The Role of Visual Attention in Product Selection

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Submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy of Imperial College London
(December, 2017)
THE ROLE OF VISUAL ATTENTION IN PRODUCT SELECTION

Declaration of Originality

I hereby confirm that I am the sole author of the written work and the thesis is in accordance with the standard referencing practices.
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Acknowledgements

Neil deGrasse Tyson once said that the “Universe is under no obligation to make sense to you.” I have felt the same way about research, but luckily many people have helped me make sense and complete this important stepping-stone of my academic journey.

My supervisors, Dr Mirjam Tuk and Prof Andreas Eisingerich, have provided useful support throughout the PhD program. I would like to thank Mirjam for sharing her insights on experimental design and for kindly reviewing each draft of my manuscript with precision. Her calmness has helped me, in turn, to maintain calm and shape my research to completion. I would also like to thank Andreas for his positive encouragement, helpful advice, big-picture thinking, and teaching opportunities. Without his help, I would not have gained the teaching experience that I currently hold. Dr Boris Maciejovsky also supervised me in the first year of the PhD program, and I would like to thank him for his patience.

I would like to extend my gratefulness to the PhD thesis examiners, Prof Amitav Chakravarti and Dr Omar Merlo, for their useful comments and feedback.

I am extremely grateful to Ms. Catherine Lester for her help throughout the degree and for her kindness. She has been a supportive figure for many PhD students, and without her we would have been lost.

I have been lucky to have the support and friendship of my PhD colleagues, many of whom have become very close friends of mine in the past five years. Thank you Vitali, Xuchang, Anupa, Cleo, Eva, Lien, Lin, Poly, Trent, Daniela, Davide, Mobeen, Sophia, Paula, Artemis, Hae-Kyun, Caterina, Yuting, and Tianyu. I also thank my Sussex colleagues, Madina, Natasha, and Hataya, for their wisdom and friendship. Further, I am thankful to my close friends across the pond from Toronto for supporting me in my move to London: Golbarg (for your support in research and life), Alina (for our endless conversations), Ana (for your on-call support), Laura (for your ‘no dessert for you’), Beste (for your positivity), Ali (for your rationality), and Nikan (for your deep analyses on life) – thank you for your friendship throughout the years, particularly through the last decade(s).

This PhD degree would not have been possible without my parents, whom I would like to thank for their love and support and for encouraging me to embark on a continuous pursuit of knowledge. Without your sacrifices, drive, and rooting, I would not be where I am today, nor the person I have become. Thank you, Mom, for your selflessness. Thank you, Dad, for sharing your passion for science and intellectual pursuits. Thank you, Bea, for your patience and kind support.

Finally, I would like to dedicate this thesis to one person, without whom my journey would have been far less enriching and fulfilling and whose support and encouragement helped me complete this PhD. I am eternally grateful, thank you.
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Abstract

The visual system is equipped with the ability to scan the environment for both threats and rewards. New and relevant objects draw more attention at the expense of old and irrelevant objects. Similarly, the online world barrages the consumer with pop-up advertisements (ads), some of which are more relevant than others. This research project explores why flashing ads attract attention in some, but not all, circumstances. Three main experiments, one replication, three pilot studies, and two pre-tests, were conducted. A mechanism of attention called Inhibition of Return (IOR) exemplifies how reaction time to a cue (ad) and a target (product) can be moderated by the timing between these two stimuli. In experiment 1, the spatial properties of IOR were observed, whereby participants were instructed to react to the location of a target. In experiment 2, participants were instructed to indicate the color of the target rather than its location. Both spatial and color IOR were observed. In experiment 3, participants responded to and rated unique objects. Color IOR became more prevalent because the complexity of the task increased. Overall, participants were faster to respond to the target when the cue appeared in the same location or shared the same color, but only under specific timing manipulations, which were reversible. These experiments demonstrated that visual disruptions can enhance and inhibit attention, depending on the timing of the stimuli, which can be used by website designers to optimize the timing of pop-ads.

Keywords: Attention, Advertising, Inhibition of Return, Online, Product Preferences
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Chapter 1: Introduction

In the online world, objects that glitter and flash are considered gold. On a global scale, banner ads have generated $14 billion, encompassing a fifth of the total internet advertising revenue in 2016 (Interactive Advertising Bureau, 2016). The future for banner ads is bright: their revenues have experienced a sharp upward trajectory, rising by 22% from 2015 and by nearly 50% from 2014 (Interactive Advertising Bureau, 2016). Due to this monetary success, it may seem counterintuitive that ads do not produce high click-through rates, meaning that consumers do not click on them (Ghosh & Bhatnagar, 2013). Surprisingly, for every 1000 ads, as few as two are clicked on (Manchanda, Dubé, Goh, & Chintagunta, 2006). Even worse, in terms of consumer responses, ads are not actively looked at or noticed (Bahr & Ford, 2011). While it is well established that ads inform consumers, it is not fully known why some attract attention while others are ignored. Attention, after all, is a valuable resource that commands a premium, and understanding why flashing ads do not always get noticed could potentially boost the effectiveness of advertising and help optimize a consumer’s visual search online.

Online advertisements are designed to not only attract attention but also to communicate persuasive information about a product or service, make the content memorable, and translate each exposure or set of exposures into a sale (Wakolbinger, Denk, & Oberecker, 2009). Browsing through the websites of electronic commerce companies popular throughout Europe and North America reveals that flashing ads are increasingly competing for attention. The academic literature offers a partial explanation of this mystery: attention and preferences are not fully captured by click-through rates. Consumers can form preferences towards the content of ads without needing to actively immerse themselves in them (Burke, Hornof, Nilsen, & Gorman, 2005; Janiszewski, 1988). Past theories do not provide the full picture: they focus on how to make ads noticeable, how to match the contents
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of an ad to the contents on a website, and whether exposing consumers to an ad multiple
times would increase their preferences for it. While the results obtained help inform how to
increase ad efficiency, they do not explain why only some interruptions automatically capture
users’ attention.

With the rise of the attention economy, every second consumers spend online is
precious in terms of the level of attention that they direct towards ads and the amount of
money companies invest in them. Moreover, the timing of ads is equally important, a
phenomenon that merits more investigation because a consumer can easily shift his or her
attention from one site to another. Rather than attempting to explain why revenue is not
associated with click-through rates, the current research project will focus on how ads
interrupt attention and the subsequent effects ads have on browsing and consumption
behavior in general. Visual processing at the millisecond scale will be explored in order to
understand the type of attention that does not require active engagement. It will be argued
that the difference of a fraction of a second can result in contrasting effects on attention,
enhancing attention in some cases, while inhibiting it in other cases. Attention towards a
product on a page can be enhanced or diminished, resulting in an increase or decrease in
awareness and processing, respectively, based on the presentation and timing of an ad.
Furthermore, the change in attention is hypothesized to result in a change in product
evaluation. The experiments in this project will examine the impact of interruptions on visual
attention and the subsequent effects on reaction time and preferences. The results will be used
to infer the role that ads play in shaping product evaluations. Therefore, this alternative model
is proposed to explain the ways in which online search behavior can be interrupted by ads in
unexpected ways.
On the Dot: Timing of Advertisements is Instrumental

Not surprisingly, interruptions diminish attention towards the main content of websites and their messages (Sundar & Kalyanaraman, 2004; Xia & Sudharshan, 2002). Analyses on ad location have shown that information near the same area in which an ad appears does not get fully processed (Pasqualotti & Baccino, 2014). Moreover, emergent research has shown that the timing of interruptions is crucial, as it can determine how well ads are received either as an enhancement or hindrance. Interruptions in certain situations, whether in online settings (Yaveroglu & Donthu, 2008) or otherwise (Coiera, 2012), have been used in communicating key messages online, rather than annoying or distracting consumers away from the content they are viewing.

While it is essential to understand how attention towards ads interacts with attention towards the content of webpages, the purpose of the current research is to examine how attention is allocated and processed within the first few hundred of milliseconds of ad exposure, that is, to decipher attentional processes before the actual ad content is analyzed in order to establish a baseline set of results. It currently remains unclear why interruptions are beneficial in some situations but not in others. Despite the heavy investment, the industry also does not provide clear explanations.

To illustrate the ambiguity in the literature, other studies have found that interruptions that appear early when reading a persuasive message are beneficial (Kupor & Tormala, 2015). For example, a consumer is more likely to be persuaded by the content of an ad if it interrupts him/her closer to when he/she starts reading, rather than towards the end of the reading session. However, early interruptions taking place when a consumer is shopping for a specific product are not as persuasive (Xia & Sudharshan, 2002). It has been thought that the degree of content relevance between the ad and content drives these results (Hervet, Guérard,
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Tremblay, & Chtourou, 2011; Yaveroglu & Donthu, 2008); nonetheless, the timing of interruptions has inconsistent effects on consumer behavior.

While companies are willing to spend money on ads, the academic literature suggests that they are perceived as potential disruptions. Most past studies have focused on the effects that ads have on website content but have not explored other variables, such as the speed and duration of exposure. It is imperative to look beyond matching and manipulating the content between an ad and a webpage. The current research systematically explores how the information in an ad is processed during the initial milliseconds of its presentation.

Repeat, Repeat, Repeat

Repetition in the early stages of attention is important: how frequently an ad is repeated has sizable effects on information processing (Calder & Sternthal, 1980; Janiszewski & Meyvis, 2001; Schmidt & Eisend, 2015). Repetition can be studied independently of the situational context. Traditional advertising literature shows that more attention is paid to ads that are repeated (Manchanda et al., 2006). For instance, when faced with understanding why animations attract attention, considerable evidence points to the act of repeated exposures rather than their movement per se. The repetition is thought to lead to changes in attitude toward content (Goodrich, 2011), which can help explain various conundrums. One such conundrum is the avoidance of consumers to look at advertisements while still being aware and recognizing their content. A practical explanation is that this is a result of repetition, which leads to increased awareness of content and, even more specifically, brands (Drèze & Hussherr, 2003). Repetition of ads is thus thought to be important because it is linked to purchasing behavior, despite the low click-through rates associated with them (Manchanda et al., 2006). In the current context, the repetition of objects and their features will be investigated in order to rule out other confounding effects such as priming. This experiment
will help to clarify situations in which the repetition of features enhances attention compared with situations in which repetition does not.

**From Attention to Memory and Preferences**

While repetition is important, it does not comprise the entire story: one-time exposures also have important effects. Exposure to online ads does not have to be repetitive and prolonged; exposure to and processing of a stimulus, object, or ad can occur in as quickly as 20-40 milliseconds. Paradoxically, being exposed to something, without intending to pay attention to it, can result in liking it, whether or not one is aware of this process (Drèze & Husssherr, 2003). In other words, incidental exposure not only affects how an ad is processed but also one’s memory of it (Janiszewski, 1993), which in turn leads to the forging of brand preferences. These preferences are thought to become memorable (Karremans, Stroebe, & Claus, 2006). Studies on traditional ads show that liking not only leads to recall, but it also has a role in forming positive judgements towards the ad’s content (Janiszewski, 1988; Smit, van Meurs, & Neijens, 2006).

There is a fine line, however, between investigating preferences being forged as a result of exposure or repetition and extreme states of arousal and excitability. While some studies have shown that animated ads increase arousal, this alone cannot be used to predict their success (Sundar & Kalyanaraman, 2004), as these ads tend to be ineffective in attracting attention (Robinson, Wysocka, & Hand, 2007). When ads are visually complex, or a website is already full of information, the ads may be ignored and/or disliked as a result of the clutter they create on a page (Ha & McCann, 2008). Banners also tend to slow the ability of consumers to search for information (Burke et al., 2005), which could induce a negative reaction toward them. Thus far, it seems that it is not just the effort that consumers place on ignoring ads but also that ads influence the way consumers engage with online content. Much remains to be understood in terms of the passive effects of attention. Too much engagement,
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in terms of excitably, can backfire by limiting attention (Ahn & Lee, 2012), although this is beyond the scope of the current research. Understanding models of attention can shed some light onto possible underlying mechanisms of action of attention behind brief exposures and preferences.

Modeling Attention: The Traditional Models

Gaining an in-depth understanding of the (potentially complicated) attentional processing of online ads is of key importance to both industry and academia. A need to understand how ads are engaged with in this new medium should build on past theories, but this should also break away with traditional perspectives that do not take into account the transitionary nature of online ads. Earlier work on reception to ads (The Elaboration Likelihood Model: ELM) has made several assumptions about the way traditional ads are attended to that might not be generalized to online ads (Cho, 1999; Duane, 1999; Petty & Cacioppo, 1986).

The advertising literature (through ELM models) explores how the level of interest in an ad affects the way information presented in the ad is perceived. This literature focuses on whether the recipient engages with the content directly or indirectly. This model assumes that active attention towards the ad drives its subsequent success in changing attitudes towards its content. This requires the ad to be available long enough for the consumer to view and to not appear and disappear too quickly, as active attention is assumed to be essential. Following a similar line of reasoning (the Hierarchy-of-Effects models) (Goodrich, 2011; Kuisma, Simola, Uusitalo, & Öörni, 2010), other traditional models have analyzed the level of involvement with the ad and the amount of knowledge the consumer has regarding its contents. However, these models have been debated in recent literature and have been suggested to be invalid due to the inherent assumption that attention is necessary. As it has been argued so far, active attention is not needed for the contents of an ad to be processed and
to be even liked, and the traditional line of reasoning might be insufficient to account for the quick exposure of ads online and preference formation.

Research in the last few decades has paved the way to the new understanding that attention does not need to be active (Mere Exposure effect) (Janiszewski, 1993; Smilek, Enns, Eastwood, & Merikle, 2006; Zajonc, 1968). Studies in this domain have negated the assumption that consumers need to be conscious of the information presented to them. Even seeing a product or brand accidentally in an ad can lead to a positive evaluation of it, including things that look similar (Gordon & Holyoak, 1983). Therefore, paying attention indirectly, which can occur without relying heavily on cognitive resources, has an impact on consumer preferences (Janiszewski, 1993). Affect can also be forged when information is presented in a nonconscious manner. Changing the position of information alters how it is processed and, as a result, the preferences of the viewer. This means that the placement of an ad can also change the affect towards it, depending on how attention is allocated (Janiszewski, 1988).

The Links among Attention, Attitudes, and Fluency

Past models of attention have been useful because they can help assess ads. Current models have built upon these past ones by showing that the level of attention allocated to an ad has an important role in forming both implicit and explicit attitudes (Dual Attitude Theory and Dual Processing Theory) (Barrett, Tugade, & Engle, 2004). This implies that some information is processed below conscious awareness, while other types of information can be consciously processed; both routes have an impact on attitudes, either implicitly or explicitly.

Newer models are also elucidating the role of ease of information processing. They illustrate the importance of how an ad is perceived, how well it matches the content of the website, and how quickly it can be understood. Simply, attention can manifest itself in the
form of eye movements toward an ad (motor fluency). More extensive movement of the eyes congruent with movement of the ad corresponds to an increased likelihood of a favorable evaluation of it (Shen & Rao, 2016). These types of models can be promising in explaining, for instance, why animation is bad for attention and brand recognition, regardless of whether or not a consumer looks at the animation (Kuisma et al., 2010). Animation easily disrupts the processing fluency of the ad’s contents and anything else the consumer might have been doing. This shows the importance of taking into consideration other factors such as eye movements in designing effective ads.

**Summary: Right Time, Right Place**

Advances in research have been made on why awareness of ads still occurs, despite attempts by consumers to ignore them (Drèze & Huss herr, 2003). To address this phenomenon, the cognitive psychology literature provides a good starting place to help explain the role that the timing of ads has on general information processing and to understand the role that ads play as interruptions of attention (Xia & Sudharshan, 2002). Since the timing of interruptions is essential, the purpose of this project is to demonstrate that some combinations of millisecond timing will increase attention and enhance preferences towards other objects, such as products on a webpage. It will be argued that within the span of one second, attentional processes can be both enhanced and inhibited depending on various factors.

An ad appearing in the same location as an object will elicit a different behavioral reaction to when the ad appears in a different location. Similarly, an ad with the same color as an object will elicit a different type of reaction to when it does not share the same color. Finally, the impact that interruptions have on preferences will also be explored given the degree to which attention allocated to an object can affect the preferences toward the object.
Thus, this project provides a new conceptual framework to understand why ads may be ignored or attended to in the matter of a split second and the aftereffects this may have.
Chapter 2: Literature Review

Overview

*Every one knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others.* (James, 1950)

Attention is not a new concept, but it has become a modern luxury considered too costly to be distributed recklessly. Aware of this issue, advertisers are fighting to break through the increasing clutter. They seek to inform potential consumers of their products and services through various mediums, including pop-up notifications. However, there is also an endless barrage of notifications, messages, products, and ads from competitors. If various products on a page are not well organized, they can appear cluttered. Complex displays can be difficult to process and can slow the visual system (Ha & McCann, 2008).

One type of medium competing for consumer attention manifests itself in the form of online flashing advertisements. By design, their role is to capture attention, but despite this aim, consumers often ignore them and even become irritated by them because they are perceived to be intrusive (Chang-Hoan & Hongsik John, 2004; Edwards, Li, & Lee, 2013). Unwanted interruptions can be more difficult to process, which translates into negative evaluations. However, it also turns out that exposure lasting seconds in duration can be enough for consumers to build preferences towards content, including brands (Drèze & Hussherr, 2003; Karremans et al., 2006). While most ads generate low click-through rates (Manchanda et al., 2006), from time to time, one-time exposures can have long term implications, which will be explored in this project.

Various streams in the literature have sought to explain these discrepancies and have tried to pinpoint the conditions that make consumers receptive to ads. Most of these studies
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have focused on the critical role of active attention and the presence of conscious involvement with the ad by the recipients (Cho, 1999; Janiszewski, 1993; Kuisma et al., 2010). Researchers have questioned whether a consumer reading an article will be more receptive to the content of an ad, which disrupts him or her, if it is relevant to the what he or she is reading (Pieters & Wedel, 2007). This type of work has also been extended to investigate the type of content that best attracts attention, be it through text or visual displays and combinations of colors. Recent findings, though, show that the underlying causes might be subtler than previously expected (Smit et al., 2006). Uncovering whether there is an appropriate time to introduce an ad (Xia & Sudharshan, 2002) in the first place offers a glimpse into why short-term exposure can be so consequential.

As such, the degree of exposure to an ad and level of attention towards it can have profound effects on preferences, but this process does not have to be explicit (Janiszewski, 1988). Marketers and researchers alike have recognized the importance of analyzing and systematically varying, not only the content, but also the location and type of disruption an ad causes. It has been noted that even exposure alone is not enough since ads that are perceived to add to the clutter on a site are not viewed favorably (Burke & Srull, 1988). In order to understand this, a theoretical framework needs to predict how raw components of information from ads are processed, filtered, and organized by pre-conscious attention.

A good starting point is to turn to a phenomenon identified in the cognitive psychology literature, referred to as Inhibition of Return (IOR) (Klein, 2000; Posner, 2016; Posner & Cohen, 1984; Pratt & Castel, 2001). It will be argued that IOR is an appropriate paradigm to explain why exposure to a stimulus for a few milliseconds has a profound impact on attention. More specifically, an investigation into its mechanisms of action will highlight how properties of ads have different consequences on attention, depending on how quickly and abruptly they appear. The IOR phenomenon will be used to illustrate that ads can have an
effect on attention, whether or not consumers will attempt to ignore them (Pieters & Wedel, 2007; Simola, Kuisma, Oorni, Uusitalo, & Hyona, 2011) or whether or not they interact with them. They can potentially have an effect on preferences as well.

The core of the literature on IOR has investigated how one stimulus, which appears suddenly, has an effect on another stimulus. The first abruptly appearing stimulus can be categorized as a distraction and the second as a target and these past studies have examined the role that the spatial properties of these stimuli have on one another. The purpose of the current set of three main experiments, one replication, and three pilot studies is to understand how other non-spatial features interact with the timing of these abrupt distractions; both spatial and non-spatial features will be manipulated in various combinations. Furthermore, the findings are then extended and applied to real objects, in a context that will attempt to be closer in nature to online browsing websites. However the design of the experimental context is simplified to show that the IOR effect can be observed in an online setting but at the same time to prevent the results from being confounded by an intricate website design. The novelty of the research lies in the contribution to the non-spatial features of IOR and to the understanding that disruptions online, such as ads can have unexpected consequences on attention and preferences of other stimuli on a page.

Attention: A Filtering Mechanism

To make sense of the contradictions surfacing in the advertising literature, glimpsing into the mechanisms of attention helps address whether ads have an impact on preferences (Bornstein & D'Agostino, 1992; Zajonc, 2016), even when they are ignored (Chang-Hoan & Hongsik John, 2004; Speck & Elliott, 1997). As one may fret, ignore pop-up ads, and judge them to have usefulness information (Hong, Thong, & Tam, 2004; Wang & Calder, 2006), they actually get filtered quite effectively. Whether or not we are aware of this, our brain makes sense of the world: what is at first considered to be a visual clutter of lines, shapes, and
colors becomes more meaningful after it enters the retina and becomes processed (Corbetta & Shulman, 2002; Desimone & Duncan, 1995). After a series of sequential and parallel steps, this initial uninformative clutter gains meaning almost instantaneously within the span of milliseconds. The visual system processes patterns of lines and labels them spatially; for instance, it starts distinguishing between the difference between moving objects in the sky and moving objects on the ground (Allenmark & Read, 2012). Likewise, it has a mechanism in place to detect novel changes, such as a new object appearing in a new location in the visual field. A combination of object placement and novelty will then inform the subsequent attentional processes whether to allocate more attention to new stimuli, or whether to ignore them (Corbetta & Shulman, 2002). In a similar vein, the brain of the consumer can detect the location of objects on any space, such as a screen, and underlying processes will decide whether to pay attention to changes, such as pop up ads, regardless of whether the content is relevant to the consumer or not (Toscano-Zapien, Velazquez-Lopez, & Velazquez-Martinez, 2016; Webb, Kean, & Graziano, 2016).

Despite the breadth of research in the area of visual attention, however, the mechanisms underlying visual distractions are still up for contention (Posner, 2016). It is not well understood how distractions, which by definition capture attention automatically, have an impact on subsequent processes and more complex behaviors (Lagattuta & Kramer, 2017). Although numerous studies show how attention is affected by the placement of visual information, the effect of non-spatial features like color are strife for debate (Jiang, Summerfield, & Egner, 2016; Livingstone & Hubel, 1988). Nonetheless, by understanding the role that spatial and non-spatial features play, this can be extended and applied to online browsing behavior. It can help demonstrate, for instance, how flashing advertisements disrupt browsing behavior of products. A framework to predict how consumers respond to these type of quick abrupt onsets, is not yet established. The purpose of this chapter is thus to assess the
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cognitive psychology literature and its contribution to the understanding of visual attention.
Furthermore, a second purpose is to expand and formulate a theoretical lens that will predict
purchasing behavior as a result of online advertisements. At the heart of this interaction lies
two goals, which can be at odds: browsing passively while being interrupted by abruptly
appearing ads.

Voluntary versus Involuntary Attention

The visual system parses through the environment, but the information that can be
attended, stored, and processed is limited as not all of it is equally important in keeping track
of personal goals (Moher, Lakshmanan, Egeth, & Ewen, 2014). In the morning, one might
have a primary goal of catching the right bus to work. However, attention might get diverted
between notifications popping up on one’s phone and the chaotic sounds of vehicles on the
road. It follows that getting distracted by the sound of a horn, while crossing the street, could
save one’s life, but immersing oneself in a text from a friend does not. Receiving texts may
not be part of someone’s goal to get to work in the morning, yet it proves to be dangerous
because it has the potential to attract attention involuntarily. Fundamentally, attention can be
roughly understood to belong to two main categories: voluntary and involuntary (Craighero,
Nascimben, & Fadiga, 2004).

Keeping an eye on a bus that needs to be caught means keeping track of information
that is vital to one’s goal of catching it. This is referred to as top-down or voluntary attention
(Corbetta & Shulman, 2002) since it does not get triggered automatically. What one might
notice after conducting a visual search can be determined by what one wants to find.
Automatically triggered attention is referred to as bottom-up. It refers to stimuli that attract
attention beyond one’s conscious goals. Usually, these consist of biologically relevant stimuli
(Jiang et al., 2016; Smilek et al., 2006). For instance, spiders tend to be spotted quite quickly
by most people (Tipples, 2015). Top-down and bottom-up attention are highly interconnected
since goal driven behavior influences processing of the visual field early on (Barrett et al., 2004). They can even occur in tandem as they are highly interconnected (Moher et al., 2014). Tension exists to activate goal-relevant features and inhibit non-relevant ones, while potentially inhibiting new and distracting stimuli.

**Top-Down versus Bottom-Up or a Combination of Both?**

The pendulum swinging between voluntary and involuntary attention is in place to balance information that is both important to one’s goals and also informative. This balance aids humans and animals to steer clear from aversive threats, like a quickly approaching poisonous insect, on the one hand. On the other hand, it may sustain attention on a positive (hedonic) stimuli, such as rewarding food (Mulckhuyse & Theeuwes, 2010). While a large body of literature focuses on goal and top-down attention, this research project primarily focuses on the effects of bottom-up stimuli, since ads often times are not relevant to consumers’ goals, but there is an increasing drive for them to appear spontaneously and unpredictably. Nonetheless, both types of attention are important and should be taken into consideration because goal relevant behaviors shape how bottom-up stimuli are perceived.

To apply this to a consumer setting, a parallel can be drawn to the type of goal a consumer has online. There is a difference between a consumer engaging in free browsing behavior (Simola, Kuisma, Ööri, Uusitalo, & Hyönä, 2011) while being receptive to ads, and having a specific product in mind and ignoring ads – but this does not occur in isolation. As much as one knows what one wants, a distracting ad can steal attention. More so, browsing on a small device like a mobile phone in contrast to a desktop might elicit a stronger effect on attention given that distractions can take up more space on the screen. This is an important consideration given that mobile phones for the first time in 2016 generate half of the advertising revenue, up from a negligible amount only six years prior to that (Interactive Advertising Bureau, 2016).
Whether one browses on a desktop device or a mobile phone an interplay of personal goals interact with visual distractions. It therefore makes sense not to focus on goal-oriented attention at the peril of bottom-up stimuli, and vice versa. In reality, consumers engage in both types of activities at the same time, as they search for information they sometimes pay attention to ads and sometimes they do not. The literature on advertising initially adopted a top-down attention model for understanding ads, but over time it has incorporated classic work on attention. The latter has focused on impact of conscious and nonconscious attention. This is becoming even more vital as recent research is questioning a dichotomous view on attention. It points to a continuum between voluntary and involuntary attention (Anderson, 2011; Tunnermann & Scharlau, 2016). There are indeed mechanisms of attention that fall well between these two categories as the real world requires monitoring stimuli that suddenly appear, capture bottom-up attention, and keep an eye on processing stimuli already on the page. It can also require identifying specific properties, like their location or color, thereby tapping into top-down attention as well.

A Mechanism of Attention: Inhibition of Return (IOR)

Inhibition of Return (IOR) is a basic phenomenon that depends on the millisecond timing of two stimuli (Milliken, Tipper, Houghton, & Lupiáñez, 2000; Takeda & Yagi, 2000). From an evolutionary perspective, it is thought to have served as a foraging facilitator in our ancestors and other animals (Klein & MacInnes, 2016), such as monkeys (Khan, Munoz, Takahashi, Blohm, & McPeek, 2016) and even archer fish (Gabay, Leibovich, Ben-Simon, Henik, & Segev, 2013). It is considered evolutionarily advantageous for a scavenger not to scan twice the same area for food. Also, to illustrate how it works in people, it has been applied to the famous Where’s Waldo (Where’s Wally) cartoon game, where the player has to find a character among many others in a crowded scene (Klein & MacInnes, 2016; Smith & Henderson, 2011). Such analyses elucidate how eye movements and visual attention are
drawn from already viewed scenes and redirected to new ones, and this is a reason why many people fail to find Waldo quickly, especially if he’s near a location that the viewer has already looked at. Another example is hockey players, who are subject to this phenomenon as they have to keep track of the location of the puck (Vickers et al., 2017). The previous examples assess how IOR behaves on a rich display. However, an equivalent way of measuring IOR is when two items flash near each other in quick succession.

In more concrete terms, when the timing between two stimuli is relatively short, attention to the second stimulus (the target) is enhanced. This means that the details of the target are processed faster and the reaction time to respond to it is quicker than to another target that does not appear as quickly. A reversal of the way attention is processed takes place when the timing between the two items is 350 ms or more. A longer timing intervals, from 350 ms and even beyond 1 second, attention is inhibited and reaction times are slower. The details of the target become harder to process and attention is shifted away to a different location. Applying the IOR mechanism to websites has the potential to clarify how the timing between distractions and objects online play a role on attentional processes. These processes are a combination of goal-driven attention and bottom-up distractions. IOR is thought to be independent from both voluntary and involuntary attention (Martín-Arévalo, Kingstone, & Lupiáñez, 2013), as the nature of its mechanism is subject to heavy debate (Fuchs & Ansorge, 2012). Overall, there is strong evidence in the literature that Inhibition of Return biases attention to novel stimuli/locations.

From a marketing perspective, one might be searching through many products on a website, and this mechanism filters those products that have already been seen, even if they appear in subsequent ads. The search is efficient since the previously (old) viewed areas are not attended more than necessary. Undoubtedly, this process interacts with attentional processes dealing with disruptions (bottom-up) and with specific internal top-down goals.
Traditionally, this mechanism has been applied to two main types of scenarios 1) static scenes, such as the previously mentioned Where’s Waldo example, where locations near the start of the searching processes are ignored, and 2) dynamic scenes where two stimuli flash quickly in succession, in the same location or in a different location from each other.

Alongside a theoretical expansion, the second scenario could build a foundation for some types of consumer behavior online, by also using real-life objects and website-like contexts. For instance, the mechanism can be useful to observe how attention gets diverted from one area to another on the screen as a result of abruptly appearing ads. Often times, when browsing through the most widely used shopping websites, ads appear shifting from one side to another or prices flash beside products. An ad that appears and disappears in the same area that a consumer is viewing a product could result in two scenarios. In one scenario attention is diverted away to another area on the screen and in the second scenario, attention is maintained on the product.

**IOR: The Mechanics**

In the past three decades the cognitive psychology literature has discussed potential mechanisms of action for Inhibition of Return and its role in visual searches. The importance of Inhibition of Return, a robust phenomenon, has solidified in series of experiments since the 1980s (Posner & Cohen, 1984; Rafal, Calabresi, Brennan, & Sciolto, 1989). It was observed when participants had to react to a stimulus after the appearance of another brief and abrupt stimulus. What is of great theoretical and practical interest is the relative timing between two stimuli, which can result in different effects on behavior: either decreasing reaction times (RTs) to the second stimulus, or increasing it. Reaction times are a good indicator of processing, whereby quick reaction times indicate faster processing. Equally interesting, all of this happens within the span of milliseconds. In these classic experiments, the first stimulus, otherwise known as a cue (conceptually similar to a distractor), appears either to the
left or right hand side of a central point which participants have to fixate on; in other words it appeared in the periphery, not in the center. The second stimulus, otherwise known as a target, appears in the same or the opposite location, also in the periphery. These stimuli were shown originally in the periphery but some studies since then placed them in the center (Lupianez, Klein, & Bartolomeo, 2006); however, centrally appearing stimuli tap into less automatic and more conscious attention. In the current research they appeared in the periphery.

To reiterate, the abrupt appearance of a cue, the first stimulus, automatically draws attention to its location (Posner & Cohen, 1984). As a result, participants are quicker to respond when the target, the second stimulus, quickly appears after it, within 100 to 300 ms. The relatively short time difference between the two stimuli and the relatively faster reaction times are understood to enhance attention; this type of event is referred to as facilitation in the literature as attention is believed to be facilitated towards the second stimulus. However, when the timing between the cue and target rises to 300 ms and beyond, up to even a few seconds time difference, inhibition takes place. Attention is no longer engaged and reaction times slow down when responding to the target when it is in the same location as the cue, as compared to the opposite direction. The way stimuli are represented in the visual system is thought to be partly responsible for whether they seem to merge and cause facilitation or whether they seem to be distinct and cause inhibition (Tunnermann & Scharlau, 2016). Moreover, this inhibition effect trails off when the cue and target are not exactly in the same location (Schut, Fabius, & Van der Stigchel, 2016), with research showing that the IOR effect reduces in a gradient-like manner as the distance between stimuli increases (Bennett & Pratt, 2001; Klein, Christie, & Morris, 2005).

A real-world parallel can be drawn to situations where LED notification lights on mobile phones flash twice in succession. If two lights flash quickly enough one’s attention
will be automatically diverted towards the phone and its screen, but if the time between the two lights flashing is slightly delayed, attention will be slowed down and inhibited away from the phone. Another example would be monitoring car movement in the periphery of one’s vision while driving. A possible “blind spot” could be when two cars move in the same area of the rear mirror. Drawing a parallel to online advertising, unintended consequences include seeing an ad and diverting one’s attention away from it when the timing between the ad and the subsequent product a consumer is looking at is relatively delayed.

As the classical studies have sought ways to optimize the conditions necessary for IOR to occur, subsequent ones explored explanations for it and its effects. For instance, to answer whether information processing is disrupted by IOR, evidence shows that it has an effect on time perception. There is a reduced perception of time during the inhibition stage (Osugi, Takeda, & Murakami, 2016). When a participant is asked to judge a time interval when inhibition occurs, a shorter estimate will be reported. In other words, while reaction times increase, the perception of time duration decreases, and accuracy goes down. Given time judgement changes, and that the time course for facilitation and inhibition occurs in less than one second, other emerging questions include whether IOR requires awareness and whether it relies on eye movements at all?

To answer the first part of the question, the answer is not necessarily. While attention and awareness can be mutually exclusive (Hsieh, Colas, & Kanwisher, 2011), inhibition of return does rely on the cue reaching some level of awareness, even though it appears quickly (Webb et al., 2016). Without awareness, its magnitude, the size of the IOR effect, decreases almost completely. This means that cues appearing for less than 50 ms are processed below conscious awareness and do not capture attention well enough. Furthermore, attentional mechanisms can take place within the span of a few hundred milliseconds; indeed attention can be measured by how quickly a response is executed towards a stimulus (Toscano-Zapien
et al., 2016). With respect to the second part of the question regarding measuring IOR based on eye movements, the answer is also not necessarily. Attention can be measured by subtle eye movements and visual trajectories (Toscano-Zapien et al., 2016). IOR can also be measured by the direction of eye movements but it can occur without them (Schut et al., 2016), and vice versa as eye movements are not affected by IOR. Hence, IOR is to some extent conscious and can be measured by response times and does not need eye tracking. The relationship between the timing of the cue and target also means that it can be studied and applied in various conditions.

So far the effects of IOR have been discussed in simple settings with few modifications to the original Posner cueing paradigm. Some have expanded on the research by exploring when this phenomenon starts solidifying in terms of age development. This type of information can offer clues into its mechanism of action. In fact, the inhibition aspect of IOR develops sometime around four months of age (Markant & Amso, 2016). In infants it can even direct attention towards pictures and can be involved with learning as well. Once IOR matures, it remains steady throughout the years but in the elderly, who are over 85 years of age, the timing between the cue and target needs to be increased for the inhibition aspect to work (Muinos, Palmero, & Ballesteros, 2016). The delay could be caused by issues with removing attention from the cue, or from a general slow-down of the processing speed. Finally, in children with ADHD, the trajectory also starts more slowly and there are more error rates (Li, Chang, & Lin, 2003), while ADHD enhancing drugs such as d-amphetamine make it more efficient (Fillmore, Rush, & Abroms, 2005). This strengthens the argument for the role of attention in IOR.

**From Detection to Discrimination: Two Types of IOR Tasks**

Probing further into IOR’s effects and mechanisms of action, research has identified two main types of tasks that can be used to study this phenomenon (Taylor & Donnelly,
These two types of tasks show that the way participants receive instructions has notable effects on the course of IOR (Smilek et al., 2006). As the complexity of a task increases, the IOR effect becomes relatively delayed and its size decreases. I.e., the inhibition aspect manifests itself at a longer time delay and the difference between the timing of the stimuli diminishes (Lupiáñez, Milán, Tornay, Madrid, & Tudela, 1997). One of these tasks is referred to as a detection task because participants have to “detect” when a target appears. This instruction is usually completed by hitting the space bar, or another key, to indicate the appearance of the target. The other type of task is referred to as a discrimination task because participants have to “discriminate” a feature of the target (Lupiáñez et al., 1997). For example, when the target is red, the participant can hit one designated key and when the target is blue, another key. In this type of task, the target can come in one of two colors and the participant is required to distinguish between these two colors. This clearly goes beyond merely indicating when the target has appeared.

The relationship that dictates how the two stimuli interact is further broken down into different paradigms (Taylor & Donnelly, 2002). There are four main types (see Table 1) that can be combined with three different types of instructions (see Table 2). When the first stimulus is designed to be visually different from the second stimulus, this implies a classical relationship between the two – normally referred to as the Cue-Target paradigm. Given that the first sets of experiments utilized an abruptly appearing stimulus as a cue, this paradigm applies a flashing, or increasingly bright, outline of a box or other shape. The cue will appear and disappear very quickly, but so quick that it will escape conscious awareness. Participants are then required to respond to the target. Two other types of paradigms are very similar to each other: these paradigms require participants to respond to more than one stimulus in one trial. The stimuli are not distinguishable from one another: they can both be two red circles, for instance. One is referred to as a Continuous-Responding paradigm and the other is a
Target-Target paradigm. The Continuous-Responding takes its name from the idea that participants need to respond to both stimuli, not just the second one. Essentially, each stimulus serves as a cue in one trial and as a target in the next. The Target-Target paradigm refers to two targets appearing in one trial and participants need to respond to both. The fourth paradigm, the No-Response-Target is similar to the classical Cue-Target one, with the exception of the appearance of the cue and target, which are identical to each other.

Having to either identify the appearance of a target (detection task), such as pressing the spacebar when it appears, or to specify a specific feature of a target (discrimination task), such as identifying whether it is red or green, leads to three types of choices. These are instructions that participants are asked to follow: localisation, occurrence, and object related ones (Taylor & Donnelly, 2002). For instance, localisation in the detection task requires participants to indicate the appearance of a target based on its location, regardless of where it occurs. Its specific features do not matter. In the discrimination task, localisation would mean that participants have to indicate whether a target, for instance, has appeared on the left or right hand side by clicking on the appropriate key button. It does not require indicating when a target appears, but what features it has. In terms of occurrence, participants have to indicate some combination of features, such as the presence of a red circle. The instructions are important to observe the IOR effect since, for instance, the results are limited for object based occurrences.

Table 1

<table>
<thead>
<tr>
<th>Paradigm Task (Cue-Target Relationship)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cue-Target</strong></td>
<td>Physically distinct</td>
</tr>
<tr>
<td></td>
<td>Respond only to target</td>
</tr>
<tr>
<td><strong>Continuous-Responding</strong></td>
<td>Responding to both stimuli</td>
</tr>
<tr>
<td><strong>Target-Target</strong></td>
<td>Two targets in one trial</td>
</tr>
<tr>
<td></td>
<td>Respond to both stimuli</td>
</tr>
<tr>
<td><strong>No-Response-Target</strong></td>
<td>Responding to second stimulus</td>
</tr>
<tr>
<td></td>
<td>Stimuli not physically distinct from each other</td>
</tr>
</tbody>
</table>
From Detection to Discrimination: Two Types of IOR Tasks

It is important to distinguish between the different types of paradigms and types of instructions. Doing so is relevant from both a methodological and theoretical perspective. First of all, the Cue-Target paradigm is methodologically robust. The IOR phenomenon relies on a sudden onset, where attention is captured by the first stimulus, but if this does not take place, inhibition cannot occur (Gawryszewski, Thomaz, Machado-Pinheiro, & Sant'Anna, 1994; Gawryszewski, Thomaz, Machado-Pinheiro, & Carreiro, 1994). Timing differences between the two stimuli do not have a subsequent effect. For this reason, some studies have not found evidence for IOR, given that the other paradigms were used. This is theoretically important because it will be used to argue that some types of IOR can indeed be observed with the right paradigm.

Second of all, in terms of type, there is also good reasoning behind favoring one type of instruction over another. Detection studies generally produce stronger magnitudes and longer-lasting effects of IOR (Martín-Arévalo et al., 2013). Simply detecting the appearance of a stimulus, like a red circle, rather than distinguishing a feature, is characteristic of this type of task. Normally, detection is used alongside localization, which means that when the
two stimuli appear in the same location, a key should be pressed to indicate this. Consistent results are borne out of this task. However, the results for discrimination tasks are not as predictable (Silvert & Funes, 2016; Taylor & Therrien, 2008). Discrimination requires more effort, attention, and even coordination to be able to distinguish between different dimensions of features. Nonetheless, the observed discrepancies in discrimination studies can be explained by the type of paradigm used. For example, Cue-Target paradigms are robust in both detection and discrimination studies. Studies which use Continuous-Responding have not produced reliable results. Since discrimination studies are not limited to spatial features, this could explain why discrimination of non-spatial features is not always successful.

Extending beyond the discussion of spatial (location-based) and non-spatial features, Taylor and Donnelly (2002) have discussed the role that IOR has on attention to objects. An object is defined as containing two or more features, like being both round and red. Successfully observing the IOR effect when discriminating a feature, like color, in one object has been inconclusive and this is why the type of paradigm and instruction is essential in observing the IOR effect. Deviating from the traditional Cue-Target paradigm is a reasonable explanation. This could explain why inhibition is not observed when participants respond to both the cue and target. Repetition of the same manual response to both stimuli can explain why facilitation is observed instead. Likewise, when the cue and target share many features in common, such as the same shape and the same color, a similar result will ensue. IOR takes place when one of the features between the cue and target is not duplicated. For instance, when the feature red repeats between the two stimuli, but the cue is star-shaped and the target is square-shaped. Surprisingly, this has not always been taken into consideration (Fox & de Fockert, 2001; Taylor & Klein, 1998).
Attention, Perception, or Motoric Processes?

Another feature that can be repeated between the cue and the stimulus is the motor response of the participant. By responding to both stimuli, facilitation is observed for objects where inhibition normally would be taking place. These type of results question whether IOR is a purely attentional process or not since it has been speculated that slowed reaction times indicate slowed motor movements (Tanaka & Shimojo, 1996; Zhou, 2008). When the eyes move, a motor element does get activated, the IOR effect requires a relatively longer timing difference to be observed, and there is a general improvement in the error rates of participants (Redden, Hilchey, & Klein, 2016). However, when participants do not move their eyes, attentional process are thought to be at play. The focus of the current experiments, presented in the methodology section, will aim to reduce/eliminate the motor aspect of IOR. Overall, reducing eye movements by asking participants to fixate on the center of the canvas has an effect on the attentional processing of stimuli, while encouraging eye movement taps into motor elements and produces a potential confound (Redden et al., 2016).

Beyond Location: Understanding Color IOR

As early work on IOR focused on its spatial properties, some research streams investigated whether non-spatial features, such as shape and color, produce the same pattern of results that location IOR does (Duncan, 1984). This meant not just investigating how the relative timing between a cue and a stimulus produce inhibition when they both occupy the same space. Instead, the purpose was to examine whether, for instance, a red cue and a red object produce inhibition at relatively long time intervals, independently of where the cue and object are located (Fox & de Fockert, 2001; Hu, Samuel, & Chan, 2011; Kwak & Egeth, 1992; Law, Pratt, & Abrams, 1995).

Location IOR relates to spatial properties. Location IOR tasks require participants to indicate the location of the target after the cue appears. The spatial properties of the two
stimuli either match or do not match, such that when they do this is referred to as same location condition and when they do not, different location condition. Color IOR, is similar in nature, but it relates to non-spatial properties. Such tasks require participants to indicate the color of the target and their reaction times are measured. When the cue and target do match this is referred to as same color condition and when they do not, as different color condition. Reaction times should be quicker when the timing is relatively quick and the stimuli match in color and slower when they do not match. When the timing is relatively slower the reverse should be observed. In theory, this pattern and trajectory for non-spatial IOR should be observed whether or not the location of the stimuli matches or not. The presence of color IOR would add to the effect that a disruption has on attention. It is significant if color IOR exists, then not only would the location of the disruption be important, but also its color and whether this color matches the object that a consumer is looking at.

On the issue of whether non-spatial properties follow a similar IOR trajectory to spatial properties, the literature has been inconclusive so far. Much debate stems from whether color IOR exists independently of location IOR (Tanaka & Shimojo, 1996). (Kwak & Egeth, 1992; Tanaka & Shimojo, 1996). A lack of color IOR observations (Tanaka & Shimojo, 1996) has led some to conclude that it does not have the same underlying mechanisms as location IOR does, which is more automatic in nature (Kwak & Egeth, 1992). At best, the literature shows that while there is ample support for location IOR, color IOR might exist when the cue and target appear in the same location.

When color IOR has been observed, and the two stimuli share the same location, its magnitude, however, was small. Magnitude, which reflects the size of inhibition, is calculated by taking the average response times to the same location and subtracting this from the average response times to the different location. This number represents the delayed reaction when the timing between the cue and target are long enough. While most IOR magnitude
sizes are around 20-30 ms, and even 50-60 ms in size, the observed color IOR are around 5 ms to 10 ms (Fox & de Fockert, 2001; Hu & Samuel, 2011; Kwak & Egeth, 1992; Law et al., 1995; Pratt & Castel, 2001; Taylor & Klein, 1998). Color IOR is non-existent when the cue and target do not share the same location. The lack of color IOR at nonmatching locations and its small magnitude were used as arguments that color, and other non-spatial features, cannot exist alone, but in conjunction with location. Expanding this further, it was believed that spatial properties drive the facilitation or inhibition of color.

**Color IOR: The Mechanics**

Clearly location IOR studies produce robust results; but, on closer inspection of the literature, subtle differences in methodology emerge. These differences could help explain why color IOR studies are inconclusive. Kwak and Egeth (1992) conducted a study which did not yield evidence for color IOR. As previously noted, the higher the difference in similarity between the cue and target, the stronger the IOR effect tends to be. The Cue-Target paradigm is thus the most robust one and the experimental setup that the authors have adopted deviates from it. The issue was that the first stimulus served two roles; in the first task participants were not supposed to respond to it (i.e. it served as the cue), in the next task it served as the stimulus that they were supposed to respond to (i.e. the target). This was a Target-Target paradigm because of the dual role that the stimulus served, which as a result, poses confounding effects. These effects are due to the similarity between stimuli and can be attributed to repeating the same response to the cue, which turns into the target.

A problematic experimental setup is also one which deviates from using one cue and one target. Multiple cues in one trial have been used in IOR studies (Birmingham & Pratt, 2005), but this measures how strong the IOR effect is in different spatial locations. Deviating from the classical one-cue and one-target paradigm is not advisable as the role that color plays still needs to be understood. Likewise, it is not yet clear what role multiple targets play
when it comes to non-spatial IOR. For instance, a study conducted by Gibson and Amelio (2000) utilized for targets, three of which also changed in a different color from the target. When the red target appeared the three other targets changed in color between white and grey. Participants were asked to respond when the target letter and the cue shared the same color, but given that multiple targets appeared, this could have confounded the results.

Successful attempts by Law et al. (1995) were due to using the traditional paradigm with colors. They found a small color IOR effect of 5.5 ms, but only when the cue and target shared the same location and not when these were in different locations. In fact, the stimuli were not shown in the periphery, but rather in the central fixation point, which shows the flexibility of the effect. Furthermore, the methodology employed a neutral cue, which appeared after the cue, but before the target; this was thought to be necessary in order to observe IOR. It was reasoned that the neutral cue helps to disengage attention from the first stimulus and to shift focus to the second (Pratt & Fischer, 2002; Pratt, O'Donnell, & Morgan, 2000). Location IOR did not require such an intervention as it does not depend on a neutral cue. Nonetheless, other researchers such as Fox and de Fockert (2001) paved the way by showing that a neutral cue is unnecessary for non-spatial IOR; they placed the cues and targets in the periphery rather than at the fixation point. A noteworthy change and reason for adopting the classical paradigm until more progress is made.

In addition, Riggio, Patteri, and Umiltà (2004) lessened some of the discord in the literature related to whether non-spatial IOR is unlike spatial IOR and whether any of the effects observed are a result of a different mechanism altogether, such as repetition blindness (Taylor & Klein, 1998). Repetition blindness takes place when two stimuli quickly succeed one another and the second stimulus is not processed or recognized. It is akin to an attentional blind spot. Riggio et al. (2004) addressed speculations (Taylor & Klein, 1998) that the short trajectory of color IOR must be due to repetition blindness. They concluded that nonspatial
IOR exists at the same location, as the previous (but limited) studies on color IOR have shown. This finding is significant because the mechanism of action of nonspatial IOR does not have to be dramatically different than spatial IOR. The authors also dispelled the argument that color IOR occurs where facilitation should normally be expected and that the lack of observed facilitation is problematic. However, a shorter trajectory was not due to repetition blindness and inhibition of return does not need facilitation, a finding which has been noted by others as well (Gawryszewski, Thomaz, Machado-Pinheiro, & Sant'Anna, 1994; Maruff, 1999).

Also arguing against repetition blindness and for an independent mechanism for nonspatial IOR (such as shape and color), Hu et al. (2011) were also the first to show that the effect of color can be a relatively large one. They used a different, more complex type of setup: the Samuel Paradigm (Samuel & Kat, 2003; Samuel & Weiner, 2001). Its importance lies in the arrangement of multiple pairs of boxes, set in a circular manner around a fixation point. These are believed to confer an advantage by reducing location IOR effects. Due to the design’s symmetrical nature, the additive and subtractive effects of facilitation and inhibition cancel each other out because they are equally distributed across the circular setup. The effect of location in the complex paradigm was reduced to show that a sizable color IOR effect exists, albeit showing up later than expected (Hu, Zhan, Li, He, & Samuel, 2014). Despite minimizing the influence and mechanisms of location, their color IOR observations were limited to instances when the cue and target shared the same location (Hu, Fan, Samuel, & He, 2013). It is important to note that these results applied to detection tasks, rather than discrimination tasks and that the stimuli were not distinct from each other.

“Seeing Red”: From Color to Emotions

Moving beyond color, researchers have explored how IOR affects personality traits, goals, and emotions. Interesting findings include a link between openness to experience
causing a broader distribution of IOR trajectory (Wilson, Lowe, Ruppel, Pratt, & Ferber, 2016) and action-orientation resulting in faster IOR developments, as a result of better inhibition and filtering abilities (Pinnow, Laskowski, Wascher, & Schulz, 2015). Stress, however, does not seem to play a role in its manifestation (Larra, Pramme, Schachinger, & Frings, 2016). Other studies focus on how IOR interacts with mental health conditions, like anxiety, phobias, and schizophrenia (Abbott et al., 2012; Berdica, Gerdes, & Alpers, 2013; Berdica, Gerdes, Pittig, & Alpers, 2014; Bustillo, Gold, Thaker, & Buchanan, 1997; Perez-Duenas, Acosta, & Lupianez, 2009). In one form or another, these types of studies have touched upon a domain deserving further consideration: namely, the effect of emotional stimuli on the course of IOR.

Work on the emotional, non-spatial, properties of stimuli takes into consideration how emotions interact with IOR: what was considered a seemingly automatic mechanism of attention; more and more hints now emerge uncovering its flexible nature. Emotional stimuli include faces, scary images, pleasant images and any stimuli that are not neutral. Emotional stimuli also behave like non-spatial ones with respect to the IOR magnitude and trajectories and color IOR and emotional stimuli go hand-in-hand because they relate to non-spatial features. It also turns out that the nature of a task and the instructions can change the magnitude and trajectory of IOR for emotionally-rich stimuli (Birmingham & Pratt, 2005). It makes a difference when participants are asked to respond to an emotionally rich target, but report its spatial location than when participants are asked to report an emotionally-relevant dimension (Silvert & Funes, 2016). Reporting spatial properties like location does not interfere with the processing of emotional stimuli, but reporting relevant properties like indicating the emotional expression on a face, or even its gender does. Given that the online world of products and ads has emotionally laden images, one might suspect that the timing of
THE ROLE OF VISUAL ATTENTION IN PRODUCT SELECTION

an interruption would play a role in this context. For instance, it make senses that looking at an emotionally rich product would prevent attention from being interrupted by an ad.

It was initially speculated that highly charged emotional stimuli should eliminate the manifestation of IOR, the reason being that emotional stimuli attract attention. This means that attention remains on a stimulus and does not move away, thereby preventing inhibition from taking place. In other words, emotional stimuli prevent the disengagement of attention. For instance, warning signals were shown to eliminate the IOR effect (Shang, Huang, & Ma, 2015) and so did fearful faces since they fully capture attention (Poliakoff et al., 2016). Also, when words are negative in nature, the IOR effect seemed to diminish (Bertels, Kolinsky, Bernaerts, & Morais, 2011). However, subsequent research demonstrated that inhibition does take place, although it is delayed (Hudson & Skarratt, 2016; Jingling, Lin, Tsai, & Lin, 2015). When emotions are associated with social symbols, like faces and gazes, these can still elicit an independent mechanism of action, separate from that of location IOR. To illustrate this, Taylor and Therrien (2008) compared face to non-face stimuli, but to avoid confounding effects the non-face stimuli were faces, but with the features, such as the mouth, nose, and eyes scrambled randomly. In their discrimination task they found that the IOR for face stimuli had a different trajectory than that of “scrambled” non-face stimuli; the magnitude was also larger. When the task was a detection one, similar IOR effects were observed for both types of stimuli. Further evidence of the independent existence of classic IOR comes from individuals with deficiencies in recognizing social cues; for instance people with autistic spectrum disorders do not show a strong IOR effect for upright faces (Zalla, Fernandez, Pieron, Seassau, & Leboyer, 2016).

All of the work mentioned so far on emotional stimuli has been linked to targets. There has been some work on making cues emotionally-rich and whether these would interact with the IOR mechanism or whether IOR would be nonexistent. When attempts have
been made to change the nature of cues, either by using emotional stimuli or words that attract attention, they have been made to no avail. For instance, neither emotional content (Stoyanova, Pratt, & Anderson, 2007), nor hazardous words (Shang et al., 2015), nor food serving as cues (Lyu, Zheng, & Jackson, 2016) elicit IOR. Since the IOR mechanism requires cues to attract attention, it would make sense that emotional content cannot work well with cues (Lange, Heuer, Reinecke, Becker, & Rinck, 2008). At best, cues can divert attention on a symbolic basis, in addition to on a location basis. Cues can be used as numbers, where a lower number indicates the left hand side, and a larger number indicates the right hand side (Hoffmann, Goffaux, Schuller, & Schiltz, 2016). However, since the duration of a cue tends to be short, emotional processing would not have enough time to occur.

So far, studies have explored the role that cues and targets play on changing the trajectory and size of IOR. Emotionally rich targets can modulate the effects of IOR, while cues do not. It has been demonstrated that the instructions of the IOR task are crucial: when participants are required to focus on spatial properties, like responding to whether the target is on the left or right side, emotional targets do not alter the IOR trajectory. Emotional targets do alter the trajectory when the instructions are task-relevant and require participants to focus on emotional features of the targets, like indicating whether a face is angry. While the effect that targets have on IOR trajectories is being explored, the reverse is not. No research to date has investigated the degree to which targets are affected by the IOR mechanism and whether targets are perceived differently as a result. In order words, since inhibition leads to a deficit in processing information, would this phenomenon interfere with the emotional valence of targets? To the best of one’s knowledge the change in preferences for a stimulus has not yet been explored. Doing so would increase the ecological validity and relevance to consumers. If ads interrupt browsing behavior, would the evaluation or preference for a product on the screen be affected by their timing?
From IOR Mechanics to Theories

Various hypotheses have been postulated to explain and predict the underlying mechanisms of IOR, including the Detection Cost Hypothesis, Three-Component Model, and Habituation Hypothesis. Proponents of classic theories argued that attention needs to be first captured for facilitation to take place and, second, withdrawn for inhibition to take place (Klein, 2000); but, this pattern of attentional enhancement followed by attentional attenuation is currently refuted (Lupianez, Martin-Arevalo, & Chica, 2013). Recent work shows that the IOR trajectory, especially for discrimination tasks, is not contingent upon facilitation. For instance, Hu and Samuel (2011) have only found inhibition, rather than facilitation, and do not think that this is problematic.

Others also argue that classical explanations cannot account for the variety of differences in results across studies (Silvert & Funes, 2016). Adding to these, the Detection Cost Hypothesis has been proposed as a viable mechanism (Martín-Arévalo et al., 2013). The premise of this hypothesis is that keeping track of, and detecting, new information is costly. The rationale is that a new stimulus gets detected, but it no longer attracts attention if it does not move or pose a threat. For the visual system to process all stimuli with fine-detail would be costly and inefficient. A bias against old information and in favor of new information therefore takes shape. This hypothesis has been useful in explaining why it is better to have one cue and one target: too many cues can decrease processing of information (Snyder & Kingstone, 2000). Therefore, for color IOR studies this may be problematic since not enough is known.

Building on the Detection Cost Hypothesis, two competing models draw considerable attention, one is called the Three-Component Model (Lupianez, Milliken, Solano, Weaver, & Tipper, 2001) and the other one is the Habituation Hypothesis (Dukewich, Lawrence, & Klein, 2010). One component of the Three-Component Model states that there is a detection
cost associated with processing already seen stimuli. This accounts for the inhibition of attention because stimuli that have already been seen are “costly” to one’s attentional resources, which is similar to the reasoning behind the Detection Cost Hypothesis. However, the Three-Component Model builds further by suggesting that the other two components account for the facilitation of attention; when cues and targets occur in the same space closely in time they become integrated as one object. As such at shorter time intervals, the strength of the cue and target integrating is stronger and attention towards the target is facilitated.

This theory has been criticized for not predicting what happens in the different location, when the target does not share the same space as the cue. Rather it focuses on the cue and target sharing the same location (Klein, Wang, Dukewich, He, & Hu, 2015). Furthermore, the Three-Component Model does not explain why IOR occurs at a relatively longer time delay between the cue and target in discrimination studies and why its magnitude is weaker for such tasks. Others (Silvert & Funes, 2016) have pointed out that IOR, for stimuli with faces, and in discrimination tasks, is strongest at relatively short-time intervals and its strength reduces in size for longer time intervals. In contrast, IOR for neutral faces, in detection tasks, does not follow this trajectory. A large premise of this hypothesis is that it can explain the patterns observed in detection tasks, but not for discrimination tasks. Finally, not all studies have observed facilitation at the shorter SOAs, but only inhibition at relatively longer ones, which is problematic for one of the components of the model, accounting for facilitation of attention.

The Habituation Hypothesis offers a parsimonious explanation in that neuronal firing increases when the cue and target are presented close together in time: there is an enhanced reaction. Time-wise, when the cue and target occur far apart, neutral firing decreases. The response habituates, therefore weakens. Attention is not required to first be held and then withdrawn in a series of sequences; this does not need to be part of the explanation. Evidence
in favor of the Habituation Hypothesis also comes from studies showing that cues have a significant role in helping to drive facilitation (Tunnermann & Scharlau, 2016), despite not being amenable to emotional rich content. This argument falls in line with the Habituation Hypothesis, which posits that the cue and target overlap and merge together to some extent.

The Habituation Hypothesis also states that task instructions are important. Asking participants to respond to targets which share features with cues, does make a difference (Klein et al., 2015). In other words, reaction times are affected by task requirements. This is significant because proponents of the Habituation Hypothesis argue that IOR can occur in discrimination tasks, whereby proponents of the Three-Component Model, believe it is limited to detection tasks. Hu et al. (2011) have conducted detection studies showing that a small color IOR magnitude occurs at 700 ms SOA, but only for the cued location, and Hu and Samuel (2011) did not find color IOR in a discrimination task. This was taken as evidence of a lack of IOR in discrimination studies. However, Klein et al. (2015) have addressed this issue by replicating the results obtained by Hu et al. (2011) and Hu and Samuel (2011), but by subtly changing the configuration of the targets to demonstrate that discrimination tasks can produce IOR as well. The original confirmation included the same shapes for the cues and targets, but Klein et al. (2015) used circles as cues and star-shapes as targets. Participants were still required to indicate the color, but the cue and target did not share all of the same features. Klein et al. (2015) argued that the cue should be distinct from the target, thus it should not share a feature that is essential for responding to the target.

Recall that for discrimination tasks, facilitation is observed, rather than inhibition when too many features are the same. Some clues to explain these discrepancies can be found in a series of experiments conducted by Taylor and Donnelly (2002) investigating the effect of IOR on objects. They showed that repeating the same features from the cue to the target can result in facilitation, rather than inhibition, whereas repeating one out of two dimensions
results in inhibition. While seemingly counterintuitive, when a cue and target, for example, are both round and red, and the participant has to identify the color, facilitation will be observed in addition to a decrease in response times. However, when the participant has to identify the color – the cue is a square and the target is a circle, and they share the same color – inhibition will be observed. These nuances show that objects, which consist of multiple features, might behave differently than single features.

Interestingly, working memory is thought to keep track of these stimuli that produce facilitation, where inhibition would be expected for objects (Taylor & Donnelly, 2002). The mental representation of a red circle is kept in working memory and when it is repeated again, it results in facilitation. This suggests that not only can location IOR be kept in working memory, but so can other non-spatial features. Since IOR is a combination of both bottom-up and top-down mechanisms, it is not surprising that it has a memory component as well. For instance, one should remember if something dangerous has appeared or there is an impending threat. However, too many stimuli in working memory can be detrimental, so a filtering mechanism is in place to process these, which compete with each other (Duncan & Humphreys, 1989; Xu & Yue, 2014). Moreover, stimuli which are inhibited are also less likely to be remembered (Markant & Amso, 2016).

Short-term of memory also plays a role in eye movements. Whatever information is processed during the split-second micro-movements can be stored in short-term memory (Schut et al., 2016). When attention is enhanced towards a target, short-term memory can also be enhanced. Conversely, IOR leads to diminished information processing, fewer eye movements, less accuracy, and decreased short-term memory. What is noteworthy and in line with previous suggestions, is that these effects apply to the inhibited location: they do not spread away to nearby areas. Other studies confirming a reduction of accuracy use physiological data where eye pupils have been observed to constrict when facilitation occurs
and dilate when inhibition takes place (Mathot, Dalmaijer, Grainger, & Van der Stigchel, 2014). While working memory has not yet been incorporated into the previous theories, it could be useful in confirming which one of the two competing theories is suitable to predict IOR effects. The existence of working memory (for eye movements) implies that participants would also be able to hold information long enough to also form evaluations of the stimuli.

In summary, while strong arguments have been made for the Habituation Hypothesis, caution should be exercised in thinking that it is incompatible with the Three-Component Model. As both predict somewhat similar things, the Habituation Hypothesis cannot account for different trajectories for detection and discrimination tasks, although the Three-Component Model accounts only for detection tasks. Furthermore, other work has shown that if one location is inhibited, the opposite location does not compensate for this deficit (Schut et al., 2016), which neither model can predict.

**Current Work**

The current work aims to investigate the role that interruptions play on subsequent behavior. The classic Cue-Target paradigm is adopted and modified to first show that location and color Inhibition of Return applies to real objects. The work contributes to the understanding of IOR by demonstrating that color IOR can exist independently of location IOR. While modest effects of this phenomenon have been documented, they apply to situations where the cue and target are the same color and share the same location. By utilizing objects with multiple features, the aim is to come closer to representing an online setting. Based on the different types of tasks and instructions, the discrimination task has been chosen to demonstrate this. Although Klein et al. (2015) potentially came the closest to establishing that color IOR exists, even for discrimination tasks, it is possible that they did not find evidence for color IOR at the different location due to the cue and the target appearing near each other. The cue did not precede the target, but they shared the same space.
It should also be taken into consideration that the way participants are instructed to react to a cue and target can have subsequent consequences. For instance, active attention in search tasks can actually result in a less effective search (Smielek et al., 2006). Instructions are thus important and the way the tasks are defined and the way participants react to the cues and targets can change whether or not IOR will be observed.

Summary

IOR is a mechanism of attention that identifies novel information, but it is sensitive to task instructions and this can alter its course. Importantly, while the existence of color IOR has been speculated, it has not been found to exist on its own, i.e. when the cue and target do not share the same location. Understanding how attention is affected by various cue-target relationships will one day aid in predicting how ads interrupt and influence online behavior. The constant bombardment of ads creates an ideal environment worthy of study, not only in terms of the effect that distractions have on consumer behavior, but also in terms of the extent to which they can change consumer preferences. Therefore, understanding how the mechanism of color IOR manifests can bring us a step closer.
Chapter 3: General Method

Introduction

Inhibition of Return has been proposed as a viable mechanism of attention to understand how disruptions are processed. It has been argued that changing the timing of an ad by a few hundred milliseconds can have contrasting effects on attention to products online. Three experiments have been designed to test these assumptions. Chapter 3 provides an overview of the methodology adopted, including a description of the participants, how they were recruited, the stimuli used, which software was used, the general procedure, and how the data was analyzed.

Participants

Participants across all studies had normal or corrected-to-normal vision and no history of color blindness. None of the participants were asked to complete more than one experiment. Informed consent was obtained before all participants began the trials. Ethics approval was obtained at Imperial College London by filling out the Imperial College Research Ethics Committee (ICREC) application form. Personal identifying information was not stored and random identity numbers were allocated for each participant.

Participants were asked to sit 45 centimeters away from the screen and to respond as quickly and accurately as possible, while maintaining their eyes on a fixation point in the form of a cross (see Figure 1). None of the participants were aware of the purpose of the experiment; regardless IOR can be observed whether or not participants are aware of the task.

Participants were recruited via email and social media for the first pilot experiment 1 on a voluntary basis. For the remaining pilots, pre-tests, and for experiments 2 and 3 participants were recruited via Amazon Turk and paid for their time. For experiment 2 they were paid $3.75 for 30 minutes, for experiment 3 pre-test participants were paid $0.50 for 15
minutes, and for experiment 3 they were paid $2.50 for 15 minutes. All participants received a link on their computers, which started the experiment online.

**Instructions:**

You should focus your attention on the cross and try not to look away from it.

You will see one of the boxes change in colour very quickly. For instance, from black it can change into green.

![Green Box](image)

However, you will still focus your attention on the cross in the centre and not respond to the colour change.

Press the space bar to continue to the next set of instructions.

**Instructions:**

Next, an object will appear in either the left or right box, as displayed below. Your task is the following: whenever the object appears in the left box, press the A key. Whenever the object appears in the right box, press the L key. You need to do this as fast and accurately as possible.

![Object Boxes](image)

In this example, the object is on the right hand side, so you would press the L key.

Press the space bar to continue to the next set of instructions.

Figure 1. Example of instructions given to participants in experiment 1.
Stimuli

The experiments ran a white background with a display resolution of 1024 x 600. The screen size was programmed to be 800 x 800. In experiment 1 and experiment 2 participants had to respond to the location and to the color of a bowl, respectively (see Figure 2). In experiment 3, two pre-tests were carried out for 126 unique stimuli (see Appendix A). All stimuli with objects measured 150 x 150 pixels, and were either red or green. These objects were the targets, which participants had to respond to. Two rectangles with black outlines measuring (15 pixels wide) were aligned equidistantly on either side of a fixation cross. The cross was placed in the middle to help keep attention in the middle of the screen (Hilchey, Pratt, & Christie, 2016). This also prevents or minimizes unwanted eye movements. The appearance of the cue was also red or green: the black outlines of the boxes changed to either one of these two colors. The duration of the cue lasted for 50 ms, enough to capture attention. The timing between the onset of the cue and the target varied between 150 ms, 350 ms, 700 ms, and 1500 ms. The relationship between the cue and target in terms of timing will be subsequently referred to as the Stimulus Onset Asynchrony (SOA).

Stimuli with boxes and the fixation point were created from scratch, but stimuli representing objects were taken from two free and open access databases. One database (Creative Commons Attribution-Share Alike 3.0 license) is called Bank of Standardized Stimuli (BOSS)(Brodeur, Dionne-Dostie, Montreuil, & Lepage, 2010), which was created by Mathieu Brodeur (https://sites.google.com/site/bosstimuli). The other open access database called Computational Visual Cognition Laboratory, contains stimuli that have been verified and used peer-reviewed projects (Brady, Konkle, Alvarez, & Oliva, 2008, 2013; Konkle, Brady, Alvarez, & Oliva, 2010).

Each stimulus was modified in a free online version of Photoshop, Free Photo Tool (http://www.freephototool.com). The sizes were standardized with Bulk Resize
(https://bulkresizephotos.com) and the colors were altered such that they were either red or green. The color filtering was set to Decimal Code (255,0,0) for red, (0,128,0) for blue, and (0,0,0) for black. The colors were adjusted so that natural lighting and shading was kept to as faithful as possible.

All participants were asked to shut down all applications or unnecessary browsers, except for the one with the experiment. They were prevented from completing the task on their mobiles or tablets and also from using Internet Explorer.

![Figure 2. Example of stimuli used in experiments 1 and 2.](image.png)

**Software**

All experiments were coded with Psytoolkit (http://www.psytoolkit.org), a free source software (Gnu Public License) developed by Professor Gijsbert Stoet (Stoet, 2010; Stoet, 2017), which embeds experiments and surveys. This software produces a web link that can be run on any PC or smartphone/tablet with an internet connection. It requires programming language C for coding experiments from scratch. While the data output can integrate and be analyzed with software package R, the data was extracted into text files. These individual text files were converted into excel files, undergoing reorganizing. Finally, the data was analyzed with IBM SPSS Statistics 23 for Windows.

**Procedure**

A practice test was administered before each experiment. After reading the instructions, participants were given 10 trials to complete. If participants did not respond correctly to at least 6 out of 10 trials, then the program continued until they received the
minimum score. This ensured that participants understood the instructions. The bowl was black in the practice trials.

Upon completing the section, participants were prompted to continue to the real trials, which were divided in four sections. They were given a break, which lasted up to 30 seconds, in between these sections, or otherwise known as blocks. Experiments 1 and 2 had a total of 296 trials each, 40 of which were catch trials. In catch trials a cue appears, but no target follows. This minimizes the chance that participants anticipates targets and respond prematurely. It also encourages participants to pay attention. The cues and stimuli appeared randomly on either side of the fixation point, either in red or green colors. The order was balanced and randomized in each block for every participant. Each block contained all the unique combinations of cues and targets, such as green cues and red targets, red cues and green targets, and either on the left or right hand-side, etc. It also contained the different combinations of SOAs, such as 150 ms, 350 ms, 700 ms, and 1500 ms.

To increase the ecological validity of experiment 3, unique stimuli were used across the trials. Two pre-tests were conducted in order to identify items that were considered to be neutral in terms of preference, such that these were neither liked nor disliked and were easy to identify. Out of 126 standardized and filtered images, 48 images were selected which were neutral and easily recognizable. The two pre-tests were conducted on different groups of participants from those in the main experiment. In experiment 3, the 1500 ms SOA was removed because the IOR effect seemed to have disappeared before this interval in the first two experiments. Also given the complex setup, it was done to avoid fatigue.

The trials in the experiment were randomized into 4 versions. A grand 272 trials were collected, with 68 trials in each version. Each version of the experiment had a unique combination of trials since it would not be possible to follow the same procedure adopted for
experiments 1 and 2 with 48 stimuli. Thus, all four versions together produced all the possible combinations. Furthermore, each block within each version also contained unique trials. There were 12 trials per block with 20 catch trials. For half of the total trials, the same stimulus was shown again and participants were also asked to indicate their preference. They did so using a mouse and clicking on a preference line which appeared across the screen. The line measured the extent to which they like the stimulus, with strongly dislike on the left-end and strongly dislike on the right-end. The X-coordinate on the preference line, of the mouse click, was recorded (see Figure 3).

**Instructions:**

Final hint: Sometimes you will be asked to indicate the extent to which “I like this image.”

![Preference Scale]

You can click on the left mouse button to indicate your preference on the line above. Clicking closer to the left indicates that you strongly dislike the image and clicking on the right indicates that you strongly like it. Click near the middle indicates that you are neutral.

Press the space bar to continue to the summary of the instructions.

*Figure 3. Example of instructions given to participants in experiment 3.*

**Data Analysis**

Trials were excluded when participants pressed on the wrong key (i.e. indicating the target was on the right when it appeared on the left) and when they timed out by not pressing any key. Feedback for incorrect or timeout responses was given after every trial. Reaction times which exceeded 2.5 SDs above or below the mean were excluded, in addition to fast
reaction times less than 150 ms. Scores were also removed when insufficient information was available to calculate the IOR score (Wilson et al., 2016).

Individual scores were collapsed across the different combinations of location positions between the cue and target (left-left, right-right, left-right, right-left) and across the different combinations of color positions (red-red, green-green, red-green, green-red). These were collapsed and categorized into the following: same location, different location and same color, and different color. Given that there were multiple repeated trials and four blocks (three blocks in experiment 3), the average of these scores was calculated for each participant.

The different timing conditions were the independent variables (Stimulus Onset Asynchrony: time between cue and target), which included 150 ms, 350 ms, 700 ms across all three experiments (in addition to 1500 ms for the first two experiments). Alpha level of \( p < .05 \) was used for all tests of significance, with \( \eta_p^2 \) effect sizes. Post hoc comparisons using Bonferroni adjustment was used. Subsequent separate one-way analyses were conducted where necessary. In experiments 1 and 2, the dependent variable was mean RT, and for experiment 3 an additional dependent variable was preference (measured by the coordinate on an X-axis line).

The analyses were divided into three parts. In the first part of the analyses, the effect of Inhibition Return was analyzed with a three-way Repeated Measures ANOVA. This rendered a 2 x 2 x 4 design, where there were two levels of location (same, different), two levels of color (same, different) and four levels of SOA in milliseconds (150, 350, 700, 1500). In the IOR literature, inhibition is understood to take place when the timing is long enough, usually longer than 250 ms, and response time increases when the cue and target appear in the same location. Conversely the response time decreases, meaning that facilitation
is taking place, when they do not share the same location, also known as the different location. This pattern can differ from SOA to SOA, usually with faster response time when the SOA is below 250 ms, and faster response time when the SOA is above 250 ms. Therefore, subsequent analyses followed for each individual SOA. Of particular interest are the differences of locations at each color, referred to as location IOR and the differences of colors at each location, referred to as color IOR. For instance, when the cue and target share the same location, it is important to assess whether there were differences between the cue and target when they shared the same color and when they did not. Conversely when the cue and target did not share the same location (different location condition), it is important to assess how the response times varied when they did share a color and when they did not.

In the second part of the analyses, color IOR scores are calculated by taking the average of scores for the different location condition and subtracting them from the same location condition (IOR = different location – same location) (Pinnow et al., 2015). Two separate scores were obtained: one for the same color and one for the different color conditions. The same was done by subtracting the same color condition from the different color condition for location IOR (= different color – same color) and two scores were obtained at each level of location. Positive scores indicate that facilitation of attention is taking place, while negative scores indicate that inhibition is occurring. The purpose of these is to illustrate the size of the IOR effect and the trajectory that location and color IOR take. The main effects were important in identifying changes in scores; this illustrates when a reversal from facilitation to inhibition takes place. Based on the theoretical importance of showing how location IOR is different from color IOR, independent ANOVAs were ran for these two main effects (Silvert & Funes, 2016).
In the third part of the analyses, error rates are taken into consideration. This indicates how many mistakes participants made in each experiment. Overall, participants in each experiment produced less than 3% errors on all the trials.
Chapter 4: Experiment 1, Spatial Effects of IOR

Introduction

Our attentional system is thought to be hard-wired to focus on novel information at the expense of old information (Berlucchi, 2006; Corbetta & Shulman, 2002). As a consequence, the consecutive appearance of two objects in the same location will direct our attention to them. However, a relatively small delay in the timing between these two objects will reverse its effect. Namely, by increasing the delay from 150 ms to 350 ms the opposite effect will be observed (Samuel & Kat, 2003). Attention will be diverted into a different direction, away from these two objects. All of this occurs within the timespan of one second.

The relationship between the cue and target is important: the Cue-Target paradigm is adopted to ensure robust results (Taylor & Donnelly, 2002). The Cue-Target paradigm can be useful in drawing a parallel between the cue and a flashing ad. Both can appear abruptly; the cue can interrupt attention from a target, while the ad can interrupts a consumer’s focus on a product. It is acknowledged that the Cue-Target paradigm is a simplified analogy, but it can build a framework for understanding how the timing of interruptions have an effect on attention.

As a first step in understanding how ads interrupt attention, Inhibition of Return is applied using real objects in experiment 1. This helps to extend the paradigm from using simple stimuli, in the form of pixelated points, to using more realistic ones. The distance between stimuli was also expanded to match that of a more realistic setting. Doing so ensures that this phenomenon is not limited to small stimuli which are placed within small distances of each other. Rather, it is to show that it can be applied to more complex, everyday objects.

Participants are asked to indicate whether the target appears on the left or right side. Given that location is prominent in this set of instructions, it is thus expected that the location
IOR magnitude will be stronger than the color IOR magnitude. As has been shown by the literature, IOR is sensitive to the task instructions (Fabius, Schut, & Van der Stigchel, 2016). Since task instructions are important, a discrimination task was used, but with location IOR. Discrimination tasks can help identify whether non-spatial features like color also follow similar trajectories. Thus, experiment 1 tested location IOR first. This was done in order to show that location IOR can be applied in the current setting.

**Hypotheses**

In the classical Posner cuing paradigm, a quick time interval between the cue and target resulted in a faster reaction time towards the target. Conversely, a relatively long time interval between the two stimuli resulted in a slower reaction time towards the target. In the current experiment, similar results are expected. For the shortest time interval, 150 ms, when the cue and target are in the same location, a shorter reaction time is expected (see Figure 4). The faster reaction time will apply to the same color condition and the different color condition. This will result in a positive IOR score, thereby denoting that facilitation has taken place. Conversely, when the time intervals are above 350 ms, a reversal will occur. Slower response times are expected at both the same color condition and the different color condition. A negative IOR score will denote that inhibition has taken place and whereby reaction times will increase. An overall main effect for the time intervals for location IOR is expected, but not for Color IOR given that the instructions for this task are to indicate the location.

**H1a:** Objects appearing in the same location as the cue will result in quicker reaction times, when the timing between the two is 150 ms.

**H1b:** Objects appearing in the same location as the cue, will result in slower reaction times, when the timing between the two is 350 ms or longer.
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Reversal

Same Location

<table>
<thead>
<tr>
<th>150 ms</th>
<th>350 ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhanced Attention (Faster RT)</td>
<td>Inhibited Attention (Slower RT)</td>
</tr>
</tbody>
</table>

Different (Opposite) Location

<table>
<thead>
<tr>
<th>150 ms</th>
<th>350 ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhanced Attention (Faster RT)</td>
<td>Inhibited Attention (Slower RT)</td>
</tr>
</tbody>
</table>

Figure 4. It is hypothesized that when the cue and target share the same location, attention will be enhanced at the 150 ms SOA, resulting in faster reaction times. At the 350 ms SOA, the reverse will be observed.

Methodology

The *Psytoolkit* software was tested before the study was sent out. For the experiment, a total of 34 participants were recruited online, via email and social media requests. This was done on a voluntary basis, there was no monetary compensation. Written consent was obtained prior to commencing the experiments. Out of these, the scores of 5 participants were removed due to high error rates and/or unusually long reaction times (RTs). The average age was 27.88 (SE = 5.28).

There was a total of 256 trials, 40 of which were catch trials, for a total of 296 trials per participant. This resulted in 8,584 trials in total. Multiple scores were collected, for each participant, for each condition. A within-subjects design helps increase power and reduce variability. This consisted of the different combinations of cue and target locations (left-left, right-right, left-right, right-left) and color (red-red, green-green, red-green, green-red) for
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each SOA (150, 350, 700, 1500). All conditions were repeated, but randomly distributed, across the four blocks. They were subsequently collapsed to two levels of location (same location, different location) and color (same color different color) and four levels of SOA (150, 350, 700, 1500). This rendered a 2 (Location: same vs different) x 2 (Color: same vs different) x 4 (Time Interval: 150 ms, 350 ms, 700 ms, 1500 ms) design. The independent variables (IVs) were the 4 time SOAs and two location and two color conditions. The dependent variable (DV) was reaction time, which can be used to measure IOR, either by comparing the average for same condition to the different condition (for either location or color) or by subtraction (different condition - same condition). The location (classic) IOR by looking at the reaction time of participants when the object was on the left or right hand side. The color IOR was tested by measuring the reaction time to when the object was the same color or was a different color than the cue.

In the first part of the results, the data is presented for each SOA, this helps to visualize how the location IOR differs from the color IOR. In the second part of the results, an IOR score is calculated to illustrate the change from facilitation to inhibition. In the shortest SOA, facilitation is predicted to occur in the same location condition: reaction times are faster. The IOR score will then change from positive to negative because beyond the 350 ms SOA, the same location condition will show slower reaction times. Location IOR = Different Location – Same Location. The same logic applies to color IOR scores which are calculated in a similar way (Color IOR = Different Color – Same Color).
Breakdown by SOA

<table>
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<th>150 ms SOA</th>
<th>350 ms SOA</th>
<th>700 ms SOA</th>
<th>1500 ms SOA</th>
</tr>
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<td></td>
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<td>Same</td>
<td>Different</td>
</tr>
<tr>
<td></td>
<td>Location</td>
<td>Location</td>
<td>Colour</td>
<td>Colour</td>
</tr>
<tr>
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<tr>
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<td>433.74</td>
<td>427.93</td>
<td>445.92</td>
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<td>61.47</td>
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<td>422.92</td>
<td>427.45</td>
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<td>424.78</td>
<td>437.56</td>
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<td>Different Color</td>
<td>461.98</td>
<td>424.78</td>
<td>437.56</td>
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<td></td>
<td></td>
<td>61.90</td>
<td>70.79</td>
<td>63.05</td>
</tr>
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</table>

Figure 5. Breakdown of SOAs in experiment 1.

Table 3

Experiment 1: Meant RTs (Dependent Variables)

<table>
<thead>
<tr>
<th></th>
<th>150 ms</th>
<th>350 ms</th>
<th>700 ms</th>
<th>1500 ms</th>
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<td>Same</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Colour</td>
<td>433.74</td>
<td>64.43</td>
<td>427.93</td>
<td>72.02</td>
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<td>Colour</td>
<td>422.92</td>
<td>48.22</td>
<td>427.45</td>
<td>75.69</td>
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<tr>
<td>Colour</td>
<td>461.98</td>
<td>58.42</td>
<td>424.78</td>
<td>70.79</td>
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<tr>
<td>Colour</td>
<td>458.86</td>
<td>61.90</td>
<td>426.90</td>
<td>57.72</td>
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</table>
**The Role of Visual Attention in Product Selection**

**Significant main effects and interactions.**

There was a main effect of Color, $F(1, 28) = 4.80, p = .037, \eta^2_p = .146$, which was statistically significant. This means that overall participants were faster at detecting the target when it was the same color as the cue, in the same color condition ($M = 443.76, SE = 10.83$), and slower in the different color condition ($M = 438.87, SE = 10.28$). The difference between the conditions was $4.89 \text{ ms} (SE = 2.23), 95\% \text{ CI} [0.32, 9.46] p = .037$.

The main effect of SOA was statistically significant, $F(3, 84) = 10.54, p = .000, \eta^2_p = .273$. Overall, the trend from the shortest to the longest SOA shows that participants’ reaction times first decreased and then their reaction times increased near the last SOA. The reaction times towards the 150 ms SOA ($M = 444.38, SE = 10.16$), 95% CI [423.58, 465.18] was longer than the 350 ms SOA ($M = 426.76, SE = 11.77$), 95% CI [402.65, 450.88]. There was a difference ($M = 17.61, SE = 5.57$), 95% CI [1.79, 33.44], $p = .023$, between these two. Participants in the 700 ms SOA ($M = 439.99, SE = 10.98$), 95% CI [417.49, 462.49] were slightly quicker in their reaction times than in the 350 ms SOA. The difference was $-13.23 \text{ ms} (SE = 4.32), 95\% \text{ CI} [-25.48, -0.98], p = .029$. For the 1500 ms SOA participants were slightly slower ($M = 454.13, SE = 10.74$), 95% CI [432.14, 476.13] than the 350 ms SOA. The difference was $-27.37 \text{ ms} (SE = 5.75), 95\% \text{ CI} [-43.70, -11.05], p = .000$. Finally, participants were faster in the 700 ms SOA than in the 1500 ms SOA. The difference was ($M = -14.14, SE = 4.01$), 95% CI [-25.54, -2.75], $p = .009$.

**Location pairwise comparisons.**

Pairwise comparisons show that at the 150 ms SOA there was a facilitation effect of location, as expected. This took place at the same color condition. Participants were slower to respond in the different location ($M = 461.98, SE = 10.85$), 95% CI [439.76, 484.21] than in the same location ($M = 433.74, SE = 11.96$), 95% CI [409.24, 458.25]. Overall the difference was $28.24 \text{ ms} (SE = 5.16), 95\% \text{ CI} [17.68, 38.81], p = .000$. 


A facilitation effect also took place at the different color condition. Responses were slower in the different location ($M = 458.86$, $SE = 11.49$), 95% CI [435.32, 482.41] than in the same location ($M = 422.92$, $SE = 8.95$), 95% CI [404.58, 441.26]. The difference was 35.95 ms ($SE = 7.18$), 95% CI [21.25, 50.65], $p = .000$.

There was an inhibition effect of location at the 700 ms SOA at the different color condition. Response times were slower at the same location ($M = 452.43$, $SE = 11.97$), 95% CI [427.91, 476.95] in contrast to the different location ($M = 424.06$, $SE = 10.9$), 95% CI [401.73, 446.39]. The difference was $M = 28.37$ ($SE = 4.49$), 95% CI [19.16, 37.58], $p = .000$.

**Color pairwise comparisons.**

Pairwise comparisons for color show that there was an inhibition effect at the different location for 700 ms SOA. Specifically, the response times were slower at the same color ($M = 437.560$, $SE = 11.71$), 95% CI [413.58, 461.54] than at the different color condition ($M = 424.06$, $SE = 10.90$), 95% CI [401.73 446.39]. The difference was $M = 13.50$ ms ($SE = 5.79$), 95% CI [1.64, 25.36], $p = .027$.

There was also an inhibition effect at the same location for the 1500 ms SOA. The response times were slower at the same color ($M = 463.33$, $SE = 11.58$), 95% CI [439.62, 487.04] than at the different color ($M = 451.39$, $SE = 59.10$), 95% CI [428.90, 473.87]. The difference was 11.95 ms ($SE = 5.76$), 95% CI [0.16, 23.73].

**Remaining interactions.**

There was a two-way interaction effect, location * SOA, $F(3, 84) = 24.66$, $p = .000$, $\eta_p^2 = .468$. This indicates that the location conditions varied across the different SOAs.
The rest of the effects were not statistically significant, not in terms of the main effect of location, $F(1, 28) = 0.25, p = .624, \eta^2_p = .009$, nor the main effect of color, $F(1, 28) = 4.80, p = .037, \eta^2_p = .146$, SOA, $F(3, 84) = 10.54, p = .000, \eta^2_p = .273$.

Neither were the other two-way ANOVAs, location * color interaction, $F(1, 28) = 0.14, p = .708, \eta^2_p = .005$, and color * SOA interaction, $F(3, 84) = 0.76, p = .520, \eta^2_p = .026$.

Finally, the three-way, location * color * SOA, $F(3, 84) = 1.71, p = .172, \eta^2_p = .057$, was not statistically significant.

**Breakdown by SOA: Summary.**

Tables 4, 5, and 6 summarize the overall finding that location IOR was observed. At the 150 ms SOA there was facilitation, which turned into inhibition at the 700 ms SOA, as expected. In terms of color IOR, there was an inhibition effect at the 700 ms and 1500 ms SOA conditions, but for the 700 ms SOA it occurred at the different location and for the 1500 ms SOA it occurred at the same location. The overall trend in SOA shows that the reversal between facilitation and inhibition took place at the 350 ms SOA, as expected in the literature. The IOR scores are also calculated. In the next section, analyses were conducted on the IOR scores to complement the current analyses.

<table>
<thead>
<tr>
<th>Table 4.</th>
<th>150 ms</th>
<th>350 ms</th>
<th>700 ms</th>
<th>1500 ms</th>
</tr>
</thead>
<tbody>
<tr>
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<td><strong>Same Color</strong></td>
<td>Facilitation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Different Color</strong></td>
<td>Facilitation</td>
<td>Inhibition</td>
<td></td>
</tr>
<tr>
<td><strong>Color</strong></td>
<td><strong>Same Location</strong></td>
<td></td>
<td>Inhibition</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Different Location</strong></td>
<td></td>
<td>Inhibition</td>
<td></td>
</tr>
</tbody>
</table>
Table 5

Experiment 1: Location IOR Score = Different Location – Same Location

<table>
<thead>
<tr>
<th>Location IOR Size</th>
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<th>350 ms SOA</th>
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</thead>
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<tr>
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<td>Different Color</td>
<td>Same Color</td>
</tr>
<tr>
<td>-8</td>
<td>-28*</td>
<td>-8</td>
</tr>
</tbody>
</table>

Table 6

Experiment 1: Color IOR Score = Different Color – Same Color

<table>
<thead>
<tr>
<th>Color IOR Size</th>
<th>150 ms SOA</th>
<th>350 ms SOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same Location</td>
<td>Different Location</td>
<td>Same Location</td>
</tr>
<tr>
<td>-11</td>
<td>-3</td>
<td>0</td>
</tr>
<tr>
<td>700 ms SOA</td>
<td>1500 ms SOA</td>
<td></td>
</tr>
<tr>
<td>Same Location</td>
<td>Different Location</td>
<td>Same Location</td>
</tr>
<tr>
<td>7</td>
<td>-13*</td>
<td>-12*</td>
</tr>
</tbody>
</table>

Breakdown by IOR Score

The previous section outlined the effects of SOA on location and color. Next, IOR is analyzed as a function of the difference in location scores and color scores on SOA. Five outliers were detected and removed: Two participants consistently scored high, with extreme deviations and had unusual fluctuations in their responses. The other three participants had high error rates and/or responded on the catch trials. Overall, the accuracy was high, with the lowest accuracy in block 4 at 97%, which was not problematic.

The results are organized by location IOR and color IOR. As a result, location IOR is calculated as the difference in location condition scores, whereas color IOR is calculated as the difference in color condition scores. The overall pattern of Location IOR and color IOR, respectively, across the four SOAs is presented graphically as well.
THE ROLE OF VISUAL ATTENTION IN PRODUCT SELECTION

Location IOR.

Since the location IOR score consists of two means (different location – same location), a Two-Way Analysis of Variance was conducted. It has two levels of location (for same color, different color) and four levels of SOA (150 ms, 350 ms, 700 ms, 1500 ms). This rendered a 2 x 4 Repeated Measures Within-Subjects design. An alpha level of .05 was used for all tests. This IOR score is meant to detect whether facilitation or inhibition of location took place across the SOAs and for the color conditions. These analyses aim to complement the SOA breakdown. Main effects were the focal aspect of the analysis and post-hoc pairwise comparisons at each SOA.

Significant main effects.

There was a significant main effect of SOA $F(3, 84) = 24.66, p = .000, \eta^2_p = .468$. This means that the different location condition RTs were significantly different from the same location RTs, across the SOAs. In other words, in some SOAs facilitation took place, while in others inhibition. The 150 ms had the largest (positive) score ($M = 32.09, SE = 4.7$), 95% CI [22.47, 41.72], confirming that facilitation took place and this was different from the rest. The average score for the other three SOAs were negative: 350 ms ($M = -1.86, SE = 6.12$), 95% CI [-14.40, 10.69], 700 ms ($M = -18.36, SE = 3.53$), 95% CI [-25.60, -11.13], and 1500 ms ($M = -6.45, SE = 3.85$), 95% CI [-14.34, 1.45]. The 700 ms SOA was also different from the 1500 ms SOA. Overall, the change from the positive to negative numbers denotes Inhibition of Return taking place from the 350 ms SOA, onwards. This was as expected, since it started from a positive score, signaling facilitation of attention, to a negative score, signaling inhibition of attention.

The main effect for location (difference between same color and different color), was not significant, $F(1, 28) = 0.14, p = .708, \eta^2_p = .005$, and neither was the interaction effect, location differences * SOA, $F(3, 84) = 1.71, p = .172, \eta^2_p = .057$. This means that the
difference in location did not vary across the different colors, neither across the different SOAs as indicated by a lack of an interaction effect. However, subsequent analyses were carried out at each level of SOA (Iacobucci, 2001).

**Pairwise comparisons.**

One-Way ANOVAs were carried out at each level of SOA. There was a statistically significant main effect for the inhibition of location at the 700 ms SOA, $F(1, 28) = 6.58, p = .016, \eta^2_p = 0.19$. There was relatively less inhibition at the same color ($M = -8.36, SE = 5.93$), 95% CI [-20.51, 3.79] than at the different color ($M = -28.37, SE = 4.50$), 95% CI [-37.58, -19.16] conditions. Bonferroni post hoc tests showed that the RT in the 700 ms SOA at the different color condition was lower than the color condition by 20 ms ($SE = 7.80$), 95% CI [-35.99, -4.03]. The IOR effect was thus stronger at the different color condition. In this case, the color and location worked together synergistically. Otherwise both conditions would have followed a similar trajectory.

**Remaining Non-Significant Effects.**

The other One-Way ANOVAs, to test the difference in RTs between the same color and different color conditions, were not statistically significant at the 150 ms SOA, $F(1, 28) = .87, p = .358, \eta^2_p = .03$; 350 ms SOA, $F(1, 28) = 0.05, p = .821, \eta^2_p = .002$; and 1500 ms SOA, $F(1, 28) = 0.22, p = .646, \eta^2_p = .008$. 
THE ROLE OF VISUAL ATTENTION IN PRODUCT SELECTION

Figure 6. Location IOR. Note: SOA is measured in milliseconds. Location IOR = different location (RTs) – same location (RTs).

Figure 7. Breakdown of Location IOR by same color and different color. Note: SOA is measured in milliseconds. Location IOR = different location (RTs) – same location (RTs). *p < .05.
THE ROLE OF VISUAL ATTENTION IN PRODUCT SELECTION

Color IOR

Since the color IOR score consists of two means (different color – same color), a Two-Way Analysis of Variance was conducted. This had two levels of color (for same location, different location) and four levels of SOA (150 ms, 350 ms, 700 ms, 1500 ms), resulting in a 2 x 4 Repeated Measures Within-Subjects design. An alpha level of .05 was used for all tests. The color IOR score helps to detect any overall changes in IOR for location or SOAs across the conditions. Main effects were the focal aspect of the analysis and post-hoc pairwise comparisons at each SOA.

Non-significant main effects.

The analysis did not produce statistically significance main effects for either SOA, $F(3, 84) = 0.76, p = 0.52, \eta_p^2 = .026$, nor color (difference between same location and different location), $F(1, 28) = 0.14, p = .708, \eta_p^2 = .005$. The interaction effect was also not significant, color differences * SOA, $F(3, 84) = 1.71, p = .172, \eta_p^2 = .057$. This result was expected as location IOR was hypothesized to be stronger than Color IOR in the first experiment, since participants have to respond to the location of the object.

Pairwise comparisons.

One-Way ANOVAs were executed at each level of SOA, with only the 700 ms SOA being statistically significant for inhibition of color, $F(1, 28) = 6.58, p = .016, \eta_p^2 = .190$. There was relatively more facilitation at the same location ($M = 6.51, SE = 5.95$), 95% CI [-5.67, 18.69] than at the different location ($M = -13.50, SE = 5.79$), 95% CI [-25.36, -1.64]. The difference in RTs between the same and different locations is positive ($M = 20.01, SE = 7.80$), 95% CI [4.03, 35.99]. This complements the difference found for Location IOR at the 700 ms SOA. Color IOR is being amplified at the different location, more so than at the same location.
Figure 8. Color IOR. Note: SOA is measured in milliseconds. Color IOR = different color (RTs) – same color (RTs).

Figure 9. Breakdown of Color IOR by the same location and different location. Note: SOA is measured in milliseconds. Breakdown of Color IOR = different color (RTs) – same color (RTs). *p < .05
Breakdown by IOR score: Summary.

Table 7

Breakdown by IOR Score. Red indicates inhibition.

<table>
<thead>
<tr>
<th>Location</th>
<th>Same Color</th>
<th>150 ms</th>
<th>350 ms</th>
<th>700 ms</th>
<th>1500 ms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Different</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td>Color</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Same Location</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Different Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Overall the results are consistent with the literature on IOR. The location IOR follows a classic trajectory. As hypothesized there was a reversal in the IOR score from the smallest SOA, which crossed-over at the 350 ms SOA. The effect of Location IOR was also amplified by the different color condition at the 700 ms SOA. For the color IOR, however, the inhibition occurred when the location of the cue and target did not match. This suggests that the color IOR might follow a different trajectory for the same location as for the different location and that the two mechanisms of attention interact.

Breakdown by error rates.

Error rates were also analyzed. The literature predicts that when inhibition occurs, a decrease in accuracy and an increase in error rates will be observed. Identifying where accuracy is affected can offer a glimpse into information processing and how attention is affected by IOR.
The main effect for SOA was statistically significant, $F(3, 84) = 3.62, p = .016$, indicating that there are differences in error rates across the SOAs. Overall, the 150 SOA ($M = 15.73, SE = 0.08$), 95% CI = [15.57, 15.89] and the 350 SOA ($M = 15.64, SE = 0.09$), 95% CI = [15.46, 15.81] had lower accuracy rates than the other two, the 700 SOA ($M = 15.84, SE = 0.092$), 95% CI = [15.65, 16.03], and the 1500 SOA ($M = 15.85, SE = 0.06$), 95% CI = [15.71, 15.98]. Participants were prone to making errors in the shorter SOAs, however, this was not distributed evenly between the locations and color conditions. The following tests were conducted to parse these differences.

The main effect for location was statistically significant, $F(1, 28) = 14.85, p = .001$, meaning that there was a difference in error rates across locations. Overall, there were fewer errors in the same location condition ($M = 15.88, SE = 0.05$), 95% CI = [15.78, 15.99] than
the different location condition \((M = 15.64, SE = 0.09), 95\% CI = [15.46, 15.83]\). This difference had a mean of 0.24 \((SE = 0.06), 95\% CI = [0.11, 0.37]\).

There was also a main effect for color, which was statistically significant, \(F(1, 28) = 7.13, p = .013\). There were less errors in the same color condition \((M = 15.81, SE = 0.07), 95\% CI = [15.65, 15.96]\) than in the different color condition \((M = 15.72, SE = 0.06), 95\% CI = [15.59, 15.85]\). The difference between the former and latter was 0.09 \((SE = 0.03), 95\% CI = [0.02, 0.15]\).

Given that in the shorter SOAs there were differences in accuracy, and that the location and color main effects were significant, it makes sense that the SOA * location interaction was also statistically significant, \(F(3, 84) = 5.76, p = .001\), as was the color * location interaction, \(F(1, 28) = 6.41, p = .017\).

**Location pairwise comparisons.**

At the 150 ms SOA, the One Way ANOVA was statistically significant, \(F(1, 28) = 6.61, p = .016\). There was a higher amount of accurate responses at the same location than at the different location, but this was true when the color was different. The same location had a higher accuracy rate \((M = 15.90, SE = 0.06), 95\% CI = [15.78, 16.01]\) than the different location \((M = 15.48, SE = 0.15), 95\% CI = [15.18, 15.78]\). The difference between these two was 0.41 \((SE = 0.16), 95\% CI = [0.08, 0.74]\).

At the 350 ms SOA, when the color was the same, there was a statistically significant main effect, \(F(1, 28) = 7.88, p = .009\). The same location had a higher accuracy \((M = 15.93, SE = 0.05), 95\% CI = [15.83, 16.03]\) than the different location \((M = 15.55, SE = 0.14), 95\% CI = [15.27, 15.83]\). The difference had a mean of 0.38, \(SE = 0.14\), 95\% CI = [0.10, 0.66].

There was also a statistically significant main effect when the color was different, \(F(1, 28) = 10.19, p = .003\). The same location had a higher accuracy \((M = 15.90, SE = 0.08), \)
95% CI = [15.74, 16.05] than the different location ($M = 15.17$, $SE = 0.21$), 95% CI = [14.74, 15.61]. The difference had a mean of 0.72 ($SE = 0.23$), 95% CI = [0.26, 1.19].

**Color pairwise comparisons.**

The 150 ms SOA, there was statistically significant for the different location, $F(1, 28) = 4.71$, $p = .039$. The accuracy was higher for the same color ($M = 15.55$, $SE = 0.14$), 95% CI = [15.27, 15.83] than the different color condition ($M = 15.17$, $SE = 0.21$), 95% CI = [14.74, 15.61]. This difference was 0.38 ($SE = 0.18$), 95% CI = [0.02, 0.74].

**Break down by error rates: Summary.**

In this experiment, the two locations in the 150 ms SOA were lower in terms of responses. In other words participants had faster reaction times and they were more accurate.

### Table 8

**Summary of Error Rates**

<table>
<thead>
<tr>
<th>150 ms SOA</th>
<th>Color</th>
<th>Location</th>
<th>Same Location</th>
<th>Different Location</th>
</tr>
</thead>
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<th>Different Location</th>
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</table>

**Discussion**

The results show that facilitation is taking place at the 150 ms SOA, as expected for location IOR. The 350 ms SOA serves as a reversal point. At the 700 ms SOA, inhibition is observed. Interestingly, the different color condition at the 700 ms SOA is driving the inhibition, which means that non-spatial features also interact with the spatial attention. It follows that for color IOR, inhibition is observed at the 700 ms SOA, but this is driven by the different location condition. Finally, there is some evidence of inhibition at the same location.
for the 1500 ms SOA, which could indicate that spatial IOR is stronger at this SOA and the effects of color IOR might have weakened between the 700 ms SOA and the 1500 ms SOA.

It is important to note that while location IOR is more prominent in experiment 1, with a clear pattern of facilitation at the 150 ms and inhibition at the 700 ms, color IOR was weaker. Even more important, Inhibition of color features was observed at the 700 ms SOA, which is not necessarily a unique finding on its own, but this inhibition took place at the different location. This is significant because the literature so far has shown that for color, and other non-spatial features, IOR occurs only when the cue and target share the same location.

The overall lower accuracies in the 150 ms and 350 ms SOA can be attributed to the higher rate of errors at the different location for both of these SOAs. For the 150 ms SOA, the same color condition had a higher amount of accurate responses, while the different color condition was driving down the accuracy. For the 350 ms SOA, the different location was also driving down the accuracy, both at the same color and different color conditions. While inhibition took place at the 700 ms SOA, it seems that accuracy rates were affected in the previous SOA.
Chapter 5: Experiment 2, Non-Spatial Effects of IOR

Introduction

The experiment 1 results showed that there was clear facilitation at the 150 ms SOA in terms of location. At the 350 ms SOA, the reaction times in all conditions were not statistically different from each other. This indicated that the facilitation effect started to reverse at the 350 ms SOA, which was a cross-over point. In the 700 ms SOA, inhibition took place. It was notable that the size of location IOR increased in the different color condition, indicating that this effect was driven by the different color condition. Likewise color IOR was driven by the different location condition.

Location IOR was not observed at the same color condition in the 700 ms SOA, although the pattern trended towards significance, hinting that there were some traces of non-spatial features. Importantly, color IOR has not yet been observed at the different location condition in the literature, but it has in this experiment. When it comes to the visual system decoding the environment in a matter of milliseconds, location information is thought to be more important than non-location (non-spatial) information. For this reason, the existence of color IOR has been questioned in the literature. However, when color becomes a priority in identifying objects, and therefore task relevant, it can become more strongly activated in the attentional system.

Since color IOR was observed at the different location, the effects of task instructions were probed further. In order to test this out, experiment 2 was designed in the same way as experiment 1 with one exception: participants were asked to indicate whether the color of the object was red or green, rather than whether it’s located on the left or right. This small change in instruction is hypothesized to strengthen the color IOR effect because emphasis is placed on color features, rather than location features.
Hypotheses

If color IOR were to exist reaction times towards the target would be faster when the cue and target share the same color and the timing between the two is relatively quick, but a slower reaction time towards the target would be observed if the two stimuli do not share the same color. The same hypotheses as in experiment 1 are expected, except that the color IOR effect should be stronger as a result.

**H2a:** Objects with the same color as the cue will result in quicker reaction times, when the timing between the two is 150 ms.

**H2b:** Objects with the same color as the cue, will result in slower reaction times, when the timing between the two is 350 ms or longer.

Methods

A pilot test was run on four participants to test that the software coding measured what it was programmed to. The main experiment included a total of 35 participants, but the
scores of one participant were excluded due to a high error rate and unusual response distributions. The average age was 36.00 years (SD = 11.93). The participants were recruited via Amazon Turk, in accordance to the procedure described in the main methodology section. A link to the experiment was generated and embedded in Amazon Turk. The methodology was akin to experiment 1, except that participants had to indicate the color of the target, rather than its location. They were required to indicate if the target was red or green and their response times were recorded.

**Instructions:**

Step 1: Keep your eyes fixated on the cross in the center. One of the boxes, either the left or right, will quickly change in colour from black to either red or green. You are not required to respond.

Step 2: The box will change back to black very quickly.

Step 3: Afterwards, an object will appear in either box. While your eyes remain fixated on the cross, you should press either the A key (= green object) or the L key (= red object).

Press the space bar to continue to the next set of instructions.

*Figure 12. Instructions given to participants in experiment 2.

**Results**

Table 9

*Experiment 2: Meant RTs (Dependent Variables)*

<table>
<thead>
<tr>
<th></th>
<th>150 ms</th>
<th></th>
<th>350 ms</th>
<th></th>
<th>700 ms</th>
<th></th>
<th>1500 ms</th>
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<tbody>
<tr>
<td></td>
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<td>SD</td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td><strong>Same Location</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Same Color</td>
<td>632.50</td>
<td>85.09</td>
<td>644.84</td>
<td>107.59</td>
<td>642.52</td>
<td>91.57</td>
<td>656.35</td>
<td>100.76</td>
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<tr>
<td>Different Color</td>
<td>638.77</td>
<td>97.28</td>
<td>632.83</td>
<td>103.61</td>
<td>661.77</td>
<td>104.26</td>
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<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Same Color</td>
<td>663.59</td>
<td>102.91</td>
<td>657.13</td>
<td>113.39</td>
<td>645.83</td>
<td>100.93</td>
<td>662.12</td>
<td>96.82</td>
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<td>Different Color</td>
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<td>632.21</td>
<td>97.52</td>
<td>643.36</td>
<td>104.73</td>
<td>671.07</td>
<td>127.80</td>
</tr>
</tbody>
</table>
SOA Breakdown

As in the previous experiment, analyses were broken down by SOA in the first section, followed by the IOR score in the second section. The results section finishes with error analyses.

**Significant main effects and interactions.**

There was a significant main effect of SOA, $F(2.46, 81.22) = 4.75$, $p = .007$, $\eta_p^2 = .126$, which means that there was a difference in response times across the four time intervals. As in experiment 1, there was a trend of an overall RT descending from 150 ms SOA ($M = 652.734$, $SE = 15.465$), 95% CI [621.27, 684.199] towards the 350 ms SOA ($M = 641.754$, $SE = 15.465$), 95% CI [620.27, 663.234] to 700 ms SOA ($M = 630.765$, $SE = 15.465$), 95% CI [609.27, 652.234] and finally 1500 ms SOA ($M = 620.785$, $SE = 15.465$), 95% CI [609.27, 641.294].
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$SE = 16.812$, 95% CI $[607.55, 675.958]$, and then going up gradually from the 700 ms SOA ($M = 648.37$, $SE = 16.292$), 95% CI $[615.223, 681.517]$ to the 1500 ms SOA ($M = 664.281$, $SE = 17.472$), 95% CI $[628.734, 699.828]$. There was a significant difference between the 1500 ms SOA and the 350 ms SOA ($M = 22.53$, $SE = 7.54$), 95% CI $[1.37, 43.68]$, $p = .032$ and the 1500 ms SOA and the 700 ms SOA ($M = 15.91$, $SE = 4.94$), 95% CI $[2.04, 29.79]$, $p = .017$.

The SOA * location interaction was statistically significant, $F(3, 99) = 6.1$, $p = 0.001$, $\eta^2_p = 0.156$, as was the SOA * color, $F(3, 99) = 3.66$, $p = .015$, $\eta^2_p = .100$.

**Location pairwise comparisons.**

For the same color condition, participants were faster to respond to same location condition in the 150 ms SOA ($M = 632.50$, $SE = 14.59$), 95% CI $[602.82, 662.19]$ than in the different location ($M = 663.59$, $SE = 17.65$), 95% CI $[627.68, 699.50]$. The difference between the same and different locations was significant ($M = 31.08$, $SE = 11.60$), 95% CI $[7.48, 54.69]$, $p = .011$. Likewise, there was a facilitation effect at the 150 ms SOA in the different color condition between the same location ($M = 638.77$, $SE = 16.68$), 95% CI $[604.83, 672.71]$ and the different location ($M = 676.08$, $SE = 17.83$), 95% CI $[639.80, 712.35]$. The difference was also significant ($M = 37.31$, $SE = 11.24$), 95% CI $[14.44, 60.17]$, $p = .002$. This means that there was a facilitation effect for location at the 150 ms SOA for both color conditions.

**Color pairwise comparisons.**

Participants in the 350 ms SOA for the same location had slower reaction times for the same color ($M = 657.13$, $SE = 19.45$), 95% CI $[617.57, 696.70]$ than the different color condition ($M = 632.21$, $SE = 16.73$), 95% CI $[598.18, 666.24]$. The difference was
significant ($M = 24.93, SE = 10.85$), 95% CI [2.85, 47.00], $p = .028$. There was color inhibition occurring at the same location at the 350 ms SOA.

However, color facilitation took place at the different location in the 700 ms SOA. Participants were faster to respond to the same color condition ($M = 642.52, SE = 15.70$), 95% CI [610.57, 674.47] than the different color condition ($M = 661.77, SE = 17.88$), 95% CI [625.39, 698.15]. The difference was significant as well ($M = 19.25, SE = 7.23$), 95% CI [4.53, 33.97], $p = .012$.

### Table 10
*Experiment 2: SOA Breakdown Showing Facilitation (Green) and Inhibition (Red).*

<table>
<thead>
<tr>
<th>Location</th>
<th>150 ms</th>
<th>350 ms</th>
<th>700 ms</th>
<th>1500 ms</th>
</tr>
</thead>
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<td>Facilitation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Different Color</td>
<td>Facilitation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td>Location</td>
<td>Inhibition</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>IOR Score = Different Location – Same Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 ms SOA</td>
<td>350 ms SOA</td>
</tr>
<tr>
<td>Same Color</td>
<td>Different Color</td>
</tr>
<tr>
<td>31*</td>
<td>37*</td>
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<table>
<thead>
<tr>
<th>700 ms SOA</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Same Color</td>
<td>Different Color</td>
</tr>
<tr>
<td>3</td>
<td>-18</td>
</tr>
</tbody>
</table>
Table 12

Experiment 2: Color IOR Score = Different Color – Same Color

<table>
<thead>
<tr>
<th>SOA</th>
<th>Same Location</th>
<th>Different Location</th>
<th>Same Location</th>
<th>Different Location</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>150 ms SOA</strong></td>
<td>6</td>
<td>12</td>
<td>-12</td>
<td>-25*</td>
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<tr>
<td><strong>700 ms SOA</strong></td>
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<td></td>
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<tr>
<td><strong>1500 ms SOA</strong></td>
<td>11</td>
<td></td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

**Breakdown by SOA: Summary.**

The analyses showed that facilitation took place once again for location at the 150 ms SOA. However, for color, inhibition took place earlier for the same location: at the 350 ms SOA, rather than at the 1500 ms SOA in experiment 1. There was also facilitation at the 700 ms SOA for the same color. It could be that for the same location, inhibition has already run its course. For the different location, color IOR could have already started and finished its trajectory or just started, but this cannot be confirmed either way.

**IOR Score Breakdown**

The same procedure was followed as in experiment 1 to identify and remove outliers. The location and color IOR scores were calculated by subtracting the same condition from the different condition for each one.

**Location IOR.**

For experiment 2, a Two-Way Analysis of Variance was conducted, with two levels of location (for same color, different color) and four levels of SOA (150 ms, 350 ms, 700 ms, 1500 ms). This created a 2 x 4 Repeated Measures Within-Subjects design. All tests used an alpha level of .05. The purpose of this analysis is to detect any overall changes in IOR for color or SOAs across the conditions. Focus was placed on the main effects analyses and post-hoc pairwise comparisons at each SOA.
Significant main effects.

In experiment 2, like in experiment 1, a significant main effect for SOA, $F(3, 99) = 6.10, p = .001, \eta^2_p = 0.156$ was observed. This means that there was a difference between the reaction times to the same location and to the different location across the SOAs. Overall, participants were faster to respond to the 150 ms SOA, which is confirmed by the positive IOR score. The 150 ms SOA ($M = 34.20, SE = 8.39$), 95% CI [17.12, 51.28] was significantly different from the 350 ms SOA ($M = 5.84, SE = 6.82$), 95% CI [-8.04, 19.71], the 700 ms SOA ($M = -7.55, SE = 8.24$), 95% CI [-24.32, 9.21], and the 1500 ms SOA ($M = 4.63, SE = 8.44$), 95% CI [-12.53, 21.79]. Since the highest, most positive score was in the 150 ms SOA, this hints that the trend from facilitation towards inhibition took place afterwards, around the 350 ms SOA.

The main effect of the location score, $F(1, 33) = 1.81, p = .187, \eta^2_p = .052$ and the interaction effect were not significant, location score * SOA, $F(3, 99) = 0.62, p = .607, \eta^2_p = .018$, respectively. Nonetheless, subsequent analyses were carried out at each level of SOA (Iacobucci, 2001).

Pairwise comparisons.

One-way ANOVAs were conducted for each level of SOA, but none of them were statistically significant, 150 ms SOA, $F(1, 33) = 0.162, p = .69, \eta^2_p = .005$, 350 ms SOA, $F(1, 33) = 0.59, p = .448, \eta^2_p = .018$, 700 ms SOA, $F(1, 33) = 3.34, p = .077, \eta^2_p = .092$, and 1500 ms SOA, $F(1, 33) = 0.03, p = .869, \eta^2_p = .001$. These results are in contrast to those in experiment 1 where there was an amplification effect at the different color condition in the 700 ms SOA. Here, the results show the size of IOR did not change drastically across the SOAs: the difference between the same color and did color were similar across SOAs.
Color IOR

For color IOR score, a Two-Way Analysis of Variance was performed with two levels of color (for same location, different location) and four levels of SOA (150 ms, 350 ms, 700 ms, 1500 ms), SOA, $F(3, 99) = 3.66$, $p = .015$, $\eta_p^2 = .100$. For this 2 x 4 Repeated Measures
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Within-Subjects design, an alpha level of .05 was used for all tests. This was conducted such that any overall changes, in IOR score for location or SOAs across the conditions, can be detected. Examining the main effects and conducting post-hoc pairwise comparisons at each SOA was important for the analysis.

**Significant main effects.**

A simple main effect was statistically significant for SOA, \( F(3, 99) = 3.66, p = .015, \eta_p^2 = .100 \), as expected since the participants were responding to the color of the objects, rather than the location. The 350 ms SOA \( (M = -18.47, SE = 8.14) \), 95% CI [-35.03, -1.91] has the largest negative mean RT when compared to the rest of the SOAs: 150 ms SOA \( (M = 9.38, SE = 5.79) \), 95% CI [-2.39, 21.15], 700 ms SOA \( (M = 8.40, SE = 4.85) \), 95% CI [-1.47, 18.27], and 1500 ms SOA \( (M = 10.09, SE = 9.04) \), 95% CI [-8.30, 28.49].

The main effect for color differences \( F(1, 33) = 1.81, p = .187, \eta_p^2 = .052 \), was not statistically significant. The interaction effect was also not significant, color differences * SOA, \( F(3, 99) = 0.62, p = .607, \eta_p^2 = .018 \). Analyses were carried out at each level of SOA, subsequently.

**Pairwise comparisons.**

The analysis was followed by One-Way ANOVAs for each level of SOA. The difference in RTs between the same and different locations at the 150 ms SOA \( F(1, 33) = 0.16, p = .690, \eta_p^2 = .005 \), 350 ms SOA \( F(1, 33) = 0.59, p = .448 \) partial, Eta Squared = .018, 700 ms SOA cIOR, \( F(1, 33) = 3.34, p = .077, \eta_p^2 = .092 \), and 1500 ms SOA \( F(1, 33) = 0.03, p = .869, \eta_p^2 = .001 \) were not statistically significant. The difference between the different location and same location did not vary across the SOAs.
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Figure 16. Color IOR. Note: SOA is measured in milliseconds. Color IOR = different color (RTs) – same color (RTs).

Figure 17. Breakdown of Color IOR by the same location and different location. Note: SOA is measured in milliseconds. Breakdown of Color IOR = different color (RTs) – same color (RTs). *p < .05
Breakdown by IOR score: Summary.

Table 13

Breakdown by IOR Score. Green denotes facilitation. Red denotes inhibition.

<table>
<thead>
<tr>
<th></th>
<th>150 ms</th>
<th>350 ms</th>
<th>700 ms</th>
<th>1500 ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

The analyses on the IOR score for location and color showed that there was a general facilitation effect at the 150 ms SOA and an inhibition effect at the 350 ms SOA. Given that the IOR score is the difference between the same and different condition, significance at the 150 ms SOA shows that the facilitation effect was stronger than at the other SOAs. Likewise, the significant inhibition at the 350 ms SOA was stronger than at the other SOAs. There is no breakdown in these results between the same and different conditions because there were no differences. This could imply that location and color features occurred separately.

Experiment 2: Error Rates

Analyses were conducted on the error rates. As previously mentioned the literature shows a link between inhibition and an increase in error rates. Error rates would help complement the data.
Significant main effects and interactions.

Only two effects were significant. The Location * color interaction, $F(1, 33) = 6.16, p = .018$, and the SOA * location * color interaction were statistically significant, $F(3, 99) = 3.95, p = .010$.

Location pairwise comparisons.

The main effect at the 350 ms SOA was statistically significant, $F(1, 33) = 4.22, p = .048$, when the color was the same. Participants had a higher accuracy rate in the same location ($M = 15.71, SE = 0.09$), 95% CI = [15.52, 15.89] than in the different location ($M = 15.44, SE = 0.14$), 95% CI = [15.15, 15.73]. The difference was 0.27 ($SE = 0.13$), 95% CI = [0.00, 0.53].

The main effect at the 350 ms SOA was also significant when the color was different, $F(1, 33) = 8.73, p = .006$. Participants had a higher accuracy rate in the same location ($M = 15.71$), 95% CI = [15.52, 15.89] than in the different location ($M = 15.44$), 95% CI = [15.15, 15.73].

Figure 18. Experiment 2: Breakdown of Error Rates by SOA
15.65, SE = 0.13), 95% CI = [15.38, 15.92] than in the different location (M = 15.18, SE = 0.16), 95% CI = [14.85, 15.50]. The difference was 0.47 (SE = 0.16), 95% CI = [0.15, 0.80].

The 1500 ms SOA was statistically significant, $F(1, 33) = 8.74, p = .006$ when the color was different. Participants had higher accuracy rates in the same location (M = 15.62, SE = 0.12), 95% CI = [15.37, 15.86] than in the different location (M = 14.97, SE = 0.20), 95% CI = [14.57, 15.37]. The difference between the two was 0.65 (SE = 0.22), 95% CI = [0.20, 1.09).

**Color pairwise comparisons.**

The 1500 SOA was also statistically significant, $F(1, 33) = 12.39, p = .001$ at the different location, where the same color had a higher accuracy (M = 15.65, SE = 0.09), 95% CI = [15.46, 15.84] than the different color condition (M = 14.97, SE = 0.20), 95% CI = [14.57, 15.37]. The difference was 0.68 (SE = 0.19), 95% CI = [0.29, 1.07].

**Error analysis: Summary.**

<table>
<thead>
<tr>
<th>350 ms SOA</th>
<th>Color</th>
<th>Location</th>
<th>Same Color</th>
<th>Different Color</th>
</tr>
</thead>
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<td></td>
<td></td>
<td>Same Location</td>
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<td>❌</td>
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<tr>
<td></td>
<td></td>
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<td>❌</td>
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</table>

<table>
<thead>
<tr>
<th>1500 ms SOA</th>
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<tr>
<td></td>
<td></td>
<td>Different Color</td>
<td>✔</td>
</tr>
</tbody>
</table>

In experiment 2, the 350 ms SOA has the same pattern of error rates like the 350 ms SOA in experiment 1. In both, facilitation occurs at the 150 ms SOA, but there is a significant change in error rates at the 350 ms SOA. It is likely the error rates represent participants making mistakes when it comes to responding to the color of targets. Since the accuracy rate
is higher for the same location, and this pattern is repeated across experiment 1 and 2, this is a reasonable explanation. Reaction times tend to be faster and more accurate when the location between the cue and target match. Following this logic the pattern observed at the 1500 ms SOA could represent facilitation taking place again. Referring back to the Breakdown of SOA section, this seems to be the case.

**Discussion**

In experiment 2, facilitation of location was observed at the 150 ms SOA and this facilitation is not surprising given that spatial properties of attention tend to be robust. Unlike in experiment 1, inhibition of location was not observed; given that color IOR was this implies that non-spatial IOR interacted with spatial IOR. A combination of location and color effects were expected. Furthermore, while in experiment 1 color IOR was observed at the different location, in this experiment it was observed at the same location, in line with the literature. In retrospect, this could either be due to insignificant inhibition effects of color at the different location or that the inhibition of color took place at a longer time interval.

Overall, the IOR scores show there was a strong facilitation effect at the 150 ms SOA for location and there was a strong inhibition effect at the 350 ms SOA for color. The high accuracy rates coincide with the facilitation effect observed at the 150 ms SOA for location. A similar pattern was observed across experiments 1 and 2, whereby the accuracy rates coincide with the location errors, rather than the color errors.

While it was unexpected to not find color inhibition at the different location, interesting results were uncovered nonetheless. It seems that location and color do interact and that color IOR might not show signs of facilitation. A replication of experiment 2 was conducted with a different object as well.
Replication Study

Experiment 2 was run again using a different stimulus in order to test its generalizability on objects with colors which are not consistent, i.e. not fully red, nor fully green, but with darker shadows. The same procedure was followed as in experiment 2, except that a basket replaced the bowl used in experiments 1 and 2. There were 50 participants recruited on Amazon M-Turk, but 4 removed due to high error rates and unusual reaction times. The average age was 35.24 years (SD = 10.16).

Table 15

<table>
<thead>
<tr>
<th></th>
<th>150 ms</th>
<th>350 ms</th>
<th>700 ms</th>
<th>1500 ms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
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<td>683.39</td>
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</tbody>
</table>

Figure 19. Example of stimuli used in experiment 2 replication.
Significant main effects and interactions.

There was a significant main effect of SOA, $F(3, 126) = 5.58, p = .001, \eta^2_p = .117,$ with a similar trend as that observed in experiment 2. There was first an overall decrease in reaction times starting from the 150 ms SOA ($M = 695.19, SE = 15.47$), 95% CI [663.96, 726.41]; to the 350 ms SOA ($M = 680.81, SE = 16.35$), 95% CI [647.82, 713.81]; subsequently there was an increase in reaction times at the 700 ms SOA ($M = 688.08, SE = 14.27$), 95% CI [659.29, 716.88]; until the 1500 ms SOA ($M = 706.46, SE = 17.05$), 95% CI [672.04, 740.88]. The highest mean RT for the 1500 ms SOA was significantly different from

Figure 20. Breakdown of SOAs in experiment 2 replication.
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the lowest mean RT of the 350 ms SOA. The difference was 25.65 ms ($SE = 6.59$), 95% CI [7.40, 43.89], $p = .002$.

The main effect of location, $F(1, 42) = 8.81, p = .005$, $\eta_p^2 = .173$ was significant. Overall participants had a higher reaction time in the different location ($M = 697.74, SE = 15.69$), 95% CI [666.08, 729.39] than the same location ($M = 687.535, SE = 15.11$), 95% CI [657.04, 718.02]. The difference was 10.20 ms ($SE = 3.44$), 95% CI [3.27, 17.14], $p = .005$

The main effect of color, $F(1, 42) = 3.92, p = .054$, $\eta_p^2 = .085$, was also significant. Overall, the same color ($M = 696.904, SE = 16.226$), 95% CI [664.158, 729.65], $p = 0.005$, had a higher RT than the different color ($M = 688.366, SE = 14.646$), 95% CI [658.81, 717.92], $p = .005$, with a difference reaching significance ($M = 8.54, SE = 4.31$), 95% CI [-0.16, 17.24], $p = .054$.

**Pairwise comparisons.**

There was location facilitation in the 150 ms SOA same color condition, with participants having a higher mean reaction time in the different location condition ($M = 719.36, SE = 18.56$), 95% CI [681.94, 756.79] than in the same location condition ($M = 692.886, SE = 17.77$), 95% CI [657.051, 728.72]. The difference was significant ($M = 26.48, SE = 9.93$), 95% CI [6.46, 46.50], $p = .011$.

There was also a facilitation at the 350 ms SOA same color, with the different location ($M = 707.39, SE = 17.36$), 95% CI [672.42, 742.36], having a higher mean RT ($M = 25.63, SE = 10.58$), 95% CI [4.33, 46.93], $p = .019$, than the same location ($M = 681.76, SE = 19.01$), 95% CI [643.47, 720.06]. Similarly, a facilitation effect was observed at the 350 ms different color, where participants had lower reaction times in the different location ($M = 706.24, SE = 18.92$), 95% CI [668.12, 744.37] than in the same location condition ($M =
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677.71, $SE = 17.94$, 95% CI [641.55, 713.87]. The difference was significant ($M = 28.53$, $SE = 10.27$), 95% CI [7.83, 49.24], $p = .008$.

Summary.

A similar trend was observed in the replication experiment, however, the location inhibition was delayed. No color IOR was observed, but this was potentially delayed since the location IOR was delayed. There was clear facilitation of location, from 150 ms, but especially at the 350 ms SOA.

Table 16

Experiment 2 Replication: SOA Breakdown Showing Facilitation (Green) and Inhibition (Red).

<table>
<thead>
<tr>
<th>Location</th>
<th>150 ms</th>
<th>350 ms</th>
<th>700 ms</th>
<th>1500 ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same Color</td>
<td>Facilitation</td>
<td>Facilitation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Different Color</td>
<td></td>
<td>Facilitation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td>Same Location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Different Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 17

Experiment 2 Replication: Location IOR Score = Different Location – Same Location

<table>
<thead>
<tr>
<th>Location IOR Size</th>
<th>150 ms SOA</th>
<th>350 ms SOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same Color</td>
<td>36*</td>
<td>21</td>
</tr>
<tr>
<td>Different Color</td>
<td>26*</td>
<td>23*</td>
</tr>
<tr>
<td>700 ms SOA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Same Color</td>
<td>-6</td>
<td>-2</td>
</tr>
<tr>
<td>Different Color</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 18

Experiment 2 Replication: Color IOR Score = Different Color – Same Color

<table>
<thead>
<tr>
<th>Color IOR Size</th>
<th>150 ms SOA</th>
<th>350 ms SOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same Location</td>
<td>-1</td>
<td>-16</td>
</tr>
<tr>
<td>Different Location</td>
<td>2</td>
<td>-1</td>
</tr>
<tr>
<td>700 ms SOA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Same Location</td>
<td>-12</td>
<td>-8</td>
</tr>
<tr>
<td>Different Location</td>
<td>-9</td>
<td>-10</td>
</tr>
</tbody>
</table>
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Breakdown of IOR: Replication Study

As in experiment 2, there was a significant main effect of SOA, $F(3, 126) = 6.43, p = .000$, $\eta^2_p = .133$ for location IOR. Participants had a larger IOR score at the 150 ms SOA ($M = 22.65, SE = 6.08$), 95% CI [10.39, 34.92] when compared to the 700 ms SOA ($M = -8.63, SE = 7.32$), 95% CI [-23.40, 6.14]. The difference was significant ($M = 31.28, SE = 10.72$), 95% CI [1.61, 60.95].

There was also a difference between the 350 ms SOA where participants had a larger IOR score ($M = 29.72, SE = 8.71$), 95% CI [12.14, 47.30] than the 700 ms SOA. The difference was significant ($M = 38.35, SE = 10.12$), 95% CI [10.32, 66.38]. Participants had a larger IOR score for the 350 ms SOA than the 1500 ms SOA, ($M = -2.94, SE = 6.80$), 95% CI [-16.67, 10.79]. The difference was significant $M = 32.66, SD = 9.66$), 95% CI [5.90, 59.42].

For color IOR, there were no main significant effects, nor a significant interaction effect.

IOR Breakdown: Summary

*Table 19*

Breakdown by IOR Score. Green = Facilitation.

<table>
<thead>
<tr>
<th>Location</th>
<th>150 ms</th>
<th>350 ms</th>
<th>700 ms</th>
<th>1500 ms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>■</td>
<td>■</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The results in this replication point to the presence of Location IOR. However, the overall RTs were longer than usual in this study. The lack of a color IOR presence may be due to the delayed Location IOR. It could also be likely that the shadows of the images of the basket, in both the red and green versions, were similar and did not provide enough of a contrast.
**Error Rates**

<table>
<thead>
<tr>
<th>Location</th>
<th>SOA 150 ms</th>
<th>SOA 350 ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same Location</td>
<td>15.68, SE = 0.09, 95% CI = [15.49, 15.86]</td>
<td>15.51, SE = 0.09, 95% CI = [15.31, 15.71]</td>
</tr>
<tr>
<td>Different Location</td>
<td>15.31, SE = 0.12, 95% CI = [15.07, 15.54]</td>
<td>15.12, SE = 0.12, 95% CI = [14.88, 15.36]</td>
</tr>
</tbody>
</table>

*Significant main effects and interactions.*

The main effect of location was statistically significant, $F(1, 45) = 6.17, p = .017$. Participants scored more accurate responses in the same location ($M = 15.68, SE = 0.09$), 95% CI = [15.49, 15.86] than in the different location ($M = 15.31, SE = 0.12$), 95% CI = [15.07, 15.54]. The difference was 0.37 ($SE = 0.11$), 95% CI = [0.15, 0.58].

Overall, the same location was higher in accuracy ($M = 15.68, SE = 0.09$), 95% CI = [15.49, 15.86] than the different location ($M = 15.31, SE = 0.12$), 95% CI = [15.07, 15.54]. The difference was 0.37 ($SE = 0.11$), 95% CI = [0.15, 0.58].

The SOA * color interaction was statistically significant, $F(3, 135) = 3.40, p = .020$. 

---

**Figure 21. Experiment 2 Replication: Breakdown of Error Rates by SOA**
Location pairwise comparisons.

The main effect for the 700 ms SOA was statistically significant, when the color was different, $F(1, 45) = 4.20, p = .046$. There was a higher accuracy rate in the same location ($M = 15.57, SE = 0.19), 95\% CI = [15.19, 15.94]$ than in the different location ($M = 15.28, SE = 0.18), 95\% CI = [14.93, 15.64]. The difference was $0.28 (SE = 0.14), 95\% CI = [0.01, 0.56].$

Color pairwise comparisons.

The main effect for the 350 ms SOA was statistically significant, $F(1, 45) = 4.34, p = .043$, when the location was different. The same color was in lower accuracy ($M = 15.15, SE = 0.24), 95\% CI = [14.68, 15.63]$ than the different color ($M = 15.54, SE = 0.13), 95\% CI = [15.28, 15.81]. The difference was significant ($M = .39, SE = 0.19), 95\% CI = [0.01, 0.77].$

Table 20

Summary of Error Rates

<table>
<thead>
<tr>
<th>350 ms SOA</th>
<th>Color</th>
<th>700 ms SOA</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td></td>
<td>Location</td>
<td></td>
</tr>
<tr>
<td>Same Color</td>
<td>Same Location</td>
<td>Different Location</td>
<td>×</td>
</tr>
<tr>
<td>Different Color</td>
<td>Same Location</td>
<td>Different Location</td>
<td>✓</td>
</tr>
</tbody>
</table>

Discussion

The replication of experiment 2 displayed the same pattern as experiment 1 with respect to location facilitation, but it seemed to have taken place at the 350 ms SOA. Color IOR was not observed. One likely reason for this is that the image of the stimulus was unsuitable. The image contained dark shadows in both the red and green versions. This could have reduced the ability of the participants to quickly differentiate between the two colors.

While location facilitation was observed, no location inhibition took place, which might be explained by the change in worker requirements on Amazon Turk group. Amazon
Turk offers the option to hire workers that have already successfully completed a certain number of tasks (also known as Human Intelligence Tasks). This ensures the quality of the worker is verified: the more successful tasks, the higher the likelihood the worker has done a good job in the past. For the replication 2 experiment, the requirements were changed from number of HITs (Human Intelligence Task) “approved greater than or equal to 1000” to number of HITs “approved greater than or equal to 50”. The number of HITs refers to the number of tasks completed and approved by Amazon Turk. It could be that the group of workers were less experienced than the other groups.

While this study did not confirm the color IOR studies observed in experiment 2, it did show that location facilitation is robust. In experiment 3, 48 unique objects were used to test the effect of location and color on real world objects.
Chapter 6: Experiment 3, From Attention to Preference

Introduction

So far, in experiment 1 both location and color IOR are manifested. There is a clear facilitation effect, followed by an inhibition effect for location. The cross-over point occurs at the 350 ms SOA, which is in line with the literature. For color, however, only an inhibition effect is recorded at the 700 ms SOA. As previously mentioned, a lack of facilitation is not necessarily an important component in order to observe inhibition. The instructions of the task where changed in experiment 2 and participants had to respond based on the color of the target, rather than its location. In this experiment, facilitation of location occurs, but there is no inhibition. While there is inhibition of color, this happens sooner: at the 350 ms SOA. This finding is not unusual because non-spatial features in the literature have been reported to either be shorter or longer in duration than spatial ones.

The change in the IOR trajectories between experiment 1 and 2 shows that task instructions are important. In experiment 3 participants are required to indicate the color of the target, like they did in experiment 2. The difference is two-fold. First, that they are shown unique images, rather than the same image on each trial. The purpose of this is to understand the role that IOR plays on different unique objects even though the literature has shown that the same stimuli can be used repeatedly to observe this effect. However, the flexibility of IOR can be tested on multiple, real world objects: it helps to minimize the robust effects of choosing an optimal stimulus (see Appendix A). Second, in this experiment participants had to indicate the extent to which they like the target, on half of the trials. The combination of multiple real-world objects and preference rating makes this task more complex and is hoped to increase the ecological validity of applying IOR beyond the laboratory.

Experiment 3 is also designed to understand whether and how IOR affects preferences, given the strong link in the literature between attention and liking (Bornstein &
D'Agostino, 1992; Bornstein & D'Agostino, 1992; Janiszewski, 1988, 1993; Janiszewski & Meyvis, 2001; Zajonc, 1968; Zajonc, 2016). The literature has shown that the more processing a stimulus undergoes, the more it is preferred. Active awareness of the stimulus is not essential in building a preference for it. The next question emerges: since attention can be facilitated or inhibited by the Inhibition of Return mechanism, would this modulation have an impact on preferences as well? Given that response times, which have been a good measure of attention for decades, are either increased or decreased as a result of IOR, so then preferences toward the target can be increased or decreased.

The work so far on IOR has investigated the effects that non-neutral content, like happy faces or scary spiders, has on its trajectory. However, this experiment explores the reverse: the effect that IOR has on neutral content and whether it can change the neutrality into preference. Given that attention is enhanced at shorter SOAs, while inhibited at relatively longer SOAs, it is expected that preferences for targets at the shorter SOAs would also be more positive while preferences for targets at the longer SOAs would be less positive.

The faster response times in the first two experiments have been associated with higher rates of response accuracy. While some research has suggested that faster response rates do not allow ample time for attentional processing, the results obtained in the first two experiments suggest otherwise. These have been confirmed by recent studies which link faster response times to enhanced attentional processing (Redden et al., 2016). Therefore, the presence of higher response rates with facilitation in addition to the link between attention and preferences leads to this third experiment.
Hypotheses

**H3a**: Objects appearing in the same location (color) as the cue will not only result in quicker reaction times, when the timing between the two is 150 ms, but also be evaluated positively.

**H3b**: Objects appearing in the same location (color) as the cue, will not only result in slower reaction times, when the timing between the two is 350 ms or longer, but also be evaluated less positively.

---

### Methods

A pilot study was run on 10 participants to check that all of the trials across the four versions were equally represented. In addition, three pre-tests were carried out in order to assess the validity of the objects. In part 1, there were 2 pre-tests with 38 participants and 34 participants, and in part 2 there were 35 participants. For part 1, participants had to rate the
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extent to which they recognize the image in the stimulus from 0 to 100, where 0 means it is easy to recognize and 100 means it is difficult to recognize. They were also asked to write the name of the object. Each correct answer received one score. The total was calculated and compared across the objects. Standard deviations were taken into consideration, however, most objects were well within one standard deviation of the mean. In part 2, participants had to indicate the extent to which they like an image, from strongly dislike to strongly like on a Likert scale, with a neutral option. The mean and standard deviation was used in assessing the most neutral objects. Finally, two sub-scores were compiled for 126 images. One score for recognition and one score for preference. These final score was taken into consideration to choose the items that were the most recognizable and as neutral as possible.

For the main experiment, a total of 58 participants were tested with an average age of 34.04 years (SD = 8.68). A total of four participants were removed for the SOA breakdown and IOR score analysis section due to their reaction times measuring 2.5 standard deviations above or below the mean. These participants also had high error rates. RTs below 150 ms were removed because these indicate premature responses. For the preference analysis section, the scores for 47 participants was used because 8 of them clicked in the same place, or very near the same place, on the line. It was very unlikely that a participant would be able to do so, unless they did not move their mouse away from the preference line.

There were four versions of this experiment, but the 1500 ms SOA was removed in order to reduce participant fatigue given that on half of the trials participants had an extra set of instructions: to indicate their preference for the target. The rated images were balanced across each time SOA: two images were rated in each SOA in each block. Numbergenerator.org was used to generate a random order for the numbers 1 to 48 for the items (see appendix).
Participants in Experiment 3 were asked to indicate to what extent they liked an image. Only half the images were rated. A line appeared below the image. The X-Axis coordinates for the preference line that participants had to click on with a mouse ranged from -300 to 300 pixels. By clicking on the far left, participants would indicate that they strongly dislike it, by clicking on the far right, they would indicate that they strongly like it, and by clicking in the middle, they would indicate that they are neutral towards it. The scores in the graphs before were computed in the same way as they have been for the location and color IOR results in experiments 1 and 2. This experiment produced two main scores: one score for RT towards the color of the object, and one score for the preference towards it.

**Experiment 3: SOA Breakdown**

*Table 21*

*Experiment 3: Meant RTs (Dependent Variables)*

<table>
<thead>
<tr>
<th>Location</th>
<th>Color</th>
<th>150 ms M</th>
<th>150 ms SD</th>
<th>350 ms M</th>
<th>350 ms SD</th>
<th>700 ms M</th>
<th>700 ms SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same Location</td>
<td>Same Color</td>
<td>718.67</td>
<td>151.67</td>
<td>709.07</td>
<td>158.09</td>
<td>762.89</td>
<td>175.43</td>
</tr>
<tr>
<td></td>
<td>Different Color</td>
<td>783.02</td>
<td>194.01</td>
<td>723.2</td>
<td>158.62</td>
<td>722.3</td>
<td>142.25</td>
</tr>
<tr>
<td>Different Location</td>
<td>Same Color</td>
<td>738.54</td>
<td>160.78</td>
<td>757.2</td>
<td>146.86</td>
<td>732.06</td>
<td>170.53</td>
</tr>
<tr>
<td></td>
<td>Different Color</td>
<td>748.76</td>
<td>164.97</td>
<td>719.3</td>
<td>158.22</td>
<td>712.81</td>
<td>160.02</td>
</tr>
</tbody>
</table>
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Figure 24. Breakdown of SOAs in experiment 3.
Significant main effects and interactions.

The main effect of SOA, $F(2, 106) = 3.46, p = .035, \eta_p^2 = .061$, was significant in experiment 3. The pattern was also similar across experiments in that participants had a slower response time in the 150 ms SOA ($M = 747.25, SE = 19.37$), 95% CI [708.41, 786.09] than the 350 ms SOA ($M = 727.19, SE = 18.09$), 95% CI [690.91, 763.48]. The response times then rose again for the 700 ms SOA ($M = 732.51, SE = 19.50$), 95% CI [693.41, 771.62]. The difference between the 150 ms and 350 ms SOA was not significant different, ($M = 20.05, SE = 8.13$), 95% CI [-0.04, 40.14], $p = .051$, but it trended towards significance.

The location * color interaction was significant, $F(1, 53) = 4.11, p = .048, \eta_p^2 = .072$. So was the color * SOA interaction, $F(2, 106) = 6.45, p = .002, \eta_p^2 = .108$. This suggests that location and color features interacted. It also shows that color reaction times varied across the SOAs.

Location pairwise comparisons.

There was a significant location facilitation at the 350 ms SOA for the same color condition. Participants were faster to respond to the same location ($M = 709.07, SE = 21.51$), 95% CI [665.93, 752.22] than the different location ($M = 757.20, SE = 19.99$), 95% CI [717.12, 797.29]. The difference was significant ($M = 48.13, SE = 14.56$), 95% CI [18.92, 77.34], $p = .002$. There was a trend towards significance for location inhibition at the 700 ms SOA in the same color, $p = .052$.

Color pairwise comparisons.

There was a color facilitation effect at the 150 ms SOA at the same location. Participants were faster to respond to the same color condition ($M = 718.67, SE = 20.64$), 95% CI [677.27, 760.07] than the different color ($M = 783.02, SE = 26.40$), 95% CI [730.07,
The difference was significant \( (M = 64.35, SE = 21.86), 95\% CI [20.50, 108.20], p = .005 \).

Color inhibition took place at the 700 ms SOA at the same location. Participants were slower to respond to the same color \( (M = 762.89, SE = 23.87), 95\% CI [715.01, 810.77] \) than the different color condition \( (M = 722.30, SE = 19.36), 95\% CI [683.47, 761.12] \). The difference \( (M = 40.59, SE = 17.60), 95\% CI [5.30, 75.89], p = .025 \) was significant.

**SOA breakdown: Summary.**

There was a facilitation effect for location and this took place at the 350 ms SOA, and inhibition took place 700 ms SOA (as it trended towards significance at the latter). The location IOR effect in experiment was delayed. Color IOR was large, and in experiment 3 it started at the 150 ms SOA. Inhibition took place at the 350 ms SOA.

---

**Table 22**

*Experiment 3: SOA Breakdown Showing Facilitation (Green) and Inhibition (Red).*

<table>
<thead>
<tr>
<th>Location</th>
<th>150 ms</th>
<th>350 ms</th>
<th>700 ms</th>
<th>1500 ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same Color</td>
<td></td>
<td></td>
<td>Facilitation</td>
<td>(Inhibition)</td>
</tr>
<tr>
<td>Different Color</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td>Same Location</td>
<td>Facilitation</td>
<td></td>
<td>Inhibition</td>
</tr>
<tr>
<td>Different Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Table 23**

*Experiment 3: Location IOR Score = Different Location – Same Location*

<table>
<thead>
<tr>
<th>Location IOR Size</th>
<th>150 ms SOA</th>
<th>350 ms SOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same Color</td>
<td>20</td>
<td>48*</td>
</tr>
<tr>
<td>Different Color</td>
<td>-34</td>
<td>-4</td>
</tr>
<tr>
<td>700 ms SOA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Same Color</td>
<td>-31</td>
<td>-9</td>
</tr>
<tr>
<td>Different Color</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 24

Experiment 3: Color IOR Score = Different Color – Same Color

<table>
<thead>
<tr>
<th>Color IOR Size</th>
<th>150 ms SOA</th>
<th>350 ms SOA</th>
<th>700 ms SOA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Same Location</td>
<td>Different Location</td>
<td>Same Location</td>
</tr>
<tr>
<td>150 ms SOA</td>
<td>64*</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>700 ms SOA</td>
<td>-41*</td>
<td>-19</td>
<td></td>
</tr>
</tbody>
</table>

Breakdown by IOR Score

The same procedure was followed as in experiment 1 and 2 to identify and remove outliers. The location and color IOR scores were calculated by subtracting the same condition from the different condition for each one.

Location IOR.

A Two-Way analysis of Variance was conducted at two levels of location (for same color, different color) and four levels of SOA (150 ms, 350 ms, 700 ms, 1500 ms). This 2 x 4 Repeated Measures Within-Subjects design, with an alpha level of .05 for all tests. This analysis served to detect any overall changes in IOR for color or SOA across the conditions. Main effects were the focal aspect of the analysis in addition to their respective post-hoc pairwise comparisons at each SOA.

Significant main effects.

A main effect of location score, $F(1, 53) = 4.11, p = .048, \eta^2 = .072$, was statistically significant. These results differ from those found in experiments 1 and 2 because the location score is significant here, while the SOAs were significant in the previous two. This means that the IOR score (different – same location) varied significantly between the same and different color conditions. In other words, the location IOR size was not the same in the same...
color as it was in the different color. As shown by Bonferroni post hoc tests, the RTs at the same color condition ($M = 12.39, SE = 9.11$), 95% CI [-5.88, 30.66], were positive and different from the different color condition ($M = -15.88, SE = 9.67$), 95% CI [-35.28, 3.51], which had a negative value. This difference was statistically significant ($M = 28.27, SE = 13.95$), 95% CI [0.29, 56.25].

In this third experiment, in contrast to experiment 1 and 2, the main effect of SOA, $F(2, 106) = 2.40, p = .096, \eta^2_p = .043$, was not significant. Neither was the interaction effect, IOR * SOA, $F(2, 106) = 2.99, p = .055, \eta^2_p = .053$. In order to investigate further, subsequent analyses were carried out at each level of SOA (Iacobucci, 2001).

**Pairwise comparisons.**

For each level of SOA, One-Way ANOVAs were conducted. The 350 ms SOA was statistically significant, $F(1, 53) = 4.53, p = .038, \eta^2_p = .079$. The IOR score for the same color condition ($M = 48.13, SE = 14.56$), 95% CI [18.92, 77.34] was positive score and larger than the IOR score for the different color condition, which was negative ($M = -3.91, SE = 20.72$), 95% CI [-45.46, 37.65]. The difference was significant ($M = 52.04, SE = 24.45$), 95% CI [3.01, 101.07]. In the SOA breakdown section, the 350 ms SOA underwent facilitation. The analysis of IOR size in this section shows that the facilitation was a result of the same color condition, which seemed to drive the facilitation effect.

The other SOAs, 150 ms, $F(1, 53) = 3.44, p = .069, \eta^2_p = .061$, and 700 ms, $F(1, 53) = 1.225, p = .273, \eta^2_p = .023$, did not produce statistically significant results.
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Figure 25
Location IOR. Note: SOA is measured in milliseconds. Location IOR = different location (RTs) – same location (RTs).

Figure 26. Breakdown of Location IOR by same color and different color. Note: SOA is measured in milliseconds. Location IOR = different location (RTs) – same location (RTs). *p < .05.
Color IOR

A Two-Way analysis of variance was conducted with two levels of color (same location, different location) and four levels of SOA (150 ms, 350 ms, 700 ms, 1500 s). This rendered a 2 x 4 Repeated Measures Within-Subjects design, with an alpha level of .05, which was used for all tests. This was done in order to detect overall changes in IOR for location or SOA across the conditions. The main effects, and the post-hoc pairwise comparisons were of interest at each SOA.

**Significant main effects.**

There was a main effect observed for SOA, $F(2, 106) = 6.45, p = .002, \eta_p^2 = .108$, which was statistically significant. The 150 ms SOA had a positive score ($M = 37.29, SE = 13.79$), 95% CI [9.63, 64.94], which was larger than the score in the 350 ms SOA ($M = -11.89, SE = 12.73$), 95% CI [-37.43, 13.65]. The difference was significant ($M = 49.18, SE = 19.53$), 95% CI [0.89, 97.46]. The 150 ms SOA was also larger and more positive than the 700 ms SOA ($M = -29.92, SE = 14.45$), 95% CI [-58.89, -0.94]. The difference was significant ($M = 67.20, SE = 19.52$), 95% CI [18.96, 115.45].

A main effect for location score, $F(1, 53) = 4.11, p = .048, \eta_p^2 = .072$, was also statistically significant in the same color condition which was larger ($M = 28.27, SE = 13.95$), 95% CI [0.29, 56.25] than the different color condition ($M = -15.64, SE = 10.50$), 95% CI [-36.69, 5.41].

The interaction effect was not statistically significant, IOR * SOA, $F(2, 106) = 2.99, p = .055, \eta_p^2 = .053$. Subsequent analyses were conducted at each level of SOA.

**Pairwise comparisons.**

One-Way analyses of variance were conducted at each of SOA. The 350 ms SOA, $F(1, 53) = 4.53, p = .038, \eta_p^2 = .079$, was statistically significant. The same location
condition was larger ($M = 14.13, SE = 16.08$), 95% CI [-18.13, 46.39] than the different location ($M = -37.91, SE = 19.09$), 95% CI [-76.19, 0.38]. The difference was significant ($M = 52.04, SE = 24.45$), 95% CI [3.01, 101.07].

The 150 ms SOA, $F(1, 53) = 3.44, p = .069$, $\eta^2 = .061$, and the 700 ms SOA were not statistically significant, $F(1, 53) = 1.23, p = .273$, $\eta^2 = .023$.

---

**Figure 27.** Color IOR. Note: SOA is measured in milliseconds. Color IOR = different color (RTs) – same color (RTs).

**Figure 28.** Breakdown of Color IOR by the same location and different location. Note: SOA is measured in milliseconds. Breakdown of Color IOR = different color (RTs) – same color (RTs). *$p < .05$
THE ROLE OF VISUAL ATTENTION IN PRODUCT SELECTION

Breakdown by IOR score: Summary.

Table 25

<table>
<thead>
<tr>
<th>Location</th>
<th>Color</th>
<th>150 ms</th>
<th>350 ms</th>
<th>700 ms</th>
<th>1500 ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same Color</td>
<td>Same Location</td>
<td>■</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Different Color</td>
<td>Same Location</td>
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<td>■</td>
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<tr>
<td>Different Location</td>
<td>Different Location</td>
<td>■</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 26

<table>
<thead>
<tr>
<th>Location X-Axis Preference Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 ms SOA</td>
</tr>
<tr>
<td>Same Color</td>
</tr>
<tr>
<td>50*</td>
</tr>
</tbody>
</table>

Table 27

<table>
<thead>
<tr>
<th>Color X-Axis Preference Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 ms SOA</td>
</tr>
<tr>
<td>Same Location</td>
</tr>
<tr>
<td>9</td>
</tr>
</tbody>
</table>

The location facilitation observed in the Breakdown by SOA analysis section for the 350 ms SOA is likely to be driven by facilitation in the same color condition. The reason being that the same color condition had a positive score, denoting facilitation, and the different color condition had a negative score, denoting inhibition. For the color, the different
location has a lower, negative score. When referring to the graph, the 350 ms SOA is the cross-over point between facilitation and inhibition.

**Error Rates**

![Error Rates Graph](image)

*Figure 29. Experiment 3: Breakdown of Error Rates by SOA*

There were no statistically significant differences in experiment 3 in terms of error rates. This could be explained by the fewer number of trials in this experiment, since it was shortened.
THE ROLE OF VISUAL ATTENTION IN PRODUCT SELECTION

Preferences

Table 28

Experiment 3: Mean Preference on X-Axis (Dependent Variables)

<table>
<thead>
<tr>
<th></th>
<th>150 ms</th>
<th></th>
<th>350 ms</th>
<th></th>
<th>700 ms</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Same Color</td>
<td>33.58</td>
<td>165.94</td>
<td>2.24</td>
<td>155.78</td>
<td>36.94</td>
<td>157.75</td>
</tr>
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<td>Different Color</td>
<td>42.94</td>
<td>157.88</td>
<td>31.33</td>
<td>118.05</td>
<td>39.44</td>
<td>140.27</td>
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<td>Different Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Same Color</td>
<td>83.53</td>
<td>155.01</td>
<td>8.64</td>
<td>134.70</td>
<td>65.49</td>
<td>157.83</td>
</tr>
<tr>
<td>Different Color</td>
<td>13.10</td>
<td>143.94</td>
<td>16.33</td>
<td>161.75</td>
<td>71.42</td>
<td>161.77</td>
</tr>
</tbody>
</table>

Figure 30. Breakdown of SOAs in experiment 3 for preferences.
THE ROLE OF VISUAL ATTENTION IN PRODUCT SELECTION

Breakdown by SOA

The main effect of SOA, $F(2, 90) = 7.095, p = 0.001, \eta_p^2 = 0.136$. Participants indicated a higher preference in the 150 ms SOA ($M = 39.28, SD = 17.78$), 95% CI [3.47, 75.1] than the 350 ms SOA ($M = 10.61, SD = 16.58$), 95% CI [-22.79, 44.00]. The preference in the 350 ms SOA was less than that in the 700 ms SOA ($M = 49.60, SD = 19.36$), 95% CI [10.61, 88.58]. The difference between the 150 ms and 350 ms SOA was significant ($M = 28.68, SD = 8.87$), 95% CI [6.62, 50.74], $p = .007$. The difference between the 350 ms SOA and the 700 ms SOA was also significant ($M = 38.99, SD = 11.98$), 95% CI [9.21, 68.77], $p = .006$.

The location * color interaction was significant, $F(1, 45) = 5.687, p = .021, \eta_p^2 = .112$. So was the location*color * SOA interaction, $F(2, 90) = 1.638, p = .200, \eta_p^2 = 0.035$.

Location pairwise comparisons.

At the 150 ms SOA in the same color condition, the participants indicated less preference for stimuli in the same location ($M = 33.58, SD = 24.21$), 95% CI [-15.14, 82.31] than in the different location ($M = 83.53, SD = 22.61$), 95% CI [38.02, 129.04]. The difference is statistically significant ($M = 49.95, SD = 24.38$), 95% CI [0.88, 99.02], $p = .046$.

Color pairwise comparisons.

At the 150 ms SOA in the different location, the participants indicated a greater preference for the same color ($M = 83.53, SD = 22.61$), 95% CI [38.02, 129.04] than the different color ($M = 13.10, SD = 21.00$), 95% CI [-29.16, 55.37]. The difference is statistically significant ($M = 70.43, SD = 23.80$), 95% CI [22.53, 118.32], $p = .005$.

SOA Breakdown: Summary
The role of visual attention in product selection

Table 29

Breakdown for preference score. Note: The darker the color, the higher the preference.

<table>
<thead>
<tr>
<th>150 ms SOA</th>
<th>Same Location</th>
<th>Different Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Same Color</td>
<td>Different Color</td>
</tr>
<tr>
<td></td>
<td>Same Location</td>
<td>Different Location</td>
</tr>
</tbody>
</table>

The participants had a higher preference for the stimuli when they shared the same location and had the same color than when they shared the same location but had a different color. Participants liked the stimuli in the different location with same color more than when it was in the different location. The participants still indicated a preference for the stimuli in the different location, different color condition, but this was the weakest.

**Breakdown by difference in preferences: Location.**

The difference between the different location and the same location was calculated in terms of preference as well. A positive score here denotes less preference for stimuli when the cue and target are in the same location and a negative score denotes more preference for stimuli when they are in the same location. From here on this score will be referred to as the preference score. A Two-Way analysis of Variance was conducted at two levels of preference score (same color, different color) and four levels of SOA (150 ms, 350 ms, 700 ms, 1500 ms). This rendered a 2 x 4 Repeated Measures Within-Subjects design, had an alpha level of .05 for all tests. This analysis served to detect any overall changes in preference for color or SOA across the conditions. Main effects were the focal aspect of the analysis in addition to their respective post-hoc pairwise comparisons at each SOA.
**Significant main effects.**

A main effect of preference score for location, $F(1, 45) = 5.67, p = .022, \eta_p^2 = .112$, was statistically significant. This means that there was a difference in preferences for location at the same color when compared to at the different color. Bonferroni post hoc tests show that the difference in preferences at the same color condition ($M = 32.70, SE = 12.93$), 95% CI [6.66, 58.74], were larger than that at the different color condition ($M = -5.61, SD = 10.67$), 95% CI [-27.10, 15.88]. This difference was statistically significant ($M = 38.30, SE = 16.09$), 95% CI [5.90, 70.71]. This means that there was less preference for stimuli in the same color condition.

**Non-Significant main effects.**

A main effect of SOA, however, was not observed, $F(2, 90) = 1.48, p = .233, \eta_p^2 = .032$. The interaction effect was not statistically significant either, IOR * SOA, $F(2, 90) = 1.65, p = .199, \eta_p^2 = .035$.

**Location pairwise comparisons.**

For each level of SOA, One-Way ANOVAs were run. The 150 ms SOA was statistically significant $F(1, 46) = 7.34, p =.009, \eta_p^2 = .138$. This indicated that there was a significant difference in preference score. The same color condition was higher ($M = 50.11, SE = 24.40$), 95% CI [1.00, 99.22] than the different color ($M = -29.77, SE = 20.03$), 95% CI [-70.09, 10.56]. The difference was significant ($M = 79.87, SE = 29.47$), 95% CI [20.54, 139.20]. These result shows that there was less preference for stimuli which share the same location when the colors matched.

The other SOAs 350 ms $F(1, 45) = 1.21, p = .278, \eta_p^2 = .026$, and 700 ms, $F(1, 46) = 0.02, p = .892, \eta_p^2 = .000$, did not produce statistically significant results.
A Two-Way analysis of variance was carried out for color preference score, with two levels of IOR (for same location, different location) and four levels of SOA (150 ms, 350 ms, 700 ms). This rendered a 2 x 4 Repeated Measures Within-Subjects design, with an alpha level of .05, which was used for all tests. The preference score here is calculated by...
subtracting the same location from the different location preference. This was done in order to detect overall changes in preference scores for color or SOA across the conditions. The main effects, and the post-hoc pairwise comparisons were of interest at each SOA.

**Significant main effects.**

A main effect for color preference score, $F(1, 45) = 5.67, p = .022, \eta^2_p = .112$, was statistically significant. The same color condition had an overall positive score ($M = 16.54, SE = 11.42$), 95% CI [-6.47, 39.54] and was significantly larger than the different color condition ($M = -21.77, SE = 10.20$), 95% CI [-42.31, -1.23]. The difference was significant ($M = 38.30, SE = 16.09$), 95% CI [5.90, 70.71]. This means that the preference for stimuli that share the same color was less than when they do not share the same color.

**Color pairwise comparisons.**

One-Way analyses of variance were conducted at each of SOA, resulting in the 150 ms SOA being statistically significant, $F(1, 46) = 7.344, p = 0.009, \eta^2_p = 0.138$. The same location condition had a positive preference score ($M = 9.38, SE = 21.45$), 95% CI [-33.80, 52.56], which was larger than the different location ($M = -70.49, SE = 23.81$), 95% CI [-118.41, -22.57]. This was significantly different ($M = 79.87, SE = 29.47$), 95% CI [20.54, 139.20].

**Other non-significant effects.**

The main effect of SOA, $F(2, 90) = 2.40, p = .096, \eta^2_p = .051$, and the interaction effect were not statistically significant, IOR * SOA, $F(2, 90) = 1.65, p = .199, \eta^2_p = .035$. Subsequent analyses were conducted at each level of SOA.
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**Figure 33.** Color IOR. Note: SOA is measured in milliseconds. Color IOR = different color (RTs) – same color (RTs).

**Figure 34.** Breakdown of Color IOR by the same location and different location. Note: SOA is measured in milliseconds. Breakdown of Color IOR = different color (RTs) – same color (RTs). *p < .05
Preference score: Summary.

Table 30


<table>
<thead>
<tr>
<th>150 ms SOA</th>
<th>Same Location</th>
<th>Different Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Same Color</td>
<td>■ ■</td>
<td>■ ■</td>
</tr>
<tr>
<td>Different Color</td>
<td>■ ■</td>
<td>■ ■</td>
</tr>
</tbody>
</table>

The results show that in the 150 ms SOA, participants preferred the different location stimuli to the same location stimuli. That is, when the cue and target do not share the same location, there is a higher preference for the target than when the cue and target share the same location. Furthermore, the participants preferred the different color stimuli to the same color stimuli.

Discussion

In experiment 3, unique real world objects were introduced. The complexity of the task was also increased by requiring participants to indicate their preference for targets on half of the trials. The results indicate that color IOR occurred. The facilitation effect begun at the 150 ms SOA and the inhibition effect took place at the 700 ms SOA. This is similar to the trajectory of location IOR in the first experiment. However, inhibition of color was observed at the same location, not at the different location.

Location IOR took place at the 350 ms SOA and the effect of inhibition was trending towards significant at the 700 ms SOA. The IOR scores suggest that facilitation for the same color and same location is driving these differences at the 350 ms SOA, while inhibition is driving these differences for the different color and different location at the 350 ms SOA.
Overall, this suggests that color features are stronger than the location features since it is expected for the same color to be facilitated at early SOAs. No differences in errors were detected possibly because there were not enough unique trials per participant or that error rates are usually associated with spatial IOR, as previously seen.

In terms of preferences there were stronger preferences for stimuli with the same color overall. Those in the different location were liked better than those in the same location. This suggests that preferences were linked to the color of stimuli, rather than their locations.
Chapter 7: General Discussion

Non-spatial features of IOR were observed independently of spatial ones. The trajectory of color IOR was affected by the timing and type of stimuli, in addition to the task instructions. These results validated the purpose of the project, which was to show that attention can be enhanced and inhibited in the span of one second, although the link between attention and preferences did not provide conclusive results.

Specifically, experiment 1 showed evidence of location facilitation at the short time delay (150 ms). Non-spatial (color) IOR was observed when the distraction (cue) and target did not share the same location. Likewise, in experiment 2 there was evidence of color IOR when the cue and target did not share the same location, although this took place earlier: at the 350 ms SOA. There was no location inhibition. Finally, in experiment 3, the color IOR trajectory became more clear and prominent, while the trajectory of the location IOR shifted. In contrast to the first experiment, color facilitation was observed at the 150 ms time delay and color inhibition at the 700 ms time interval. Location facilitation was observed at the 350 ms SOA. Only in the shortest time interval were preferences higher targets that shared the same color as the cue, but this was observed at the different location only.

From Pixels to Products

The purpose of experiment 1 is to assess whether IOR can be applied to real-world objects and to a setting that, to some extent, resembles an online context without sacrificing the simplicity of the experimental design. The rationale for expanding the size of the stimuli is two-fold. The first is to increase the relevance of the task (Corbetta & Shulman, 2002) by emulating the size of ads and products that can be encountered while browsing. Since the original setup (Posner & Cohen, 1984), stimuli have been created for laboratory use, programed to be the size of a few pixels on a computer screen. The closest stimuli to resemble the real world were outlines and shapes of drawn objects (Paul & Tipper, 2003).
The second is to use complex stimuli, not simple ones, such that there will be a distinction between the cue and target (Taylor & Donnelly, 2002). This ensures that the cue-target paradigm can be used appropriately.

The most essential analyses were the ones that investigated pairwise comparisons within each SOA. While there were significant main effects of color and SOA, the lack of a three-way interaction effect was not problematic because IOR must be analyzed within each SOA separately. To echo the calculations executed in the methods section, in which inhibition is calculated by subtracting the same location from the different location, IOR is identified to occur at each location separately within one SOA. Across the SOAs, the facilitation of location is first observed, followed by a neutral crossover point, and finally, this trend leads to inhibition; a three-way interaction, therefore, would not be expected to be significant because the significant main effects at each SOA would cancel each other out.

Overall, the analyses in experiment 1 reveal that, as predicted, location IOR occurred. Thus, the IOR trajectory is manifested even when the distance between stimuli is stretched and by using real-world objects instead of simple images. Color IOR was also present, although the instructions were to respond to the location of the target. This result was surprising because past studies have argued that inhibition of color and other non-spatial stimuli are not present for tasks that require responses to the location of the target (Taylor & Donnelly, 2002).

Although color inhibition has not been previously documented to occur when the location of the cue and target do not match, it is likely to have been observed in this project as a result of the paradigm adopted. Specifically, the cue-target paradigm was adapted with objects that are relevant to the real world. The larger size of the stimuli could have
accentuated the differences between the cue and target, while in other studies, any differences between the two could would have been too subtle to be noticed.

The presence of both spatial and non-spatial features suggests that color features interact with spatial ones and can exist independently of them. This was highlighted by the IOR size for each type, which was especially large at 700 ms SOA. The interaction between these two types of features, however, is not linear. While both location facilitation and inhibition were observed, facilitation of location occurred regardless of the color matching. Thus, the participants were more likely to respond to the cue and target at the same location in the 150 ms SOAs, regardless of whether the cue and target matched in color. However, in the 700 ms SOA, color inhibition occurred, resulting in a discrepancy between the color match and the mismatch conditions. Overall, participants were slower to respond to the same color condition. The presence of color inhibition at this SOA indicated that location inhibition was only observed when the color between the cue and target did not match. Although there was a lack of facilitation for color (which was supposed to occur at 150 ms), this does not preclude its existence, as many authors have argued that inhibition can occur without facilitation (Danckert, Maruff, Kinsella, de Graaff, & Currie, 1999; Gawryszewski, Thomaz, Machado-Pinheiro, & Sant'Anna, 1994).

In experiment 2, the instructions were changed from responding to the location of the target to responding to its color. Location facilitation was observed in the 150 ms SOA, as reflected in the IOR score analyses. As predicted, color inhibition was observed, but it occurred earlier than in experiment 1: instead of the 700 ms SOA, it was documented in the 350 ms SOA. Given the literature discussion of various factors affecting the duration of IOR, this finding does not seem as surprising. For instance, when a feature of a target increases in complexity, then the target requires more attention processing. Consequently, it becomes more difficult to withdraw and disengage attention away to another stimulus (Bertels et al.,
2011). In this case, it was easier to identify the color of the target, which explains the shorter duration of the IOR effect and why the color inhibition was not significant in the 700 ms SOA, but rather in the 350 ms SOA.

While there was evidence of color IOR, in contrast to experiment 1, there was no evidence of inhibition of location. Only location facilitation occurred. Past studies have shown that too much focal attention on non-spatial features interferes with the spatial IOR (Taylor & Therrien, 2008). It is likely that the color inhibition interfered with the location inhibition. Since the purpose of this experiment was to show evidence of color IOR, a lack of location inhibition is not problematic as non-spatial features had a stronger ability to attract attention.

In experiment 3, a trade-off occurred between administering unique objects to increase the ecological validity of the study and preventing the experiment from running too long. Although the task instructions remained the same as in experiment 2, the complexity of the task increased to accommodate the preference rating of targets in half of the trials. The combination of complexity and the discrimination task led the way for a strong color IOR effect, which exhibited facilitation in the 150 ms SOA and inhibition in the 700 ms SOA. Given that these effects are measured by subtle millisecond differences, the presence of a strong color IOR effect is unlikely to be coincidental. A lack of color IOR at the different locations in this experiment could be explained by the complexity of the task. Participants had to respond to the color of the target, in addition to rating half of the targets by switching to the mouse. This process likely prevented the dissociation of spatial from non-spatial attention. A glimpse at the graphs and the IOR score calculations revealed the presence of inhibition at different locations and in different color conditions in the 350 ms SOA. Thus, inhibition of color at different locations could occur if perhaps there was another additional SOA beyond the 700 ms one. Finally, the location of the IOR trajectory was shorter, with
facilitation taking place in the 350 ms SOA and a trend towards inhibition taking place in the 700 ms SOA. The strong color IOR effect likely reduced the appearance of the location IOR.

The purpose of experiment 3 was also to understand the effects of IOR in terms of preference. In the 150 ms SOA, when the location between the cue and target was equivalent, stimuli with the same color were preferred to those with a different color. However, when the color was the same, the stimuli in different locations were preferred. Overall, the strongest preference for stimuli in this SOA was for stimuli that were in different locations but with the same color. These findings indicate that preference for the same color over different colors in the same location coincides with the facilitation of color. The preferences forged in this experiment were for color rather than spatial features. These findings remain inconclusive because participants might have been overwhelmed by having to switch between the keyboard, to indicate the color of the target, and the mouse, to indicate their preference. A small number of participants did not vary their preference for the targets. They clicked on the same part of the preference line, which suggested that they did not move their mouse.

Across the first two experiments, a pattern of response times was observed in the 150 ms SOA, which coincided with higher accuracy rates. In experiment 1, the error rates for the different location condition in the 350 ms SOA foreshadowed the inhibition taking place in the 700 ms SOA. This result suggests that the presence of error rates may reflect error rates associated with location rather than with color. In experiment 2, there was also a higher accuracy rate in the 350 ms SOA for location, immediately after the fast response times were documented in the 150 ms SOA. The lack of notable differences in accuracy rates in experiment 3 could have been due to the strong color IOR effect. If accuracy rates are linked to location features only, then this could be a viable explanation. However, it is also likely that there were not enough unique trials to observe differences in error rates in the last experiment.
IOR and the Habituation Hypothesis

From a theoretical perspective the results obtained in this project sway in favor of the Habituation Hypothesis over the Three-Component Model. The Habituation Hypothesis offers a parsimonious explanation, which does not rely on the presence of facilitation in order to predict that inhibition will occur. This theory’s proponents have also argued that task instructions are paramount in observing non-spatial IOR (Klein et al., 2015), but the type of task, such as whether it is a detection task or a discrimination task should not affect the results. Rather, the instructions should ensure that there is a difference in how participants respond to the cue and target. Since the aim of the cue is to attract attention, it does not need to share all of the same characteristics with the target. This is key. Taylor and Donnelly (2002) published a critical study in line with the idea that not all characteristics should be the same between the cue and target.

There is also evidence in favor of the Habituation Hypothesis, with respect to its emphasis on habituation. Originally, this theory stems from the Dual-Process Model. The Dual-Process Model suggests that a passive attentional system balances habituation and sensitization towards stimuli. Habituation means that responses towards stimuli weaken, while sensitization means that responses strengthen. The shaping of subsequent preferences and judgments for stimuli is thought to be influenced by the attentional system. The Dual-Process Model has also been utilized to explain how the mere-exposure effect translates into liking (Janiszewski & Meyvis, 2001).

The link between habituation and sensitization on attention makes it reasonable to predict that preferences are linked to IOR as well. Not only is sensitization, measured by faster response times to a target, linked to increased attention, but it is also linked to memory (Mathot et al., 2014). Conversely, inhibited items do not get stored well in memory. Items that do get stored in memory can increase the likeability of a stimulus as well (Janiszewski &
Meyvis, 2001). Although there was limited evidence in favor of the link between IOR and preferences in the current set of results, there are a variety of reasons for not observing it. There might not have been a sufficient amount of trials in experiment 3 or that the task of using the mouse and then switching back to the keyboard could have confounded the results. It is significant that 7 participants did not evaluate the stimuli accurately. A possible solution to this methodological drawback could be to ask participants to rate the stimuli with the number pad on the keyboard, rather than switching back and forth between the keyboard and the mouse. Another solution would be to reduce the number of images that are rated per participant.

**Theoretical Implications**

This work attempts to demonstrate that attention can be modulated by interruptions in unexpected ways. An unexpected cue can moderate behavioral responses to other visual stimuli, depending on the speed of the cue’s onset and whether the cue and stimuli share the same features. For instance, reaction time towards the second stimulus is reduced when the timing between the stimuli is less than 350 ms and they share the same location. Even if there is no conscious goal of paying attention to a suddenly appearing cue, it is nonetheless processed by the visual system. Since IOR is neither a purely top-down, nor a bottom-up mechanism of attention, it is hard to pin it down to either. Its mechanism of action is still up for contention, but our understanding of attentional mechanisms has come a long way from the early models of attention.

Influential models like the Broadbent bottleneck, formulated in the 1950s, have highlighted the role of attention in filtering the visual environment and its limits in processing every possible stimulus (Deutsch & Deutsch, 1963; Lachter, Forster, & Ruthruff, 2004). Moving forward, one of Broadbent’s PhD students devised the Feature Integration Theory, which asserts that features of stimuli get integrated in a pre-conscious stage and subsequently
assigned to mean something (Ward, 2004). Newer models expand these theories by linking attention with motor processes (Rosenkranz & Rothwell, 2004). Motor responses and visual attention go hand-in-hand, which is why keeping track of accuracy rates is important.

How does IOR fit into these attentional models? IOR fits into the research on visual orientation, which examines how attention is diverted towards novel stimuli. Novel stimuli, form an evolutionary perspective, signal that a reward is fast approaching or that danger is looming around the corner. IOR has also been thought to help animals and our ancestors with foraging for food (Klein & MacInnes, 2016). A mechanism of attention that filters information almost automatically is advantageous because it can distinguish between rewards, threats, and other stimuli across the visual space.

To answer the question: can non-spatial features, like color, affect behavior in a similar way to spatial ones in Inhibition of Return? Certainly, although research on the non-spatial features of attention in IOR have contributed to contentious debates throughout the years. Biologically, it may be important to identify objects based on color. For instance, a poisonous fruit or a menacing snake inching near one’s feet should not be ignored. When relevant, colors do stand out in the way the visual system filters information (Corbetta & Shulman, 2002).

Finally, IOR has theoretical implications beyond spatial and non-spatial visual attention. IOR can be applied to a variety of marketing contexts, such as the Spillover effect on brands: when the effects of advertising or preferences for products spill over to other competing brands. IOR can also have implications for contexts where consumers battle visual clutter and have to change from task to task frequently. Finally, IOR may affect individuals differently, depending on their mindsets or personality traits.
Theoretical implications: Spillover effect.

The experiments in this project demonstrated that attention can be enhanced and inhibited depending on the manipulation used. An effect in the marketing literature named the Spillover effect bears resemblance to some of the effects observed in IOR. Spillover means that a consumer’s indirect exposure to a new source of information or an object could give rise to new perceptions (Ahluwalia, Unnava, & Burnkrant, 2001). In advertising, Spillover from ads causes an increase in the likelihood that consumers purchase products other than the advertised one (Sahni, 2016). The Spillover advertising effect has been documented as the increase in sales for one product as a result of advertising another product that falls under the same parent brand (Balachander & Ghose, 2003).

Spillover effects can include not only perceptions of the products of the same brand but also attributes of the same brand (Ahluwalia et al., 2001), perceptions from one brand to other competing brands (Trump & Newman, 2016), and a spillover of scandals between brands (Roehm & Tybout, 2006). These effects can also occur and extend from generic searches to brand-related ones (Rutz & Bucklin, 2011). Spillover effects are not always positive as they can also have negative repercussions. Spillover between competing brands can occur when they are perceived to be similar (Janakiraman, Sismeiro, & Dutta, 2009; Sahni, 2016). The Spillover effect can therefore transcend brands and product categories.

Spillover effects: Within visual attention.

Similarly, in terms of inhibition, stopping a response can change the perceived value of a stimulus (Wessel, Tonnesen, & Aron, 2015). A study conducted by Wessel et al. (2015) have shown that knowing the value of a reward strengthens the stopping-induced devaluation effect observed. Furthermore, Inhibition of Return has been documented to have both attentional and motor effects (Zhou, 2008). Responding to targets slows down due to inhibition, and there is also a decrease in quality of the perceptual processes (Wang, Satel, &
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Klein, 2012). In terms of decision making, inhibitory Spillover effects can also dampen impulsive choices (Tuk, Trampe, & Warlop, 2011).

In experiments, the properties of the cue have an impact on the properties of the target depending on their timing, which can mean various things for advertising. If the cue and the target represent an ad and a product, respectively, then the properties of the ad have a spillover effect on the response towards the product. Likewise, when the cue and target are both ads, then one can be presumed to have an effect on the other. While it would be more complicated in terms of having multiple windows open in a browser and browsing from one to the other, in theory it could also be possible for ads and/or products to have effects on each other.

The inhibition effect could also apply in a search setting. Rutz and Bucklin (2011) examined the interaction between generic and branded search activity, in which a generic search creates awareness that the brand is relevant to the goals of the search and, consequently, spills over to influence the subsequent branded search. This awareness leads to future branded keyword searches where the user is more likely to notice brands and/or to complete a purchase. In terms of IOR, seeing a product, a category, or a brand might result in increased attention for it if the timing between the stimuli is fast, but it might result in the converse if the timing is relatively slow. If this turns out to be experimentally verified, it poses an interesting dilemma for advertising online: that timing is important and can result in reserve effects.

The IOR phenomenon has also been documented to have an effect in terms of numerical processing (Fischer, Castel, Dodd, & Pratt, 2003). In various experiments, it has been shown that smaller numbers can be associated with the position on the left, and larger numbers with the position on the right. Therefore, showing small numbers and having the target appear on
the left-hand side in relatively quick succession would result in a facilitation effect. As a result, IOR could interfere with the content, especially if the content contains numbers. Symbols can also be used to direct attention (Hommel, Pratt, Colzato, & Godijn, 2001). Words and symbols corresponding to locations automatically shift attention and bias decision-making.

Moreover, in terms of content, the placement of an ad could affect the content on a website that is examined in terms of location. Likewise, it might have an effect on shifting attention to color on the content of a website. It could be that if two brands are shown together quickly, they could elicit positive co-branding.

**Cross-modal attention.**

One of the first studies to examine the cross-modal effects of IOR predicted that not only visual stimuli but also auditory stimuli would be affected by the relative timing between the cue and the target. A different study by Spence and Driver (1998) found that cross-modal attention between an auditory cue and a visual target requires an auditory middle neutral fixation point to observe the cross-modal effect. This cross-modal effect has also been extended to the tactile modality (Spence, Lloyd, McGlone, Nicholls, & Driver, 2000). However, when the target is visual, IOR effects are greatest, followed by a moderate effect when the target is auditory and the smallest when it is tactile. Overall, cross-modal performance is slower than intra-modal performance, and the most consistent effects are observed for visual, rather than haptic, attention (Bushnell & Baxt, 1999; Easton, Greene, & Srinivas, 1997).

In regard to other types of cross-modal attention, there is a difference between semantic and synesthetic correspondence. Synesthetic correspondence occurs when matching between stimuli is not based on meaning or identity (Hagtvedt & Brasel, 2016). For example,
by conducting an experiment in the supermarket, Hagtvedt and Brasel (2016) have shown that music frequency has an effect on the type of shelf color on which products are placed. (Shen & Sengupta, 2014) investigated visual processing and how it is affected by unrelated stimuli processed cross-modally. They used vending machines to illustrate the connection between sounds and product preferences.

Cross-modal attention has also been examined in a search setting. Knoeferle, Knoeferle, Velasco, and Spence (2016) investigated the effects of a multisensory brand search. Their study is one of the few to take into consideration how visual processing interacts with cross-modal attention in a consumer behavior setting. By investigating cross-modal attention under low-load and high-load contexts, they showed that attention can be modulated in various settings and simultaneously increased the generalizability of the research to real contexts.

Attention-to-motivation Spillover effects.

Generally, items that serve as distractions are evaluated negatively more than novel items or previously seen items. In terms of IOR, cues can either serve as distractions because they capture attention automatically or they can symbolize novel pieces of information. Can an ad that serves as a cue prompt a consumer to look for new products because the cue symbolizes novel information, or does it represent a distraction? Would this ad then be devalued as a result?

De Vito, Al-Aidroos, and Fenske (2017) discuss the devaluation-by-inhibition hypothesis to illustrate how negative affective evaluations are coded onto stimuli that serve as visual distractions. They define distractors as affecting emotional judgements, such as likeability, stimulus valence, favorability, beauty, cheerfulness, dreariness, pleasantness, and trustworthiness. Distractors closest to the target are thought to be the most negative. In
general, distractions are perceived to be less significant emotionally because they are inhibited from selective attention, and even asking participants to forget helps to devalue a stimulus emotionally (Vivas, Marful, Panagiotidou, & Bajo, 2016).

In terms of the Spillover effect, it is likely that if a consumer needs a specific brand or a product category, then the spillover effect might not work (Brendl, Markman, & Messner, 2003). Once a need is activated, it may not generalize; however, the converse would also be true: once a need is activated, then the spillover effect is more likely to occur within a brand extension or a specific category type. The question as to whether brands bypass this effect remains to be answered. Brendl et al. (2003) found that devaluing an option also decreases one’s preference for it. When information about a product is inconsistent, the object can become associated with a state of negative arousal as a result of feeling the implicit ambivalence (Rydell & Durso, 2012).

The spillover effect can also apply to spatial attention, such that attention is biased away from where brands are positioned on a page. Last, but not least, the spillover effect can be based on color. A result of this outcome is that preference towards a location or color can carry over to another unrelated product or brand, which can be measured in terms of liking, attitude, and memory.

Mere exposure.

The mere exposure effect occurs when the preference for a specific stimulus increases as a result of frequent exposure to it. This phenomenon can carry over to stimuli that are part of the same category or share similar properties. Would the facilitation or inhibition effect in IOR spillover to other stimuli? Incidental exposure to brand names and product packages can occur within one incidence without the need for multiple exposure, and the mere exposure effect may not apply to IOR (Janiszewski, 1993).
Furthermore, repetition serves to reduce uncertainty with a stimulus, such that it reduces arousal (Wang & Chang, 2004). To confirm whether the mere exposure effect applies to IOR, it should be demonstrated that the familiarity rating of a stimulus increases during the facilitation stage. However, during the mere exposure effect, older items carry a fluency activation, which means that they are rated as being more familiar. Familiar stimuli are therefore more predictable and less startling. In the IOR phenomenon, the stimuli that are presented in the facilitation stage (i.e., within 150 ms) are considered to be novel. Therefore, this is at odds with the mere exposure explanation.

**Switching tasks and the Zeigarnik effect.**

Switching tasks generally increases errors of participants and slows down their reactions (Vandierendonck, Liefooghe, & Verbruggen, 2010). Overall, switching from task to task increases perceptual encoding (Elchlepp, Best, Lavric, & Monsell, 2017), which can either enhance the effect of IOR or prevent it from occurring, depending on the nature of the task. Too much encoding might indicate that attention is not withdrawn from the cue.

In the Zeigarnik effect (Zeigarnik, 1927), a goal is more likely to be completed if it is interrupted, but an uncompleted goal can also result in poor performance on other tasks (Masicampo & Baumeister, 2011). It may well be that one’s shopping experience is negatively affected by visual disruptions in the form of ads. An ideal scenario is when the disruption is meant to sway the consumer to take into account new information about a product. However, it might impair the consumer’s experience. If a consumer completes his/her primary task and the interruption comes at the end, they may not be as greatly affected by it (Liberman, Förster, & Higgins, 2007).
Individual level differences.

Based on evolutionary psychology, the Hunter-Gatherer theory related to spatial gender differences predicts that females would be better at finding objects and therefore better at performing spatial location tasks. Brown (2013) predicted that females are better than men at location-IOR tasks due to a higher likelihood of being better at foraging. The author argues that objects are more important for women in terms of navigating through space, such that landmarks are more memorable, whereas cardinal directions are more important for men.

Inhibiting one’s action allows for flexibility in adapting to the environment; a lack of control over this function may lead to impulsive choices (Tannock, Schachar, Carr, Chajczyk, & Logan, 1989). Those with anxious or neurotic traits tend to be better at attending to locations (Ávila, 1995). Overall, those with neuroticism have stronger Inhibition of Return than controls. However, those with anxious scores (neurotic introverts) have a harder time withdrawing their attention to negative locations, whereas those with neurotic extraversion have a harder time disengaging from positive locations.

Ávila and Parcet (1997) found that males have faster and more inaccurate responses overall. They also showed that individuals who score high on the Sensitivity to Reward scale cannot inhibit responses to irrelevant distractors. Individuals who score highly on sensitivity to punishment show a poorer ability to withdraw attention in short SOAs in IOR (Poy, Eixarch, & Ávila, 2004). Those who are impulsive also show worse performance on inhibition and have higher Behavioral Activation System (BAS) activity (Ávila & Parcet, 2001).
Mindsets.

Inhibition of Return is a phenomenon based on visual searching, but for future work it would be vital to understand how IOR functions in individuals with various mind-sets. Similar to how IOR can potentially induce different Spillover effects, it is likely that individual differences can play a role in mediating the IOR size as well. It is noteworthy that irrelevant product information can also have a negative impact on how a consumer views a product (Meyvis & Janiszewski, 2002).

A mindset includes the processes and judgements that arise during a task. These processes can spill over to how one behaves in other contexts (Wyer & Xu, 2010). Adopting a maximizing mindset, for instance, can result in increased regret and reduced satisfaction, leading to returning or exchanging products (Ma & Roese, 2014). In such an instance, developing a preference for a product in an ad will unlikely help those who adopt a maximizing mindset. In contrast, if the product in the ad matches a consumer’s goal, their selective attention may be narrowed, and the IOR effect will be stronger as people tend to focus on information that already confirms their current views (Henderson, de Liver, & Gollwitzer, 2008).

Those who adopt implemental mindsets tend to adopt illusory optimism, whereas those who adopt deliberative mindsets tend to adapt more realistic risk perceptions (Keller & Gollwitzer, 2017). In terms of visual attention, the research shows that deliberative mindsets are more amenable to wider breadths of attention, whereas implemental mindsets are narrower (Buttner et al., 2014).

Shoppers can also be divided as those with experiential shopping orientations and those with task-focused shopping orientations. Those who are experiential tend to enjoy high-arousal contexts, and those who are task-focused enjoy low-arousal contexts (Kaltcheva &
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Weitz, 2006). Research has shown that an experiential orientation can lead to a deliberate mindset in which a consumer will think more about the benefits and drawbacks of a product versus a task-focused orientation in which consumers would focus more on the implementation of their shopping tasks, such as where to look for products (Büttner, Florack, & Göritz, 2013). Therefore, consumers with an experiential mindset would be more likely to be sensitive to IOR effects.

Openness to experience results in a wider distribution of the IOR effects (the distance between the cue and target lasts longer), whereas conscientiousness results in the opposite effect (Wilson et al., 2016). A study on Transportation Security Administration (TSA) officers in the USA showed that conscientiousness is one of the big five personality traits that predicts visual searching (Biggs, Clark, & Mitroff, 2017). Extraverts also tend to pay attention to pleasant stimuli (De Pascalis & Speranza, 2000). Those who are Thinkers (high cognition, low affect) prefer processing verbal information, whereas Feelers (low cognition, high affect) prefer processing visual information (Sojka & Giese, 2001).

After completing an approach task participants tend to adopt more global perceptual attention, whereas an avoidance task results in local (narrowed) perceptual attention (Förster, Friedman, Ölzelsel, & Denzler, 2006). The authors hint at the link between global and local perceptual and conceptual processing to prevention and promotion focus mindsets.

Non-consumer contexts.

Given the nature of the IOR phenomenon, its application does not need to be limited to consumer settings. When playing video games, it is expected that experienced players more rapidly identify stimuli than the average person. However, the size of the IOR does not necessarily differ between video playing and non-video playing groups, but the former has an overall faster reaction time regardless of the complexity of the search task (Castel, Pratt, &
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Drummond, 2005). Thus, while reaction times may vary, the IOR effect can still be observed across a wide range of groups. Practice may only change the overall reaction time rather than reverse the inhibition effect.

Decreases in the IOR size have been attributed to impairments in withdrawing attention from stimuli, such as food in overweight individuals (Carters, Rieger, & Bell, 2015). Moreover, attention withdrawal has even been documented in average weight individuals with eating problems (i.e., binge eating), whereby they have a hard time moving their attention from food with high calories (Lyu et al., 2016). To understand attentional biases in withdrawing from food stimuli, Carters et al. (2015) observed that obese participants had lower IOR sizes compared with normal-weight ones.

Other groups of individuals who have been measured are drivers, providing evidence showing that IOR is linked to driving safety (Bédard et al., 2006). A reduction in the IOR effect has been correlated with more errors when driving. It would make sense that not only driving and IOR are correlated but also other areas such as flying. The air patrol staff who have to monitor blinking symbols on a radar will benefit if the presentation of the stimuli is optimized so that they can follow the visual targets on the screen.

Last, but not least, numbers can serve to orient attention either away or towards an area (Hommel et al., 2001). For instance, lower numbers accompanied by cues on the left can produce IOR when the timing between the two is relatively slow. Findings such as these can be applied to auctioning contexts. For instance, in an online setting, when the countdown to buy a product changes, lower numbers might shift attention to a different area than higher numbers. The placement between the buy button and the countdown could bias a consumer to purchase the product.
Practical Implications

How is manipulating the millisecond timing between stimuli relevant to the real world? The literature has shown that brief exposures to stimuli increases familiarity, preferences, and forges positive attitudes for them (Bornstein & D'Agostino, 1992; Gordon & Holyoak, 1983; Janiszewski, 1993; Janiszewski & Meyvis, 2001; Zajonc, 1968, 2001). Whether the stimuli are simple images or brands, brief exposures can have a lasting impact.

There are numerous situations where stimuli appear in quick succession of one another, such as advertisements abruptly appearing on the screen, disrupting the consumer’s browsing behavior. Parallels can be drawn between this scenario of pop-up ads and abrupt and unexpected cues appearing during an IOR task. The literature in advertising acknowledges the role that even a 50-millisecond exposure has on building preferences (Lindgaard, Fernandes, Dudek, & Brown, 2006). Active attention is not required to generate revenue from ads, and passive browsing has shown to increase revenue generation (Simola, Kuisma, Oorni, et al., 2011). IOR thus has the potential to be applied in an online context, given the similarity between cues and the rapid and intrusive appearance of ads. Neither can be predicted. A brief exposure to either can also influence judgements and reaction times.

The practical implications include the relative placement of ads to products and the relative color difference between the two. For instance, as a consumer browses through images of products, from page to page, an ad appears abruptly. After half a second or a second passes, the distracting ad disappears. Subsequently, the consumer’s response towards clicking on a product to view more information is delayed. This delay could cause the consumer to divert attention away from that product and to potentially change his or her evaluation of it. Similarly, if the consumer has a particular product and color in mind, such as searching for the classic (red-colored logo) Coca Cola and an ad of (another red-colored logo) Heinz appears, attention will be inhibited towards Coke because both stimuli match in color.
Conversely, if the ad contains (a green-colored logo) Starbucks, then attention in this case is facilitation and the subsequent response time decreases because the two stimuli do not share the same color. These predictions are made based on the results of experiment 3, which used a variety of real world objects and integrated mouse clicking. These types of implications elevate the importance of the location and design (color) of the ad and suggest how non-content-based features interact with attention.

Navigating the online world.

It is feasible to apply Inhibition of Return to a variety of contexts because the timing between two stimuli can influence attention spatially, non-spatially, and (potentially) preference-wise. On websites, ads are embedded in different locations to attract attention, which makes it reasonable to investigate the effects of location IOR in such settings. There are possible implications for companies offering a plethora of products online, such as Amazon, John Lewis, and Argos, which could opt to change how they utilize notifications and ads. For instance, the panes of information or pictures on websites that sweep across the screen, designed to inform consumers of new deals, can best be utilized when they appear quickly, within 150 ms. This should hold true if the consumer has recently started browsing the page. This type of moving or sweep announcement might be ignored if the appearance of the sweeping ad is slow and the process takes approximately half a second up to one second. The same scenario could apply to other types of websites selling more specialized products, such as grocery stores including Waitrose, Sainsbury’s, and Asda. Similarly, news websites that contain a mixture of ads and pictures with headlines can be designed to modify attention in a spatial manner. While the IOR effect is likely to occur under conditions in which the placement of pictures or ads is important, as mentioned above, it could also apply to contexts in which color is important, such as where brands are positioned. A prominent color for brands such as Starbucks (green) or Coca Cola (red) can theoretically interact with a
prominent color in an ad. Take, for instance, an example in which a website refreshes after the consumer is exposed to an ad for 700 ms. If a product appears in the place of the ad after the page refreshes, attention towards the product could slow down and even move away.

When opting between using different platforms, such as websites on desktops and on mobile phones, the IOR effect should be stronger on phones since this phenomenon was originally observed in the laboratory with smaller stimuli within closer proximity to each other. This also indicates that there is less clutter on a mobile screen and that only a few objects are visually processed. The IOR effect would not be dispersed through a long distance on the screen. While the benefits are logically clear, it is important to also consider the trade-offs since consumers might be more distracted when using mobile phones.

Overall, IOR can impact consumers’ attention, not merely in terms of where products are located on a website or their colors, but it also has the potential to have a subsequent effect on preferences, memory, or even mood. An optimal timing between an ad and a product can lead to increased memory of the product or even a preference for it. Even if the IOR effect might not have a large impact on one consumer at a time, it could produce an overall noticeable shift in behavior across millions of consumers. The effects can accumulate when taking into account a large pool of consumers, such that small biases towards or away from a product can be documented. Given that ads are not successful with most consumers, increasing their efficiency by small amounts can still result in increases in the generated revenue.

Finally, re-targeting, in which an ad based on a previous viewing habit of a consumer follows the consumer between websites, might not be a good context to apply the IOR mechanism. If an ad does not suddenly appear and capture the consumer’s attention, then IOR is unlikely to occur. IOR will occur if the ad suddenly appears, and the effect is likely to
be observed with the same magnitude. Strong evidence for this stems from experiments 1 and 2, which utilized the same bowl, but with two colors, over hundreds of trials. The effect restarted itself every time the last stimulus was cleared from the screen, which explains why the priming effect was not responsible for the facilitation part of IOR (Milliken et al., 2000). Following this line of reason, re-targeting should not pose an effect above and beyond the IOR effect. While it might seem that IOR is limited because re-targeting might not boost its effect, this implies that the timing of an ad can be effective the first time it is shown, rather than follow a consumer through many browsing “journeys”, whereby theories such as the mere exposure effect would suggest that the more something is shown, the more it is liked.

In summary, the theoretical contribution of this work leads to the understanding that not only do distractions have unintended consequences on our attention, but where they are located and how they are colored are also important. Building on the point that our attention is driven by our goals, novelty, and the relevance of a task, the current research concludes that depending on the type of context created, non-spatial features can exist independently of spatial ones. Websites are excellent contexts to evaluate the IOR phenomenon due to the combinations of products located on a page and the various associated colors. Location is sometimes more important when searching for specific categories of products or ignoring ads on one side of a page, and colors are sometimes more important when searching for brands. Furthermore, given the link between attention, preferences, and memory, it would make sense that subsequent evaluations of stimuli be driven by the way they are processed. The various contexts in the experiments lead to the suggestion that IOR is a flexible cognitive mechanism that helps us adapt to the changing world around us, whether it is searching for a product online or avoiding incoming traffic on the street.
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Limitations

To shed light on the intricate mechanisms of IOR, caution should be practiced during its measurement. While care was taken to minimize potential confounders, there were a few potential limitations worth noting. Being able to measure attention via changes in millisecond response times is a double-edged sword. It allows one to analyze how abrupt changes in the visual field have an effect on attention; however, these events are difficult to measure. Eye-tracking studies are expensive, but they would complement this research well, and their absence is not problematic as reaction times are a good measure of attention. Furthermore, some studies have deployed attention-grabbing fixation crosses to help participants focus on the center of the screen and avoid unnecessary eye movements. The dynamic nature of these crosses is problematic because they appear and disappear rather than remain static. There are few ecologically valid situations online in which this could be the case. While using dynamic fixation crosses could have produced more robust results, the consensus is that if the appearance of the cue is sufficiently abrupt, it will automatically draw attention to its location (Posner & Cohen, 1984).

The requirement of this project of millisecond precision leads to another potential limitation. The current experiments were conducted online rather than in a laboratory, which indicates that these two settings could lead to different results. Specifically, potential issues include variability in the computer hardware and software of the participants, fluctuations in internet speed, and an inability to monitor the participants. First, the utilized software does a reasonable job controlling for variability. Second, while the overall reaction times of some participants might have been higher because they were using a slower computer, the relative difference between their reactions in each condition were more important. As long as their computers produced consistently slow reaction times, then their responses were not as problematic. Third, only a few participants had unusual reaction times that exceeded 2.5
standard deviations above and below the mean, and they were excluded from the analysis. Additionally, catch trials ensured that participants were minimally distracted, otherwise they would not have noticed when the cue did not appear. The overall correct percentage of responses was also high (usually well above 97% for each participant). This rate would have been lower if the participants were distracted or interrupted by other tasks. Fourth, participants were given practice trials to get used to the experiment, and they would not be able to proceed if they did not reach a threshold of correct responses. They were also asked to respond as quickly and accurately as possible to be paid on MTurk. Fifth, the software did not run if a participant used a mobile or tablet device or did not use a computer with a keyboard. Finally, the purpose of experiment 1 was to show that IOR applies to the experimental design. The specific pattern of results could not have occurred coincidentally. These robust results were observed despite the presence of dependent variables across all three studies that were measured in milliseconds. The experiments were tested in highly variable environments, and while potentially increasing the noise in the studies, this design also increased the validity of the results. Finally, the robust differences between the conditions were repeated across experiments, which could not be due to chance.

Another source of potential noise was derived from coding the experiments. The free software was an excellent tool to test the IOR effect; however, potential coding errors could have occurred, especially since each experiment generated the equivalent of a few hundred pages in Microsoft Word. The program generated approximately 10,000 lines in Excel for statistical analysis, but care was taken to organize the data appropriately. Pilot tests were also conducted for each experiment, and the scripts were carefully checked and color-coded.

In experiment 3, preferences towards the object were not as precise as initially anticipated. This discrepancy could be traced to the finding that participants had to alternate between the keyboard and the mouse numerous times, which is unnatural and could have
been quite repetitive. Some of the participants, as previously mentioned, clicked on the same part of the dimension scale, which could indicate either a lack of motivation or fatigue. To minimize fatigue, it could have been possible to ask participants to verbally indicate their preference for an object, such that they responded out loud. However, this process can introduce new confounding issues, such as being able to record and retrieve the data for the hundreds of trials to which each participant is assigned. A more efficient setup would be to reduce the number of items that were rated, and/or to use a keyboard with numbers, rather than the mouse, to indicate preference to minimize the disruption between switching hands between the two apparatuses.

Clearly, the next step in solidifying the results is to apply the current IOR design to various contexts that mimic online browsing behavior and resemble real-life products and ads as much as possible. The initial experiments were developed to show that IOR is manifested with real objects, not just pixelated stimuli, in addition to objects that are placed further apart, as would be expected on a website. Having used a more realistic shopping design from the beginning would not have established the cause of this effect. Using simple objects ensures that the effect is first observed, which serves as a baseline for future experiments that manipulate different types of shopping contexts. For instance, shopping experiences can be very personal and can either irritate consumers or increase their joy. It is not yet clear how these emotions interact with the IOR effect. The first stages have therefore been established to illustrate that IOR can be expanded to real objects and to a large canvas. In addition, some light has been shed on how not only location IOR behaves in this setting but also color IOR.

**Future Applications**

The battle between consumers intentionally ignoring ads and companies finding innovative ways to grab attention is intensifying. Attention is now considered to be a commodity, and as many marketing activities are moving online, it is imperative to analyze
how the two interact. The reasons are multi-fold. On the one hand, companies attempt to understand how effectively their messages/pictures are processed by consumers. On the other hand, potential policies could be established to help inform consumers of the ways that interacting with online media impacts their attention and other types of behavior. Since consumers are bombarded with large amounts of information, it is crucial to anticipate the impact of the first few milliseconds, before the information is even elaborately processed.

The promising link between attention, even that lasting a few hundred milliseconds, and memory offers a venue for consideration. The applications of Inhibition of Return are vast: this mechanism, which facilitates searching behavior, has been applied to test safe driving habits (Bédard et al., 2006). It can also be applied to monitor the movements of airplanes in air traffic control centers. Keeping track of peripheral objects and being able to identify new ones (incoming cars) is paramount, and even more so for airplanes. From a marketing perspective, games could also be designed to improve the experience of videogame players (Castel et al., 2005). Games can also be used to create programs for consumers to regulate their diet by presenting the right combination of images and pairing these with the appropriate responses, such as slowing down response times when images of unhealthy cupcakes appear.

Finally, IOR can be applied to test whether brands are sufficiently strong to bypass the IOR mechanism: strong brands that capture attention will result in facilitation effects rather than inhibition. Future work could extend the experimental design and include a more realistic online shopping context with various products on a page. Behavior can be measured by whether a consumer clicks on an image to obtain more information, or on the purchase button. When a consumer is rushed in particular, this design could test the impact of ads on behavior, such as whether the ad is ignored and whether it impacts attention in unintended ways.
A clearer link between purchasing and interruptions in the form of ads should be forged. It is expected that brands that are strongly preferred will not be subject to attentional modulation in the same way as neutral brands. Ads might therefore be more beneficial for neutral products; however, this can also backfire. It may be likely that attention and memory go hand-in-hand for IOR, and future work could also explore the effects of ads on learning and memory.

In summary, the spatial and non-spatial properties of IOR have been investigated. The results suggest that the two can exist independently of each other. When two stimuli share the same location, attention towards them is inhibited when the timing is sufficiently long. However, when two stimuli share the same color, it depends on the task instructions. For example, when participants are asked to indicate the location or color of a target, and the cue matches in color, then inhibition will be observed. However, color IOR will behave in a similar way to location IOR when the task complexity is increased and a variety of unique objects are utilized.

Conclusion

The results produced in this research project show that attention has contrasting effects on behavior, which can be observed within the span of one second. Participants were faster to indicate the location of a target when it shared the same area as the cue and the timing between the two stimuli was relatively quick. Participants were slower to respond to the stimuli when they shared the same location, but their timing was relatively slow. By changing the task instructions and increasing its complexity, the experiments showed that the color properties of stimuli can follow a similar pattern to spatial ones.

The originality of the current research lies in using timing to demonstrate that the appearance of stimuli can have contrasting effects on attention. The design has been modified
to illustrate how spatial features interact with non-spatial ones and how all of these factors potentially have subsequent effects on preferences. Previous studies examining the role of attention in advertising have not taken into consideration the role of ad timing in shaping preferences towards ads or products.

IOR, therefore, provides a promising framework to understand how ads interrupt shopping behavior and influence product selections. By altering the Posner cueing paradigm, the project is one step closer to examining IOR in a realistic marketing context. The modifications were minimal to maintain the paradigm’s simplicity and to minimize the confounding variables. By showing that spatial and non-spatial IOR can exist independently of each other, a plethora of marketing applications can be examined, ranging from Spillover effects, brand extensions, and mobile advertising.

Perhaps William James would never have been able to predict how attention is attended to and withdrawn from online ads, but it is safe to say that not all that glitters online turns into gold. The timing, location, and color of those glittering ads need to be examined as well.
References


Gawryszewski, L., Thomaz, T., Machado-Pinheiro, W., & Sant'Anna, A. (1994). Onset and offset of a visual cue have different effects on manual reaction time to a visual target. *Brazilian journal of medical and biological research= Revista brasileira de pesquisas medicas e biologicas/Sociedade Brasileira de Biofisica...[et al.], 27*(1), 67-73.


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Figure 35. Examples of stimuli tested in experiment 3.
Figure 36. Examples of stimuli tested in experiment 3.
Figure 37. Examples of stimuli tested in experiment 3.
THE ROLE OF VISUAL ATTENTION IN PRODUCT SELECTION

Experiment 1:
- 1,075 lines. 35 pages.

 Experiment 2:
- 1,321 lines. 43 pages.

 Main Experiment 3:
- Version 1: 3,173 lines. 103 pages.
- Version 2: 3,221 lines. 104 pages.
- Version 3: 3,170 lines. 103 pages.
- Version 4: 3,077 lines. 100 pages.

Link to word document with codes:
https://drive.google.com/drive/folders/0B3QNVN3fXD_fTW9aMFF1VnR4X2M?usp=sharing
### Version 1

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<td></td>
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<tr>
<td>Uncued Color</td>
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<tr>
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<tr>
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**Figure 39.** Version 1 and 2 of experiment 3 and how each image was balanced across.

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<tr>
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**Figure 40.** Version 3 and 4 of experiment 3 and how each image was balanced across.
Table 31. The rating of each stimulus in experiment 3.

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Figure 41. Location IOR. Note: SOA is measured in milliseconds. Location IOR = different location (RTs) – same location (RTs).

Figure 42. Breakdown of Location IOR by same color and different color. Note: SOA is measured in milliseconds. Location IOR = different location (RTs) – same location (RTs). *p < .05.
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Figure 43. Color IOR. Note: SOA is measured in milliseconds. Color IOR = different color (RTs) – same color (RTs).

Figure 44. Breakdown of Color IOR by the same location and different location. Note: SOA is measured in milliseconds. Breakdown of Color IOR = different color (RTs) – same color (RTs). *p < .05.
Appendix C

Experiment 3: Mouse-click Preference RT

Version 1 (semi-randomized)
28 22 29 13 1 39 23 24 19 44 20 27 41 25 34 30 7 16 6 11 12 38 4 8 47 5 42 14 17 43 48 26
40 21 15 37 3 18 9 32 35 2 31 45 36 33 10 46

Version 2 (semi-randomized)
27 32 30 22 12 7 11 33 40 39 41 5 36 46 4 9 19 29 2 35 8 47 20 28 43 13 1 25 10 38 44 14 37
23 45 48 26 24 17 18 3 15 21 6 31 16 42

Version 3 (semi-randomized)*
8 27 26 23 5 40 17 24 48 31 21 6 15 37 29 36 16 19 25 4 30 11 38 9 33 35 2 46 34 47 3 28 45
41 12 13 32 43 1 10 22 20 39 42 44 14 18

Version 4 (semi-randomized)*
22 39 7 1 35 8 6 5 41 33 21 32 36 11 4 45 47 10 12 15 23 26 25 42 19 43 31 46 20 38 9 13 40
34 27 2 37 48 17 28 30 44 3 18 24 29 14

*Note: Numbers in version 3 and 4 were randomly generated, but the order of some of these numbers were modified in order for each image to be rated twice across the four versions. Each image was rated in a different type of condition.
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Appendix D

Figure 45. Experiment 3: Location IOR. Note: SOA is measured in milliseconds. Location IOR = different location (RTs) – same location (RTs). Measure of RT of mouse clicking.

Figure 46. Experiment 3 Breakdown of Location IOR by same color and different color. Note: SOA is measured in milliseconds. Location IOR = different location (RTs) – same location (RTs). *p < .05. Measure of RT of mouse clicking.
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Figure 47. Experiment 3: Color IOR. Note: SOA is measured in milliseconds. Color IOR = different color (RTs) – same color (RTs). Measure of RT of mouse clicking.

Figure 48. Experiment 3: Breakdown of Color IOR by the same location and different location. Note: SOA is measured in milliseconds. Breakdown of Color IOR = different color (RTs) – same color (RTs). *p < .05. Measure of RT of mouse clicking.