

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

An Examination of Inattentional Blindness in the Team Ball Sport of Netball

A thesis presented in partial fulfilment of the requirements for the degree of

Master of Health Science

in

Sport and Exercise

at Massey University, Manawatū, New Zealand

Melissa Lee Blackmore

2023

Abstract

The world around us is a detail-rich place. Therefore, there are numerous stimuli to observe, and as humans, we only have a limited information processing capacity. Thus, on occasion, we can have failures of attention. Inattentional blindness is a specific failure of attention when a person fails to see a clearly visible, but unexpected stimulus because their attention is engaged elsewhere. Inattentional blindness becomes an issue in team ball sports as missing critical stimuli, such as a freely available teammate, may be the difference between winning and losing. The present study examines inattentional blindness in the team ball sport context of netball. This examination has been conducted using a more ecologically valid sport inattentional blindness research paradigm than previously used. The findings of this study provide evidence that inattentional blindness exists in netball.

Keywords: inattentional blindness, attention, sport, netball

Acknowledgements

On the cover of this thesis, there is only one name-- my own; however, this thesis would not have been possible without so many others. I have had the best proverbial village of people supporting me, and I apologise for my inability to adequately express my deepest gratitude to everyone involved in this journey. Please understand that I am immensely thankful to each and every one of you who dedicated your time, expertise, love, and support.

First and foremost, I would like to thank my supervisors, which has become a list of many. To Associate Professor Dennis Slade, thank you for encouraging me to embark on this journey. I owe my topic selection to a seed you sowed in late 2020.

To Dr. Philip Fink, Associate Professor Toby Mundell, and Associate Professor Darryl Cochrane thank you for being present during the different seasons of this journey.

To Associate Professor Stephen Hill and Dr. Michael Philipp, thank you for coming on board partway through and ensuring I made it to the end. Your vast knowledge continues to astound me, and it was a gift to listen to you both and witness your pondering. You made me see that it was okay to wonder and that it is alright not to have all of the answers.

To MANAKURA and specifically the senior netball students, thank you for being wonderful video participants. It was a joy to work with you all.

Finally, I need to thank my family and friends. To my parents, we made it. It has been 18 years since you dropped me off on my first day of school, and the finishing of this thesis marks the end of a very long chapter. I appreciate the support you have given throughout the years. You have always believed in me. To Nan and Pop, thank you for being a source of calm amidst the busyness. I am sincerely grateful for the role that you have in my life. To my big brothers, Josh and Dion, thank you for being a big source of motivation. You both bring out the best in me. To Dale, Peri, Jeremy, Gill, and my friends, my sincerest thank you.

Table of Contents

List of Figures	vi
List of Tables	vi
1. Introduction	1
Introduction to Inattentive Blindness	1
Inattentive Blindness Research Paradigm.....	2
The Cross Task Paradigm.....	3
The Gorilla Video Paradigm	5
The Object-tracking Task Paradigm	9
Attention in Sport	11
Sport Inattentive Blindness Paradigm	12
Modifying Factors of Inattentive Blindness Prevalence in Sport.....	14
The Saliency of the Critical Stimulus: The Unexpected Player.....	14
Inattentive Blindness: Endogenous and Exogenous Attention	15
Sport Expertise	17
Ecological Validity of the Sport Inattentive Blindness Paradigm	19
Summary	21
The Present Study.....	22
Research Question.....	22
COVID-19 Influence on Study Design, Method, and Procedure	22
2. Methods	24
Ethics.....	24
Participants	24
Procedure.....	25
3. Materials	27
Netball.....	27
Video Development.....	29
Netball Players.....	30
Filming.....	32
Video Creation.....	36
The Online Data Collection Application	38
4. Results and Discussion	41
Data Preparation: Exclusions and Missing Data.....	41
Analysis	41
Inattentive Blindness.....	41
Distractor Attention Task – Task One.....	47
Correlation Analysis: Inattentive Blindness and Passes Counted	48

Age Analysis	49
5. General Discussion	51
Inattentional Blindness in Netball.....	51
Endogenous and Exogenous Attention	52
Diversity of Age of Participants	53
Secondary Analysis of Inattentional Blindness	53
Age and Expertise Influencing Inattentional Blindness.....	54
Enhancing Ecological Validity of Inattentional Blindness Studies in Sport	55
Methodological Enhancements: Extended Trial Duration.....	56
Methodological Enhancement: Removal of Freeze Frames	57
Methodological Enhancement: The Use of Multiple Stimuli and the Diversity of Findings	58
Future Directions for Enhancing Ecological Validity	60
Limitations.....	61
Data Collection Method: In person versus an Online Application.....	61
Unexpectedness of the Critical Stimulus	63
Participant Interviews.....	65
Recommendations / Future Study	66
Concluding Remarks.....	67
References	68

List of Figures

Figure 1: Player Positions on a Netball Court.....	33
Figure 2: Critical Stimulus Example.....	35
Figure 3: The Major Steps in the Online Application.....	39
Figure 4: Inattentive Blindness Rates	42
Figure 5: Participant Spacebar Presses.....	43
Figure 6: WA Player Movements and Critical Stimulus Two, Three, and Four.....	45
Figure 7: Distribution of Passes Counted.....	47
Figure 8: Accuracy of Passes Counted.....	48
Figure 9: Correlation Analysis of Passes Counted and Critical Stimuli Missed.....	49
Figure 10: Correlation Analysis of Inattentive Blindness Rate and Participant Ages	50

List of Tables

Table 1: Table Outlining the Footage Types Required.....	34
--	----

1. Introduction

The belief that to 'see' requires a person to simply open their eyes and look is not entirely accurate (Mack & Rock, 1998). If to 'see' was as simple as to 'look', then why do sports fans get frustrated on occasion when a crucial pass is missed despite the tactically advantageous option being obviously apparent? In this situation, when questioned post-game, the player who missed the game's critical pass often simply explains, "*I did not see them*". For the passionate fan, this may appear as an infuriating excuse; however, cognitive psychology research suggests that there may be a reasonable explanation for this phenomenon.

Humans exist within a detail-rich environment, yet we face limitations in processing the vast amount of information in our surroundings (Broadbent, 1958). Typically, our surroundings have significantly more information than we can efficiently process. Consequently, we employ an attention filter to determine what information receives our focus and what gets disregarded. The selection of information is primarily influenced by what information from the surrounding environment is relevant and important. We can effectively navigate through a complex environment by selectively attending to essential environmental information. However, as illustrated by the example above of the player missing the game-changing pass, information selection is not infallible. There are instances where the filtering process proves overly effective, causing significant information to elude our conscious awareness (Broadbent, 1985; Mack & Rock, 1998). This phenomenon is known as inattentional blindness.

Introduction to Inattentional Blindness

Inattentional blindness is a relatively new phenomenon and research area. Although, the phenomenon explains a condition that has been experienced for centuries. Inattentional blindness refers to the condition where a person fails to see a clearly visible but unexpected stimulus (i.e., task, object, event) because their attention is engaged elsewhere (Mack & Rock,

1998; Newby & Rock, 1998). The phenomenon of inattentional blindness is related to but different from “other failures of awareness such as change blindness, repetition blindness, visual masking, and the attentional blink” (Simons, 2007).

The difference from the other failures of awareness phenomena is that for the experience to be inattentional blindness, it must meet certain criteria (Simons, 2007). First, there must be a failure to notice a visual object or event. Next, the object or event must be fully visible (clearly within a person’s field of vision), and the person must be able to readily see it when they are actively looking for it. Thirdly, the failure to notice the critical visual object/event must result from an engagement of attention elsewhere within the visual field, not the visual stimulus itself. Finally, the object or event must be unexpected. The unexpected factor is essential because inattentional blindness refers explicitly to the failure to notice an unexpected event/object.

Generally, inattentional blindness experiments include an unexpected stimulus that enters the visual field, stays present for a short period, and disappears. Participants may or may not notice the unexpected stimulus when simultaneously undertaking a cognitive task (Oktay & Cangoz, 2018). The concept of inattentional blindness has arisen from the attention and selective attention studies conducted previously.

Inattentional Blindness Research Paradigm

Over the past two decades, inattentional blindness has emerged as a prominent area of research (Redlich et al., 2020). Within this field, three primary research paradigms have developed to investigate attentional awareness and inattentional blindness. The following subsections will provide an overview of these paradigms. The first paradigm is the cross-test, which represents the earliest form of inattentional blindness research. The second paradigm to be discussed is the gorilla video, which played a crucial role in popularising the phenomenon of inattentional blindness. Lastly, the third paradigm involves object tracking and is the most commonly employed method for studying inattentional blindness (Redlich et al., 2020).

The Cross Task Paradigm

The first study to explicitly research inattention blindness was conducted by Mack and Rock (1998) using a task known as the cross-task. The experimental procedure consisted of several trials. Firstly, participants completed three non-critical trials where no stimulus was presented. They were required to report which line of the cross, displayed at the centre of the computer screen for 200ms, appeared longer in length after the cross disappeared. The fourth trial was the critical trial, which included an unexpected stimulus and the cross-judgement distractor task. The critical stimulus was a small black square inserted into one of the quadrants formed by the cross, within 2.3 degrees of the fixation point, for the same duration of 200ms.

After the fourth trial, participants were asked to indicate which line of the cross appeared longer, as in the previous three tests. Additionally, they were asked if they noticed anything different from the previous trials, aiming to assess their awareness of the unexpected critical stimulus and explore what could be perceived without attention (Mack & Rock, 1998). If participants reported awareness, further questions about the stimulus's location (quadrant) and characteristics (small black square) were asked.

The study's results showed that approximately 25% of the participants did not consciously perceive the unexpected object during the critical trial. Based on this finding, Mack and Rock (1998) suggested that these participants experienced a condition of inattention blindness in this particular experiment.

To enhance the rigour of their study, Mack and Rock modified the experimental design. They presented the cross at the parafoveal region (2.3 degrees away from the fixation point), while the unexpected stimulus was presented at the fixation point. It was hypothesised that this modification would lead to a decrease in inattention blindness. However, contrary

to expectations, the results showed that inattention blindness significantly increased to approximately 60-80% when the unexpected stimulus was presented at the fixation point, compared to the initial 25% when it was presented at the parafovea (Mack & Rock, 1998).

This unexpected outcome suggests a clear causal relationship between perception and attention. The findings indicate that merely looking at something does not guarantee its conscious perception. Instead, attention is crucial for conscious awareness and perception to occur. The study highlights the importance of attention in shaping our conscious experience of the world and emphasises that selective attention plays a fundamental role in determining what we perceive.

Since its introduction by Mack and Rock (1998), the cross-test paradigm for studying inattention blindness has been widely adopted by subsequent researchers in the field. Downing et al. (2004) and Newby and Rock (1998) conducted studies that replicated the original experiment, thus providing further support for the validity of the findings. Moreover, researchers have utilised variations of the cross-test paradigm to investigate various factors that may modulate inattention blindness.

In these modified versions, the unexpected stimulus of a small black square has been substituted with coloured photos, allowing researchers like Mack et al. (2017) to explore the effects of different visual stimuli on the occurrence of inattention blindness. Other studies, such as the work of Li et al. (2015), have replaced the unexpected stimulus with images of ice creams to examine whether the shape or familiarity of an object influences the likelihood of inattention blindness within a given population. Additionally, researchers have manipulated factors such as the colour of the cross arms (Cartwright-Finch & Lavie, 2007) or changed the location of the cross within the computer screen (Lee & Telch, 2008) to investigate their impact on inattention blindness.

A comprehensive review conducted by Redlich et al. (2020) revealed that a total of 35 experiments had been conducted so far, using the cross-test paradigm as the foundation for their research design methodology. These studies have further expanded our understanding of inattentional blindness and shed light on the factors influencing its occurrence.

In summary, the development of the cross-test inattentional blindness paradigm has been a crucial milestone in advancing research on this phenomenon. Mack and Rock's (1998) pioneering study provided a methodology to quantitatively measure and study inattentional blindness, which has since been replicated by subsequent researchers using the cross-test paradigm. Furthermore, their work supported the notion that conscious perception requires attention.

However, the cross-test paradigm has faced criticism regarding its ecological validity, as it relies on static images that do not fully capture the dynamic nature of the real world (Redlich et al., 2020). Consequently, the generalizability of findings from studies using the cross-test paradigm is limited. To address this limitation, researchers have developed dynamic paradigms of inattentional blindness. The following section will present an overview of one such dynamic paradigm.

The Gorilla Video Paradigm

The original cross-task experiment examined inattentional blindness in a static experimental design, which has been recognised as a limitation in terms of ecological validity (Redlich *et al.*, 2021). The cross-task's static nature fails to capture the dynamics of the real world. As mentioned earlier, both the distractor task (cross-arm line length judgment) and the unexpected stimulus in the cross-test paradigm were static. However, considering humans interact with a dynamic environment, a more ecologically valid approach is needed to assess inattentional blindness dynamically. Recognising this gap in research, Simon and Chabris

(1999) addressed the issue by introducing a dynamic paradigm for studying inattention blindness.

The design of Simon and Chabris's (1999) study was influenced by earlier selective attention studies, such as the studies conducted by Becklen and Cervone (1983), Neisser and Becklen (1975), and Neisser (1979). These earlier studies presented participants with dynamic video scenes of people passing a basketball while the participants were instructed to count the passes silently. The purpose of the pass counting task was to engage participants' attention. During the video, while participants were focused on the pass counting task, a clearly visible but unexpected stimulus, in the form of a person wearing a gorilla suit, was also presented. The researchers were primarily interested in determining whether participants were aware of the gorilla person's presence (Neisser & Becklen, 1975; Neisser, 1979). These studies not only contributed to our understanding of attentional awareness, diverted attention, and selective attention processes, but they also served as the foundation for the development of the second paradigm of inattention blindness, known as the gorilla video paradigm.

Based on the dynamic experiment design developed by Neisser and colleagues (1975), Simon and Chabris (1999) created a similar dynamic video paradigm to investigate inattention blindness. Their paradigm, known as the gorilla video, consists of a 75-second-long video. In the video, two teams, one wearing black shirts and the other wearing white shirts, pass a basketball while moving in seemingly random patterns. At the 44-second mark, an unexpected critical stimulus is introduced. This stimulus can either be a woman wearing a gorilla suit or a woman carrying an umbrella. Both the gorilla and umbrella appearances last for 5 seconds and are clearly visible within the video. When presented to participants, this video can be used as a method to explore inattention blindness.

Researchers utilising the inattentional blindness paradigm based on the gorilla video instruct participants to watch the video and count the number of catches one of the teams made throughout the 75-second duration. This counting task serves as a distractor task to engage participants' attention, similar to the line judgment task in Mack and Rock's (1998) cross-test study mentioned earlier. At the conclusion of the video, participants are asked to recall the number of catches made by their assigned team and whether they noticed anything unusual occurring during the video. These questions aim to assess participants' level of awareness regarding the unexpected stimulus (the gorilla or umbrella lady). The level of awareness determines the presence or absence of inattentional blindness experienced by the participants.

According to the findings reported by Simon and Chabris (1999), using this paradigm, approximately 46% of the research participants were unaware of the presence of the unexpected critical stimulus (the gorilla or umbrella lady). Even though the gorilla or umbrella lady walked directly through the display and within the participants' visual field, they failed to perceive them consciously.

Simon and Chabris's (1999) study shed light on two significant factors that influence attention to an unexpected stimulus. The first important factor identified was task difficulty. Beyond the basic experimental design within Simon and Chabris's study, where participants were instructed to count all passes made by one team, Simon and Chabris asked some participants to count the passes the people playing basketball made and the different types of passes. This variation enabled the examination of inattentional blindness under varying levels of difficulty in the distractor task. The study showed that more participants failed to notice the unexpected stimulus when the distractor task was more challenging (counting both passes and types of passes simultaneously). This finding suggests that as the perceptual load of the task

increases, attentional resources become more limited, leading to a higher likelihood of inattention blindness.

Another factor identified in Simon and Chabris's study that influences attention to unexpected stimuli is stimulus similarity. The study revealed that stimulus similarity impacted participants' likelihood of noticing an unexpected stimulus. Specifically, participants assigned to count the passes made by the black team were more likely to notice the gorilla stimulus than those assigned to count the passes made by the white team (58% versus 27%, respectively). Moreover, the umbrella lady stimulus was noticed more frequently than the gorilla stimulus (65% versus 44%, respectively). This finding contradicted the claim made by Neisser (1979) that visually different stimuli "pop out" during attention-demanding tasks. Instead, Simon and Chabris's results indicated that when an unexpected stimulus shares basic visual features, such as colour, with the expected stimulus, it is more likely to be noticed. This suggests that dissimilarity between the unexpected stimulus and the expected stimuli contributes to the tendency to ignore irrelevant or critical stimuli, leading to inattention blindness.

The work from Simon and Chabris has been replicated and varied multiple times. One such replication study by Huttermann and Memmert (2012) explored the impact of physical exercise load on inattention blindness. While using the original gorilla video, they introduced a physical exercise task for participants. The findings revealed that moderate physical load decreased the occurrence of inattention blindness compared to a resting state, whereas high physical load increased inattention blindness.

Another adaptation of the gorilla video paradigm was conducted by Wayand and colleagues (2005). In this study, instead of the gorilla or umbrella lady, a lady walking in and scraping her nails down a chalkboard was inserted into the dynamic video scene of basketball

players passing the ball. This modification introduced both visual and auditory sensory stimuli. The study found that 53% of participants exhibited inattention blindness, indicating that the unexpected stimulus went unnoticed. These replications and variations of the gorilla video paradigm demonstrate the versatility of the paradigm and the ability to explore different factors that may influence the occurrence of inattention blindness. They provide further evidence of the complex nature of attention and its relationship to perceptual awareness.

In summary, comparatively, the gorilla video inattention blindness paradigm is a more ecologically valued method for testing the presence of inattention blindness. This paradigm is dynamic, like the environment that humans exist within. Additionally, the paradigm is realistic as the video uses real people; therefore, this realism increases results generalisation into non-laboratory settings (Redlich et al., 2020). The gorilla video as a testing paradigm is advantageous because it is real and dynamic. However, in exchange for these advantages, the gorilla video substitutes them for a comparatively (to the cross-task) reduced level of experimental control. The following section outlines the third inattention blindness paradigm, which attempted to converge the advantages of the cross-test and the gorilla video.

The Object-tracking Task Paradigm

The third and most common paradigm for testing inattention blindness is the ‘object-tracking’ paradigm, which originated from Most and colleagues (2000: 2001). The paradigm combines the benefits of the dynamic display of critical and distractor stimulus that Simon and Chabris (1999) utilise in their gorilla video with the experimental control that the static cross-task uses (Mack & Rock, 1998).

In brief overview, the object-tracking inattention blindness paradigm is a computerised task. During this task, participants are asked to focus on a fixation point on a display screen. Then a 15-second trial is initiated where four black and four white shapes (‘L’

and 'T's) randomly move around a computer screen. The screen is divided into two sections by a horizontal line. The distractor task had the participants track one colour set (white or black) of shapes and silently record how many times they touched the centre line (Most et al., 2000). The participants are instructed to ignore the opposite colour shapes' movements. Per the two previous inattentional blindness paradigms, the participants were asked to recall the number of bounces their allocated shapes made during the trial. The test structure was repeated multiple times for each participant, and on the third repetition, the participants were presented with an unexpected stimulus test for inattentional blindness.

In object-tracking tasks, the unexpected critical stimulus is a simple cross shape. The unexpected stimulus cross shape was present for 5 seconds, and it moved in a horizontal-linear path across the screen, with a brief pause at the fixation point. In addition to recalling how many touches the participant's allocated shapes made, the participant would also be asked about their awareness of the unexpected stimulus. If participants indicated awareness, they were questioned regarding the unexpected stimuli's location and details (size, shape, colour, motion path). The outcomes of Most et al. (2000) study found that 53% of the participants were unaware of the unexpected stimulus during the critical trial and, therefore, inattentionally blind.

Like the previous two inattentional blindness research paradigms discussed, this object-tracking paradigm has garnered many replications and adaptations. Studies have used the object tracking paradigm to begin to understand how in different testing variations, inattentional blindness exists (e.g., stimulus luminosity test: Most et al., 2005; different testing durations: Zhang et al., 2017; different unexpected stimulus movement speed, Kreitz et al., 2016). These few studies are a small portion of the total object-tracking paradigm study group. A recent systematic literature review conducted by Redlich et al. (2020) identifies the object-tracking task as the most frequently used paradigm. Redlich et al. suggest this high

frequency is due to the object-tracking task having both the gorilla video paradigm's dynamic display aspect with the cross-task paradigm's control (Redlich et al., 2020).

In the second part of the systematic review by Redlich et al. (2020), the object-tracking task lacks real-world representation. The object tracking task, while beneficial to test the different conditions of inattention blindness, is not well representative of the real-world context. One real-world context of concern for this literature review is the sporting context. It would be challenging to generalise the results from an inattention blindness study using the object-tracking paradigm in the sporting context. In the section below, inattention blindness research in the context of sports will be reviewed.

Attention in Sport

Team ball sports are complex and dynamic games that require players to perceive and tactically respond to various visual stimuli (Memmert & Furley, 2007). In team ball sports, players are constantly bombarded with environmental stimulus information (Redlich et al., 2020). These stimuli may include the colour of painted lines indicating the game area, the presence of opposing players, the teammates' movements, the crowd's cheers, the constantly moving ball, and even objects such as a drink bottle left on the sidelines. All of these objects and events within the players' field of vision and hearing range serve as stimulus information.

Sports players, like all humans, have a limited information processing capacity; therefore, not all objects or events within our field of vision can be perceived. As a result, players need to selectively attend to some stimuli and ignore the remainder in order to respond accordingly to the gameplay. Generally, in sports, some stimuli are more directly relevant to the game than others; for example, the goal, the painted lines on the ground, the movements of the opposing team, the ball, and the player's teammates are relevant stimuli in a player's field of vision. Whereas a drink bottle on the sideline or the crowd may not be as directly

relevant to the game; however nonetheless, they still fall within the players' field of vision. Both directly and non-directly relevant stimuli are available for processing, but due to the limited capacity of the information processing system, only a portion of the information reaches conscious awareness. Understanding attentional processes in team ball sports may provide valuable insights for developing effective tactical solutions.

Sport Inattentive Blindness Paradigm

As outlined, early inattentive blindness research was primarily based on the three main paradigms of inattentive blindness. The early inattentive blindness studies assisted in developing research techniques to quantify the inattentive blindness phenomenon; however, these studies were laboratory-based and severely lacked real-world applicability. The understanding gained from these foundational studies was limited due to the lack of real-world representation within the research design. Thus, a movement towards researching inattentive blindness in real-world settings began because whilst we now could prove inattentive blindness occurs in a laboratory, we could not necessarily explain how it exists in specific real-world settings. For example, the team-ball-sports context vastly differs from that of a controlled laboratory. Therefore, to understand if inattentive blindness exists in team-ball-sports, a more ecologically valid sport-inattentive blindness paradigm was required.

The first issues that researchers of inattentive blindness research in sport had to overcome were the lack of representative research paradigms. The three main inattentive blindness paradigms are laboratory-based (Redlich et al., 2020); therefore, they are limited by their generalisation capability when researching inattentive blindness in sport-specific settings. Using these main inattentive blindness testing paradigms (cross-test, gorilla video, and object-tracking task) as they were originally developed to explain inattentive blindness in the sport context would be ill-suited.

Two early inattentional blindness in sport research studies sought to develop a team ball sport representative inattentional blindness task. Memmert and Furley (2007) tested whether inattentional blindness could be measured by a sports representative inattentional blindness dynamic video. They used the principles from the gorilla video paradigm but substituted the gorilla video with footage from an actual team ball sport game (handball). The study asked the participants to complete two tasks simultaneously whilst watching the videos. The participants were asked to assume the role of (act as though they were) the yellow-bibbed player on the court. The first task required participants to keep a silent record of where the yellow player moved during the video. The second task required the participant to make a judgement call about who the yellow player should pass the ball to once the video clip ended. This test procedure was repeated three times.

During the initial two trials, there was no clearly unmarked player to whom the yellow player should pass; therefore, it did not matter who the participant chose to pass to. However, in the third trial, there was an unmistakably unmarked player. This particular trial aimed to investigate attentional awareness and gauge the presence of inattentional blindness. The key factor determining the existence of inattentional blindness was whether or not the participant noticed the obviously available player to whom they should pass in the third trial. The results of this experiment revealed that 45% of the participants did not consciously perceive the obviously unmarked player during the third trial (Memmert & Furley, 2007). This finding of 45% inattentional blindness is comparable with the outcomes of general studies on inattentional blindness (Memmert, 2006; Most et al., 2005; Simons & Chabris, 1999).

In a subsequent study conducted in 2010 by some of the same researchers, Furley and colleagues examined the occurrence of inattentional blindness in a different team ball sport. Their study utilised the sport inattentional blindness task paradigm to provide evidence that inattentional blindness is present in the sport of basketball. Similar to the study by Memmert

and Furley (2007), Furley and colleagues developed a series of videos depicting 5v5 basketball gameplay. The first three videos did not feature any obviously free or unexpected teammates, while the fourth video did. Once again, the ability to notice the free teammate served as the measure for determining the presence of inattention blindness. Furley's study showed that 38% of the participants experienced inattention blindness (Furley et al., 2010). These findings align with the results from the earlier sport study (Memmert & Furley, 2007) and support the notion that inattention blindness is a robust phenomenon that can be observed in various sporting contexts (Furley et al., 2010).

Modifying Factors of Inattention Blindness Prevalence in Sport

The Saliency of the Critical Stimulus: The Unexpected Player

A modifying factor studied in inattention blindness research relates to the saliency of the critical stimulus. Saliency refers to the degree of perceptual prominence or significance a stimulus possesses within a given context. It reflects the extent to which a stimulus stands out or captures attention relative to other stimuli in the surrounding environment. Saliency plays a critical role in guiding our cognitive processes and determining what captures our awareness in the context of perception and attention.

Saliency is influenced by stimulus properties, contextual information, and individual factors. Stimulus properties such as colour, luminance, motion, and orientation can contribute to the saliency of a stimulus (Nothdurft, 2000). For example, a brightly coloured object in a monochromatic environment will likely be more salient and attract attention (Kamkar et al., 2018). Similarly, a moving object among stationary objects may grab our attention (Kerzel et al., 2011). In addition to stimulus properties, contextual information also influences the saliency of a critical stimulus. For that, the relevance of a stimulus to the current task or goal can enhance its saliency. Additionally, individual factors such as a person's interests, past experiences, and biases can influence saliency (Moray, 1959). People tend to pay more

attention to stimuli that are personally meaningful or relevant to their goals, and their past experiences can shape their attentional biases towards certain types of stimuli.

These three factors of stimulus saliency influence the selection of attention towards certain stimuli within the surrounding environment. In sport inattentional blindness research, stimulus saliency within a game has been examined. Typically in sport inattentional blindness research, the critical stimulus has been an unexpected player. In fact, Memmert and Furley (2007), as the early researchers of inattentional blindness in sports, examined the saliency of the unexpected player as a modifying factor of inattentional blindness in sports.

In this study, the unexpected player waved their arms to increase their saliency by highlighting the stimulus property of stimulus in motion. Inattentional blindness was measured by whether the participants noticed the unexpected player. The results found that only 6% of participants did not notice the unexpected and unmarked player when their arms were waving. When the unmarked and unexpected player was not waving their arms (standing still), they were missed (not noticed) by 45% of participants. The outcome of this experiment shows that increasing the saliency of the unexpected player can minimise the prevalence of inattentional blindness. Moreover, the findings also suggest that there may be strategies for decreasing inattentional blindness in sports.

Inattentional Blindness: Endogenous and Exogenous Attention

Inattentional blindness is a type of failure of attention. Interrelated to the literature on failures of attention is the associated knowledge of attention mechanisms that aid in directing our attention to certain aspects of our environment. Endogenous and exogenous attention are two different mechanisms by which our brains allocate attention to certain stimuli in our environment. This allocation of attention, either by endogenous or exogenous mechanisms, can modify inattentional blindness prevalence.

Endogenous attention, also known as goal-driven attention, refers to the ability to focus consciously and deliberately on a specific stimulus or aspect within the environment (Peelen et al., 2004; Posner, 1980). When using endogenous attention, a person actively directs their attention to particular objects or locations based on what they want to focus on or consider relevant to their current task or goal (Chica et al., 2013). It involves the engagement of higher-order cognitive processes, such as working memory, executive functions, and goal-setting mechanisms, to select and maintain attention to specific information. Endogenous attention allows you to filter out irrelevant or distracting stimuli and concentrate on what is most important at the moment (Meyer et al., 2018). It plays a vital role in various cognitive tasks, including problem-solving, decision-making, and visual search (Brosch et al., 2013).

Sports activities are mainly goal-focused, such as in the case of netball, where the primary objective is to score more points than the opposing team by putting the ball through the hoop. Each team will have a series of 'tactical plays' that will aid in them intercepting and moving the ball towards the hoop more often than the other team. These plays are pre-planned, and players on a team are primed to expect their occurrences. Players have a certain degree of expectation during a play that their teammates will be located in the pre-planned locations and ready to execute the plan. As a result, players orient their attention to these locations consciously, thus using endogenous attention. However, the limitation of endogenous attention in netball is that, unlike a choreographed dance sequence, netball involves another completely independent team whom do not know the plan, nor do they intend to assist the other team to execute it flawlessly. This causes a degree of unpredictability and the potential for inattentional blindness to occur (Memmert & Furley, 2007).

An experiment by Memmert and Furley (2007) found that inattentional blindness was more prevalent when the coach's instructions were very specific, thus narrowing the focus to one certain occurrence. The result of this meant that the players failed to find the optimal

tactical solution to a situation because the coach had narrowed their focus of attention (endogenously) and goal to a point whereby unexpected occurrences were not seen. The players failed to notice the obviously unmarked teammate. Not noticing this meant they made a less tactically advantageous decision, impacting the team's performance.

Conversely, endogenous attention is exogenous attention. Exogenous attention is stimulus-driven attention, whereby attention is involuntary orienting towards often-unexpected salient external stimuli. When an exogenous attentional shift occurs, our focus is involuntarily drawn to a stimulus that stands out in the environment, such as a loud noise or a sudden movement (Peelen et al., 2004; Posner, 1980). These stimuli can grab our attention without any deliberate effort or intention on our part. In sports, exogenous attention is crucial in enabling players to react swiftly to the dynamic events unfolding within the game. It allows players to respond quickly and instinctively to unexpected occurrences on the court, ensuring they can adapt and make split-second decisions in high-pressure situations.

Combining both endogenous and exogenous attention is crucial for sports players to excel in their respective sports. Effective players can seamlessly shift their attention between consciously planned actions (endogenous), such as pre-planned plays, and reflexive responses to external stimuli (exogenous), such as a salient teammate. Optimizing both endogenous and exogenous attention in sports can have several significant benefits for players and their overall performance. By honing these attentional mechanisms, players can enhance their decision-making, situational awareness, and ability to respond effectively to unpredictable events, thus decreasing inattentional blindness occurrences.

Sport Expertise

Another modifying factor that has been researched in relation to inattentional blindness prevalence in sports studies is participant expertise. Inattentional blindness literature

has begun to explore whether personal expertise influences a person's likelihood of experiencing inattentive blindness.

In the field of inattentive blindness in sports, researchers have been interested in understanding whether novice players exhibit higher levels of inattentive blindness than their more experienced counterparts (Memmert, 2006; Furley et al., 2010). The earliest study to review the effect that sport expertise had on inattentive blindness prevalence found that novices were more likely to experience inattentive blindness. The study utilized Simon and Chabris's (1999) gorilla video inattentive blindness task (Memmert, 2006). The researchers conducted the study with two groups of adult participants: one group with significant experience playing basketball (average 12 years of experience) and another group with minimal basketball experience. Memmert's (2006) study revealed that 62% of experienced adult basketball players noticed the gorilla in the Simon and Chabris video, whereas only 38% of novice adult basketball players noticed it. Therefore, individuals with basketball-specific expertise were more likely to detect the unexpected object compared to those without specific previous experience (Memmert, 2006). Memmert suggested that these findings may indicate that expert team sport players possess "special perceptual skills" that enable them to direct their attention towards seemingly unimportant stimuli (2006, p. 625). Thus, this study implies that previous experience in team sports influences the likelihood of experiencing inattentive blindness.

In a subsequent study by Furley and colleagues (2010), the relationship between prior experience in a team ball sport and inattentive blindness was further investigated. The researchers examined whether the experience level¹ influenced the likelihood of experiencing inattentive blindness. The study design involved participants watching multiple video clips

¹ Participants experience in basketball.

of a basketball game and instructing them to focus on the player wearing the green bib (while all other players wore white or black). After each video, the participants had to report who the green-bibbed player would pass to immediately. In the first three videos, there was no obviously unmarked player to pass to; however, in the fourth trial, an obviously unmarked player was present.

The study included both experienced and novice basketball players. The results showed that experienced basketball players noticed the unmarked player 92% of the time, resulting in an 8% rate of inattention blindness (Furley et al., 2010). Comparatively, the novice group noticed the unmarked player 89% of the time, resulting in an 11% rate of inattention blindness (Furley et al., 2010). Statistical analysis did not reveal a significant difference in the rates of detecting the unexpected but available player between the expert and novice groups.

Ecological Validity of the Sport Inattention Blindness Paradigm

As ecological validity refers to the extent to which the findings of a study accurately reflect real-world settings, ecological validity is essential because it ensures that research findings are relevant and applicable to the contexts in which they are intended to be used. Ecological validity is important as it refers to the extent to which the findings of a study can be generalized and applied to real-world settings (Xu et al., 2021). Previous inattention blindness research has been restricted concerning ecological validity due to the use of laboratory settings, artificial induction of inattention blindness, non-sport-specific responses, and participant awareness. As a result, previous research has been limited by the applicability of findings to real-world situations.

Most studies on inattention blindness are conducted in controlled laboratory settings. While these settings provide researchers with precise control over experimental variables,

they often lack the complexity and dynamism of real-world environments. For example, the cross-task or the object tracking task paradigms are simple animations that lack the stimulus complexity and diversity found in the world (Mack & Rock, 1998; Most et al., 2000: 2001). In these studies, it could be assumed that participants may be more focused and attentive due to the experimental context, which may not accurately reflect their attentional state during everyday activities.

Currently, when researching inattentional blindness, it is impossible to capture data in the field; therefore, researchers have been creating experiments that artificially induce inattentional blindness. These experiments may not perfectly replicate the conditions under which inattentional blindness naturally occurs in real-world situations. For example, Memmert and Furley (2007) asked participants to remember a particular player's movements throughout the video. Tracking a single player in a sports game would be highly unlikely. Instead, most sports and sports coaches would encourage a broad breadth of attention to multiple players to optimise awareness of the entire game context. However, Memmert and Furley structured the experiment to require participants to undertake a task and comprehend the game in a way that is non-representative of the actual game. It is important to note that both Memmert and Furley (2007) and Furley et al. (2010) have progressed the inattentional blindness paradigm from a highly laboratory-based to something that resembles the real-world context of sport. However, as Furley et al. (2010) outlined, "it is necessary to show that inattentional blindness also exists in ecologically more valid settings."

Many studies in the field of sport psychology use non-sport-specific responses, such as pressing buttons or verbal responses, to assess attention and perception (Ranganathan & Carlton, 2007; Furley et al., 2010). These responses may not capture the complexity and specificity of real-time sport performance, where athletes must process visual information and

make immediate motor responses. This limitation can affect the ecological validity of findings when applied to sports contexts.

In laboratory studies, participants are typically aware that they are participating in an experiment, which can influence their attentional state and behaviour. Participants are cued to direct attention to certain aspects of the videos and are instructed on what is expected of them. In the real-world context, this explicitness of instructions is often not given. Therefore, this limits the generalisation of findings to real-world contexts.

Overall, these restrictions to ecological validity in inattentional blindness research highlight the need for studies that incorporate more ecologically valid methodologies. These methodologies may include real-world simulations or field studies. By utilizing such approaches, researchers can gain a better understanding of the occurrence and implications of inattentional blindness in naturalistic contexts.

Summary

In summary, this literature review focuses on inattentional blindness and its relevance in the team ball sports environment. The review examined the three main paradigms of inattentional blindness research studies and subsequently emphasized the importance of understanding this phenomenon in team ball sports. Inattentional blindness can have a detrimental impact on personal and team performance in these dynamic and complex settings, where perception-action coupling is crucial for tactical success. Consequently, gaining a deeper understanding of inattentional blindness in team ball sports contexts can lead to the development of strategies to mitigate its adverse effects on performance. This knowledge has the potential to benefit players and coaches across all levels of team sports, enabling them to optimize their performance. However, the current issue lies in the significant gaps in

knowledge and ecological validity of inattentional blindness research within the team ball sports context.

The Present Study

Research Question

The purpose of this study was to answer the research question: does inattentional blindness occur in the team ball sport context of netball? In addition to the primary purpose, this study sought to develop a more ecologically valid sport-inattentional blindness research paradigm. Inattentional blindness has been shown to be a robust finding in the laboratory; however, only a few studies have explored inattentional blindness in sports settings (Memmert & Furley, 2007; Furley et al., 2010). These few studies are limited by their real-world representativeness of the dynamic and complex sport setting.

COVID-19 Influence on Study Design, Method, and Procedure

The present study was initially intended to be conducted in person; however, the COVID-19 Omicron outbreak in New Zealand in 2022 prompted a change in the study method. The purpose of this change in method was to ensure the study complied with New Zealand government instructions to minimise the potential for transmission of COVID-19 through group gatherings. As the COVID-19 pandemic and the associated response to it constrained the capacity to collect data in person, the decision was made to modify the data collection process to be entirely online. The following methods section outlines the development of an online application to collect data using the online research participant recruitment platform, Prolific (www.prolific.com).

While using Prolific was not initially intended, it provided different opportunities and advantages that in-person research could not. The primary benefit of using Prolific was the ability to research amid COVID-19 restrictions. The present study collected data across three

countries, all of which had differing COVID-19 isolation requirements; therefore, Prolific enabled data collection irrespective of individual national COVID-19 restrictions. Moreover, as it was not initially intended for data collection to occur via online platforms, data collection was going to be restricted to participants in the Manawatū region of New Zealand. Using Prolific enabled the data collection of participants from New Zealand, Australia, and the United Kingdom. No previous sport-inattentive blindness literature has been researched across multiple countries before.

2. Methods

Ethics

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern A, Application 21/48.

Participants

Fifty-five female participants aged 19 to 70 ($M = 41.04$, $SD = 15.57$) participated in the study. Participants were recruited from Prolific, a platform for online participant recruitment (Palan & Schitter, 2018). Participants were reimbursed for their participation through Prolific.

Using Prolific's participant screening function, we could screen/ restrict the participant group. For this study, the participants must have reported that they had played netball at a high school and/or college/university level as a part of a competitive league. Additionally, the study was only made available to participants who were currently residing in the United Kingdom ($n = 31$), Australia ($n = 12$), and New Zealand ($n = 7$). The purpose of restricting the participant recruitment pool to the United Kingdom, Australia, and New Zealand was due to netball being a popular sport and English as a national language in these countries. All participants in this study reported their first language as English.

There was no participant screener for sex; however, of the participants recruited, 100% were female. This percentage is unsurprising, considering netball is primarily a female sport. Most netball leagues do not allow males to participate.

Procedure

The study was conducted by using a custom online inattention blindness research application created for this study². Participants accessed the application and were informed they would watch videos of people playing sports and completing several cognitive tasks simultaneously. Participants completed two cognitive tasks whilst watching a video of people playing netball half-court.

Task One was to count all passes of the ball made during the video. It was explained that ball passes must be from one player to another, and goal shots should not be counted in the total. The participants entered the number of passes counted at the end of the video into the provided textbox. Task One was explained to the participants in both written and video form. To confirm the participant understood the task requirements, they were required to complete a practice trial successfully before continuing. Participants were able to review the task explanation if required and were able to retake the practice trial multiple times.

Task Two asked participants to press the Spacebar Key each time the Wing Attack (WA) player³ was freely available (unmarked) AND had their arm/s raised, indicating that they wanted to receive the ball. As per Task One, participants were provided written and video explanations of task two. Participants were shown a video of who the WA player was and a situation where the WA player was both freely available and with their arms raised. The participants were also shown a clip where the WA player was not freely available. They completed a practice trial for task two to ensure they understood the instructions.

² A Participant Point of View (POV) of them completing the study is available via this link:

https://youtu.be/A_eFto_xroM

³ The Wing Attack (WA) is a position in netball. The WA player is allowed in both the centre third and the goal third in the direction their team is shooting, however they are not allowed in the shooting circle and therefore are unable to shoot. They primarily mark the Wing Defence of the opposing team. The WA position assists in moving the ball into the shooting circle to the goal shooters.

After successfully completing the practice trials, the participants began the full trial. They were instructed to watch the video and complete Task One and Task Two simultaneously. The application automatically made the video full-screen. The trial video was two minutes and 10 seconds long. The video started with 25 seconds of instructions and setting orientation. The clips of people playing netball totalled one minute and 45 seconds. During the video, there were seven presentations of the critical stimulus, meaning that there were seven opportunities to measure inattentive blindness per participant.

Once the video had finished, the participants were asked to enter into the provided textbox their total count for how many passes of the ball were made during the video. The total number of passes made during the video was 34 passes. The participants were then advised that the study had concluded and thanked for participating. Each participant was provided with the researcher's contact details.

Prolific provided a record of the participants' demographic information. The record included age, sex, current country of residence, first language, and competitive sporting history. The accuracy of personal data collected from the participant's Prolific profile was dependent on Prolific's system providing accurate participant descriptor reports.

3. Materials

The research question for the present is, ‘Does inattention blindness occur in a team ball sport like netball’. Due to the specificity of context (netball), and the absence of suitable existing research material, there was a requirement to develop new inattention blindness in sport research materials. In addition, with consideration to the research aim of developing a more ecologically valid method of detecting inattention blindness in sport, developing new research materials enabled the opportunity to increase ecological validity through the design of the research materials. The following sections outline the processes for selecting the team ball sport to be used as the real-world setting for the study, the capturing of raw footage and the creation of the video stimulus material, and the design of the online application.

Netball

An integral component of this study was the selection of the team ball sport. Inattention blindness is a phenomenon observed in various aspects of life (Mack, 2003) and has primarily been investigated through laboratory studies that lack real-world applicability (Redlich et al., 2020). Therefore, it was crucial for the present study to adopt a real-world setting that would enable a more ecologically valid exploration of inattention blindness compared to previous research. The sport chosen for this study was netball, specifically a version played on a half-court. Several reasons justified the selection of netball as the team ball sport for this study. Firstly, the fundamental structure of netball and the half-court variation provided a suitable context for investigating inattention blindness within a sporting environment. Additionally, netball had not been previously utilized in inattention blindness research, making it an untapped domain for exploration.

The fundamental structure of netball makes it an ideal setting for investigating inattention blindness within the context of team ball sports. Despite their dynamic and complex nature, team ball sports are governed by specific rules that provide constraints. In

netball, the gameplay revolves around passing the ball between players to advance it down the court. Unlike other team ball sports like basketball, where players have the option to pass or dribble the ball, netball restricts players from running with the ball.

In a previous study conducted in 2010, basketball was used as the sport setting, giving participants a choice between passing or dribbling the ball when asked about what action the player in the video should choose (Furely et al., 2010). For this study, by selecting a sport with fewer options for ball advancement, the study can focus more precisely on the occurrence of inattention blindness without confounding factors related to decision-making or alternative actions. The simplified nature of netball, specifically regarding ball advancement, offers distinct advantages for researching inattention blindness. It allows for a clearer examination of inattention blindness within team ball sports, providing valuable insights into the phenomenon.

In addition to the simplified means of ball advancement in netball, netball also has a standard rule of time for which a single player can hold the ball. Netball enforces a rule prohibiting players from holding or possessing the ball for over three seconds. This three-second rule played a significant role in the study's design. It established a specific time range within which participants were expected to notice the critical stimulus when presented in the video.

To elaborate further, each critical stimulus had an acceptance period during which participants could identify and respond. If participants noticed the critical stimulus within this acceptance period, it was considered a positive identification, indicating that they were not experiencing inattention blindness according to this metric. Conversely, if participants failed to notice the critical stimulus within the acceptance period, it was classified as a "miss," indicating they were inattentionally blind to that specific stimulus. The three-second rule

aided in determining the appropriate acceptance period for positive identifications. Furthermore, aligning the acceptance period with the three-second rule provided a real-world/game-representative rationale for establishing the timeframe to capture inattentive blindness data. By utilizing a rule directly applicable to netball gameplay, the study ensured that the acceptance period was grounded in the actual constraints of the sport, adding further ecological validity to the research design.

Another compelling reason for selecting netball as the team-ball sport is its similarities to handball and basketball. These three sports share common rule structures and game objectives, making them highly comparable. These similarities proved beneficial in adapting the paradigms used in two previous studies on inattentive blindness in the context of team sports (Memmert & Furley, 2007; Furley et al., 2010). By leveraging the existing research paradigms from these studies, the present study was able to build upon their foundations and design a more ecologically valid research approach. The similarities between netball, basketball, and handball facilitated the adaptation process. This approach ensured that the study's design and procedures were grounded in established frameworks, thereby enhancing the reliability and comparability of the results. Furthermore, the resemblance between netball, basketball, and handball enables potential comparisons of inattentive blindness rates between these studies. Such comparisons can provide valuable insights into the generalizability of findings across different team-ball sports, shedding light on the broader implications and underlying mechanisms of inattentive blindness within these contexts.

Video Development

The development of research material involved capturing video footage of individuals playing netball, which was subsequently transformed into videos to be integrated into the data collection application. The raw footage was pivotal in creating the data collection application, as it served as the primary video stimulus material to which research participants would

respond. However, acquiring the raw footage was complex, as it required capturing more than just netball players engaged in the sport—the footage needed to include specific stimuli while maintaining the appearance of authentic and natural netball gameplay.

The process of collecting the raw footage required careful planning and execution to ensure that the desired stimuli were adequately represented. It was essential to balance incorporating the necessary elements for the research objectives and maintaining a realistic portrayal of netball gameplay. This ensured that the videos presented to participants during data collection closely resembled actual game scenarios, thereby enhancing the ecological validity of the study. By meticulously selecting and capturing the raw footage, I was able to develop video stimuli that effectively engaged participants and elicited their responses. This step was crucial in designing a data collection application that authentically replicated the real-world context of netball and facilitated accurate measurements of participants' perceptions and potential instances of inattention blindness.

Netball Players

The initial step in developing the video footage involved recruiting netball players to participate in filming. However, this presented a challenge due to the research project's unique circumstances. The study was conducted during the COVID-19 pandemic, specifically during the first Omicron outbreak in New Zealand in 2022. At that time, it was still discouraged to gather in larger groups, posing logistical difficulties for capturing footage of people playing netball together. To address this challenge, stringent COVID-19 risk management controls were implemented to ensure the safety of all participants and crew involved in the filming process. Despite the limitations imposed by the pandemic, careful coordination and adherence to the established risk management protocols made it possible to carry out a successful filming session. These controls included using N95 masks by the filming crew, providing

separate pens and paper for participants to sign consent forms, and selecting an outdoor environment for filming to reduce the risk of transmission.

There were initially intended to be two filming sessions; however, unfortunately, it had to be postponed due to illness and adverse weather conditions. Despite the setbacks, implementing COVID-19 risk management controls during the first filming session demonstrated the commitment to prioritize the health and safety of all involved in the research project.

The participants in the video footage were students aged 16 years and older who belonged to a netball team from a local secondary school in Manawatū, New Zealand. Prior to filming, the players were provided with a comprehensive explanation of the task and how the footage would be utilized in the research. Each participant willingly provided written informed consent to be filmed. During filming, the student's teacher and netball coach were present to ensure supervision and support.

Several factors influenced the decision to select a local secondary school team to participate in the video. Firstly, the players already knew each other, which was advantageous in promoting fluent and cohesive gameplay. The existing familiarity between players facilitated a natural and comfortable interaction on the court, eliminating any potential awkwardness that might have arisen from unfamiliarity. Additionally, using a pre-existing team ensured a consistent gameplay style among all the players on the court. This uniformity was beneficial for maintaining consistency in the stimulus material presented to research participants and reducing potential confounding factors related to individual playing styles. Lastly, opting for a school-based team simplified the management of COVID-19 risks. The school would have already established policies and protocols to prevent the spread of COVID-19 among the student population. This provided an added layer of assurance and

compliance with safety measures during filming. By selecting a local secondary school team, the study ensured a conducive environment for capturing authentic netball gameplay while prioritizing participant comfort, consistency, and the well-being of all involved in the research project.

Filming

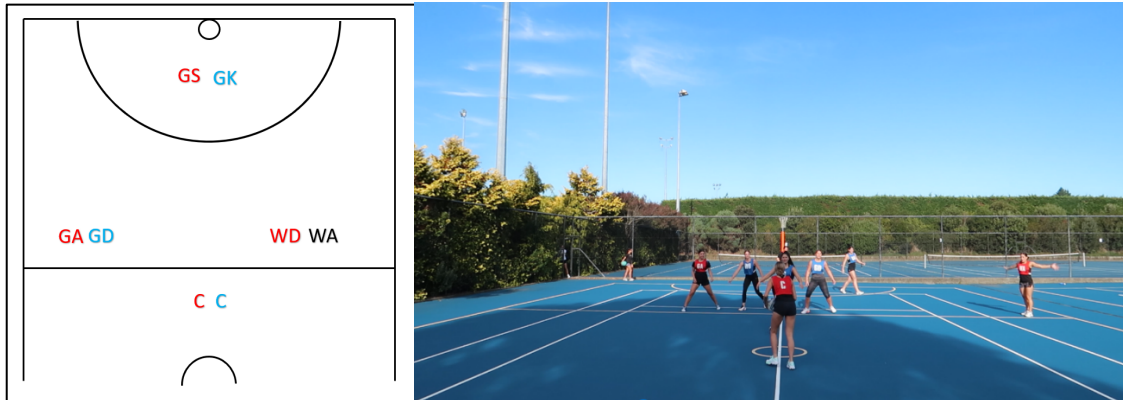
Eight students participated in the filming. The students were instructed that they would be playing a game of classic netball half-court. The students were familiar with netball half-court, with all students having played it previously. Netball half-court is a representative game of netball but played with less than the usual number of players⁴ and on half the standard netball court. All standard netball rules around contact, no stepping or obstruction apply.

The basic set-up was eight students played in the following positions: one Goal Keep (GK), one Goal Shoot (GS), one Wing Attack (WA), one Wing Defence (WD), one Goal Attack (GA), one Goal Defence (GD), and two Centre's (C). The defending team (GK, GD, WD, C) were wearing light blue bibbs, and the attacking team (GS, GA, WA, C) were wearing red bibbs (refer to Figure 1). A white netball was used. The game was set up on an outdoor netball court (blue court with white line markings). The day of filming was a sunny day with minimal-no cloud cover. Two cameras were used to capture gameplay. The first camera was set up approximately 10 meters behind the centre circle to capture the whole half-court in frame. This camera was a Canon PowerShot G7 X Mark II, and it was set to auto-focus and captured in 1080p HD video quality. A second camera was set up on the right-hand sideline (a 45-degree angle to the centre circle). No footage was used from the second camera. The cameras were set up on tripods to ensure stable video capture. Each camera had a person monitoring the footage being captured.

⁴ Half court is played with typically eight players, instead of the normal 14 required for a full game of netball.

Figure 1

Player Positions on the Netball Court.



Note. This Figure shows the netball players' starting positions before each centre pass-off.

To ensure that the footage would have the specific stimuli required for the present study, the students were briefed that they would receive “random instructions” to follow while playing a typical netball half-court game. It was necessary to have the students playing ‘normally’ and as unscripted as possible to ensure the footage produced appeared realistic whilst still capturing the required footage. To make the videos to be used in the study, I needed to capture footage of normal gameplay, gameplay where the WA had their arm raised and was not marked, and gameplay where the WA had their arm raised but was heavily marked. Table 1 shows the three footage categories and their associated significance to the inattentional blindness data collection.

Table 1*Table Outlining the Footage Types Required*

Three Types of Footage Required and the Associated Research Purpose	
Footage Type	Function in the Final Inattentive Blindness Research Videos
Normal gameplay	<ol style="list-style-type: none"> 1) Used as filler footage between critical stimuli and false alarm presentations to increase gameplay authenticity in videos and regulate stimulus presentation frequency/ tempo throughout the video. 2) Used as footage of players passing the ball for the participants to count whilst watching the video. Task One requires the participants to count players' passes throughout the video.
Gameplay where the WA player is available (unmarked) and has their arm/s raised	<ol style="list-style-type: none"> 1) The WA player free and with their arm/s raised is the critical stimulus. Participant's noticing/ not noticing the critical stimuli throughout the final video will measure their rate of inattentive blindness.
Gameplay where the WA player is unavailable (marked) and with their arm raised	<ol style="list-style-type: none"> 1) Capturing the WA not freely available (marked) and with their arm/s raised will likely result in false alarms. Participants are not to associate the WA with their arm/s raised as the critical stimulus as this is not a tactically advantageous stimulus to identify in netball. Participants need to identify both the unmarked (freely available) WA and have their arms raised for a positive identification.

Note. The table outlines the three types of footage required and the associated research purpose. Prior planning of required footage was necessary, due to the constrained capacity to capture footage, due to Covid-19 restrictions. Planning the footage required and considering the research purpose of each footage type ensured that the footage captured was appropriate and useful for the research study.

The students complied with the instructions and continued playing as normally as possible. The first random instruction given was to the defending players (blue-bibbed C, WD, GD, GK). This instruction required them to defend "like a starfish" with their arms

raised above their heads. The attacking players were instructed to continue playing normally. The purpose of this was to capture footage where there were a lot of arms waving about, which created visual clutter. The next instruction was only to the red-bibbed WA player. They were told to stand behind the blue-bibbed WD purposefully and make themselves unavailable to receive the ball as possible. Then the WA player, whilst still standing behind the WD, raised their arm straight up in the air as if they wanted the ball. These instructions created a situation where the WA was unavailable to receive the ball but still indicated to their teammates that they wanted it.

The next instruction was given to the WA. This time the WA was told to try and “get away” from the WD and put themselves in a position where they can successfully receive a pass. Additionally, the WA was told to raise their arm/s to indicate they wanted the ball and were available to receive it. These instructions created situations where the WA had their arm/s raised and were freely available (unmarked by WD). When the WA player was freely available/ unmarked, with their arm/s raised, it was to be used as the critical stimulus in the study and was to be used to measure inattention blindness.

Giving the instructions to the players enabled the capture of footage with instances of potential false alarm identification and positive critical stimulus identification. Capturing these situations/stimuli enables the ability to construct the video for data collection via the application.

Figure 2*Critical Stimulus Example*

Note. An Example of the WA Player with their arms raised. The WA player (red-bibbed girl on the right side of the image) has both arms raised and not marked by another player, therefore meeting the classifications of the critical stimuli. An occurrence such as this would be what the research participants were required to identify in the study. Not identifying this occurrence would be deemed as inattentionally blind. Figure 2 also shows the real-world representativeness of the footage captured.

Video Creation

Once the raw footage was obtained, the next phase involved processing and creating the final videos required for the study. This included an explanation video for both tasks, a practice test video for both tasks and the final video used for data collection. To accomplish this, a thorough footage review was conducted, and the necessary editing was performed to assemble the five videos.

During the footage review process, it was observed that the secondary camera did not capture usable footage. This was primarily due to the frame's angle and the footage's overall quality. In contrast, the primary camera, positioned behind the centre circle, yielded superior quality and more suitable footage. The straight-on shot from the primary camera provided a clear view of the gameplay without any angle distortion. Furthermore, the primary camera recorded in 1080HD ensures a higher quality output than the secondary camera. Based on these considerations, the decision was made to rely primarily on the footage captured by the

primary camera. This choice ensured the videos maintained consistent and optimal visual clarity and quality.

Following the footage review, the next step involved processing the footage into individual clips that captured plays from the centre pass-off until a goal was scored. These clips were categorized based on the presence of critical stimuli, false alarm situations, and standard gameplay. Within each category, further sorting was conducted based on the authenticity and clarity of the plays. The goal was to include only the most genuine and clear clips while excluding confusing or overly scripted footage.

The sorting process prioritized the clips' cleanliness and clarity to ensure the study's success. It was crucial to have video clips that effectively conveyed the gameplay to participants, enabling them to follow and comprehend the events on the court efficiently. To achieve this, clips that exhibited messy gameplay or appeared too scripted were omitted from the selection. The emphasis on clean and clear clips was to enhance the participants' engagement and understanding of the game scenarios, ultimately facilitating accurate responses and observations related to inattentional blindness. The chosen clips, which were the most obvious and authentic representations of gameplay, were then carefully edited together to produce the final videos to be used in the online application. By focusing on selecting high-quality and authentic clips, the study ensured that the video stimuli used in the online application accurately represented real gameplay situations, promoting the ecological validity of the research and optimizing the participants' experience during data collection.

The full-length video for the trial was two minutes and 10 seconds long (refer to https://youtu.be/A_eFto_xroM to view the trial video). The video started with 25 seconds of instructions. The clips of people playing netball totalled one minute and 45 seconds. During the video, there were seven presentations of the critical stimulus; therefore, meaning that there were seven opportunities to measure inattentional blindness per participant.

Alongside the trial video, two exemplar videos were created to explain the study clearly to the participants. These exemplar videos served as instructional guides, allowing participants to simultaneously understand and engage in the required mental and cognitive tasks. Each task was explained individually through written instructions and a corresponding video to facilitate comprehension. These videos familiarized participants with the study setting and the specific tasks they were expected to perform. Furthermore, the videos included a small practice task to ensure participants understood the instructions and could successfully complete the assigned tasks. Participants were required to demonstrate proficiency in the practice tasks before proceeding with the actual study.

By incorporating written instructions and explanatory videos, the study aimed to provide comprehensive guidance and ensure participants' understanding of the tasks. The inclusion of practice tasks further enhanced participants' ability to grasp the requirements of the study, promoting accurate and meaningful data collection. Please refer to the procedure section for more specific information regarding the task explanation process.

The Online Data Collection Application

The final component required for this research project involved developing an online application. Given the constraints posed by the Covid-19 pandemic and the subsequent Omicron outbreak in New Zealand, conducting in-person data collection was not a viable option. Therefore, creating a custom online data collection application that allowed participants to engage in the study independently became imperative. The application was designed to guide the research participants through the entire research process and record all necessary data.

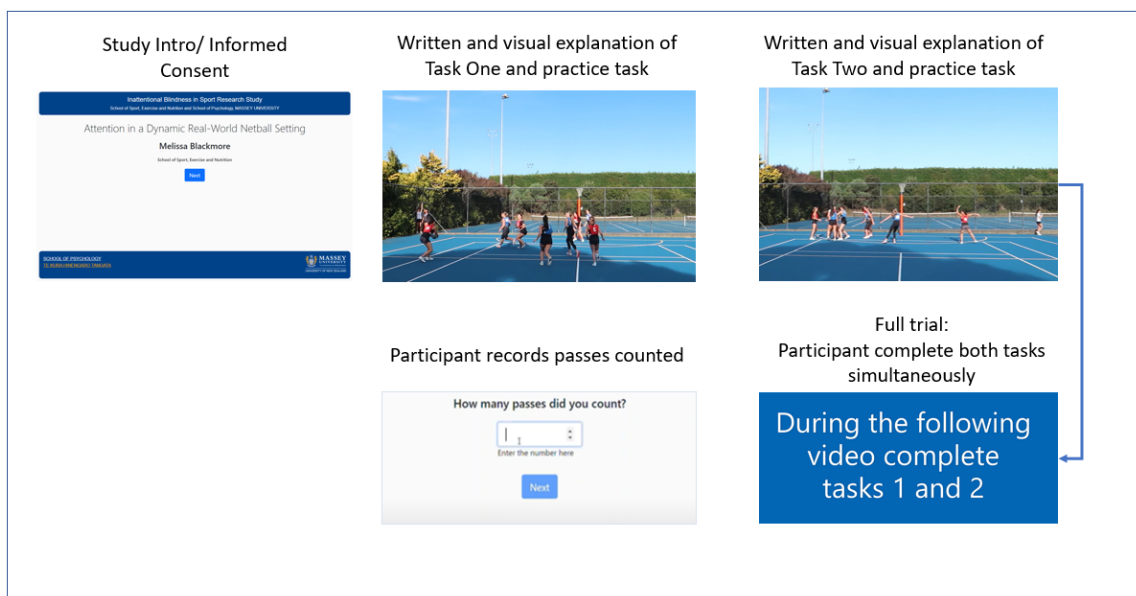
The application's design and development was a collaborative effort between the Master's student and a specialist programmer from the university. Together, we worked on creating and refining the application to ensure it met all the specific requirements and served

its intended purpose. Figure 3 depicts the key stages of the research study, which provided valuable guidance for the application's development. Following this basic outline ensured the inclusion of all major components of the study within the application.

The application design process involved several stages of iterative development, testing, and refinement. This thorough approach continued until the application achieved its desired functionality. The synergy between the student and the programmer allowed for the creation of a comprehensive and user-friendly application.

Figure 3

The Major Steps of the Online Application.



As part of developing the online application, data collection methods were carefully designed to capture relevant information from each participant for the study. The final application design included specific functionality to gather important data from participants. Firstly, it recorded the screen size to ensure that participants used a computer for study completion, as the application and study were not optimized for tablet or smartphone use. Additionally, the application collected the duration it took for participants to complete the study, which served as a metric to measure task engagement and time commitment. These

initial two data sets were recorded to provide an opportunity for assessing, during data analysis, whether participants were sufficiently engaged in the research process.

In addition, the application also captured important data that aided in the examination of inattention blindness in netball. Concerning task one, the application recorded the number of passes made by each participant during the full trial, offering insights into their performance and engagement with the task. Regarding Task Two, the application meticulously recorded all spacebar presses in four ways. Firstly, it logged the timestamps of all spacebar presses. Secondly, it distinguished whether spacebar presses occurred during the presence of critical stimuli or not, allowing for differentiation between positive identifications and false alarms. Thirdly, it counted the number of spacebar presses made by each participant when critical stimuli were present. Lastly, it captured the total number of spacebar presses made by each participant throughout the task.

The application compiled all the collected data into a downloadable Excel spreadsheet. Each participant's data was organized into individual lines, facilitating further analysis and interpretation of the collected data. By capturing these diverse data points, the application enabled researchers to examine participants' performance, response patterns, and task completion times, providing valuable insights into the study's objectives and research outcomes.

4. Results and Discussion

Data Preparation: Exclusions and Missing Data

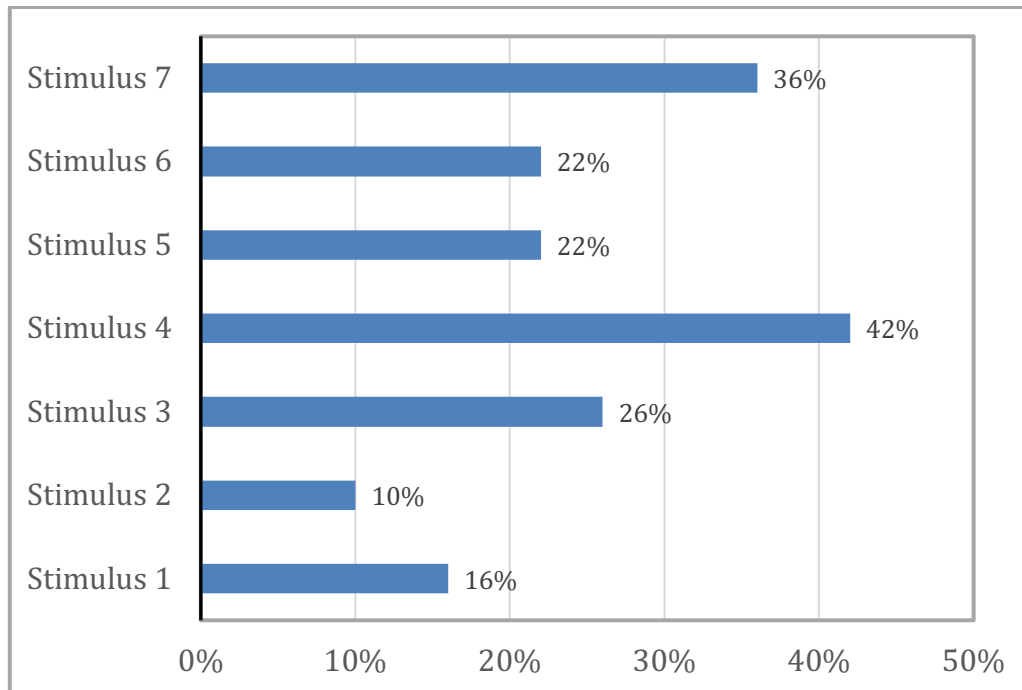
In total, 60 people entered the online application through the Prolific website. Of these 60 people, five chose not to participate or had a malfunction with the application, for example, server issues or accessing the study using a tablet device and did not undertake the study, and no data was collected from them. An additional five participants were excluded from analyses due to not producing any data for task two – the critical stimulus identification task. These participants did not press the spacebar during the trial. It cannot be confirmed whether they did not identify any instances of the WA with their arms raised and available or if they did not understand the instructions to participate as required. Due to these questions regarding these five participants' participation, it was decided to remove their data (or lack thereof) from the analysis. The remaining 50 participants' data were assessed to be of usable quality.

Analysis

Inattentional Blindness

Fifty participants collectively missed 87 critical stimuli out of a total of 350 presented; this equates to an overall 25% failure rate to notice the critical stimuli. For this study, the failure to notice the critical stimuli was used as the metric to inform experiences of inattentional blindness. It is inferred that inattentional blindness equated to 25%.

Each participant was presented with seven critical stimuli, and the rate of inattentional blindness across the whole study was calculated by averaging the rate of inattentional blindness for each critical stimulus presentation ($n = 7$). Whilst inattentional blindness was recorded at 25% across the study, the individual critical stimuli reported an inattentional blindness rate between 10 - 42% (refer to Figure 4).

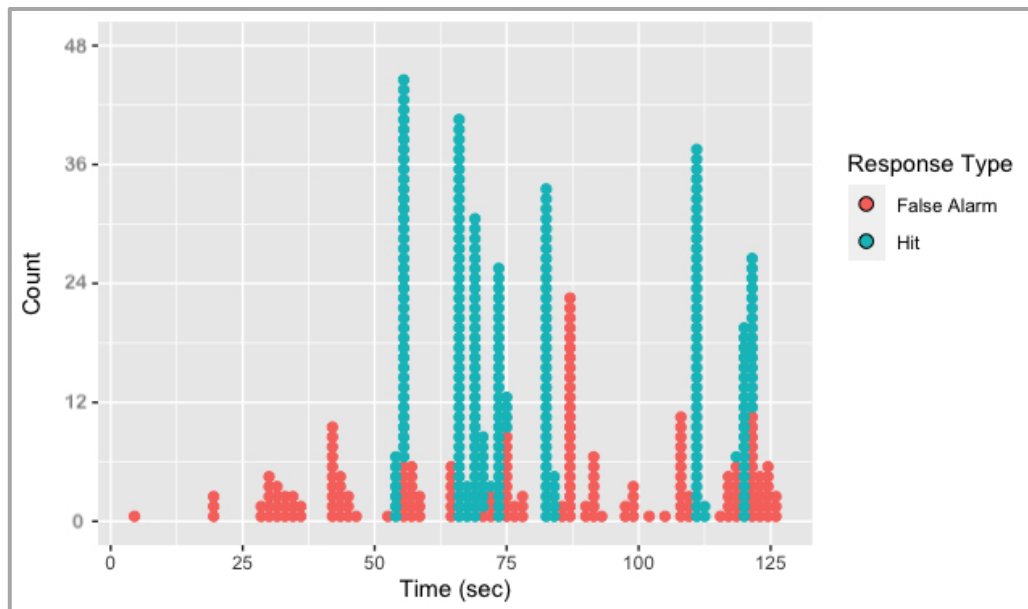
Figure 4*Inattentive Blindness Rates per Critical Stimulus*

Note. Rate of inattentive blindness measured, in percentage, per critical stimulus.

Temporal Map Analysis. A temporal map analysis has been used to review task two's raw data. Figure 4 shows all spacebar presses made by participants during the full trial. The spacebar presses have been colour-coded to show the 'hit' and 'miss' indices. Hits are the spacebar presses that occurred whilst the critical stimulus was present; the misses were when the spacebar was pressed when no critical stimulus was present. When reviewing the data spread on the temporal map, there is a cluster between 55 and 75 seconds. The spacebar presses occurring within this time frame are both numerous in 'hits'⁵ and 'misses'⁶.

⁵ Hits are defined as the positive identifications of critical stimuli

⁶ Misses are defined as participants falsely identifying critical stimuli or identifying the critical stimuli outside of the allotted time period.

Figure 5*Participant Spacebar Presses*

Note. Temporal map showing the distribution of spacebar presses throughout the video. The spacebar presses have been segregated into positive hits (green dots) and misses (red dots).

Analysing what occurred during the 55-75 second period shows three critical stimuli presented to the participants in close succession to one another. Critical stimuli two, three, and four all occur between 55 and 75 seconds. The WA player's movements and critical stimuli have been screen-captured and annotated in Figure 4. This shows that between each critical stimulus present, there are only one or two player movements (drives to advance towards the ball/ away from the WD player). Due to the close presentation of the critical stimuli, there may have been the potential that participants consider critical stimuli two and three to be one critical stimulus and not two. Examining the raw data, 23 participants saw both critical stimuli two and three, 20 only identified one critical stimulus, and seven did not notice either critical stimulus two or three. For the participants that only noticed one of the two critical stimuli, 70% indicated that they only saw critical stimulus two; thus, the participants that only identified one critical stimulus were 2.3 times more likely to see stimulus two than stimulus three.

Critical stimulus four also occurs during the 55-75 second time period. Notably, critical stimulus four had the highest rate of inattention blindness measured (refer to Figure 4) at 42%. When reviewing the data and correlating video footage, it is apparent that the momentum (pace) of play had slowed. During critical stimulus four, the ball was in the shooting circle with the GA (Goal Attack) in preparation for her to score a goal, and the WA was standing outside of the goal circle, unmarked, and with her arms raised. Once the ball is in the goal circle and the shooter (GA in this instance) is in a reasonable position where they are likely to make a successful shot, it is unlikely that the ball will be passed out of the circle to the WA. The participants may have assumed that at this point in the play, the WA raising their arm to indicate they want the ball is unlikely to happen, so they missed this critical stimulus.

Figure 6

WA player movements and critical stimuli two, three, and four



Note. These images have been annotated to include arrows to show player movement between each photo. Between each picture, there are only one or two WA player movements; therefore, within a short period and limited player movement, several critical stimuli occur. Participants had a high perceptual load during this period.

Critical stimulus 7. Critical stimuli four and seven recorded a high rate of inattention blindness (42%, 36%) compared to the other critical stimuli. To analyse critical stimulus seven, which recorded an inattention blindness rate of 36%, showed a variation in time the stimulus was present in the video compared to the other critical stimuli. The time period that the participants had to identify critical stimulus seven was of similar duration to the other critical stimuli, as the time period was based on the rule that in netball, the ball must be passed within 3 seconds. For critical stimulus seven, a period of 00:03.13 was given for participants to identify the critical stimulus within and press the spacebar to record a positive identification. However, whilst a three-second period was allocated, the critical stimulus was not present for the entire duration; rather, the critical stimulus was only present for 1.5 seconds. 1.5 seconds, comparatively to the other critical stimuli in the video, was a shorter presentation of the critical stimuli; for example, critical stimulus one was present for the entire time period.

Another factor differentiating critical seven from the other critical stimuli was that critical stimulus seven had the WA only raising one arm, not two. The instructions indicated that the critical stimulus was the WA player when they were freely available (unmarked) and had their arm/s raised. Whilst the condition that one or both arms could be raised, there may have been the aspect of saliency that was not accounted for the critical stimuli that only had the WA player putting up one arm.

False Alarms. The temporal heat map indicates a cluster of spacebar presses at approximately 87.5 seconds into the full trial. These spacebar presses occurred outside of a critical stimulus time period, thus meaning there was no critical stimulus present. When reviewing the video, the WA player does have their arm raised, indicating that they would like to receive the ball; however the WA player is directly behind, thus marked and not freely available, two of the opposition players. The WA player being freely available (unmarked)

was one of the characteristics required for a situation to be classified as a critical stimulus.

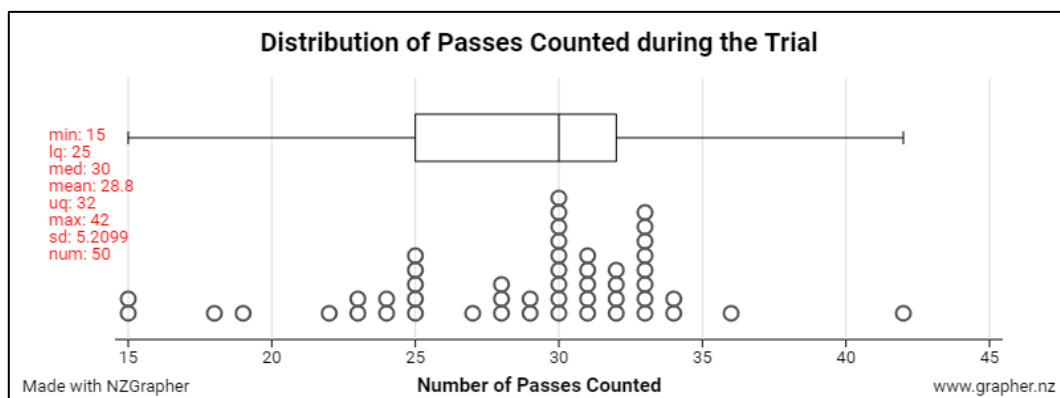
Twenty-six participants miss identified this stimulus as the critical stimulus, thus pressing the spacebar and logging a miss, which is otherwise known as a false alarm.

Distractor Attention Task – Task One

The average number of passes counted by participants was 28.8 (median 30 passes counted, SD = 5.21, Range = 15-42). The correct number of passes occurring during the video was 34 passes. Only two participants correctly counted all 34 passes. A total of two participants counted more than 34 passes; therefore, the remaining 46 participants counted less than 34 passes.

Figure 7

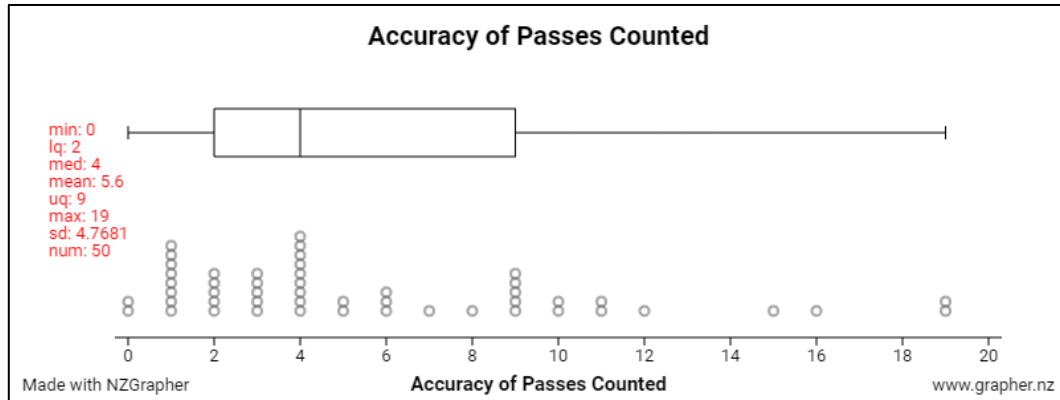
Distribution of Passes Counted



Note. Graph illustrating the distribution of passes counted during the trial by the 50 participants.

Pass counting accuracy. Figure 7 shows that the participants reported a wide range of pass counts (Range = 15 – 42). The data has been expressed as pass count accuracy to account for the range of pass count totals, which is both higher and lower than the true count (34).

Figure 8 shows the distribution of passes counted on a scale of accuracy. The minimum number is 0, which equals 34 passes counted. The maximum is 19; the raw data set shows that two participants counted 15 passes, which is 19 passes inaccurately counted.

Figure 8*Accuracy of Passes Counted*

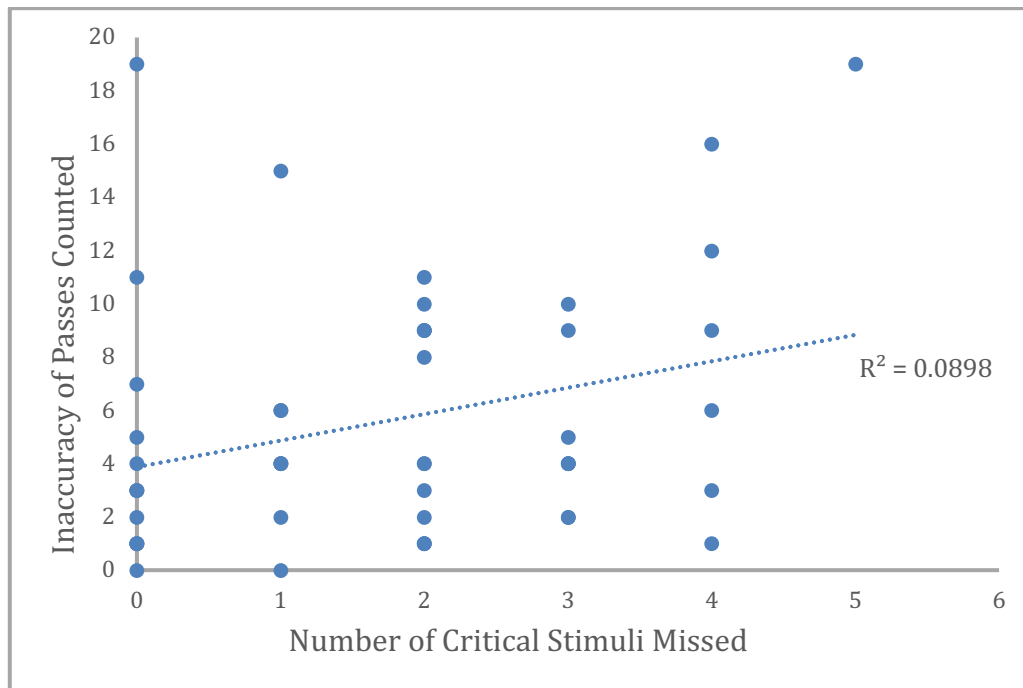
Note. Graph showing the accuracy of passes counted during the trial by the 50 participants. The accuracy of passes is shown as the number of passes +/- away from 34, of which 34 was the correct number of passes counted. If a participant counted all passes ($n = 34$), then the accuracy of passes counted = 0. A participant that overcounts or undercounts would receive an accuracy of passes counted = <1 .

Correlation Analysis: Inattentive Blindness and Passes Counted

A correlation analysis was completed to identify if there was a relationship between the counting accuracy (variable one) and inattentive blindness rate (variable two) and the strength of any potential relationship (refer to Figure 8). There was no statistically significant correlation between counting accuracy and IB rate, $r(48) = .30, p = .035$.

Figure 9

Correlation Analysis of Passes Counted and the Number of Critical Stimuli Missed, Per Participant



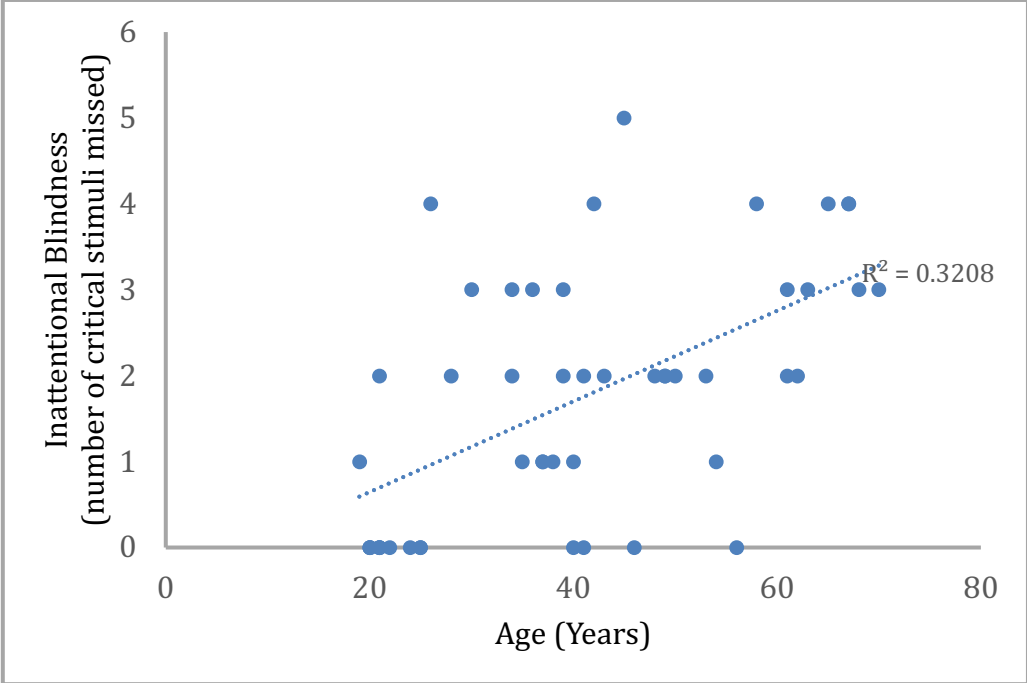
Note. Graph showing the number of critical stimuli missed per participant (total possible misses = 7) correlated with the participants’ pass count accuracy. The graph shows a weak positive correlation.

Age Analysis

Participants’ inattentive blindness rate (number of missed critical stimuli) correlated significantly to participant age. The correlation relationship, as graphed below (refer to Figure 9), is significant, $r(48) = 0.566, p < .001$.

Figure 10

Correlation Analysis of Inattentive Blindness Rate and Participant Age



Note. A graph showing the correlation analysis between the number of missed critical stimuli (Inattentive Blindness) per participant and the participants' ages.

5. General Discussion

The present study demonstrated that inattentive blindness exists in the team ball sport context of netball. Moreover, the findings of this study replicate the results of previous inattentive blindness in sport research studies (Memmert & Furley, 2007; Furley et al., 2010). Alongside exploring inattentive blindness in sports, this study sought to develop a new, more ecologically valid sport-inattentive blindness paradigm. For that, previous studies have tended towards less ecologically valid methods of researching inattentive blindness.

Inattentive Blindness in Netball

The results of this study show that inattentive blindness does occur in the team-ball-sport context of netball. Participants in the study demonstrated failures of awareness by failing to identify all of the critical stimuli presented to them. The participants collectively experienced an average failure rate of 25% for not detecting the critical stimuli. Concurrent with missing 25% of the critical stimuli, the participants could all provide a count of the ball passes made during the video. The combination of participants being engaged in the counting task and missing some critical stimuli indicates that the failures of awareness experienced in this study may be assessed to have been occurrences of inattentive blindness (Simons, 2007). In addition, by using netball as the situational context of this study, the results provide evidence to suggest that inattentive blindness occurs in netball, therefore answering the research question.

When examining the present study's results to prior research, it is worth noting that the average inattentive blindness rate is slightly lower than the earlier sports studies (Memmert & Furley, 2007; Furley et al., 2010). Although, in inattentive blindness research, typically, most research does not seek to measure the prevalence of inattentive blindness, but rather does it exist. During this early research period, the focus has been mainly on the

development of paradigms. Therefore, the findings of this study show that inattentive blindness does occur in netball, which correlates with earlier findings that inattentive blindness also occurs in handball and basketball (Memmert & Furley, 2007; Furley et al., 2010). However, the prevalence to which inattentive blindness occurs in team ball sports still requires further examination, as all three sports studies have recorded various rates.

Endogenous and Exogenous Attention

In sports, both endogenous and exogenous attention are crucial for successful performance. Endogenous attention involves consciously directing one's attention to specific environmental stimuli (Peelen et al., 2004; Posner, 1980). In the current study, participants were primed to focus on critical stimuli and count ball passes, demonstrating their engagement of endogenous attention. It was signalled to participants that counting the passes accurately was important, and therefore, the participants likely engaged endogenous attention to seek for these occurrences throughout the trial. As a result, the participants were likely to be consciously selectively focusing on those elements of the video. This contrasts with a player's experience playing netball. Netball players would never selectively focus on counting ball passes, as it has no tactical advantage in netball. Netballers would instead be visually selecting certain relevant stimuli that assist in making strategic decisions and the execution of precise actions within the complex setting of netball.

Players often use endogenous attention to concentrate on specific game elements, such as opponents' movements, teammates' positioning, or key areas of the playing field. By voluntarily directing their attention, athletes can enhance their perception, anticipation, and decision-making abilities, leading to improved performance. Skilled players with well-developed endogenous attentional skills can effectively filter out distractions, maintain a sustained focus, and allocate their attention resources to relevant information, enabling them to perform at their best. However, it is important to acknowledge that both endogenous and

exogenous attention play vital roles in sports, necessitating effective balance and utilization of both forms of attention for optimal performance. The capacity to seamlessly transition between endogenous and exogenous attentional modes in response to situational demands is a key aspect of skilled performance in sports.

Exogenous attention, on the other hand, refers to externally driven and automatic attention (Peelen et al., 2004; Posner, 1980). It involves the involuntary capture of attention by salient stimuli in the environment. In the present study, the critical stimulus of a WA player with their arms raised and waving was designed to increase exogenous saliency. This salient stimulus may attract attention from both teammates and opponents, as previous research suggests that waving arms can enhance the visibility and attention of a player (Memmert & Furley 2007). Players with well-developed exogenous attentional abilities can effectively respond to critical stimuli in their environment, allowing for quick adjustments and appropriate decision-making in dynamic sports scenarios.

The present study began to show the interrelation between exogenous and endogenous attention and inattention blindness in sports. Further research in this area will contribute to a deeper understanding of how attentional processes influence performance in sports contexts.

Diversity of Age of Participants

Secondary Analysis of Inattentional Blindness

The data collected through Prolific provided participants' ages, to which it was realised that there was a wide range of participant ages, prompting an unplanned analysis of inattentional blindness prevalence and age. Leveraging the diverse age range of participants, a secondary analysis was conducted to compare the findings with previous studies exploring age as a factor in inattentional blindness prevalence. Given the scarcity of research on inattentional blindness in sports, this secondary analysis of inattentional blindness data against the participants' ages added rigour to the study. Furthermore, analysing the data by age

allowed for an exploration of whether age could shed light on the participants' expertise in netball.

Age has been identified as a factor in the occurrence of inattentional blindness (Horwood & Beanland, 2016). Research studies have shown that older adults tend to be more susceptible to experiencing inattentional blindness compared to younger individuals (Graham & Burke, 2011; Stothart et al., 2015; Horwood & Beanland, 2016; O'Shea & Fieo, 2015). Stothart et al.'s (2015) study showed across an age range from 18 to 75 years that, the probability of noticing an unexpected object significantly reduced the older a participant was. The strength of this study was that it examined age as a continuous variable; therefore, it could show the progressive probability of experiencing inattentional blindness throughout adulthood. Due to the data collection method of the present study, it too could examine age as a continuous variable.

The results of this study revealed a continuous positive relationship between age and the rate of inattentional blindness. The older participants were, the more likely they were to experience inattentional blindness. These results replicate previous age and inattentional blindness research (Stothart et al., 2015; Graham & Burke, 2011). Therefore, supporting the theory that the older an adult is, the more susceptible they are to experience inattentional blindness (Stothart et al., 2015). The replication of results, specifically the Stothart et al. (2015) study, and the other inattentional blindness and age research (Graham & Burke, 2011; Horwood & Beanland, 2016; O'Shea & Fieo, 2015), provides additional support that the modified sport inattentional blindness paradigm yielded comparable results to previous research conducted outside of the sports field.

Age and Expertise Influencing Inattentional Blindness

The relationship between age and the rate of inattentional blindness in this study may be influenced by factors beyond just biological age. In this study, participants were required

to have experience playing netball, and the screening process through Prolific relied on whether they had played netball competitively during high school or university. As high schools and universities typically attract young individuals seeking knowledge and educational opportunities, sports offered by these institutions are predominantly played by younger people. Consequently, the study did not consider that younger participants were more likely to still be actively playing netball or have recent experience in the sport. On the other hand, for older participants, it is unknown how long it has been since they last actively played netball. It is plausible to theorize that the oldest participant (age = 70) may not have played netball in many decades. Thus, the study did not consider the influence of the recency of experience on inattentional blindness.

Despite being able to replicate the results of previous age and inattentional blindness research, the study's findings were limited in that they did not account for the potential impact of the recency of netball experience on the relationship between age and inattentional blindness rate. This aspect could be an important consideration for future research in understanding the nuanced factors influencing inattentional blindness in individuals of different age groups.

Enhancing Ecological Validity of Inattentional Blindness Studies in Sport

Alongside exploring inattentional blindness in netball, this study sought to research inattentional blindness within a more ecologically valid sport-inattentional blindness research paradigm. Previous studies in the field have utilised methods such as short videos and freeze frame techniques to study inattentional blindness (Memmert & Furley, 2007; Furley et al., 2010). However, these methods have limitations in accurately representing real-world sporting contexts.

It is crucial to consider that in the real world, including sports, the environment does not pause for a person to notice all important stimuli in their surroundings. Recognising this limitation, it was necessary to modify previous research designs to enhance ecological validity while still replicating inattention blindness data. By developing a research method that is more ecologically valid, this study aimed to create a research paradigm that better reflected real-world sports. This approach seeks to bridge the gap between laboratory-based studies and the actual experiences of athletes and individuals in sports settings.

Methodological Enhancements: Extended Trial Duration

One significant modification in the present study is extending the trial duration from seconds to minutes. Previous studies conducted by Memmert and Furley (2007) and Furley et al. (2010) used short videos lasting only a few seconds each. However, in the current study, it was recognized that real-world sports games occur over more extended periods of time, such as 40-60 minutes for netball, 48 minutes for basketball, and 60 minutes for handball. By replicating the longer duration of actual sports games through the study design, the study provides a more accurate representation of the attentional demands and challenges faced by athletes and individuals in team ball sports.

Increasing the trial duration is important in research that is being used to explore attention in team ball sports. Notwithstanding that sports games are typically longer than a couple of seconds, there is also documented evidence regarding the impact that sustained attention has on performance. A study by Ling and Carrasco (2006) found that sustaining attention during an attention research trial is taxing, particularly during longer trials (duration < 16 seconds). The previous research by Memmert and Furley and Furley et al. used very short trials (duration >15 seconds), therefore avoiding the weakening of the ability to sustain attention during longer trials. In reviewing the results of this study, the failure to detect the critical stimulus for critical stimulus seven was much higher than the failure to detect critical

stimulus one or two. Whether the weakening of attention towards the end of the trial impacted the participants' ability to detect the critical stimulus is unknown. There may have been other factors influencing this drop in performance too. However, there may be a correlation between sustained attention and inattention blindness beyond the initial few seconds. To understand whether there is a correlation, it will require additional research.

In summary, extending the study duration from seconds to minutes is a significant modification in the present study. It has improved the alignment of the research design with the real-world conditions of team ball sports. It enhances the study's ability to investigate inattention blindness, in sports, in a more ecologically valid manner.

Methodological Enhancement: Removal of Freeze Frames

Another significant modification in the present study involved the removal of the freeze frame element utilized in previous studies conducted by Memmert and Furley (2007) and Furley et al. (2010). In real-world sports, the action does not halt for players to carefully observe their surroundings and make decisions about the importance of the stimuli in their field of vision. Instead, athletes have limited time to perceive and process information in a continuously evolving environment. To better represent this aspect of real-world sports, the study design eliminated any freeze frames or pauses in the video material. Participants were required to identify critical stimuli while the gameplay continued without interruption. This approach aligns with the research conducted by Simons and Chabris (1999) in their gorilla video study, where participants had to maintain attention during an ongoing activity. By removing freeze frames and maintaining continuous gameplay in the study design, the present research was able to replicate the time constraints and information processing demands faced by athletes in real sporting scenarios. This modification enhances the ecological validity of the study by reflecting the dynamic nature of attention and decision-making in team ball sports.

Methodological Enhancement: The Use of Multiple Stimuli and the Diversity of Findings

One of the significant strengths of this study is the use of multiple critical stimuli to measure inattentional blindness. The findings of this study demonstrate that inattentional blindness was experienced. Concurrently, the results show multiple experiences of inattentional blindness, per participant, within the same trial. There were consistent failures in awareness across all the repeated exposures to the critical stimuli. Previous research has typically only focused on one singular critical stimulus and, therefore, only one measurement of the failure of awareness (Memmert & Furley, 2007; Furley et al., 2010).

Designing the present study to have multiple measures of inattentional blindness per participant has provided a more complete understanding of inattentional blindness occurrences in netball. Inattentional blindness occurred between 10-43% of the time across the seven critical stimuli. This variance in inattentional blindness rates does not incite speculation about whether inattentional blindness exists in netball but rather acknowledges that measures of attention and inattention are vulnerable to random influences.

One trade-off for increasing the ecological validity of the sport inattentional blindness paradigm is the concurrent increase in the potential for random influences to interfere with the results. Compared to Mack and Rock (1998) and Most et al. (2000: 2001), where these studies used animated videos that had little direct representation of the real world, the present study used videos of people playing netball. Therefore, the complexity of the footage increased. There were significantly more irrelevant stimuli in the footage and more stimuli to capture the participants' attention. Moreover, it was a video of an actual game; therefore, the participants all with netball experience likely were influenced by personal biases. These influences were not measured in this study, but it is anticipated that they did have some level of impact on the findings of this study.

Nonetheless, in the present study, by employing multiple critical stimuli, this study enhances the robustness of claims regarding the existence of inattentional blindness in netball. The inclusion of multiple stimuli in measuring inattentional blindness in netball adds weight to the claims made in this study. It strengthens the argument that inattentional blindness does exist in netball, bolstered by the considerable amount of evidence produced by this research.

Another advantage of incorporating multiple stimuli in this study to measure inattentional blindness in netball is the opportunity to explore the variability in experiences of inattentional blindness. By utilizing diverse stimuli within the same study, it becomes possible to compare and analyse the differences in the occurrence of inattentional blindness across various critical stimuli.

The use of multiple critical stimuli has allowed for a much more in-depth comparison of the study's results with previous research. On average, the present study's inattentional blindness rate was slightly lower, but when comparing only critical stimuli four and seven to the studies conducted by Memmert and Furley (2007) and Furley et al. (2010), the inattentional blindness rates were comparable. Conversely, the rates of critical stimuli one, two, three, five, and six were lower than the rates reported in previous research. As a result, the present study exhibits both comparable and contrasting results in comparison to previous research on inattentional blindness in sports. Examining the results of each critical stimulus individually provides valuable insights into the complexities of inattentional blindness during netball gameplay. At the simplest level, these insights are that inattentional blindness occurrences are inconsistent and likely influenced by various factors.

The study's findings revealed a wide range of inattentional blindness rates observed across the seven critical stimuli, ranging from 10% to 43%. This variation in results challenges the notion that inattentional blindness occurs at a fixed rate. Instead, it highlights that the experiences of inattentional blindness can differ. These variations may be influenced

by factors in the environment or other modifying elements such as saliency or participants' expertise. Although the study did not specifically investigate the contributing factors or influences behind the varying rates of inattentional blindness, this aspect could be explored in future research.

Future Directions for Enhancing Ecological Validity

Literature describes ecological validity as the degree to which results from a study conducted in a laboratory can be replicated in the real world (Xu et al., 2021). While the present study has made strides in enhancing the ecological validity of researching inattentional blindness in sports, it is important to acknowledge that it does not fully represent the real-world sporting context. In terms of ecological validity, it can be conceptualised into two approaches: verisimilitude and veridicality. Verisimilitude refers to the extent of similarity between the task demands of a research study and the real world (Xu et al., 2021). Whilst the present study has increased the similarity between the sport inattentional blindness paradigm and an actual netball game, further development is still possible. A more complete representation could potentially involve research methods that do not rely on computers or require participants to count passes. Netball players do not play netball behind a computer, nor would they ever be asked to count all passes made in a game. Therefore, despite addressing some of the limitations of previous research, there is still room for improvement in refining the sport-inattentional-blindness paradigm to enhance its ecological validity further.

Future research endeavours should aim to develop methodologies that closely simulate the complexities and demands of real-world sporting environments to improve the ecological validity of inattentional blindness research in sports. This could involve incorporating more dynamic and interactive elements, such as utilising virtual reality or immersive simulations, to create a more authentic sports experience for participants. Additionally, exploring alternative distractor tasks that align with the cognitive demands faced by athletes during actual

gameplay could contribute to a more ecologically valid approach. By continually striving to enhance the ecological validity of research paradigms, we can gain a deeper understanding of inattentional blindness in sports and its implications for athletes' performance. This ongoing refinement of methodologies will contribute to the advancement of knowledge in the field and facilitate the application of findings to real-world sporting scenarios.

Limitations

Data Collection Method: In person versus an Online Application

The present study was initially planned to be conducted in person, aiming for a more immersive and ecologically valid experience for participants. However, due to the COVID-19 outbreak in New Zealand in 2022 and the associated government guidelines to minimize the risk of transmission, it was required to adapt the study's data collection method. The decision was made to shift to a fully online data collection process to ensure compliance with government instructions and prioritize the safety of participants and researchers.

Moving the study to an online platform had implications for the ecological validity of the research. The original intention was to have participants physically present in a laboratory setting, where they could actively respond to the videos by engaging in actions such as catching and throwing netballs or physically moving towards specific stimuli as if they were immersed in an actual game. This setup would have provided a more representative experience, closely simulating the dynamics of actual gameplay. However, due to the limitations imposed by the COVID-19 pandemic, conducting the study in person became unfeasible. As a result, the research had to be hosted on an online data collection platform, which introduced a shift in the format and reduced the immersive nature of the study. Participants were no longer physically engaged in the game-like tasks but viewed and responded to the videos on a computer using the specially designed research application.

Although the online data collection method allowed the study to continue amidst the pandemic, it is important to acknowledge that this adaptation may have limited the extent to which the study accurately reflects the real-world context of netball. The shift to an online format reduced the ability to create an ecologically valid experience where participants were responding physically as if they were embedded into an actual game. Future research may consider exploring alternative methods to enhance the ecological validity of studying inattentive blindness in sports.

The current study's adoption of an online format introduced limitations in terms of ecological validity, but it offered a notable advantage by granting access to a larger and more diverse participant pool. The challenges associated with individually collecting data from 50 participants in a laboratory setting, both logistically and financially, made the online platform, like Prolific, an attractive option. By doing so, the study could encompass a more extensive participant pool compared to what would have been achievable through in-person data collection. Consequently, this approach likely facilitated the inclusion of individuals from a broader age range, a task that would have been challenging using traditional in-person recruitment methods. In contrast, previous studies conducted by Memmert and Furley (2007) and Furley et al. (2010) focused on a younger and more homogeneous age group, emphasizing the distinct advantage of the current study in attaining a more diverse age distribution.

Furthermore, employing an online application allowed data collection from three different countries: Australia, New Zealand, and the United Kingdom. This international reach enriched the study's sample by incorporating participants from diverse cultural backgrounds and varying levels of playing experience, thereby enhancing the generalizability of the results.

Unexpectedness of the Critical Stimulus

The results and initial part of this general discussion clearly outlines that inattentive blindness was found during this study; however, there is a question about whether it truly was inattentive blindness or another type of attentional failure. Simons (2007) clearly outlines four classifying criteria to classify a failure of awareness as inattentive blindness as opposed to a different type of attentional failure. For that, not all instances of failures in awareness resulting from distraction or lack of attention to a stimulus can be equated with inattentive blindness. The present study arguably meets the first three criteria 1) participants must fail to notice a visual stimulus; 2) the stimulus must be fully visible, and observers must be able to readily see it if they are looking for it; and 3) the failure to notice a stimulus must result from the engagement of attention on other aspects of the display. This study's contention and potential limitation occurs with criteria four, whereby the critical stimulus must be unexpected.

Unexpectedness is a characteristic of the critical stimulus in inattentive blindness research that has not been elaborated upon. An unexpected critical stimulus, in early literature, looked like an object that has absolutely no relevance to the environmental context—for example, the gorilla in the gorilla paradigm (Simons & Charbis, 1999). The gorilla had nothing to do with people passing a basketball; therefore, the gorilla is completely unexpected in that situational context. Seeing a gorilla in a zoo exhibit, however, is not unreasonable and could be expected. In the case of the gorilla inattentive blindness study, it is quite simple to determine that the gorilla as the critical stimulus was unexpected and therefore, participants missing the gorilla when their attention was engaged elsewhere was inattentive blindness. However, in designing the present study choosing a critical stimulus as unexpected to netball as a gorilla was likely to limit the ecological validity of the study.

In the present study, the critical stimulus consisted of a WA player in netball raising their arm/s and being freely available. This occurrence is not unexpected in netball, as it is a common behaviour for the WA player to indicate their readiness to receive the ball. The participants were explicitly informed and shown examples of such situations before the study commenced. So, the ability to classify the critical stimulus as completely unexpected is limited. This raises an important question regarding the level of unexpectedness required for stimuli in studies aiming to represent real-world contexts. It prompts consideration of whether stimulus unpredictability would suffice, rather than absolute unexpectedness.

The study's results indicate instances where participants failed to identify the critical stimulus. While previous research on inattention blindness has categorized such failures as indicative of inattention blindness, it is essential to consider that in this study, these failures might reflect insufficient attention rather than true inattention blindness. For example, critical stimulus four, in terms of the context of the game of netball, there was no reason to consider the WA player as, in that situation, the WA player did not contribute a tactical benefit. Whilst freely available and with their arms raised, the WA player was not in an ideal location on the court. There was no reason tactically for participants or the other netball players on the court to look for the WA player. As a result, at best, the participants may have briefly attended to the WA player but given insufficient attention.

In summary, a potential limitation of this study is the ambiguity regarding the level of unexpectedness required for a critical stimulus to be considered as meeting the fourth criterion of inattention blindness research, as proposed by Simons (2007). The term "potential limitation" is used because it remains uncertain whether the critical stimulus used in this study met the necessary degree of unexpectedness. The concept of unexpectedness has not been explicitly defined or sufficiently specified in inattention blindness research. Additionally, this study raises the question of whether the presence of an "unpredictable" critical stimulus

alone is enough to fulfil the requirements of inattentional blindness research. Further investigation is needed to clarify these aspects and provide a more comprehensive understanding of the criteria for identifying inattentional blindness in sports studies.

Participant Interviews

An important aspect missing from this study was the inclusion of participant interviews to gather their personal experiences and insights related to playing netball and how it may have influenced their performance in the study. By incorporating participant interviews, it would have provided an opportunity to explore the potential influence of participants' level of experience playing netball on their performance in the study. Additionally, the study could have evaluated whether the recency of playing netball impacted the results. Interviews would have allowed for a deeper exploration of the potential random influences that may have affected the study's outcomes. By incorporating qualitative data from participant interviews, a more comprehensive understanding of the relationship between netball experience and performance in the study could have been achieved.

Additionally, incorporating post-trial interviews in the present study could have provided valuable insights into participants' experiences during the study, specifically regarding their awareness of the critical stimulus. Previous inattentional blindness studies have used interviews to ascertain whether participants were genuinely unaware of the critical stimulus (Simons & Chabris, 1999; Furley et al., 2010). Unlike these studies, the present study relied solely upon participants accurately pressing the spacebar key to indicate awareness. This led to a binary outcome: either the participants noticed in time, or they did not. This binary outcome of noticing or not noticing the critical stimulus may oversimplify the complex nature of both attention and the sport of netball. By conducting post-trial interviews, I would have had the opportunity to gather more nuanced information about participants' experiences, potentially capturing details and insights that may have been missed through the

binary outcome measure alone. This would have enhanced the understanding of participants' experiences and added depth to the findings of the study.

Recommendations / Future Study

In conclusion, the results of this study need to be confirmed and further scrutinized to continue to develop an understanding of inattentional blindness in netball and, more generally, in sports. Throughout the General Discussion, numerous recommendations have been made in relation to future studies. Each of these recommendations will contribute to a greater understanding of inattentional blindness, inattentional blindness in sports, and inattentional blindness in netball. However, to summarise all recommendations for future study, the following four recommendations would provide significant valuable insight into inattentional blindness in netball.

An essential first step would be to design a study that data collects in person and immerses the participants into the game as much as possible for ecological validity. This was the initial intent of the present study; however, due to the COVID-19 pandemic was not possible at the time of this study. Increasing ecological validity will provide a more in-depth understanding of inattentional blindness in netball. Secondly, to increase the reliability of the study, it is recommended that future studies standardise what and how the information is presented to the participants. For example, ensuring that all participants view the visual information in the same manner as one another by standardising screen size, viewing distance, and visual quality. The third recommendation is to include participant interviews and better participant screenings. A strength of this study was the diverse age range of participants; however, upon analysis, there were questions regarding the recency of netball experience, as sport expertise is a known modifying factor of inattentional blindness prevalence. Fourth, another avenue for further study is to develop a definition of the unexpected concerning the unexpectedness of the critical stimulus in inattentional blindness research. The final

recommendation is to undertake a more in-depth analysis of the variations identified between the seven critical stimuli used in this study. This part of the results was not examined in-depth in this study; however, it is expected that there are factors beyond what has been mentioned that contributed to the 32% difference in inattentive blindness rates.

Concluding Remarks

Sports games hinge on the decisions made during gameplay, determining whether a team is victorious or defeated. The preferred path to success lies in making tactically advantageous decisions, but this requires sufficient awareness of all available options. Unfortunately, the fast-paced nature of gameplay can lead to some options being overlooked, resulting in subpar performance. One approach to address this challenge is better understanding attentional failures in sports games. The current study aimed to shed light on a specific type of attentional failure known as "inattentive blindness" in netball in the hopes that this knowledge will contribute to the enhancement of sporting performance.

The study provided compelling evidence of the existence of inattentive blindness in netball and demonstrated its occurrence in sports using a more ecologically valid method than previous research. While there is far more research to be undertaken, the present study makes a small but significant contribution to this important endeavour. By delving deeper into the phenomenon of attentional failures, we can pave the way for substantial improvements in sports performance.

References

- Becklen, R., & Cervone, D. (1983). Selective looking and the noticing of unexpected events. *Memory & Cognition*, *11*(6), 601-608. <https://doi.org/10.3758/bf03198284>
- Broadbent, D. E. (1958). *Perception and communication*. Pergamon Press.
- Brosch, T., Scherer, K., Grandjean, D., & Sander, D. (2013). The impact of emotion on perception, attention, memory, and decision-making. *Swiss Medical Weekly*, *143*(1920), w13786-w13786. <https://doi.org/10.4414/smw.2013.13786>
- Cartwright-Finch, U., & Lavie, N. (2007). The role of perceptual load in inattention blindness. *Cognition*, *102*(3), 321-340. <https://doi.org/10.1016/j.cognition.2006.01.002>
- Chica, A. B., Bartolomeo, P., & Lupiáñez, J. (2013). Two cognitive and neural systems for endogenous and exogenous spatial attention. *Behavioural Brain Research*, *237*, 107-123. <https://doi.org/10.1016/j.bbr.2012.09.027>
- Downing, P. E., Bray, D., Rogers, J., & Childs, C. (2004). Bodies capture attention when nothing is expected. *Cognition*, *93*(1), 27-38. <https://doi.org/10.1016/j.cognition.2003.10.010>
- Furley, P., Memmert, D., & Heller, C. (2010). The dark side of visual awareness in sport: Inattention blindness in a real-world basketball task. *Attention, Perception, & Psychophysics*, *72*(5), 1327-1337. <https://doi.org/10.3758/app.72.5.1327>
- Graham, E. R., & Burke, D. M. (2011). Ageing increases inattention blindness to the gorilla in our midst. *Psychology and Aging*, *26*(1), 162. <https://doi.org/10.1037/a0020647>
- Gu, E., Stocker, C., & Badler, N. I. (2005). Do you see what eyes see? Implementing inattention blindness. In *Intelligent Virtual Agents: 5th International Working*

- Conference, IVA 2005, Kos, Greece, September 12-14, 2005. Proceedings 5* (pp. 178-190). Springer Berlin Heidelberg.
- Horwood, S., & Beanland, V. (2016). Inattention blindness in older adults: Effects of attentional set and to-be-ignored distractors. *Attention, Perception, & Psychophysics*, *78*(3), 818–828. <https://doi.org/10.3758/s13414-015-1057-4>
- Hüttermann, S., & Memmert, D. (2012). Moderate movement, more vision: Effects of physical exercise on inattention blindness. *Perception*, *41*(8), 963-975. <https://doi.org/10.1068/p7294>
- Kamkar, S., Moghaddam, H. A., & Lashgari, R. (2018). Early visual processing of feature saliency tasks: a review of psychophysical experiments. *Frontiers in Systems Neuroscience*, *12*, 1-15. <https://doi.org/10.3389/fnsys.2018.00054>
- Kerzel, D., Schönhammer, J., Burra, N., Born, S., & Souto, D. (2011). Saliency changes appearance. *PLoS One*, *6*(12), e28292. <https://doi.org/10.1371/journal.pone.0028292>
- Kreitz, C., Furley, P., Memmert, D., & Simons, D. J. (2016). The influence of attention set, working memory capacity, and expectations on inattention blindness. *Perception*, *45*(4), 386-399. <https://doi.org/10.1177/0301006615614465>
- Lee, H. J., & Telch, M. J. (2008). Attentional biases in social anxiety: An investigation using the inattention blindness paradigm. *Behaviour Research and Therapy*, *46*(7), 819-835. <https://doi.org/10.1016/j.brat.2008.04.001>
- Li, X., Tao, Q., Fang, Y., Cheng, C., Hao, Y., Qi, J., Li, Y., Zhang, W., Wang, Y., & Zhang, X. (2015). Reward sensitivity predicts ice cream-related attentional bias assessed by

inattentional blindness. *Appetite*, 89, 258–264.

<https://doi.org/10.1016/j.appet.2015.02.010>

Ling, S., & Carrasco, M. (2006). When sustained attention impairs perception. *Nature Neuroscience*, 9(10), 1243–1245. <https://doi.org/10.1038/nn1761>

Mack, A. (2003). Inattentional blindness: Looking without seeing. *Current Directions in Psychological Science*, 12(5), 180-184. <https://doi.org/10.1111/1467-8721.01256>

Mack, A., & Rock, I. (1998). *Inattentional blindness*. MIT Press.

Mack, A., Clarke, J., Erol, M., & Bert, J. (2017). Scene incongruity and attention. *Consciousness and Cognition*, 48, 87-103.

<https://doi.org/10.1016/j.concog.2016.10.010>

Memmert, D. (2006). The effects of eye movements, age, and expertise on inattentional blindness. *Consciousness and Cognition*, 15(3), 620-627.

<https://doi.org/10.1016/j.concog.2006.01.001>

Memmert, D., & Furley, P. (2007). “I spy with my little eye!”: Breadth of attention, inattentional blindness, and tactical decision making in team sports. *Journal of Sport and Exercise Psychology*, 29(3), 365-381. <https://doi.org/10.1123/jsep.29.3.365>

Meyer, K. N., Du, F., Parks, E., & Hopfinger, J. B. (2018). Exogenous vs. endogenous attention: Shifting the balance of fronto-parietal activity. *Neuropsychologia*, 111, 307-316. <https://doi.org/10.1016/j.neuropsychologia.2018.02.006>

Moray, N. (1959). Attention in dichotic listening: Affective cues and the influence of instructions. *Quarterly Journal of Experimental Psychology*, 11(1), 56-60.

<https://doi.org/10.1080/17470215908416289>

- Most, S. B., Scholl, B. J., Clifford, E. R., & Simons, D. J. (2005). What you see is what you set: sustained inattention blindness and the capture of awareness. *Psychological Review*, *112*(1), 217. <https://doi/10.1037/0033-295X.112.1.217>
- Most, S. B., Simons, D. J., Scholl, B. J., & Chabris, C. F. (2000). Sustained inattention blindness. *Psyche*, *6*(14).
- Most, S. B., Simons, D. J., Scholl, B. J., Jimenez, R., Clifford, E., & Chabris, C. F. (2001). How not to be seen: The contribution of similarity and selective ignoring to sustained inattention blindness. *Psychological Science*, *12*(1), 9-17. <https://doi.org/10.1111/1467-9280.00303>
- Neisser, U. (1979). The control of information pickup in selective looking. In *Perception and its development* (pp. 201-219). Psychology Press.
- Neisser, U., & Becklen, R. (1975). Selective looking: Attending to visually specified events. *Cognitive Psychology*, *7*(4), 480-494. [https://doi.org/10.1016/0010-0285\(75\)90019-5](https://doi.org/10.1016/0010-0285(75)90019-5)
- Newby, E. A., & Rock, I. (1998). Inattention blindness as a function of proximity to the focus of attention. *Perception*, *27*(9), 1025-1040. <https://doi.org/10.1068/p271025>
- Nothdurft, H. C. (2000). Saliency from feature contrast: additivity across dimensions. *Vision Research*, *40*(10-12), 1183-1201. [https://doi.org/10.1016/S0042-6989\(00\)00031-6](https://doi.org/10.1016/S0042-6989(00)00031-6)
- O'Shea, D., & Fieo, R. (2015). Individual differences in fluid intelligence predicts inattention blindness in a sample of older adults: a preliminary study. *Psychological Research*, *79*(4), 570-578. <https://doi.org/10.1007/s00426-014-0594-0>

- Oktaý, B., & Cangöz, B. (2018). I thought I saw “Zorro”: An inattentive blindness study. *Archives of Neuropsychiatry*, 55(1), 59. <https://doi.org/10.29399/npa.19227>
- Palan, S., & Schitter, C. (2018). Prolific —A subject pool for online experiments. *Journal of Behavioral and Experimental Finance*, 17, 22-27. <https://doi.org/10.1016/j.jbef.2017.12.004>
- Peelen, M. V., Heslenfeld, D. J., & Theeuwes, J. (2004). Endogenous and exogenous attention shifts are mediated by the same large-scale neural network. *NeuroImage*, 22(2), 822-830. <https://doi.org/10.1016/j.neuroimage.2004.01.044>
- Posner, M. I. (1980). Orienting of attention. *Quarterly Journal of Experimental Psychology*, 32(1), 3-25. <https://doi.org/10.1080/00335558008248231>
- Ranganathan, R., & Carlton, L. G. (2007). Perception-Action Coupling and Anticipatory Performance in Baseball Batting. *Journal of Motor Behavior*, 39(5), 369–380. <https://doi.org/10.3200/JMBR.39.5.369-380>
- Redlich, D., Memmert, D., & Kreitz, C. (2020). A systematic overview of methods, their limitations, and their opportunities to investigate inattentive blindness. *Applied Cognitive Psychology*, 35(1), 136-147. <https://doi.org/10.1002/acp.3746>
- Simon, D. J., & Chabris, C. F. (1999). Gorillas in our midst: Sustained inattentive blindness for dynamic events. *Perception*, 28(9), 1059-1074. <https://doi.org/10.1068/p281059>
- Simons, D. J. (2007). Inattentive blindness. *Scholarpedia*, 2(5), 3244. <https://doi:10.4249/scholarpedia.3244>

Stothart, C. R., Boot, W. R., & Simons, D. J. (2015). Using Mechanical Turk to Assess the Effects of Age and Spatial Proximity on Inattentional Blindness. *Collabra*, 1(1).

<https://doi.org/10.1525/collabra.26>

Wayand, J. F., Levin, D. T., & Varakin, D. A. (2005). Inattentional blindness for a noxious multimodal stimulus. *The American Journal of Psychology*, 339-352.

<https://doi.org/10.2307/30039070>

Xu, C., Oberman, T., Aletta, F., Tong, H., & Kang, J. (2020). Ecological Validity of Immersive Virtual Reality (IVR) Techniques for the Perception of Urban Sound Environments. *Acoustics*, 3(3), 11–24. <https://doi.org/10.3390/acoustics3010003>

Zhang, H., Yan, C., Zhang, X., Shi, J., & Zhu, B. (2017). The relationship between fluid intelligence and sustained inattentional blindness in 7-to-14-year-old children. *Consciousness and Cognition*, 55, 172-178.

<https://doi.org/10.1016/j.concog.2017.08.003>