct, 95% CI = [40.8%, 67.3%], p = .603, BF10 = 0.7622). While residual sensitivity for location was significant, (*d'*=

0.51, 95% CI = [0.035, 0.99], p = .0355), shape was not (d'= 0.15, 95% CI = [-0.30, 0.60], p = .516). Comparisons of sensitivity for location across confidence ratings for Non-Noticers and Noticers are shown in Figure 10, compared to Nartker and colleagues' same figure for location sensitivity per Non-Noticers and Noticers in Figure 11 (2025):

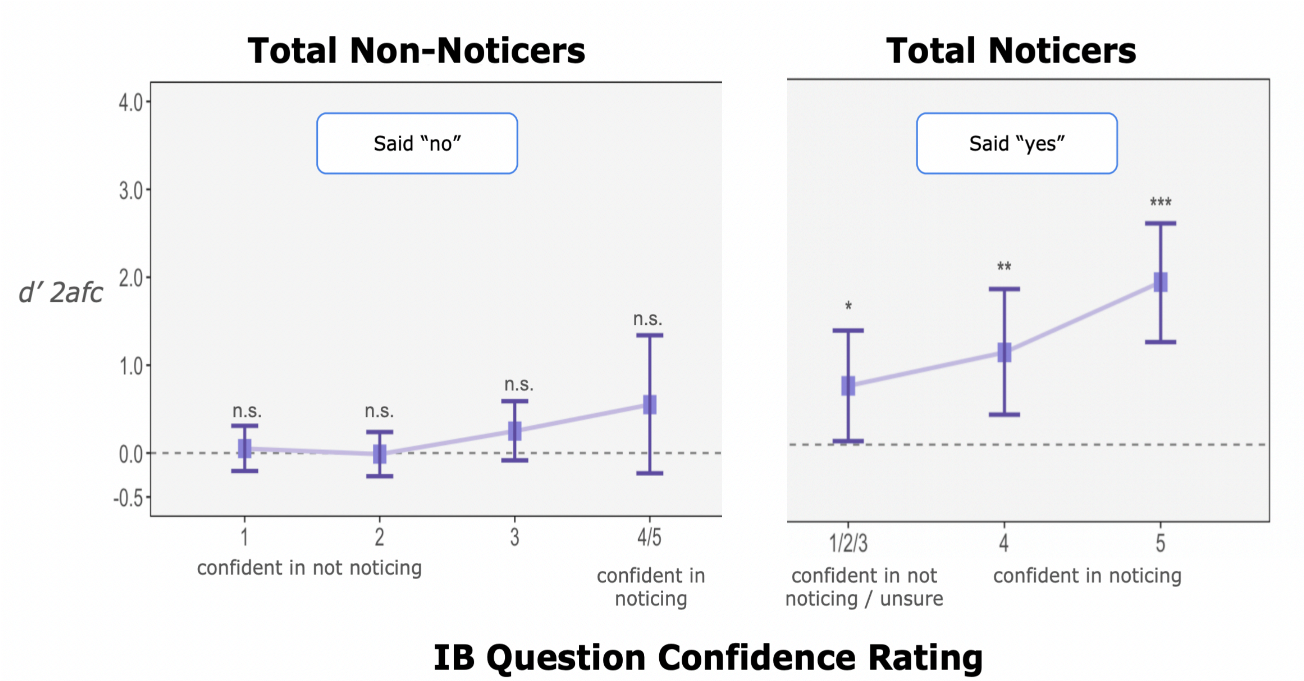

Figure 10. The present study: residual sensitivity for location on the 2AFC question, for Non-Noticers (left) and Noticers (right), split by confidence ratings. Significant residual sensitivity was found for Noticers (all confidence groups), but not for Non-Noticers.

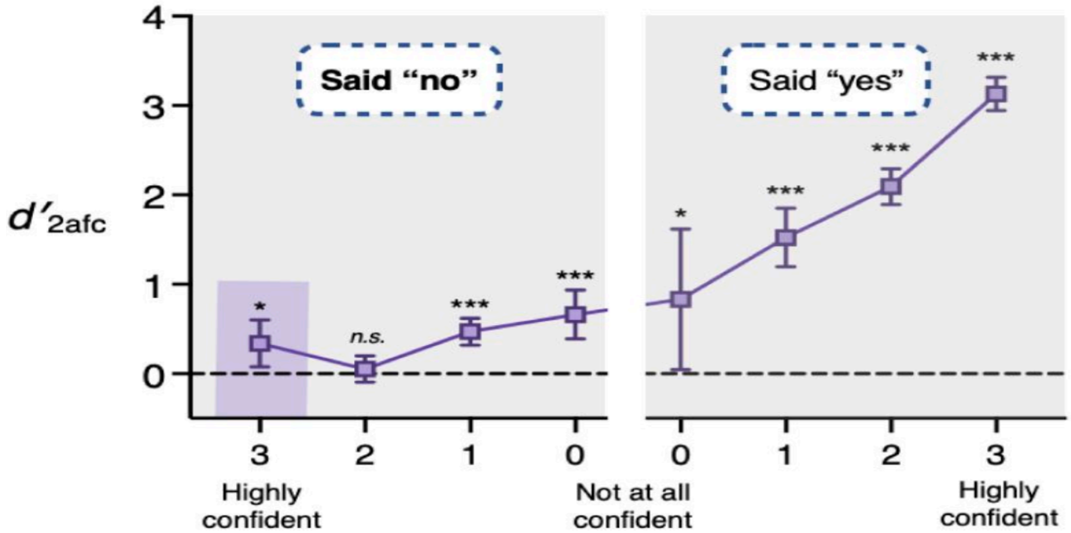

Figure 11. Nartker et al. (2025): residual sensitivity for location on the 2AFC question, for Non-Noticers (left) and Noticers (right), split by confidence ratings. Significant sensitivity (d') was found for both Non-Noticers and Noticers.

3.4 Exclusion of Failed Full Attention Participants

3.4.1 Pass Rate

In total, in the full attention critical trial, 90.4% of participants answered "yes" to noticing the critical stimulus. Total participants (without any exclusions) went on to answer the location 2AFC question with 90.3% accuracy, and the shape 2AFC question with 87.9% accuracy. Out of the total Non-Noticer group, 90.9% answered "yes" to noticing the critical stimulus in the full attention critical trial, and proceeded to answer the location 2AFC with 87.0% accuracy and the shape 2AFC with 83.2% accuracy. And, for Noticers, 89.3% answered "yes" to noticing the critical stimulus in the full attention trial, with 81.1% correct for the location full attention 2AFC and 85.2% correct for shape.

Next, as preregistered, the same analyses listed above were performed after excluding participants who *failed* the full attention condition. Failed criteria resulted from those who answered "no" they did not see anything else presented besides the cross, even when told to focus their attention on detecting the critical shape stimulus, *and/or* those who incorrectly answered the full attention 2AFCs for location or shape. As previously mentioned, it was expected that these exclusions would provide a more accurate estimate of overall IB rates, and in turn, would enable a cleaner test of whether participants have sensitivity to visual information during IB. Out of 730 total participants (presented a critical stimulus), 79.8% passed the full attention condition (N = 583), with the strictest criteria for inclusion (needing to correctly answer all 3 questions).

3.4.2 IB Rate Post-Exclusion

After excluding data from participants who failed the full attention condition, the IB rate remained similar to the rate found from all participants, with 77.2% of participants answering "no" to seeing anything besides the cross (the post-exclusion Non-Noticers; N = 450) and 22.8% answering "yes" (the post-exclusion Noticers; N = 133).

3.4.3 Post-Exclusion Non-Noticers

Post-exclusion total Non-Noticers (N = 450) did not display above chance accuracy for location (53.6% correct, 95% CI = [48.8%, 58.2%], p = .144, BF10 = 0.359) or shape (49.1% correct, 95% CI = [44.4%, 53.8%], p = .741, BF10 = 0.126). Similarly, significant sensitivity was not found for location (*d′* = 0.127, 95% CI = [-0.036, 0.29], p = .128) or shape (*d′* = -0.0361, 95% CI = [-0.20, 0.12], p = .666).

Split into a combined "confident" group, Non-Noticers who answered "1" or "2" (N = 329), these participants also did not display above chance accuracy for location (52.6% correct, 95% CI = [47.0%, 58.1%], p = .378, BF10 = 0.210) or shape (47.4% correct, 95% CI = [41.9%, 53.0%], p = .378, BF10 = 0.110). Sensitivity was also not significant for location (*d′* = 0.0707, 95% CI = [-0.13, 0.27], p = .490) or shape (*d′* = -0.0858, 95% CI = -0.28, 0.11], p = .382).

Split even more, highly confident Non-Noticers post-exclusion, those who answered "1" (N = 152), did not show above chance measures for accuracy of location (53.9% correct, 95% CI = [45.7%, 62.1%], p = .372, BF10 = 0.313) or shape

(43.4% correct, 95% CI = [35.4%, 51.7%], p = .123, BF10 = 0.702). These participants did not display significant sensitivity towards location (*d′* = 0.152, 95% CI = [-0.142, 0.446], p = .310), but did display slightly significantly NEGATIVE sensitivity (responding wrong) for shape (*d′* = -0.332, 95% CI = [-0.62, -0.044], p = .0241).

Somewhat confident Non-Noticers post-exclusion, those who answered "2" (N = 177), did not display above chance accuracy for location (51.4% correct, 95% CI = [43.8%, 59.0%], p = .764, BF10 = 0.198) or shape (50.8% correct, 95% CI = [43.2%, 58.4%], p = .885, BF10 = 0.189). As expected, sensitivity was not found for location (*d′* = -0.003, 95% CI = [-0.28, 0.27], p = .979) or shape (*d′* = 0.042, 95% CI = [-0.22, 0.30], p = .754).

Unsure Non-Noticers (who answered "3"; N = 107), did not display above-chance accuracy for location (53.3% correct, 95% CI = [43.3%, 62.9%], p = .562, BF10 = 0.291) or shape (52.3% correct, 95% CI = [42.5%, 62.1%], p = .699, BF10 = 0.261). Sensitivity was similarly not found for location (*d′* = 0.202, 95% CI = [-0.16, 0.56], p = .269) or shape (*d′* = 0.081, 95% CI = [-0.26, 0.42], p = .638).

Confused Non-Noticers post-exclusion, those who answered "4" or "5" (N = 14), did not display significantly above-chance accuracy for location (78.6% correct, 95% CI = [49.2%, 95.3%], p = .0574, BF10 = 2.91), or shape (64.3% correct, 95% CI = [35.1%, 87.2%], p = .424, BF10 = 0.817). Significant sensitivity was not found for location (*d′* = 1.14, 95% CI = [-0.078, 2.19], p = .0354) or shape (*d′* = 0.457, 95% CI = [-0.50, 1.42], p = .350).

3.4.4 Post-Exclusion Noticers

Total Noticers post-exclusion (N = 133) did perform above-chance on accuracy for location (78.9% correct, 95% CI = [71.0%, 85.5%], p < .001, BF10 = 1.40 x 10^9) and shape (72.2% correct, 95% CI = [63.7%, 79.6%], p < .001, BF10 = 85150). Sensitivity was also found for location (*d′* = 1.126, 95% CI = [0.79, 1.47], p < .0001) and shape (*d′* = 0.967, 95% CI = [0.63, 1.30], p < .0001).

Split into a combined "confident" group of Noticers who selected "4" or "5" on the IB confidence scale (N = 92), significantly above-chance accuracy was also found for location (82.6% correct, 95% CI = [73.3%, 89.7%], $p < .001$, BF10 = 1.03 x 10^8) and shape (75.0% correct, 95% CI = [64.9%, 83.4%], $p < .001$, BF10 = 18867). Sensitivity was also found for location (d' = 1.23, 95% CI = [0.79, 1.67], $p < .0001$) and shape (d' = 0.942, 95% CI = [0.55, 1.34], $p < .0001$).

Split more, highly confident Noticers (those who answered "5"; N = 53) had the highest accuracy for location (88.7% correct, 95% CI = [77.0%, 95.7%], $p < .001$, BF10 = 2.78 x 10^6) and shape (85.0% correct, 95% CI = [72.4%, 93.3%], $p < .001$, BF10 = 1.01 x 10^5). Heightened sensitivity was also displayed for location (d' = 1.53, 95% CI = [0.88, 2.19], $p < .0001$) and shape (d' = 2.50, 95% CI = [1.08, 3.90], $p < .0001$).

Somewhat confident Noticers (answered "4"; N = 39) showed above chance accuracy for location (74.4% correct, 95% CI = [57.9%, 87.0%], $p = .0034$, BF10 = 23.1) but not shape (61.5% correct, 95% CI = [44.6%, 76.6%], $p = .200$, BF10 = 0.90). Sensitivity was also displayed for location (d' = 0.943, 95% CI = [0.34, 1.55], $p = .0023$) but not shape (d' = 0.41, 95% CI = [-0.16, 0.97], $p = .161$).

Total non-confident Noticers (answered "1", "2", or "3"; N = 41) displayed significantly above chance accuracy for location (70.7% correct, 95% CI = [54.5%, 83.9%], $p = .0115$, BF10 = 8.28) but not shape (65.9% correct, 95% CI = [49.4%, 79.9%], $p = .0596$, BF10 = 2.20). Similarly, sensitivity was found for both location (d' = 0.758, 95% CI = [0.18, 1.33], $p = .0098$) and shape (d' = 0.577, 95% CI = [0.016, 1.14], $p = .043$).

3.5 Presented Stimulus Confidence Ratings

3.5.1 One Critical Stimulus and Three Foils

After participants went through the first sequence of cross-line trials and were asked about noticing the critical stimulus, they were shown visual snapshots of each of the four possible critical stimuli, and asked to rate their confidence on a scale from 1 = highly confident that particular stimulus was NOT presented to 5 = highly confident that stimulus WAS presented (return to 2.3 - Procedure for a visual example). One of the four possible snapshots would be participants' critical stimulus (same shape, same location), and the other three (which never appeared during the experiment for that participant) would act as foils. Thus, confidence ratings were assessed for:

1. Same Shape, Same Location (stimulus presented in participants' actual critical trial)
2. Same Location, Different Shape (i.e. a triangle on the left, if they were presented a circle on the left in their critical trial)
3. Same Shape, Different Location (i.e. a circle on the right, if they were presented a circle on the left in their critical trial)
4. Different Shape, Different Location (i.e. a triangle on the right, if they were presented a circle on the left in their critical trial).

3.5.2 Non-Noticers

Importantly, Non-Noticers' confidence ratings (1-5) did not change as a function of the four possible presented stimuli (i.e. they were not any more confident in seeing the presented stimulus vs. any of the foil stimuli that never appeared) (Figure 12).

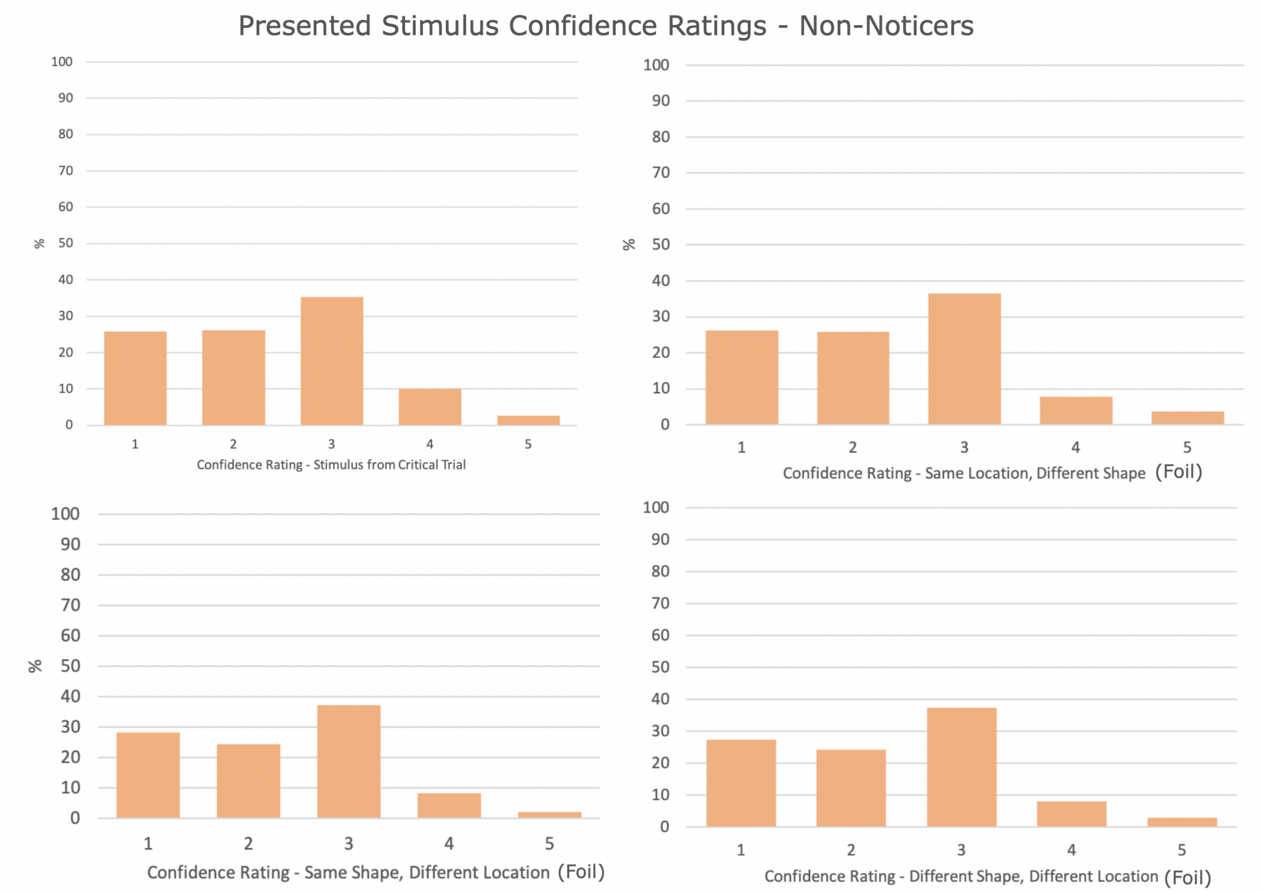

Figure 12. Non-Noticers' presented stimulus confidence ratings for the critical trial stimulus (top left) and three foils, showing no difference in ratings per the presented stimulus vs. foils.

3.5.2 Noticers

On the other hand, as expected, Noticers' confidence ratings (1-5) did change as a function of the four possible presented stimuli (i.e. they were more confident in seeing the presented stimulus vs. any of the foils) (Figure 13).

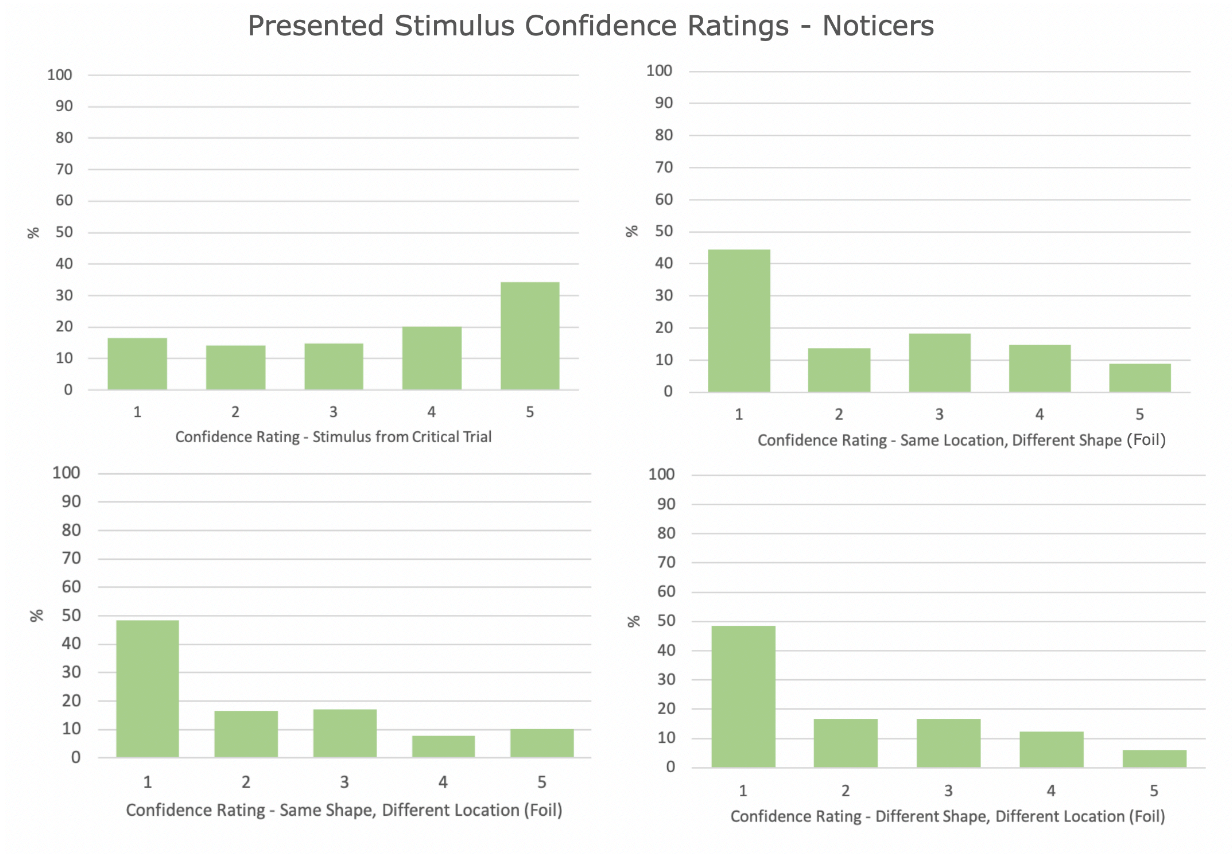

Figure 13. Noticers' presented Stimulus confidence ratings for the critical trial stimulus (top left) and three foils, showing a difference in ratings per the presented stimulus vs. foils.

3.6 Criterion (Bias)

Finally, as found in Nartker et al. (2025), participants across the entire experiment displayed a slight bias to respond "no" to the initial IB noticing question. This was calculated using methods first described by Gourevitch and Galanter (1967); re-assessed by Macmillan and Creelman, 2005; and further described in Nartker et al., 2025 (including the Hautus correction of adding 0.5 to every cell in the 2x2 matrix preventing infinite values, Hautus, 1995):

"Did you notice anything besides the cross?"

	"Yes"	"No"
Present	169	561
Absent	21	163

Corrected hit rate (say "Yes" when Present) $= \frac{169 + 0.5}{(169 + 0.5) + (561 + 0.5)} = 0.23$

Corrected false alarm rate (say "Yes" when Absent) $= \frac{21 + 0.5}{(21 + 0.5) + (163 + 0.5)} = 0.12$

where criterion (c) = (-1/2) (z(H) + z(FA)). This resulted in a criterion value of 0.96, indicative of a conservative bias across total participants to respond "no" to the IB noticing question overall (95% CI = [0.29, 1.62], p = .0048).

Chapter 4: Discussion

4.1 What Does It All Mean?

4.1.1 IB Rate

To begin, one might inquire as to why the inattentional blindness rate found in the present study reached a staggering 76.9% (as compared to the 29% found in the cross-line experiments run by Nartker et al. (2025)). One probable cause could be due to the difficulty of the cross-line distinction trials. Having less of a visual angle difference between the horizontal and vertical lines (less distinction) would likely be more attentionally demanding than easier distinction trials (where it would not require "looking as hard" or "occupying as much attentional resources"). If participants were more attentionally focused on the task due to its difficult nature, this could also produce higher IB rates. Yet, for all crosses on the line-distinction trials as well as the critical trial, Nartker et al. (2025) used one 200 px line and one 140 px line (randomized for either horizontal or vertical, respectively), and though they did not report these visual angle calculations, assuming a viewing distance of 57cm would imply that this is an approximately 0.9 degree difference, the same as the second cross-line trial implemented in the present study (70px x 135 px). Given this, it is unlikely that differences in the difficulty of the cross task itself completely explain the differences in IB rates, but it is possible since the crosses in the present study got progressively harder (lessened in visual angle difference) from trials 1-4 to account for learning effects while those in Nartker et al. (2025) always composed 0.9 degree difference across trials 1-4.

So, if comparing the difficulty of the cross-line task did not explain such major differences in IB rates between Nartker et al. (2025) and the present study, what might be the culprit? One probable cause are differences in the size of the critical stimulus between Nartker et al. (2025) and the current thesis. As mentioned earlier, the critical stimulus in the present study was a small, outlined shape composing 0.6 degrees of visual angle to either the bottom-left or bottom-right of the cross. Not fully filling in the shape most likely raised IB rates (as found in Mack & Rock's 1998 experiments), and, its size (visual angle) remained on the smaller end of the range specified by Mack & Rock (1998). This range specified that any critical stimulus smaller than 0.6 degrees would likely be too difficult for attentionally distracted participants to see (ruling out IB as the cause for not noticing) and any larger than 1.0 degrees would be too easy to see, thus preventing IB altogether. Most IB studies in the literature aim for a sweet-spot, or middle-ground, in which ~50% of participants fail to notice the critical stimulus (Jensen et al., 2011; Ward & Scholl, 2014). Nartker et al. (2025) implemented a red line as the critical stimulus on either the right or left side of the screen measuring 200px long and 3px wide. Thus, the critical stimulus extended longer than one arm of the distracter cross! Once again assuming a viewing distance of 57 cm, this critical stimulus would have composed 2.9 degrees of visual angle, substantially larger than the ideal range specified by Mack & Rock (1998) that tops out at 1.0 degrees of visual angle for the critical stimulus in their original cross-line experiments. Thus, one could argue that Nartker et al. overshot this sweet-spot, using critical stimuli that were too easy to see (resulting in 71% noticing rates), while the current study undershot the sweet-spot, using stimuli that were slightly too difficult to see (resulting in 23% noticing rates). Subsequent studies could make small adjustments to the size or filling-in of the shape stimuli to better approximate this ideal range of ~50% noticing rates.

Lastly, Nartker and colleagues utilized a *line* as the critical stimulus, instead of a shape. Similarity and dissimilarity between the distracter and critical stimuli have been shown to effect IB rates. For example, in Simons & Chabris' original gorilla study (1999), participants counting passes by the players wearing black t-shirts were more likely to notice the gorilla than participants counting passes of players wearing white t-shirts, since their attended team's colors were more similar to the critical stimulus. Since then, similarity and dissimilarity effects in IB have been studied in great detail, implying that the similarity of the distractor stimuli/task to the critical stimulus really does influence rates of noticing (Most et al., 2001; Drew & Stothart, 2016; Goldstein & Beck, 2016; Ding et al., 2023). Thus, the implementation of a LINE critical stimulus in Nartker et al. (2025) while participants were attending to the cross (also lines) likely produced a similarity effect that lowered IB rates across the board.

4.1.2 Non-Noticers

While reading through the Results section, many readers may have been wondering… why so many non-significant results? Is this bad…? I thought research aimed to find SIGNIFICANT results? Counterintuitively, this thesis aimed to find exactly what the results showed: a bunch of non-significant p-values for Non-Noticers, along with Bayes Factors indicating support for the null, which is consistent with the phenomenon of inattentional blindness. In other words, if IB is in fact a real phenomenon, participants who claimed to not have noticed the critical stimulus *should* be at-chance and show zero sensitivity on follow-up discrimination tasks aimed at assessing the details of what they claimed to have not seen.

In returning to Nartker et al. (2025), they found that Non-Noticers were able to perform significantly above-chance on measures of accuracy (% correct) and likewise displayed significant sensitivity (d’) as a whole group. This also rang true when Non-Noticers were split by their confidence ratings on the IB question, with the exception of the group of Non-Noticers who selected “2 – *somewhat confident*” which was not significant. Due to these findings, it was stated that inattentionally blind participants, i.e., Non-Noticers, “can see after all” (17), and, “inattentionally blind subjects consciously perceive these [critical IB] stimuli… they show sensitivity to IB stimuli because they can see them” (16). These findings for Non-Noticers went against decades of meticulous research on the prevalence and mechanisms of IB, which if validated, could question the future path of attention and consciousness research, which is heavily reliant on IB and other paradigms similarly demonstrating the necessity of attention for awareness.

The present study, which ran nearly 1000 participants (a large sample for IB studies, and comparable to sample sizes in Nartker et al. (2025)) *did not* *encounter any above-chance accuracy or significant residual sensitivity for any Non-Noticers*. This was true for the whole Non-Noticer group before any breakdowns, as well as broken down into confidence groups (1-2, 3, 4-5), and broken down by individual confidence ratings (1, 2, 3, 4-5). This stark contrast in results between the current study and Nartker et al.'s study leads to the fundamental question of "why?": why did the present study not encounter the same findings as Nartker and colleagues?

In one view, it is possible that the experimental paradigm implemented by Nartker et al. (2025) contained some sort of flaw, resulting in such surprising findings inconsistent with the majority of literature surrounding IB. This may be due to the wording of the IB question as "unusual", causing many participants to answer "no" placing them in the Non-Noticer group, when they did in fact clearly see the critical stimulus, the red line that they may have not considered at all *unusual* in the context of the experiment. Similarly, this critical stimulus was highly salient, measuring 2.9 degrees of visual angle, immensely larger than recommendations set by the original cross-line task authors, Mack & Rock (1998), and similarly indicative of their low IB rates overall. And, once again, this critical stimulus, a line, was similar in physical quality to the cross-line distracter task, which has been shown to increase rates of noticing (Most et al., 2001; Drew & Stothart, 2016). Lastly, the confidence scale implemented in Nartker et al. (2025), which asked participants *"how confident are you in your answer?"* to the IB question and the subsequent 2AFC (for either location or color), can be seen as non-specific and somewhat vague, progressing from 0 = *not at all confident* to 3 = *highly confident*, introducing potential confusion when combined with noticing vs. not noticing. The questions "*how confident are you in your answer?*" and "*how confident are you in noticing anything else besides the cross?*" are two *slightly* different questions that could be interpreted different ways. It is possible that in combination, these factors may have set the stage for Non-Noticers' retention of visual information during IB as found in Nartker et al. (2025).

In another view, it is possible that the present experiment contained some sort of flaw, resulting in the failure to replicate findings from Nartker et al. (2025). While the present study implemented a less-biased IB question, "*did you notice anything presented on the last screen besides the cross?*" as opposed to "*did you* *notice anything unusual on the last trial*?" it is possible that the critical stimulus was just too difficult to see, as indicative of the high IB rates and low noticing rates. In the present study, the critical stimulus composed 0.6 degrees of visual angle, on the smaller end of the range specified by Mack & Rock (1998), and similarly, it was solely outlined instead of fully filled-in. Each of these factors have been shown to raise IB rates, as they make the critical stimulus less salient. Working together, it is possible that the critical stimulus was just too hard to see. Similarly suggestive of this can be seen through Noticers' less-than-perfect accuracy on the 2AFC questions for the location and shape of the critical stimulus. While Nartker and colleagues (2025) reached upwards of 100% correct on follow-up 2AFCs, in the present study, Noticers did not ever fully reach 100% correct on the 2AFC questions for location and shape, the highest accuracy reaching 88.7% correct for location (in the post-exclusion Noticers who rated their confidence as "5"). Accuracy on the 2AFCs for shape was consistently lower than accuracy on the 2AFCs for location across the board. Of particular interest, both pre-exclusion and post-exclusion "somewhat confident Noticers" (those that selected "4 – *I am somewhat confident I saw something else*") surprisingly did not display significantly above chance accuracy of the shape of the critical stimulus. The full-attention trial did help verify that the critical stimulus was easy to see with attention directed towards it (if not, IB would not be fair to attribute to Non-Noticers), yet, the full-attention noticing rate only reached 90.4% as opposed to an ideal 100%.

Lastly, through decades of research on IB, it has been demonstrated time and time again that Non-Noticers cannot perform significantly above-chance on follow-up questions regarding the nature of the critical stimulus they just reported not noticing. Nartker and colleagues' 2025 investigation did not find significant accuracy across the board for Non-Noticers, consistent with past research. Their arguments against IB were mainly grounded in findings of residual sensitivity calculated through d', a measure typically implemented in experimental procedures involving at-threshold stimuli that are fully attended to (such as a very faint noise you might hear in a hearing test). Assessing sensitivity to IB is a recently developed methodological strategy; in this sense, Nartker and colleagues can be viewed as pioneers of this process. While the first surprising study demonstrating novel results in scientific research is exciting, consistent with the philosophy of science and the scientific method, it must be replicated time, and time, and time again before any firm conclusions can be made. Thus, findings from Nartker et al. (2025) may suggest surprising new evidence of the true nature of IB, but must be able to be replicated (in various ways) before critically challenging the existence of IB. All in all, in the present study, Non-Noticers did not display above-chance accuracy for the shape or location of the critical stimulus, and, utilizing the same signal detection theory analysis as pioneered by Nartker et al. (2025), did not find any significant sensitivity towards its features. The current results are thus consistent with IB as a genuine phenomenon, and in turn, support the mainstream view that attention is necessary for conscious awareness.

4.1.3 Noticers

While Non-Noticers did not display any residual sensitivity or above-chance accuracy for identifying features of the critical stimulus, perhaps unsurprisingly, Noticers as a whole did. This is important for making sure the critical stimulus can be reported above chance when it is in fact seen (as well as the full attention condition, described below). Yet, when broken down by confidence groups (1,2,3, 4-5), while jointly confident Noticers (4-5) displayed the same significant accuracy and sensitivity for both shape and location, when split separately (4 and 5), somewhat confident Noticers (4) did display significant sensitivity for the shape of the critical stimulus, but not above-chance accuracy. Similarly, confused Noticers (1,2,3) again did not display above-chance accuracy or significant residual sensitivity for the shape of the critical stimulus. Consistent with higher accuracy and sensitivity rates for location compared to shape across all participants, the location of the critical stimulus may have been easier to get a brief glimpse of than its correct shape. While a circle and a triangle are distinct, they are plausibly more difficult to tell apart (especially when presented in the periphery, while attention is focused on a task in the center) compared to something appearing on the left vs. the right side of the screen. In other words, it is entirely possible that Noticers were aware of the location of the critical stimulus without noticing its shape.

4.1.4 IB Question Confidence Ratings and Confused Participants

Confidence ratings implemented in the present study were geared to be more intuitive and clear than those used in Nartker et al. (2025), where one somewhat unspecific scale was used (0 to 3, with 0 being "not at all confident" and 3 being "highly confident"), with no specificity on noticing vs. not noticing. The scale implemented in the present study aimed to counteract possible confusion by having a high confidence option for noticing (5) as well as a high confidence option for NOT noticing (1) and an option in the middle for unsure (3). Of particular interest in testing accuracy and residual sensitivity were confident Non-Noticers, i.e., those who responded "1" or "2" on the IB confidence question. Although this group displayed significant residual sensitivity in Nartker at al. (2025), neither accuracy nor sensitivity was significant for this group in the present study. It was predicted that sensitivity would increase as a function of participants' IB question confidence rating, which indeed was found (Figure 10). Importantly, even though d' grew with participants' confidence rating, none of the Non-Noticers' d' values were significant, while all of the Noticers' d' values were significant (as expected).

4.1.5 Confused Noticers and Non-Noticers

Somewhat peculiarly, a few participants who had just responded "yes" to seeing the critical stimulus (Noticers) then went on to rate their confidence in noticing as "1 - I am highly confident I did NOT notice anything else" on the IB confidence scale. Likewise, a few participants who had just responded "no" to seeing the critical stimulus (Non-Noticers) went on to rate their confidence in noticing as "5 – I am highly confident I DID notice something else" on the IB confidence scale. Participants with opposite, somewhat nonsensical IB confidence ratings, Noticers who selected "1" or "2" and Non-Noticers who selected "4" or "5", were named "confused". Confused Noticers did not display significant sensitivity for the shape of the critical stimulus, and while they did for location, it was *somewhat* on the border of being not significant (p = .036). One possible interpretation of these results is that confused Noticers caught a brief glimpse of something flashed in their right or left periphery, and therefore answered "yes" to the initial IB question, but when asked to rate their confidence, they changed their mind after realizing they could not confidently say much about what was actually presented besides the cross (perhaps mixed-in with a little self-doubt). The opposite effect may have occurred for confused Non-Noticers: perhaps they caught a very brief glimpse of *something* flashed on the screen, doubted their initial judgement and answered "no" on the IB question, but when asked to rate their confidence, thought again and changed their mind (though it still remains unclear why they would select "5 – highly confident in noticing" as opposed to "4 – somewhat confident in noticing" or "3 – unsure"). Also unfortunately likely, due to the nature of online data collection, it is possible that some participants were speeding through the study as fast as possible, not paying much attention to anything at all, including the carefully worded questions about what they might have noticed and how confident they were in noticing it. Yet, overall, confused Non-Noticers and confused Noticers made up a very small proportion of total participants, and, the added full attention exclusion may have helped filter out data from participants who were not fully engaged in the online study.

4.1.6 Presented Stimulus Confidence Ratings

As described, participants also rated their confidence in noticing each of four possible critical stimuli, one being the critical stimulus they were presented, and the other three acting as foils (described in 3.5 - Presented Stimulus Confidence Ratings). The distribution of Non-Noticers' confidence ratings did not change from the critical stimulus to the other three foils, consistent with them truly not noticing the critical stimulus. Noticers' distribution of confidence ratings did change between the critical stimulus and the three foils, with "5" displaying the highest frequency for the critical stimulus and "1" for the foils. Yet, "5" was not as high a percentage as may have been predicted for the critical stimulus, perhaps indicative of the slightly more difficult to see shape.

The methods employed here, i.e., the inclusion of additional opportunities for participants to express what they might have just noticed by showing visual examples, provides a means for obtaining a more accurate estimate of genuine IB rates. Because IB is a somewhat surprising phenomenon, the default starting assumption should be that participants likely noticed the fairly obvious critical stimulus, even though it was unexpected. Participants should then be given every possible opportunity to indicate what they noticed, including being shown exact replicas of what appeared on the screen during the critical trial. It is well known that recognition memory is better than free recall (Haist et al., 1992), and it is likely that participants may have been thrown off or otherwise misinterpreted the initial "did you notice anything besides the cross" question. Follow-up questions have been employed since the advent of research on IB, with the general notion that participants should be given every chance possible to report what they might have seen on the critical trial. This conservative approach considers participants as inattentionally blind only if they (1) answer "no" to the initial question, AND (2) rate their confidence in having seen the critical stimulus as low when shown a visual depiction of it, AND (3) cannot perform above chance on discrimination tests for any of the visual features of the critical stimulus, AND (4) when actively looking for the critical stimulus in a control trial can detect it and discriminate its features at levels well-above chance. The current study demonstrates (at least for the stimulus parameters used here) that all four of these criteria can be met by a substantial proportion of participants (78.0%).

4.1.7 Full Attention Condition

While the critical stimulus' properties may have heightened IB rates due to its slightly more challenging-to-notice nature, the full attention control condition (not included in Nartker et al. (2025)) validated that IB was in fact the mechanism at play since participants were able to see the critical stimulus and successfully report its features when their attention was directed towards it. In the full attention critical trial, 90.4% of participants answered "yes" to noticing the critical stimulus. The other 9.6% may have just not seen it due to other factors, or, may not have been paying attention to the online study to begin with. Total participants (without any exclusions) went on to answer the location 2AFC question with 90.3% accuracy, and the shape 2AFC question with 87.9% accuracy. Out of the total Non-Noticer group, 90.9% answered "yes" to noticing the critical stimulus in the full attention critical trial, and proceeded to answer the location 2AFC with 87.0% accuracy and the shape 2AFC with 83.2% accuracy. And, for Noticers, 89.3% answered "yes" to noticing the critical stimulus in the full attention trial, with 81.1% correct for the location full attention 2AFC and 85.2% correct for shape. Thus, the difference between noticing rates and/or accuracy rates on 2AFC tasks in the critical trial versus the full attention trial (most importantly, for Non-Noticers) was quite substantial, thereby validating that the attentional manipulation actually worked. If the critical stimulus was truly too difficult to see, IB rates in the present study may have been due to individual differences in peripheral visual acuity, where some participants may have had a hard time seeing the critical stimulus both in the actual experiment critical trial and in the full attention trial, whereas others may have been able to see it okay. Since the great majority of Non-Noticers went on to respond "yes" to noticing the critical stimulus in the full attention condition, and had high accuracy for its shape and location (interestingly, outperforming Noticers), it is safe to assume an *attentional* effect (IB) as opposed to an actual physical "blindness" effect.

4.1.8 Full Attention Exclusion

As mentioned, a re-analysis of Noticers' and Non-Noticers' accuracy and sensitivity was preregistered, this time excluding participants who failed the full attention condition. In a conservative exclusion criteria, participants "passed" if they answered all three full attention questions correctly: "yes" they noticed the critical stimulus, correctly identified its location, and correctly identified its shape (80% of total participants passed). These exclusions provide a more accurate estimate of overall IB rates, and enable a cleaner test of whether participants have sensitivity to visual information during IB.

So – what changed? First, the IB rate after excluding failed full attention participants minutely shifted to 77.2% (from 76.9% initially), not indicative of any cause for concern. The only differences for the Non-Noticers include a slightly significant NEGATIVE d’ value for the shape of the critical stimulus from highly confident Non-Noticers (1). The significant negative d’ value for highly confident Non-Noticers does not necessarily make a lot of sense, as this indicates these participants were responding significantly opposite of whatever was presented. This is likely due to pure chance, but could also be explained by a slight bias to vote one shape versus another (which was found for circle over triangle).

4.2 Limitations and Future Directions

Once again, one might argue the present study implemented critical stimuli that were too difficult to see. Evidence for this argument comes from the low rates of noticing on the critical trial and the less than perfect rates of noticing and discriminating location and shape on the full attention control trial. If this were the case, inattentional blindness could not be assumed to be the primary driving factor for participants not noticing the critical stimulus. As shown through the full attention condition, however, this argument is challenged by the high success rates of accurately reporting the visual features of the stimulus (90% correct for location, 88% correct for shape). This data confirms that when participants no longer had their attention distracted by the cross-line task, they were able to see the critical stimulus clearly, countering claims that it was too difficult to see. Nevertheless, these numbers still did not reach or approach 100% correct, as found in several other studies in the literature utilizing full attention controls (e.g., Drew et al., 2013; Kreitz et al., 2016; Wood & Simons, 2019; Calvillo & Jackson, 2013). Similarly, accuracy and sensitivity for Noticers did not quite reach levels as high as might be expected. That is to say, participants who happened to see the critical stimulus under conditions of distracted attention were still not able to report its features 100% of the time, and while their d’ values were significantly greater than zero, they did not quite reach the d' magnitudes found in Nartker et al. (2025).

In order to verify the present results and continue the investigation of utilizing d′ as a measure of residual sensitivity to features of the critical stimulus during IB, a follow-up study could increase the physical salience of the critical stimulus to make it slightly easier to see. This could include filling in the shape instead of leaving it outlined and/or increasing its size (visual angle). This would likely increase accuracy for Noticers, bringing % correct on the 2AFCs closer to 90%-100%, as well as strengthening their d′ values to those which more closely match Natker et al. (2025). Overall noticing rates on the critical trial would increase (ideally to ~50%), and performance on the full attention control trial should also increase (ideally approaching 100%). The key question would then be: do initial Non-Noticers still show chance-level performance and zero sensitivity on the 2AFC task, even with this stronger, easier to see critical stimulus? After the completion of this thesis, data from the remaining 86 participants for the present study will be gathered (those that agreed to participate but then dropped out before or during the actual experiment), bringing the total number of participants up to 1000 as preregistered. A follow-up study will also be conducted with stronger, easier-to-see critical stimuli as discussed above.

Finally, zooming back out, why does it really matter whether Nartker et al. (2025) are correct in their assessment that Non-Noticers retain visual information of stimuli they fail to report seeing? As argued in their analysis, this may be evidence that participants traditionally classified as “inattentionally blind” actually do consciously perceive the critical stimulus, and thus, IB is not as robust, reliable, or prevalent as previously thought. This would have implications for future research on consciousness and conscious awareness, as many studies rely on IB to test for differences in brain activity between perceived vs. not perceived stimuli. Outside of the lab, understanding IB and its mechanisms can give insight into preventing dangerous, harmful, or life-threatening situations before they occur. It is well known that texting while driving distracts drivers’ attention, leading to an increase in accidents and fatalities on the road, and, this understanding has led texting while driving to be banned across many U.S. states. IB can have implications for scenarios such as driving (cars, buses, bikes, even airplanes), eyewitness testimony, airport security (TSA), radiology, medical diagnoses, seismology, research, statistics, and many, many more. The twelve radiologists who failed to notice the gorilla in Drew et al. (2013) were not "unskilled" radiologists, in fact, many held top-tier positions at some of the most highly esteemed hospitals in the country, and were high-ranking members of radiology committees. While easy to laugh about, research such as Drew et al. (2013) implies the sobering, broader question of: *how much are we truly missing?* Focused attention is necessary for everyday life, and especially necessary when managing the sheer magnitude of superhuman tasks that radiologists manage to complete on a daily basis, yet, focused attention can result in the failure to notice anything else that may be unexpected. IB is prevalent everywhere, and, it is only through understanding and acknowledging it that we can work to rescue some of the information (and even lives) lost resulting from it.

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