Visualisations and Interaction Gestures: Enhancing the Football Watching Experience via Second Screen

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To my beloved parents, Binnur and Cavid Sezen

Declaration

This thesis has not been submitted in support of an application for another degree at this or any other university. It is the result of my own work and includes nothing that is the outcome of work done in collaboration except where specifically indicated. Many of the ideas in this thesis were the product of discussion with my current and former supervisors, *Dr Andreas Mauthe*, *Dr Emmanuel Tsekleves* and *Dr Neil Boynton*.

Excerpts of this thesis have been published in the following conference manuscripts and academic publications.

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Abstract

Advancements in mobile technologies and the Internet have changed the habits of TV audiences. As a result, second screen, which can be defined as a form of companion device use to augment TV watching experience, is emerging as a practice. Research shows that a considerable proportion of TV football audiences use second screen when they watch football matches on TV. However, certain details regarding the usage of second screen and how they affect the users' watching experience are unknown. This thesis investigates how most common visualisations of certain match-related information on second screen affect the watching experience of football matches on TV. This research also investigates how the most used and newly emerging interaction gestures for the retrieval of match-related information via second screen influence the watching experience of football matches on TV. Furthermore, this research provides design recommendations for second screen applications in terms of visualisations and interaction gestures. The design recommendations address to ensure an effective and enjoyable presentation of match-related information adapted to the users' needs. In order to achieve this, questions such as how memorable and enjoyable most common types of visualisations are, if there is a trade of between them, and what other relevant factors impact on the viewing experience are considered.

To address the questions, first, an initial literature review is conducted to analyse how people have experienced football. This is followed by the analysis of people's behaviour of seeking match-related information on second screen. The findings revealed that match statistics are one of the most sought types of match-related information and smartphones are the most used as second screen. For this reason, the visualisations of match statistics in mobile football apps and websites are evaluated. On

top of that, the interaction gestures that were used in those apps and websites were identified.

Two types of visualisation and interaction gestures were compared in prototype experiments in terms of their effectiveness, memorability and enjoyment. The findings revealed that different visualisations and interaction gestures had different effects in terms of effectiveness and enjoyment on the watching experience. Specifically, plain number visualisation seems to be less effective and enjoyed than bar charts in general. However, plain numbers seemed to be slightly more memorable than bar charts when the information access through second screen occurred in active gameplay. In addition, tapping for information retrieval on second screen seems be more effective and enjoyable than swiping in general except the performance of recalling verbatim match statistics seems to be slightly better with swiping when second screen activity is performed in non-active gameplay. Therefore, the findings recommend that different purposes need to be considered for the design of the relevant apps and websites in this regard.

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List of Abbreviations and Acronyms

BC: Bar charts.

PN: Plain numbers.

GBC: Grey bar charts.

GPN: Grey plain numbers.

CBC: Coloured bar charts (team-coloured bar charts, colour-blind-safe-team-coloured bar charts and warm-cold coloured bar charts).

TCBC: Team-coloured bar charts with repositioned numbers.

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1 Introduction

Advancements in mobile devices and the Internet have drastically changed our communication habits. For instance, letters were replaced by emails and instant messages. Moreover, phones were augmented from their sole purpose of voice communication with remote people to devices that people could realise a variety of activities that they could not before such as watching videos, listening to music, taking photographs, reading articles and disseminating all of these forms of content. Nowadays, people do not have to watch TV shows at their scheduled time. In addition, they do not have to use TVs to watch them and they do not have to watch them in their living room. Briefly, compared to traditional media such as print, phone, radio and TV in the past, ways of communication have loosened in terms of time, space and format (Jensen, 2008). Moreover, as Miah (2017) highlighted, viewers are no longer passive whilst spectating but also get involved in the event thanks to advanced digital technologies.

The changes in media and mobile technologies have influenced how people have experienced consumption of sports-related content. Compared to pre-internet and mobile era when sports consumption was heavily dependent on analogue media, the usage of multiple media for sporting events emerged in the experience of sports-related content consumption. Today, *"…the audience uses multiple distribution systems to fulfill different needs that cannot be satisfied by one system alone."* (Boehmer, 2016, p.463).

One of the distribution systems is social media. Miah (2017) pointed out that since 2008 use of social media as part of viewer experience has been an agenda for media companies. In current times, social media became an important element in sports media (Boehmer, 2016). All stakeholders in sports realm such as broadcasters, sportsmen and sportswomen, sports organisations, institutions and clubs have connected with audience on a variety of social media platforms and thereby sports-related content became an important subject on social media (Boehmer, 2016). Furthermore, Miah (2017) stated that the inclusion of social media brought a complementary watching experience rather than a detrimental type.

Second screen or second screening is a prominent example of complementary watching experience. It can be defined as a mobile device that is used in a relevant way to extend the experience of watching TV. In this context it could be defined as a mobile device such as a smartphone, that viewers use to access supplementary information regarding sports events that are being watched, as well as, via messaging platforms and/or social media, chatting with other people about anything related to the sports events they watch.

Naturally, the emerging experiences of spectating sporting events are observed in football, the most popular sport. Prior to advancements in mobile technologies and the Internet, football enthusiasts used to watch football matches, shows and programs on TV, read football news in newspapers, and listen to football broadcasts on radio. In addition, their ability to produce and disseminate football content was limited to fanzines (Rowe and Hutchins, 2012). However, the reach of such content was quite restricted compared to a similar type of content that is now published on the Internet. Technological advancements have also given football enthusiasts the opportunity to interact with governing bodies, players and other people who were not local to them.

Unlike nowadays football enthusiasts did not have the opportunity to access football content on an anywhere anytime basis, as they would need to wait for the next day to read comments in newspapers regarding the football match that they had watched. Moreover, they had to watch football shows on TV to catch the highlights of matches played at the weekend. Although the conventional TV experience could be augmented through recordings of TV broadcast via video recorders, such as VCRs and DVRs, to watch the content at non-scheduled times, this still required the effort to set the timer and the volume of content was quite limited compared to the level of resources and effort to reach them today, due to the advancements in Internet and mobile technologies.

Today, with the help of mobile devices connected to the Internet, people, who are interested in football, can interact with the governing bodies, players and other people who are interested in the sport. They share their emotions and thoughts related to football related topics, such as matches and players, learning other viewers' reactions towards them, creating a sense of community and being connected to other people even if they are at remote locations (Gantz and Lewis, 2012). In addition, they have the chance to access different types of information about teams, competitions, players and matches. Furthermore, it seems that a considerable number of people use second screen as it was reported that more than half of the fans who watched as many matches of 2014 FIFA World Cup as they could on TV used second screen (Mander, 2014).

The digital realm accommodates a plethora of resources such as mobile apps and websites, which a football audience could use to obtain relevant match-related information, such as statistics. Although the literature reflects how different statistical visualisations affect our memory and task completion (Tufte, 2001; Bateman et. al. 2010), there is little knowledge regarding how different visualisations of match statistics on second screen affect viewer experience of watching football matches on TV. In addition, the relevant literature lacks research on how different interaction gestures to retrieve match-related information through second screen affects the watching experience.

The focus on the different types of visualisations and interaction gestures in the second screen context is crucial due to the following factors: First, football audiences generally do not show tolerance against disturbances whilst they watch matches. Therefore, in the context of watching football matches on TV and accessing match-related information via second screen, quickness and ease is quite important since multitasking could be challenging and distracting. Due to such restrictions, rapid retrieval of information, seamless interaction and effective types of visualisation are crucial to enhance user experience. According to Robbins (2005, p.6) a visualisation is effective as *"…its quantitative information can be decoded more quickly or more easily by most observers…"*. Second, visualisations are known that they augment the memorability (Stusak et. al. 2015). Memorability of match-related information is important for football enthusiasts who use second screen retrieve match-related information via second screen since using such information, they try to understand the match and engage in discussions with other people (See Chapter 3). However, rapid information access and memorable information may not be enough for viewers since such usage should be enjoyable, too (Preece et. al., 2005). An effective and enjoyable display of match-related information on second screen as well as smooth retrieval of such information via second screen appeared to increase the user experience.

Since little is known regarding the effect of visualisations of match-related information and methods of retrieving this type of information through second screen on the watching experience of football matches on TV, this thesis makes contribution as in the following. First, it reveals that different visualisations of match related information on second screen affect different aspects, effectiveness, memorability and enjoyment, of the watching experience of football matches on TV. Second, this PhD produces design recommendations for visualisations of match-related information. The recommendations in this regard are based on the varied effects of different visualisations of match related information via second screen on the watching experience of football matches on TV. In addition, the thesis highlights how different interaction gestures to retrieve match-related information on second screen shape the experience of watching football matches on TV. Furthermore, this PhD gives recommendations on how investigated interaction gestures could be used effectively to retrieve match-related information as part of watching experience of football matches on TV. The recommendations in this regard are important because:

> *"Mobile devices are… an important feature of the media sport content economy. They are significant in terms of creating the multiscreen reality of contemporary media production, transmission and consumption (Hutchins, 2014, p.515).*

1.1 Aims, Research Questions and Goals

The aim of this PhD thesis is to develop recommendations regarding interaction and visualisation design on second screen applications and websites to ensure that applications and websites offer optimal combination of useful and enjoyable visualisations of match-related information, as well as the most favourable means for the retrieval of such information.

The PhD thesis has the following research questions:

- How effective, memorable and enjoyable are the most common types of visualisations of match-related information on second screen?
- What is the optimal level of effectiveness, memorability and enjoyment that most common visualisations of match-related information offer on second screen?
- How seamless is the information retrieval that common type of interaction gestures offer?

To answer these research questions the following steps are necessary:

- To review the literature regarding people's consumption of football, information visualisation and interaction design in various environmental and media settings.
- To understand people's behaviour of seeking match-related information on additional media while watching football matches on TV.
- To identify the popular types of match-related information on second screen and archetypal visualisations for the type of match-related information.
- To identify current modes of interaction to retrieve the prominent types of match-related on second screen.
- To test prototypes to understand effects of archetypal visualisations of match-related information via second screen on the watching experience of football matches on TV through prototype testing.
- To test prototypes to see how common and novel interaction gestures match-related information via second screen influence the watching experience of football matches on TV.
- To list design recommendations for visualisations of match-related information on second screen and interaction gestures for the retrieval of such information

through second screen that will augment the watching experience of football matches on TV.

The scope of the research questions will be limited to two types of visualisation for one type of match-related information and two types of interaction gesture for the retrieval of the match-related information. Only two types of visualisation for one type of match-related information are investigated because of the following reasons: First, there is a plethora of types of match-related information and they cannot be depicted with the same types of visualisations. For example, bar charts can be used to depict match statistics but they cannot be used to visualise people's comments regarding a football match on social media. In addition to this, although certain types of match-related information such as statistics can be depicted with a large variety of visualisations; however, the review of most-relied information sources (mobile football apps and websites) reveal (See Chapter 3.2) that only a few number of types of visualisations, especially certain two different types, are used to depict match statistics which is one of the most sought types of match-related information through second screen (See Chapter 3.1). Having been aware of other visualisations that could be used to depict the match statistics, the frequency of these particular visualisations in mobile football apps and websites lead the research focus on these visualisations.

The reason why the scope will be limited to two types of interaction gesture is the following: The review of mobile football apps and websites shows that a certain type of interaction gesture is predominantly employed for the retrieval of aforementioned type of match-related information though it requires a certain level of focus on screen which could be detrimental for second screen experience. Although this gesture is widely used in other non-sports apps, too, an emerging form of interaction gesture is seen on few popular non-sports mobile apps. In addition, from the literature, it was understood that this new gesture might increase the user experience due to its casual way of application on screen. Therefore, it was wondered whether a novel but casual type of interaction would increase the level of user experience compared to the former type that is more familiar but demanding in terms of user attention for application.

1.2 Rationale Behind the Thesis

Since the emergence of mobile phones in 1980s, portable access to information has been practiced (Goggin, 2013). Due to advancements in mobile technology and the rise of the Internet, the variety of content that are accessed through mobiles has become proliferated (Goggin, 2013). As a result, a huge app economy that is estimated to be worth of USD$6.3 trillion by 2021 (currently USD$1.3 trillion) emerged from the growing digital realm (Levitas, 2017). Sports content is one of the most popular categories in this app economy (Hutchins, 2014). Even before the emergence of the today's mobile apps, mobile phones were hugely appreciated to access sports content (Goggin, 2013). For instance, in 1990s, they replaced radios in football grounds and Wimbledon in 2000 received a huge mobile phone attention in terms of accessing scores (Goggin, 2013).

The result of such huge app economy is the emergence of novel forms of watching such that *"...a positive trend that is emerging is the complementary nature of multi-screens to the overall viewing experience..."* (Beltrame, 2011, p.63.6). For instance, second screen usage in UK has been reported popular that in a month in 2015, it was reported by Google that *"64% of people in the UK have used an online device while watching TV…"* (Google Consumer Barometer, 2015). The popularity in second screen usage seemed to rise to the level that *"[t]hree-quarters of [Britons] use a connected device while watching TV, a trend that rises to 93% in the under 25 age range..."* (Goodfellow, 2017). Furthermore, it was highlighted that, similar to the app economy, sports-related content has been one of the most popular type of content in second screen context (Abreu et. al., 2013).

Football is a huge industry. Former president of Lazio Football Club of Italy, Sergio Cragnotti once highlighted this as: *"…You tell me another product that is bought off the shelf by three billion consumers. Not even Coca-Cola comes close…"* (Lovejoy, 2002, p.188). Such popularity was confirmed that *"…about 50% of humans who were alive on July 11, 2010, watched the final of the [2010] World Cup."* (Palacios-Huerta, 2014, p.2). Football's popularity has been truly reflected in the digital space that is full of information resources in the form of apps and websites. Since user engagement is crucial in app economy, knowing the details and factors that affect the user experience of apps is important. As Preece et. al. (2005) stressed that design is known as a vital factor that shapes user experience, it is important to show the related industry how the presentation of football-related information and the ways of interaction that allows the retrieval of such information on the mobile apps and websites affect the user experience. Eventually, these concerns founded the fundamental motivation that lies beneath this thesis.

1.3 Thesis Structure

The thesis has seven chapters including this chapter. The references and appendices come after the seventh chapter.

In the second chapter a review of the relevant literature is undertaken considering the following aspects: people's interest to football, the historical context regarding how they have experienced football, second screen as an emergent phenomenon as a part of general and sports watching experience on, prominent and less popular types of graphics, sports information visualisation for audience, interaction gestures on mobile devices and other means of interaction.

The third chapter introduces the results of an online survey and individual interviews regarding people's behaviour of seeking information on additional media during their act of watching football matches on TV. Evaluation of mobile football apps and websites, with respect to their means of interaction, for the retrieval of a certain type of match-related information and types of visualisation for the same type of match-related information.

Chapter four begins with a brief discussion of the methodological approach. This is followed by the discussion of used and unused research methods that are considered as appropriate for the thesis. The methods which are used are described in the last part of this chapter.

The fifth chapter delivers the results of prototyping experiments that are conducted to understand the effects of different visualisations and interaction gestures on the watching experience of football matches on TV.

In the sixth chapter the discussion of prototyping experiments is provided. Design recommendations regarding visualisations and interaction gestures for second screen apps and websites follow this.

Chapter seven summarises reasons, methods and contributions. This chapter also highlights research limitations and points future research directions. The thesis ends with a brief reflection.

2 Background & Literature Review

In this part of the thesis, details regarding people's interest to the most popular sport in the world are presented because it is important to understand how their interest to football drives their consumption of football-related content and shapes their football experience. Highlights regarding consumption experience of football in a variety of social settings and watching experience of *the beautiful game* through different sorts of media follow this. Details regarding how technology has shaped general sports experience follow this. Next, the rising phenomenon of the second screen experience is explained along with the changing habits of consumption due to the advancements in Internet and mobile technologies. After this, previous research on the various aspects of second screen usage, such as details of general usage, motivation, timing, frequency, cognitive load and contribution to audience are discussed. In addition, related work on the most and less common types of visualisation that general audiences are likely to encounter, via various media, are highlighted. Highlights of research on sports visualisation follow this. Furthermore, earlier studies on interaction gestures and interaction on second screen are presented.

Together these research components set the whole picture of background for this research. They first show people's level of interest to football and their need for football-related content consumption. Then, they state how the practice of sports, the experiences of spectating sports and football-related content consumption have evolved. Further, they highlight what lacks in research regarding the effects of visualisations of match-related information via second screen on the watching experience. Finally, they indicate the gaps in literature on the effects of interaction gestures for the retrieval of such information via second screen on the watching experience.

2.1 Football Fandom

Fans are *"[people] who ha[ve] a strong interest in or admiration for a particular person or thing."* (Oxford Dictionaries, 2017). Fandom is *"[t]he state or condition of being a fan of someone or something."* (Oxford Dictionaries, 2017). When it comes to football, fandom is an integral part of the most popular sport in the world.

There are various reasons why people become football fans. Family influence such as the *dad effect* is one of the known factors (Dixon, 2011). The dad effect could be described as a process that people become fans because from their early childhood they observe their family members, such as their fathers, who are football fans (Dixon, 2011). They are influenced by their fandom through observation and become fans, too (Dixon, 2011):

> *"I've always been a football fan since I was younger coz my dad always supported Liverpool so I didn't have a choice in the matter because it's always surrounded me. My whole family are Liverpool fans, even my nan." (Dixon, 2011, p.286)*

Moreover, the difficulties that people encounter within their daily lives could lead them to fandom in order to change their focus and find relief (Wann, 1995). In addition to this, a handsome player or slick-designed merchandise may bedazzle and make others be fond of certain teams temporarily (Richardson and Turley, 2008; Giulianotti, 2002). Furthermore, football fandom can provide a solid ground for people who have the need to construct a stable identity in a hyper-changing post-modern world where identity is a relatively easy subject to change (Porat, 2010; Kytö, 2011). Therefore, in relation to the previous argument, the joy of sharing emotions with other fans in the community could be considered as a motive why people embrace fandom.

Fandom could be rooted from ethno-nationalism and entwined with it. For instance, the official slogan of *FC Barcelona* is *més que un club* (more than a club) signifies *Catalan nationalism* (Porat, 2010). On top of that, religious sectarianism is known as an important factor to stimulate fandom. One of the fiercest football rivalries in the world is between two clubs in Glasgow, *Rangers* and *Celtic*. Whilst the base of Rangers supporters is composed of Protestant people, the majority of Celtic followers come from Catholic background (Porat, 2010). On top of that, Rangers are associated with *British-Scottish-Ulster* and Celtic are with *Irish* identities (Bradley, 1998). Their matches usually go *beyond the pitch* and have the utmost potential of creating violent scenes. Also, socio-economic class differences could result similar violence (Bosevski and Hallinan, 2009). For instance, the clash of Boca Juniors and River Plate fans could result as murder in the opposition supporters:

> *"...In 1994 a busload of River Plate fans en route to the game were ambushed at gun-point with two shot dead. River Plate won the match 2-0 but soon after graffiti sprang up around Buenos Aires stating 'River 2 Boca 2'" (Ste, 2012).*

The intensity of fandom occurs in a variety of degrees. For instance, like the example above, some fans are extremely connected to their teams and nothing else seems to be more important in the world. They often identify themselves with their team, even to the point of imagining ownership of them (Gibbons and Dixon, 2010) or vice versa, for example in South America, clubs are considered as *mothers* of supporters (Giulianotti, 2002). For others, it is just a weekend pastime activity.

Different researchers classified fans and fandom in terms of *authenticity* (Giualianotti, 2002; Wann and Branscombe, 1993). Their base of analysis was heavily dependent on how, why and when fans are connected to their favoured clubs. However, while explaining and elaborating on fans, they were also wary of modelling them because they acknowledged that fandom was a complicated process due to daily routines, age, financial situation, occupation, location, culture, ethnicity, religion and personality that determine the levels of fans' passion and their devotion to the teams (Gantz, 2011, Tapp and Clowes, 2012).

Globalisation affects fandom through the increasing effect of mass media due to technological developments. Since Europe has always been centre of attraction for football, major clubs of the old continent and the league organisations that they participate in extend these clubs' dominant role through media and they increase their popularity. For instance, in a growing scale, Nigerian football fans stop following the teams in Nigeria and become fans of clubs such as Juventus and Chelsea FC due to the attraction of the style of football being played in the leagues they belong to and the quality of players they possess (Omobowale, 2009). The big clubs and popular leagues, such as Manchester United and the Premier League, do not just attract fans outside of their domestic reach but also affect the behaviour of them around the world. For example, the fans of a Japanese football club, *Urawa Red Diamonds*, sing in English and French during domestic league matches (Shimuzu, 2002). Additionally, due to internationally televised English football, a young generation of Finnish supporters support their team with English-style cheerings and songs, dress similar to English fans and their overall mood is more aggressive compared to the passive, quiet, patient and dignified way of traditional Finnish football supporters (Heinonen, 2002).

The passion and devotion of football fans does not always lead to violent acts. It is not surprising to see creative slogans, satire and visual material in the stands or on the media. For instance, the image below (Fig 2.1) was taken at the derby match between *AC Milan* and *FC Internazionale* that was played in September 2004. The photo (Fig 2.1) displays one of the choreographies of a former fan group of AC Milan, *Fossa Dei Leoni*. The visual is an adaptation of Edward Munch's famous work of art, *Scream*, by Fossa Dei Leoni to tease Internazionale fans (Fig 2.1).

Figure 2.1: A fan choreography (Source: Flickr, Image by Unknown).

The involvement of fans within football is not limited to watching the matches, chanting or exchanging banter or clashing with other fans but creating and attending social events and buying club merchandise (Guschwann, 2015). What they seem to have in common is the connection to their clubs, their need for information about the teams they support and consume various textual and audio-visual materials related to their teams. Gantz and Lewis (2012, p.25) described the level of consumption as *"…[m]any have crammed in so many facts, figures, rules, and statistics it seems they worship the deity of sports data."* In the following sections of this chapter, the effects of advancements in mass communication on such consumption are explained.

2.2 Experience of Watching and Consuming Football

2.2.1 Stadium Experience

Watching football matches in stadiums was the only way to witness the game until radio broadcasting of matches began in 1920s (Guschwan, 2016). Stadiums do not just offer an opportunity to watch football matches in situ but also to socialise with other fans and experience the game in an authentic way (Gantz et. al., 2006; Sandvoss, 2003). The authenticity could be explained through various reasons, one being that everyone in the stadium watches a match from an individual perspective, because everyone has a different seat and therefore views it from a different angle. Additionally, the stadium experience for the watcher is unique, since viewers cannot control many elements such that once they miss an action, there were not many opportunities for them to review it. Prior to the development of mobile devices with internet connection, their only chance to watch a replay of an important event in the matches at the stadiums was the big screens that were mounted in some stadiums (Fig 2.2). Nowadays, stadiums are being equipped with latest technological infrastructure to offer their attendants free high speed Internet connection (Hutchins, 2016).

Figure 2.2: Big screen showing the match played in the stadium (Source: Getty Images, Image by Matthew Ashton).

More than that, their source of information in the stadiums was limited to other people who are nearby to them in the stands, printed materials such as match programmes and radios (Fig 2.3).

Figure 2.3: A spectator listening to radio while watching the football match in the stadium (Source: Reddit, Image by Unknown).

Nuisances such as flares, thrown objects, brawls, excessive noise can also be part of their personal experience because spectators can interact with any events taking place in the stadium (Sandvoss, 2003). However, since the aftermath of Heysel and Hillsborough disasters, various changes in stadiums e.g. replacing terraces of standing crowds with all-seater stands and hyperinflation in ticket prices have transformed the traditional atmosphere in stadiums into *McDonaldised* venues (Giulianotti, 2002; Sandvoss, 2003; Williams and Neatrour, 2002). The fireworks, passionate chanting and banners that were associated with many fans with low incomes who used to support their teams were replaced by the principles of *McDonaldisation* as *"…increased efficiency, calculability, predictability, and control…"* (Kellner, 2003, p.37) and as a result, those fans became excluded from the stadiums (Giulianotti, 2002; Sandvoss, 2003; Williams and Neatrour, 2002).

2.2.2 TV Experience

Hundreds of millions of people around the world have been watching football matches on TV for more than half a decade (Guschwan, 2015). The BBC screened its first live football match in 1958 and the TV broadcast of football started in Italy around the same time. TV functions as a *rationalisation device* for fans because they can save time and money when compared to the watching experience at the stadium (Sandvoss, 2003). TV also offers a wide variety of options for them to re-evaluate matches with instant feedback (Sandvoss, 2003). Broadcasters offer audience replays, different viewing angles and some basic information regarding the matches such as scores, substitutions and bookings that are displayed on the screen. In addition, commentators provide some entertainment and additional information to fans by narrating matches (Whannel, 1998).

TV does not simply show the event that takes place on the pitch but converts it into a narrative shaped by the director of broadcast (Barnfield, 2013). In reality, the football match becomes a narration on TV since during matches, through the information shown in graphical forms, different cuts, scenes and angles, the broadcaster directs the audience to focus on certain elements and actions occurring on certain areas on the pitch. Additionally, commentators might prioritise certain elements, events and profiles over others during matches. Therefore, they reframe and guide the audience's attention and knowledge. Furthermore, TV programs promote particular teams and players. TV itself, therefore, shapes the ideas and impressions of people towards teams and the game itself. In this regard, TV acts according to what *Agenda Setting Theory* states: *"…[T]he media do not tell people what to think but what to think about…"* (Yoo et. al., 2013, p.10).

When TV transforms the watching experience of football into a directed narrative, it industrialises the viewing activity (Bale, 1998). Via TV, compared to the in-situ setting, the experience becomes a copy of the same product for everyone as if it was mass produced at a factory; that is to say, everybody watches a match from the same angle, views same highlights and replays. Additionally, everybody hears the same comments and opinions. Moreover, the broadcast does not just present an identical product to everyone but also removes authentic elements such as smell, sound and touch (Sandvoss, 2003).

Previous research regarding how sport fans view competitions on TV tell us that fans could be emotionally involved with the actions on the screen:

> *"…While watching sporting events, viewers' feelings of euphoria or sadness (and even anger) are accentuated when the focus is on a favorite team or player. 'Nervousness' about the contest appears heightened as well when favorites are involved…"(Wenner and Gantz, 1998, p.238)*

It is common to observe the aforementioned types of mood among football audience while watching matches on TV:

> *"…Sport fans signif[y] active viewing and keen interest in the action on the screen. [They] [a]re likely to feel anxious, argue or fight, and tell people to be quiet…"* (Gantz et. al., 2006, p.110)

2.2.3 Pub Experience

According to the research by Weed (2007), pubs have become common grounds to watch football matches due to the transformation of stadiums and TV broadcasting deals. Transformation of football stadiums, i.e. new all-seater stadiums with higher admission prices, resulted in the exclusion of people who are regular attendees of football matches at the stadiums although as Johnsen and Solvoll (2007, p.315) explained that they are *"…the segment with the highest willingness-to-pay"*. Therefore, pubs appear as relatively cheaper alternatives for those who no longer can afford to experience the matches in situ. Another asserted factor why pubs arose as venues to watch football matches is the TV broadcasting deals that require viewers to subscribe to *pay-TV* channels should they wish to watch the matches in their homes. For more than two decades, the broadcasting deals have increased reaching exorbitant prices for TV channels to air the matches, the deals have had an effect on the end consumer, the fans. Similar to the situation in stadiums, the people who cannot afford to watch matches through pay-TV channels see the pubs as solutions that satisfy their need of watching. Furthermore, Weed (2007) mentioned some people see pubs as a way of escaping potential violence due to hooliganism.

The research highlights that pubs form good alternatives to stadiums and pay-TVs at home, not just because they are cheap alternatives for the experience of watching matches, but also because they possess a sense of community and a simulation of atmosphere that viewers have experienced at the stadiums. People can exchange banter and share opinions with each other as well as chant together while watching the games on big screens at a relatively lower cost of just few beers while avoiding fights, long travels and bad catering at the stadiums (Horky, 2013; Weed, 2007). Apart from that, as Guschwan (2016) pointed out, pubs could create *fan diaspora*s that such places gave rise to the formation of groups of likeminded individuals who are far away from the original places where their fandom was formed. As Gibbons and Dixon (2013) highlighted that watching live matches in pubs is just one example of different practices of fandom. The other novel forms of fan engagement emerged with the new media technologies.

2.3 Internet, New Media and Emerging Experiences

2.3.1 Overview

People’s experiences of sports and sporting events have been evolved by technology. For instance, professional athletes in various sports have been receiving help from developments in science and technology to improve their performances. The range of such help have been varying in different areas such as nutrition, equipment, facilities and treatment (Houlihan and Green, 2008, Hawkins, 2017). Apart from *doping* usage, in some occasions, they even use technology illegally to gain advantage against their competitors. For instance, an investigation held by *Major League Baseball* in US revealed that *Boston Red Sox* team used *Apple Watch*, a smart watch produced by *Apple*, to cheat during the matches (Lee, 2017).

Developments in performance analysis is another evidence of technology’s impact on the sports scene. For example, coaches can use wearable technology that allows real-time tracking system to understand how their athletes perform individually or as a group on the field (Barkett, 2009). Moreover, improvements in video technology allowed them to analyse different aspects such as performance of their athletes and opposition tactics (Nelson et. al., 2011). Beyond this, coaches have been receiving help from specialised institutions regarding big data analysis to understand and boost the performance of their teams (Park et. al., 2016). Furthermore, they even use tablet computers for in-game analysis and designing their strategies during the sports events (Seifert, 2014).

Spectating experience of sports has not been immune from the technological advancements. First and foremost, technology has made the broadcasting of sporting events to remote locations possible. Moreover, the recent developments in mass communication even changed the remote spectating experience via providing people textual and audio-visual content as well as enabling them to create and disseminate their own regarding such events almost in anytime and anywhere basis. For example, people, who are stuck in a morning traffic jam in New Delhi, India, can watch NBA matches that are played in USA and follow the scores of other matches via their mobile devices. Additionally, being able to reach content in almost anytime and anywhere basis has transformed broadcasting into *narrowcasting* that is *"…the personalization of mediated content…"* (Miah, 2017, p.35) in live or televised sporting events. Beyond this, technological advancements allowed people to create and disseminate their own content regarding the event; thus, they became *citizen journalists* (Miah, 2017). Besides, the communication between spectators and sports people has become less reliant on mainstream media thanks to social media (Miah, 2017). Due to this transformation, multi-screen spectating experiences of sporting events have emerged, the distance between viewers and athletes has converged and the access to content has become more fragmented (Jensen, 2008; Miah, 2017).

The recent technological developments promise new sporting experiences. For instance, BBC (2017) reported that virtual reality (VR) may be used at pubs in near future for playing darts. Miah (2017) highlighted the use of augmented reality (AR) as a company produced goggles for snowboarders that may display information regarding their slalom route and former champions' performances in detail on the same route; therefore, they can understand their performances against them. *Hawk-Eye* in tennis and *Goal-Line* in football are other recent technological developments that have been being used to help referees for their instant judgement whether the tennis ball is *in* or *out* and whether the football *crossed the line* between goal posts. Even technology has intervened the stadium experience that for instance, vibration technology was installed in the seats of the stadium of Atlanta Falcons, an NFL team in USA to make people feel the clash of players on the pitch (Miah, 2017).

A new form of sports is another evidence for how technology has changed sports. The term, eSports which can be broadly described as *"…competitive video gaming… sponsored by business organisations…"* (Hamari and Sjöblom, 2017, p.211) has emerged. By definition, it is:

> *"[A] form of sports where the primary aspects of the sport are facilitated by electronic systems; the input of players and teams as well as the output of the eSports system are mediated by human-computer interfaces." (Hamari and Sjöblom, 2017, p.211).*

A considerable number of people seem to spectate eSports. Warr (2014) highlighted that an estimate of more than 70 million people around the world watched eSports in entire 2013. Moreover, the number of eSports spectators will highly likely increase since the eSports industry is expected to grow from $900 million to $1.5 billion in between 2016 and 2020 (Lumina Search, 2017).

The changes in sports and spectating experiences create new design challenges. The challenges are important because sports world is a giant industry and it can only be sustained through understanding how they are handled in a way that work for all the stakeholders in this realm.

2.3.2 Digital Football Experience

Previous research (Gantz et. al., 2006) shows that the watching of a football match does not begin with kick-off and finish with the final whistle and the viewing experience is extended by preparing for watching the game, watching post-match interviews, highlights and sport programmes. As Reagan (1996) found out, people who show a greater degree of interest in certain topics are likely to utilise multiple resources and paths to acquire information about them. In that respect, football fans' huge appetite for information about anything related to their teams is well known:

> *"…The fanatics' need for a relationship with their club/football stretched beyond the match day experience. 66 per cent of fanatics saying they would attend supporter evenings and 63 per cent showed more interest in receiving regular information about the club…" (Tapp and Clowes, 2002, p.1261)*

The invention of the Internet and the development of mobile technologies have drastically changed how individuals and institutions acquire and disseminate information:

> *"…Traditional or mainstream media content is often fixed or embedded into the host media, that is, it is only consumable in its original form... The content of a book can only be read from the book, the telephone conversation can only be listened to on the telephone, and TV news can only be watched via the television screen. However, thanks to digital technology, interactivity, convergence, etc. now different forms of user-controlled content emerge. It is possible to dissolve these forms of user-control in different types of shifting. In*

the current media landscape we see three prevailing forms of shifting: Time shifting, space shifting, and format shifting…" (Jensen, 2008, p.131)

Prior to the Internet, as Hutchins and Rowe (2012) highlighted football audiences were heavily dependent on traditional resources such as radio, TV and print media e.g. newspapers, fanzines and magazines. However, with the appearance of the Internet and the emergence of new media technologies, such as mobile computers, fans can more quickly access enriched textual and audio-visual content. One of the remarkable contribution of technology to TV audience has been rapid provision of information. For instance, people who are interested in *fantasy sport* have benefitted from this. Fantasy sport can be defined as *"…a game overlay on any sport where fans pick and manage their personal virtual team during the season."* (Vasudevan et. al., 2013, p.182). Recent studies (Holz et. al, 2015; Cunningham and Easting, 2017) explained that some viewers used additional media to check scores so that they could immediately see how their fantasy teams were performing while they were watching the sports events.

Developments in the communication technologies, compared to the past, made alterations in the relationship between the content producers and receivers. According to Guschwan (2016), fans became *prosumers*, meaning that they have no longer been just the bodies of consumption but also the content producers. Guschwan (2016) also highlighted the fact that new technology sped up everything in the process of content creation and distribution. The evidence for such transition of being prosumers and technology's effect on rapid content creation and dissemination are plethora of fan-made textual and audio-visual content on various blogging and video portals on the internet.

As Nicholas et. al. (2003) mentioned, the end-user has become a player and consumer of information who has little attention span and wanders around a sea of information and content provided by multi-channel TVs, smartphones, tablets and laptops. Nevertheless, fans have routines to follow events and consume information from certain websites and forums, especially for young fans, it is not difficult to change the habits and adapt using new technologies. Although nowadays, thanks to the penetration of the Internet and ubiquitous computing around the world, accessing content is not a major concern for fans. They can reach information on the basis of *anytime anywhere*. There are some limitations that can potentially prevent the information access in this context. For instance, as Taneja et. al. (2012) put, time that individuals have for their have day-to-day commitments such as work and their habits of media usage as well as their daily routines put barriers in front of the anytime anywhere mode of consumption. Besides, it is a known fact that especially older people, mostly due to facing difficulties of adapting the use of new technologies, still prefer more traditional ways of accessing information (IJsselsteijn et. al., 2007).

2.3.2.1 World Wide Web

Before the Internet reached a global audience, football fans used to receive information regarding matches and their teams in discrete time periods; that is to say, they usually had to follow news on TV through teletext in daytime and special TV programmes such as *Match of the Day* in the evenings. Also, they used radio for the same purpose. Moreover, they used to wait for tomorrow’s newspaper to read comments and box score. Today, the Internet has given fans the means of accessing content at any time of the day to receive news, watch highlights, read comments and any other informative material related to their point of interest in this respect. They no longer have to await the delivery of the newspaper for match analysis or broadcasting time of their favourite football show to watch the highlights because they can view the show and/or highlights on a video portal at any time and access match statistics on various web portals.

Another important change that the Internet creates is the vast choices in source of information that fans can reach. In terms of information source, they do not have to be reliant on the content delivered by the traditional media such as TV companies and newspapers since they are not the only ones who can produce and disseminate content. Due to today's more affordable technology for content making and distribution, the social media and video portals as well as blogs and dedicated websites are full of textual and audio-visual content made by non-professionals and fans. Hutchins (2011) underlines this change as *"...a shift away from broadcast-centric understandings of media sport..."*. Apart from this, the Internet alters and even diminishes the barriers between fans and clubs, supporters and players. For instance, followers of a team can get information regarding the first eleven of their team just before a match via a verified social media account of their club or follow players' activities through their social media accounts; therefore, their dependency on journalists, pundits and reporters does not need to be as tight as it used to be.

The phenomenon of having the opportunity to reach information/content in anytime anywhere basis has created non-linear patterns of information consumption for fans. Like video recordings, they now have the ability to skip past or fast-forward undesired or boring parts of a TV football programme when they watch it on the Internet. In addition to this, they can replay a key moment of a match on social media in the form of a *Youtube* video embedded on *Twitter timeline* while viewing it on TV. Furthermore, similar to having the ability to fast-forward/replay/skip content while watching, fans can disregard irrelevant content on a certain medium by using filtering and personalisation features provided by the medium.

Without any doubt, the amount and quality of information provided by the Internet may bring few issues along with advantages such as the rich sources of information and ease of access to content. For instance, the wealth of information may easily turn into data bombardment to confuse minds and overwhelm people. Moreover, the anonymity and ease of reaching other people may give rise to harassments such as online bullying and racial abuse. Discussions on chat rooms and forums may become forms of trolling and can ignite violence among fans.

2.3.2.2 Second Screen

The Internet and the developments in mobile computing have not just created new formats of content and forms of media but have also enriched the usage of traditional media. Therefore, in today's world of home viewing, the focus of the TV audience is more fragmented than before and is not solely on the television in terms of consuming any form of related content (Livingstone, 2004). People are engaging with mobile devices more and more while they are watching TV. The forms of engagement vary from accessing supplementary information regarding the content they watch on the screen to conversing with friends, family, acquaintances and people who have common interests and live in remote locations, and exchanging opinions with them about a specific programme on TV (Doughty et. al., 2012). When TV viewing is coupled with TV-content-related use of mobile devices is defined as *second screening* (Doughty et. al., 2012).

Second screening is not the only way to enhance the TV viewing experience as the rise of interactive TVs (iTV) provides another path of enhanced watching for the TV audience:

> *"Interactive TV is a medium providing the users with hundreds of video channels, on-demand delivery of programs, information services, on-line shopping, telebanking, etc." (Kim, 1999, p.87).*

A study by Cruickshank et. al. (2007) found various reasons why second screen could be essential for the use of iTVs. First of all, they pointed out that a separate screen is important because having the TV content and support services of iTVs such as Electronic Program Guide (EPG), which is *“a list on a television screen that says which programmes are going to be broadcast on which channels”* (Anon, 2017), on the same display could create a distraction for the viewers. Moreover, iTV users have suffered from a low reaction time of the iTV user interface as the transition from an iTV service to the main image could be frustrating because they could miss a part of broadcast; therefore, a second screen approach is highly recommended for seamless interaction. Additionally, unlike traditional (physical-buttoned) TV remote control, second screen offers more opportunities of interaction, such as browsing through web and communicating with other people. Their research also emphasises the functionality of second screen that allows users to customise the interface according to their needs and priorities. Furthermore, the study highlighted the fact that second screen is a better tool in terms of legibility of textual information compared to iTV screen.

2.3.2.2.1 Second Screen Usage

The literature accommodates studies that covered different aspects of second screen and its general use. When it comes to analysing the details of visual attention that viewers have during their act of watching TV, recent evidence suggests that TV remarkably dominates the attention (Holmes et. al., 2012; Brown et. al., 2014). The study of Holmes et. al. (2012) shows that while watching TV, TV itself takes 63% of the viewer attention whilst a tablet occupied 30% and off-screen had just 7%. The research of Brown et. al. (2014) confirms the dominance of TV in this sense as their research showed that the average user attention was mainly focused on TV (76.5%) and occasionally on the secondary device (10.9%). Apart from that, Holmes et. al. (2012) indicated that the average viewer gaze on second screen was around one second when it was two seconds on TV. Additionally, they did not see any difference in patterns of visual attention in relation with TV genres. Furthermore, Bokenham and Hughes (2013, p.6) highlighted that *"[u]sers switch attention between screens 27 times per hour."*

The previous studies reported timing of second screen usage. For instance, the same study by Holmes et. al. (2012) demonstrated that second screen usage increased and TV viewing decreased during the adverts. In addition to this, Bokenham and Hughes (2013, p.6) emphasised the adverts as an important time period for second screen usage that *"60% look at secondary device during TV ad breaks…"*. Another effort made in this context was a TV-series-based study conducted by Mukherjee and Jansen (2014) to understand whether the intensity of social interactions regarding a TV series on second screen differed in between the times when the content was being broadcasted or not. Their work (Mukherjee and Jansen, 2014) discovered that there was a significant difference between air times and non-air times of a TV series in terms of social interactions on second screen. The research showed us that people made more postings on social media in air times than non-air times (Muhkerjee and Jansen, 2014).

Some other studies on second screen focused on types of user-driven usages of second screen. One of the earlier studies in this area was done by Cesar et. al. (2008) and they have identified four main categories of second screen usage: *"Control, enrich, share and transfer"* (Cesar et. al., 2008, p.168). In their research, *control* was referred to as the use of secondary screen to select what is shown on TV; hence, allowing viewers to become independent of the TV stream. Apart from that, their work underlined that the *control* aspect of secondary screen enables users to reach enhanced material regarding a TV programme; thereby, a viewer can receive extra information about TV content without interfering others' watching experience. In their paper, *enrich* covers the aspect of user contributions on media content such as customising a certain segment of a video that they watch on a video portal. Moreover, the paper explained *share* by denoting the role of second screen as a device that users could use in order to send other people, mostly friends, their personal recommendations as well as share their personalised parts of TV content. Furthermore, according to their research (Cesar et. al., 2008), *transfer* symbolises transferring the content shown on TV to secondary screen in time periods when the viewer had to leave the environment where TV was located.

Sandvik et. al. (2013) contributed to the analysis of second screen usage types by describing modes of second screen user engagement as *communication as collaboration*, *communication as participation* and *communication as co-creation*. According to their classification, the first term refers to dissemination of what is consumed, or experienced, on the media and participation into discussions regarding content material on various platforms, such as blogs and social media. Their second classification, communication as participation, is explained as putting an impact, even in the slightest measure, on a TV show through a voting system. The third one is creating their own media content such as writing reviews, posting questions and creating discussions (Sandvik et. al., 2013).

The thematic work performed by Ainasoja et. al. (2014) on the behavioural analysis of second screen users identifies four different models: *Commentator*, *Analyzer*, *Home Gamer* and *Active Follower*. In their research, *Commentato*r was explained that they have a preference to watch TV programmes with other people and they like to spot and comment on different situations that happen during the programmes (Ainasoja et. al., 2014). The second category, *Analyze*r, is defined as someone who monitors evaluations and comments made by other people about a TV show on second screen, to compare whether his/her opinions match or differ from theirs and to make an effort to converge a true analysis of what he/she watches (Ainasoja et. al., 2014). In addition to this, the third group, *Home Gamers* are people who show willingness to compete with other viewers on second screen such that they are keen to play second screen applications of TV programmes, such as quiz shows and see how they perform against the others (Ainasoja et. al., 2014). The final type of persona, *Active Follower*, is interpreted as people who have tendencies to look for additional information e.g. facts, biographies, backgrounds and history regarding people whom they watch on TV programmes and feel connected to them, sometimes even in the level of fandom (Ainasoja et. al., 2014).

According to Breidbach et. al. (2015), under the user-driven motive, people prefer to use second screen in two ways: *experience avoidance* and *experience enhancement*. Experience avoidance occurs when viewers avoid a negative experience caused by the first screen and experience enhancement is observed when a relatively good first screen experience is wanted to be enhanced via consumption of additional content through an extra screen. In addition, the researchers suggested that switching screens for escaping from bad experience might occur, due to boredom or trying to cope with others' needs and satisfy them. Finally, the study explained that improving the existing experience with second screen could be due to the need of increasing self-satisfaction or enriching others' experiences specifically in the public domain.

2.3.2.2.2 Motivations of Second Screen Usage

Giglietto et. al. (2014) took Wohn and Na's (2011) application of the *Uses and Gratifications (U&G)* theory proposed by Katz et. al. (1973) on the social television and asserted that the needs that lie beneath the reasoning of audience's media consumption suited the reasons of people's utilisation of second screen:

> "…cognitive needs (information), affective needs (emotion), personal integrative needs (credibility and status), social integrative needs (social role) and tension release needs [such as] entertainment and diversion." (Giglietto et. al., 2014, p.263-264)

The research conducted by Han and Lee (2014) listed user motivations of complementary usage of text-based media during TV viewing and their findings resonate with what was highlighted in the work of Giglietto et. al. (2014) as *needs* and the details of personas in the study of Ainasoja et. al. (2014). Han and Lee (2014) reported that exchanging impressions and thoughts of a programme with others, using TV content for opening conversations, the need of validating own opinions regarding the content with others, as well as the need to analyse and elaborate further, are major reasons. According to their research, other reasons could include seeking and sharing information regarding the TV content, curiosity of other people's ideas and breaking the feeling of loneliness via simulating a co-viewing experience (Han and Lee, 2014).

Marinelli and Andò (2014) suggest similar findings with the research above. Their work points out that the role of interaction in the form of exchanging emotions and meanings, checking opinions of others and verifying one's own perceptions with the rest are important to viewers. Their research also highlighted the importance of information gathering and sharing as another reason for second screen activities of viewers (Marinelli and Andò, 2014).

2.3.2.2.3 Time of Second Screening

Studies conducted by Gantz and Lewis (2014) and Johns (2012) revealed time patterns of second screen use of sports fans that are similar to the findings of studies that were interested in general use of second screen (Holmes et. al, 2012; Bokenham and Hughes, 2013). They revealed that in various breaks due to incidents, nature of play and commercial timeouts, fans extensively use second screen to access additional event-related information and communicate with other fellow viewers in remote locations. Research by Kim et. al. (2015) focused on a more specific usage of second screen by investigating how fans used Twitter during the FIFA World Cup 2014. They have identified a variety of patterns showing fans used this particular social media platform. First of all, their findings told us that fans tweeted more often while the matches were on compared to the off-match periods of time (Kim et. al., 2015). Moreover, they probed whether the diversity of topics change accordingly with on-gameplay and off-gameplay times and people appeared to touch on more variety of talking points during the matches than when the games were not played (Kim et. al., 2015). Thirdly, they discovered that, while the matches were on, fans preferred *retweeting* i.e. spreading others' opinions rather than *giving mentions* i.e. interacting with each other. They speculated on this situation that fans might opt out of being proactive on second screen since *mentioning* was a more cognitively demanding task that requires typing, than *retweeting* which needed a single click.

2.3.2.2.4 Popularity of Second Screen Usage

Measuring the popularity of second screen usage among a sports audience has been another point of research interest and relevant studies have confirmed that popularity of second screen use is in growing density. According to Gantz et. al. (2012), almost half of the sports audience in the US use second screen during their consumption of soccer and American football matches (Gantz et. al., 2012). This increasing trend, as the report by Mander (2014) shows, 65% of fans, who watched as many matches as they could in FIFA World Cup 2014, declared that they had a second screen experience while they were watching matches on TV. According to Mander (2014), they mostly chatted with their friends through *WeChat* and *WhatsApp*, sharing opinions on *Twitter* and interacting online content through *Squawka*, a comprehensive football app, that gives match-related information including detailed statistics. A survey by Haddad et. al. (2013, p.1) stressed that *"76% of adults have used a second screen… while watching sports match on TV."* The survey also confirmed the increasing trend as the rate was around 62% percent in their previous study that was conducted two years ago before the latest one.

2.3.2.2.5 Second Screen and Cognitive Load

How human cognition works under multi-stimuli is explained as follows:

> *"Human cognitive capacity is limited and attention is selective. This implies that the so-called phenomenon of multi-tasking is based on switching, rather than dividing attention… [A]t any given point in time, a person's attention is focused on one stimulus (e.g. the first screen) and that if another stimulus (e.g. the second screen) demands attention or offers a focus for attention then for the time the person attends to content on the second screen s/he does not attend to content on the first screen." (Klein et. al., 2014, p.40)*

Thus, although second screen enhances the watching experience of a TV audience by offering them access to extra information about TV content or the opportunity interact with other people to discuss and have fun regarding TV programmes, this way of watching TV equally brings a certain issue that may overwhelm viewers: High cognitive load. Van Cauwenberge et. al. (2014) proved the fact that through second screen activity, the level of cognitive load on viewers soared and people found it more difficult to recall information compared to others who did not participate in this kind of dual screen engagement during their act of viewing news on TV.

2.3.2.2.6 Second Screen's Contribution to TV Sports Audience

Although Guschwan (2015, p.337) highlighted the fact *"…broadcasters were quick to realize that drama and emotion in the voice of the announcer drew more interest than encyclopaedic knowledge of the sport or tactical expertise..."*, the interest of TV sports audience to any kind of match/competition-related information or content cannot be ignored. In this regard, Abreu et. al. (2013, p.8) draws our attention to the fact that *"…sports shows [were] those that most encourage the use of secondary screens."*.

Therefore, it could be deducted that second screen seemed to be a remarkable contribution to their viewing experience. Specifically, some studies revealed that second screen could offer additional depth of knowledge for fans during the act of watching; that is, fans were likely to use Internet in order to augment their TV watching experience of sports via an additional screen (Gantz et. al., 2012, Galily, 2014). The research by Gantz et. al. (2012) shows that fans appeared to have four different ways of how socialisation through technology contributed their experience of watching games. First, parallel to what Basapur et. al. (2011) reported, the research draws attention to fans' liking of sharing their emotions and thoughts related to games. Second, the study brings forth the tendency of the audience to learn other viewers' reactions towards games. In addition to this, they discovered that these technologies help fans to have fun in the form of joking and trash talking. Over and above that, thanks to digital platforms, fans feel a sense of community and connected to other people even if they watch the matches alone. From the initial sections of this work, we already know that fans have a great need of feeling part of a community of like-minded individuals. Overall, the study shows similar findings to the body of work conducted on the general use of second screen, such as the need for information access/dissemination and socialisation.

The study by Anstead et. al. (2014) focused on the aspect of accessing information that second screen contributes to. For this, they developed and tested an application for 2012 London Olympics. Through the app installed on a tablet, the test participants could check statistics regarding a competition in the Games, e.g. after they had watched it. Almost one third of the participants were positive towards statistics as additional content for Olympics (Anstead et. al. 2014).

Another type of second screen activity happens on eSports scene. Emmerich et. al. (2014) pointed out that there has been a trend of smartphone/tablet usage to complement gaming experience. Some games have already had companion apps that have served different purposes such acting as an additional controller or providing in-game information such as characters and statistics (Emmerich et. al., 2014). Moreover, Emmerich et. al. (2014) stressed that a challenge regarding design of second screen content in this respect and cautioned that the design should be clear and simple as well as tailored to the gamers' instant needs. In this respect, Lumina Search (2017) stated that companies have already begun working on second screen solutions to create more engaging experiences for gamers such as offering the viewers *leader-board* for self-evaluation. Furthermore, Hamari and Sjöblom (2017) emphasised the social side of eSports spectating. therefore, second screen experience in this regard can be deduced.

2.4 Information Visualisation

Card et. al. (1999) define *information visualisation* as an effective interactive tool to foster our perception regarding any specific issue, case, event or incident. According to their definition (Card et. al., 1999) information visualisation is a method of depicting various types of abstract information via visual cues with the advanced technology of computers. Undoubtedly, Information visualisation positions itself with a clear-cut aim: To build up our cognition, develop our understanding towards a topic or a problem. Its power lies behind its ability to transform any *less meaningful* data to *more imaginable* one. Briefly, information visualisation can be considered as a complex functional machine making things visible.

Ware (2013) praised information visualisation as it quickens the process of acquiring and clarifying large quantity of data in seconds. Therefore, the viewers leap from a stage where they must review every single detail of plenty of measurements to a point where they wander around the data in a lightning speed. Basically, to achieve such rapid access of information, as Chen (2006) explained, it should have a function as a guidance which helps the viewers to get valuable information and make decisions rather than just staring at a confusing pile of information. Moreover, Spence (2014) indicated that information visualisation unveils hidden sides of data, leads us to reveal secret aspects of information and enables us to develop new questions about the data, re-examine it. Furthermore, according to Munzner (2002), information visualisation has a crucial ability that facilitates people to form basic cognitive paths and maps in their minds which allow them to follow and reach any specific target in an effective fashion.

Since information access is one of the main reasons of why fans use a mobile device when they watch sports events on TV, how the relevant information is visualised on the mobile screen is very important to create a seamless and frustration-free watching experience with second screen. The first part of the next chapter analyses match-related information seeking behaviour and reveals that one of the main types of match-related information that TV football audience are interested in is in-game statistics. *Pie charts*, *bar charts*, *plain numbers* and *treemaps* are commonly used ways of depicting this sort of game information as they are seen in the next chapter where several football mobile applications and websites were reviewed. Before that, this section will briefly mention early studies regarding these sorts of visualisations in general context with different aspects. Furthermore, research on other types of visualisations that were not really popular on many football apps and websites in terms of displaying information will be summarised.

Cleveland and McGill (1984) investigated how differences in vertical bar chart designs (stacked vs adjacent bar charts) influenced people's perception. Their experiments revealed that people's estimates of relative heights through stacked bar charts were less accurate than their perception via aligned bar charts (Cleveland and McGill, 1984). Moreover, their study showed that adjacent bar charts seemed to yield more accurate estimates than divided bar charts (Cleveland and McGill, 1984). Talbot et. al. (2014) experimented further on the work of Cleveland and McGill (1984) on bar chart design in the direction of *"…how different bar chart designs impact accuracy."* (Talbot et. al., 2014, p.2152). Their study first experimented on adjacent and separated bars and revealed that *"...separating bars in space makes comparison of their heights more difficult."* (Talbot et. al., 2014, p.2155). Plus, aligned and unaligned bars in stacked bar charts were compared in this study. The results showed that comparison of bars in unaligned stacked charts were more problematic than the comparison of bars in the aligned versions (Talbot et. al., 2014). Third, their research revealed that comparison of bars that were next to each other in the same stack was more difficult than comparison of bars that were separate from each other in the same stack (Talbot et. al., 2014).

Cleveland and McGill (1984) also compared bar charts and pie charts. In their experiments they asked the participants to find the maximum values in twenty graphs of sets of data of which ten were displayed in pie charts and the remaining were in bar charts. Additionally, the test subjects were requested to evaluate the rest of the values in each data set in percentage compared to the maximum ones. The results indicated that bar charts were significantly better than pie charts in terms of accurate comparison of values in a data set (Cleveland and McGill, 1984).

Simkin and Hastie (1987) found that bar charts function better than pie charts with regard to comparing different values; however, they found that pie charts were equal with bar charts in connection with the perception of the right proportions in whole. Moreover, a study by Schonlau and Peters (2008) revealed comparative performances of tables, bar charts and pie charts. Their research showed that displaying data in a table yielded better results in terms of remembering information accurately, compared to the depiction of data in a pie chart and a bar chart. Furthermore, they found that there was no significant difference between bar charts and pie charts in this respect.

Spence and Lewandowski (1991) revealed that a pie chart was slightly better than a vertical bar chart in terms of speed and accuracy when participants were asked to compare two different sums (A+B vs C+D).

Tufte (2001) claimed that tables worked best for displaying exact numerical information. Moreover, Tufte (2001) added that tables outperformed graphics in terms of depicting small data sets. Tufte (2001) also highlighted that a *supertable*, a big table composed of many small tables that represent different categories, was far more appropriate than ten dozen mini bar charts. Apart from this, Cleveland and McGill (1984) highlighted that tables worked better than bar charts in terms of conveying the information as accurately as possible.

There has been research and debate around the effects of embellishment on information visualisation. Tufte (1998) defied the usage of any form of visual element on information visualisations that does not tell anything regarding the depicted data and described them as *chart junk*. In addition to this, Tufte (1998) questioned the credibility of this type of visualisation that as he claimed that nobody would trust them since they lack interesting data and they recoup it with cosmetic decoration. However, a study by Bateman et. al. (2010) made a comparison between minimalist bar charts and visually embellished bar charts in terms of interpreting accuracy, short and long-term recalling and reader preferences. They (Bateman et. al., 2010) revealed that there was no significant difference between the former and the latter regarding accuracy of interactive interpretation and correct recalling in a 5-minute period. Moreover, their findings remarked that charts with decorative elements outperformed the plain charts in terms of remembering the topic, trends and categories in the charts after 2-3 weeks.

Furthermore, their study volunteers declared that non-minimalist charts were more attractive as well as the easiest and fastest to remember.

In a similar fashion, an investigation about the memorability of different visualisations was made by Borkin et. al. (2013). Their study showed that visualisations that possessed more human recognisable features were more memorable than the ones that did not have such elements (Borkin et. al., 2013). In addition to this, they found that visualisations that were styled in a more minimalistic way and had a *cleaner* look performed significantly worse scores in this sense (Borkin et. al., 2013). Apart from these, their research discovered that memorability was improved through visualisations with seven distinct number of colours in comparison with the ones that had less than seven number of distinct colours (Borkin et. al., 2013).

In the study conducted by Borgo et. al. (2012), plain and embellished versions of a variety of visualisations (horizontal and vertical bar charts, time series, bubble graphs, treemaps, computer-generated imagery) were tested with participants. The findings showed that *"when embellishments are grouped with the numerical representation, that they have the most beneficial influence on [short term] memory tasks."* (Borgo et. al., 2012, 2766). In addition to this, their research indicated that embellished visualisations were superior to the plain displays in terms of remembering for the long term, visual search and concept comprehension (Borgo et. al., 2012). Aside from this, Skau et. al. (2015) conducted an analysis to look at the influence of visual embellishment (human recognisable element) in bar charts on communication accuracy. In their study, the embellishments on the bar charts were simple and the type of embellishments were decided upon their frequency of occurrence. They tested six embellishments (rounded tops, triangle shaped bars, capped bars, overlapping triangle bars, quadratically increasing area bars, bars extend below zero) against the control type, ordinary baseline bar chart. The results of their study demonstrated that none of the embellished versions of bar charts worked better than the baseline bar chart in terms of communication of data. They strongly recommended designers to avoid using triangular bar charts and put greater negative emphasis on quadratically changing area versions and overlapping ones in this regard. In addition, they stated that capped bar charts were useful for absolute judgments but they were not good enough for comparing bar values. Furthermore, they reported that bar charts that extend below zero were not problematic to use provided that the sub-zero part had a distinct colour.

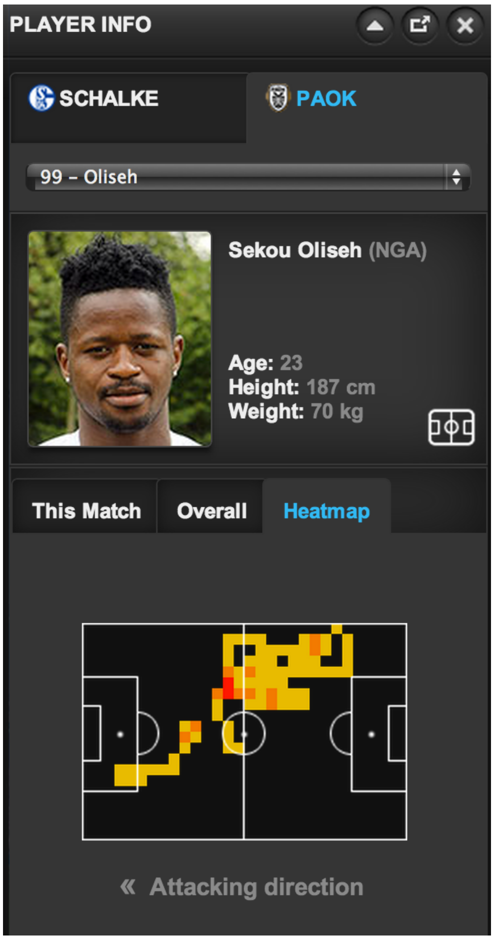
Games and Joshi (2015) studied effective types of interactive data visualisations on tablets. In their research, they compared tables, bar charts and line charts. Their findings demonstrated that tables were found the easiest to understand and least frustrating by users (Games and Joshi, 2015).

It should be noted that the participants of those aforementioned studies in this section were tested in a non-distractive environment that were unlike second screen environments and the visualisations were not on a mobile screen.

Apart from tables, bar charts, pie charts and treemaps, the realm of visualisations accommodates plenty of variety in visualisation types. For instance, one of them is *data maps* (Tufte, 2001). Data maps are *"…thematic maps…"* (Tufte, 2001, p.20) that *"…information can be organized in association with geographical positions in a very natural and intuitive way..."* (Chen, 2006, p.8). Tufte (2001) highlighted the power of data maps that they can accommodate a plethora of data in small space. A famous example that shows how useful they are is the map of Dr John Snow who revealed a great hint of why certain cholera incidents happened more often at a certain area (Tufte, 2001). However, as Tufte (2001) remarked, data maps could be misleading that they can shift the reader's focus via emphasising the sizes of geographical areas over the statistics.

Data maps in football that are usually referred as *heatmaps* which are colour-shaded areas on pitch representations are used to show the activity of a player on the pitch throughout a match (Fig 2.4).

Figure 2.4: Pitch coverage information of a player (Source: UEFA, Image: UEFA).



Another type of visualisation is radar graph which is *"…a circular graph that encodes quantitative values using lines that radiate from the center of the circle to meet the boundary formed by its circumference."* (Few, 2006, p.131). Although such visualisation is rarely used in football apps and websites, there were some uses of it.

For instance, football video games such as *Super Sidekicks 3* (1995) used radar graphs to illustrate users the weaknesses and strengths of the teams (Fig 2.5).

Figure 2.5: Team Menu on Super Sidekicks 3 video game (Source: Video Games Museum, Image: SNK).

However, Few (2006) urged that radar graphs may be less effective than bar charts *"…because it is more difficult to read values arranged in a circular fashion."* (Few, 2006, p.131).

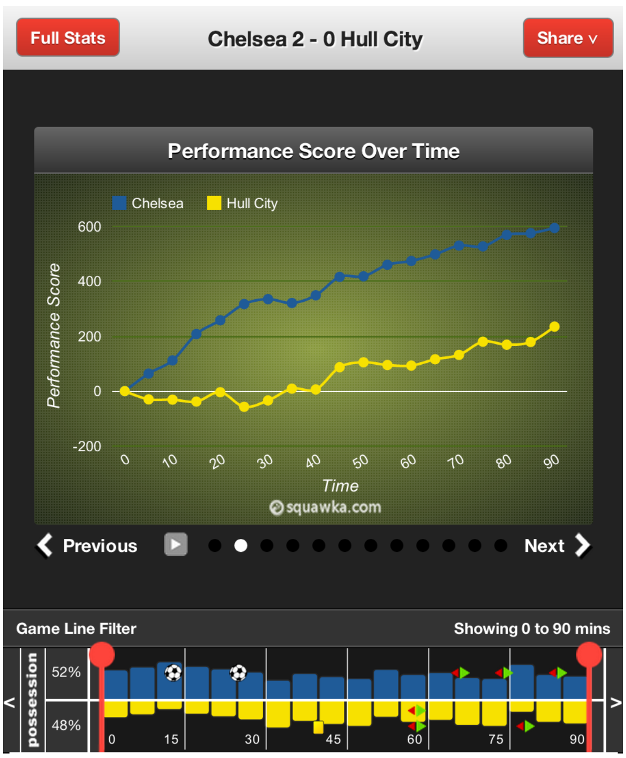
Time-series which can be displayed in a multitude of different forms (Aigner et. al., 2011) is one of the most used visualisations (Tufte, 2001). Tufte (2001) claimed that time-series visualisation is the strongest and most efficient visualisation for the interpretation among others. Cartesian coordinate system that shows time on one dimension (horizontal axis) and quantity on another dimension (vertical axis) is one of the simplest and most utilised ways to illustrate time-series (Aigner et. al., 2011).

Scatterplot is a timer-series form that is quite useful to highlight individual values (Aigner et. al., 2011). *Line chart* is the most popular time-series representation; however, such kind of time-series might lead wrong conclusions regarding the data between individual values; therefore, the connection between the values might not be fully certain to identify the other values in the middle (Aigner et. al., 2011).

Horizontal bar charts can also be employed as a type of time-series visualisation and it offers a good comparison of values while it emphasises individual values like scatterplot does (Aigner et. al., 2011). With such visualisation, when it is in a thinner form known as spike, *"...a good visual balance is achieved between focusing on individual values and showing overall development of a larger number of data values."* (Aigner, et. al., 2011, p.154).

These forms of time-series are not widely used in industry; however, examples (Fig 2.6) could be found in applications that have sections for in-depth statistical analysis.

Figure 2.6: Combined scatterplot and line chart visualisation for performance score of teams and horizontal bar chart for ball possession over time (Source: Squawka, Image: Squawka Android App).



Sparklines are another type of visualisation that are *"…small, intense and wordlike graphics…with an intensity of visual distinctions…"* (Tufte, 2006, p.48). According to Aigner et. al., there is an increasing trend of using sparklines for depicting a variety of information such as web usage, sport statistics (Fig 2.7, 2.8) and financial data. For sports, they are used in the following way:

> *"For the special case of binary or three-valued data, special bar graphs can be applied that use ticks extending up and down a horizontal baseline [Fig 2.7]. One use for this kind of data are wins and losses of sports teams where the history of a whole season can be presented using very little space…" (Aigner et. al., 2011, p.155).*

Figure 2.7: League table for top 5 leading teams in Bundesliga (Source: Visualization of Time-Oriented Data. Image: Aigner et. al.)

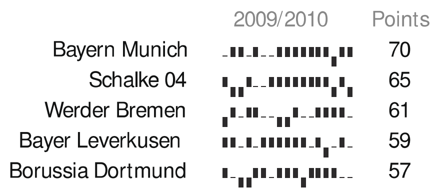


Figure 2.8: Premier League Table (Source: The Guardian. Image: The Guardian)

P	Team	GP	W	D	L	F	A	GD	Pts	Form
1	Man City	14	13	1	0	44	9	35	40	
2	Man Utd	14	10	2	2	32	8	24	32	
3	Chelsea	14	9	2	3	25	11	14	29	
4	Arsenal	14	9	1	4	28	16	12	28	
5	Liverpool	14	7	5	2	28	18	10	26	
6	Burnley	14	7	4	3	14	11	3	25	
7	Spurs	14	7	3	4	22	12	10	24	
8	Watford	14	6	3	5	24	25	-1	21	

2.4.1 Colour in Visualisation

Colour in visualisation is another subject that is worth mentioning. Colour blindness is one of the issues to be taken into account for the use of colour. Ware (2004) highlighted that a considerable portion of the human population are colour blind, with the majority of them having problems with identifying colours in the red-green spectrum. Ware (2004) added that nearly everyone can distinguish the colours in the yellow-blue scale, however, this would limit potential design solutions. Apart from this, Ware (2004) was not in favour of using gray-scale colours on visualisations as a method of displaying quantitative information due to the following factor, the contrast effect and stated that *"...differences are perceived as larger when samples are similar to the background color."* (Ware, 2004, p.90). In addition, Ware emphasised (2004) that the role of background lightness on the perception of grey scales show that the differences between light grays are more evident when the background is light and in the case of a dark background, the differences between dark greys are clearer.

Rheingans and Landreht (1995) focused on how visualisations in different colours are perceived and found out *"...warm colors (red, orange, yellow) appear larger than cool colors (blue, green)."* (Rheingans and Landreht, 1995, p.64). Moreover, they (Rheingans and Landreht, 1995) discovered that rectangles that possessed high saturation colour were perceived smaller than other rectangles that were coloured with low saturation. In addition, the researchers (Rheingans and Landreht, 1995, p.64) highlighted an early study that revealed *"...that the color of a region influences the perceived size of the region, and the effect is strongest for very saturated colors."* The study showed that red-coloured areas of land on a map were usually perceived larger than their original size and such bias happened less often for the areas that were coloured in green when both colours were highly saturated. However, such distortion in perception was not seen significantly when the colours had less saturation.

Benson (1982, p.9) suggested that *"[v]ivid, fully saturated, colors are expected to enhance selectivity."* Due to the same reason, Few (2006) approached the use of bright colours cautiously, and suggested that they should only be utilised for specific data that needed to appear distinctively from the rest. Few (2006) also urged that too bright and dark colours may not be the best for coding data since they cause the eyes to tire rapidly. Additionally, Few (2006) suggested that a non-pure white background should be used because a 100% white background may create a sharp contrast that must be avoided. Other than that, Few (2006) stressed on the relationship between colour and meaning, stating that the assigned colours to data elements have to be meaningful, because otherwise the readers waste their effort and attention to look for implications that did not exist.

So and Smith (2002) studied decision performance in multivariate decision making under the conditions of two different information complexities (low and high) and graphics (non-redundant colour coded and black-and-white). The study (So and Smith, 2002, p.584-585) found out the following:

> *"When information complexity [wa]s low, decision accuracy [wa]s significantly affected by the color coding [that] [u]sers ma[d]e significantly fewer errors with the color bar charts compared with the black-and-white bar charts…" (So and Smith, 2002, p.584-585)*

Moreover, So and Smith (2002) revealed that when the information complexity increased, there was no significant difference between color-coded bar charts and black-and-white bar charts with regards to decision performance. Furthermore, within their research, So and Smith (2002) discovered that, in general, colour in bar charts worked significantly better for women since they made less errors with colour-coded visualisations; however, colour had no effect on the performance of men in this regard.

Hoadley (1990) compared four different types of visualisation that were mono-coloured to their multi-coloured versions in terms of information extraction performance that was measured in time and accuracy. The results (Hoadley, 1990) demonstrated that multi-coloured pie charts, bar charts and tables outperformed their mono-coloured counterparts in terms of time, whereas there was no significant difference for both versions of line graphs in this aspect. In addition to this, Hoadley (1990) highlighted that multi-coloured pie charts and line graphs showed better accuracy compared to their mono-coloured equals. However, bar charts were not affected by such differences in this respect. It should be noted that in both cases, bar charts were recorded with high accuracy performance.

2.4.2 Sports Information Visualisation

Page and Vande Moere (2006, p.25) classified team sports visualisations in 3 categories as *"[a]thlete-centered"* that referred to players and coaching staff, *"[s]pectator-centered"* for the viewers and *"[j]udgment-centered"* for the supported the moderating officials e.g. referees regarding their game-related decisions. Page and Vande Moere (2006, p.26) also highlighted:

> "Either when team sports are in play or after they have concluded, the remote participant is *often interested in obtaining only a summary of the game which highlights key events. Activity history visualization of team sports has satisfied this need by providing a means to obtain necessary game information all-at-once." (Page and Vande Moere, 2006, p.26).*

Cox and Stasko (2006) proposed two different visualisations that allowed users to explore large amount of baseball statistics. The first visualisation was baseline bar display that represented performance of a specific team in all games during one season (Cox and Stasko, 2006). The performance attributes were displayed in vertical bars that were aligned horizontally and supported by colour coding (Cox and Stasko, 2006, p.1).

The study (Cox and Stasko, 2006, p.1) claimed that *"[t]he combination of visual attributes (particularly bar length and coloring) leverages preattentive processing to facilitate easy detection of trends or patterns over a season."* The second visualisation was a treemap visualisation for baseball player statistics (Cox and Stasko, 2006, p.2). They state *"[t]he player map display… provide[d] a way to quickly identify ineffective allocations of playing time [and] …an overview of the efficiency of playing time allocation."*. However, the user feedback was unknown against the proposed visualisations.

Page and Vande Moere (2007) experimented with a wearable display system, *TeamAwear*. It was electronically mounted on basketball jerseys to show game-related information during a basketball game. The study aimed to understand whether such augmentation would boost awareness; and therefore raise the level of understanding. The experiment received positive feedback from the audience who watched the game at the basketball court saying that the display system provided them with a more enjoyable experience of watching the match (Page and Vande Moere, 2007).

Perin et. al. (2014) proposed an alternative to the classical table display that only showed the rankings of football teams in league competitions. In their work, they created a design solution that revealed changes in the rankings. In addition, their design allowed users to interact with rankings data and to explore this visually. Their solution was significantly favoured by participants compared to classical tables (Perin et. al., 2014).

He and Zhu (2016) developed an interactive visualisation system for tennis match statistics for a general audience. In this work, match statistics were visualised in the combination of small multiples and time series (He and Zhu, 2016). Unfortunately, user feedback towards this visualisation system is not known.

Apart from the works mentioned above, there is a plethora of studies dedicated to information visualisation in various sports (Goldsberry, 2012; Legg et. al., 2012; Perin et. al., 2013; Pileggi et. al., 2012; Rusu et. al., 2010; Rusu et. al., 2011, Wang et. al., 2016). However, these studies were for a professional audience e.g. journalists, analysts, experts and coaching staff.

2.5 Interaction Gestures

Previous studies found out that people showed a great tendency to use tapping to perform the majority of tasks on mobile devices (Dou and Sundar, 2016; Wigdor and Wixon, 2011). Other early work explained the association of using tapping with to interact with on-screen buttons or similar interface elements (Hinrichs and Carpendale, 2011; Wörndl et. al., 2013). Apart from that, Werning (2015, p.65) defined swiping as a rather casual mode of interaction that is *"…dismissing the currently presented content and usually 'serves up' the next best option…"* within a relatively more specific set of data. Moreover, Werning (2015) emphasised on the practicality of swiping against accidental actions. Dou and Sundar (2016, p.25) drew on our attention to the addition of swiping on tap-only phones that *"…[it] can induce a feeling of enjoyment among [users], and… make them want to use the website again."*.

The use of gestures in distracting conditions was another field of research. In a study, swiping was compared to buttons and kinetic scrolling methods in the context of using an in-car music player (Lasch and Kujala, 2012). The researchers recommended swiping over the other two techniques in menu browsing tasks *"…due to lower levels of visual accuracy required for changing the pages…"* (Lasch and Kujala, 2012, p.47). In another paper by Angelini et. al. (2014) related to gestural interactions in in-car interfaces, it was revealed that the use of *swipe* and *tap* changed due to the type of command. The work (Angelini et. al., 2014) demonstrated that *"…[swipe] almost not* *used for the select/back commands, has been used often for next/previous commands, and much more appreciated for volume up/volume down commands…"* whilst tap was *"… appreciated for the select/back commands…"* and the rate of its use reduced (Angelini et. al., 2014, p.6). Furthermore, Negulescu et. al. (2012) was concerned with the comparison of move (as motion gesture), swipe and tap in the matter of the cognitive load that each method of interaction put on the user under the conditions of walking and eyes-free interaction (interacting with phone beneath desk). They found that each mode of interaction was not significantly different from each other in each scenario (Negulescu et. al., 2012).

2.5.1 Interaction on Second Screen

Some researchers investigated how interactions on second screen affect the watching experience. Chuang et. al. (2013) developed a second screen prototype that detected content that users were watching and automatically supported them with content-related extra information. They tested the prototype with a variety of genres. For sports, the prototype was instantly updating statistics of a match that was being watched. According to their evaluations, the participants particularly found the statistics feature and auto-update function useful (Chuang et. al., 2013).

There are more sports-specific work in terms of improving TV watching experience through interactions on second screen. First of all, Centieiro et. al. (2012) devised a prototype that encouraged match viewers to connect with the moments of applauses during the games through a certain mode of interaction on second screen; i.e. holding a mobile device on one hand and moving the device to the other hand as if clapping. Users were challenged to *clap* in synchronisation with the applauses in matches in order to be rewarded with points in their competition of *best support*. The prototype gave visual messages and vibrations in order to prompt users to clap. They found that participants felt more engaged with the games while having fun by competing with each other and trying to give the best support (Centieiro, 2012).

In another study, Centieiro et. al. (2013) focused on a betting system that signalled users to bet whether a goal was about to happen via an *eyes-free* way of interaction on second screen in order to enrich viewer experience of watching football matches on TV. In this case, users were notified by sound and vibrations on second screen and they could bet without looking at the second screen constantly through swiping from bottom and tapping once. With an eyes-free approach, the aim was decreasing any potential cognitive load due to users' need to switch their focus in between TV and second screen. The findings displayed that even though a third of all participants found the interaction method difficult, most of them felt positive regarding the betting feature in that it made them more connected to the matches (Centieiro, 2013).

Centieiro et. al. (2014) turned their attention towards a slightly different approach in their follow-up study compared with their earlier work. In this study, they presented users with a betting feature in an existing second screen application. With this betting feature, users could check match information and make a transition from the information page through swiping upwards in any time during the game in order to bet whether a goal is about to be scored. Similar to their first app in their preceding research, the app accommodated sound and vibration as betting notifications for the users. The outcome of this study showed more positives than negatives in that it increased user engagement to the match, *"…[p]articipants enjoyed using the… feature and felt very excited to correctly guess that a goal was about to happen."* (Centieiro, 2014, p.10).

Unlike their previous work Centieiro et. al. (2014) aimed to improve the watching experience on TV in a slightly different way. They let viewers share their thoughts and feelings with other people via TV screen by utilising a mobile device. They assumed adding user-generated content on the main screen could prevent people from failing to see key moments that they would not like to miss. The researchers found that the test subjects showed a great level of pleasure from using mobile devices to share emotions with other people through TV and seeing theirs input to it. According to their feedback from the majority of study volunteers, clicking the buttons on mobile devices to go through menus and send their reactions to the screen was an experience that they would like to use in real time (Centieiro, 2014).

2.6 Summary

- Origins of football fandom vary. Some people become fans because their families and other fans due to football related factors such as consecutive achievements of a football team. Off-the-pitch appeals such as physical attraction to players and beautifully designed merchandise of football clubs also create fandom. Additionally, fandom may arise from sectarian, ethnic, nationalist or political motives.

- Advanced communication technologies helped the spread of football culture from the leading footballing countries to everywhere in the world.

- The degree of fandom differs among individuals. Some fans devote themselves to football clubs while others may just see them as part of their weekend leisure due to their socio-economic background and status, personality and lifestyle.

- Fans practice their fandom in different ways. They can reflect their love in highly creative ways such as displaying humorous slogans. However, they may also become violent, causing fights and even deaths.

- Football is a business sector that generates huge sums of money from broadcasting rights, player transfers, match & season tickets. Stadiums are renovated or rebuilt in order to increase revenues by offering fans more than just the opportunity of spectating matches, such as catering, merchandising and entertainment. As a result, the profile of supporters at the stadiums has changed from traditional low-income working class to rich upper class citizens.

- Exclusion of low-income pfans from stadiums and pay-TV caused the emergence of other means of watching football matches. Public places such as local pubs, cafes and other places become convenient alternatives since they are cheaper to watch and more convenient to travel. Furthermore, those public places offer fans alternatives for stadium atmosphere and socialisation. Apart from this, pirate online streams provide people free access to watch matches on TV.

- Watching a football match on TV is different than watching it in a stadium. It is a filtered, mediated experience because what viewers watch and hear is determined by the director and broadcaster. In this regard, football fans experience within the restraints of broadcasting. More than that, match commentators and pundits may affect the ideas of the audience with their comments during matches.

- Technological developments have changed experiences of sports and spectating sports.

- The Internet has changed the pattern of fans' information consumption in a way that they seem to break their dependency on traditional print (newspapers) and analogue (TV and radio) media and turn their collective experience into many personalised ones is an increasing trend. Developments in mobile technologies, smartphones and tablets, have complicated habits of information consumption in a way that fans increasingly have access to content in *anytime anywhere* basis.

- Football fans use new media for the following purposes: Content access, content dissemination, discussion, socialisation and fun.

- The amount and variety of information on new media which fans have access to is quite large compared to what traditional media offer them. Also, the quality of content on new media is more varied.

- Though TVs have become more equipped with interactive features, they are not the best devices for viewer interaction with TV-related content. This is often exacerbated by frustrating remote controls and distracting user interface on the screen. However, *second screen* enhances the TV watching experience because of richer and more rapid interaction opportunities.

- People use second screen to access supplementary information, share their views and converse with others regarding the TV content. They even use second screen reproduce the TV-related content. Such activities are based on the following needs: information, emotion, credibility, status, socialisation, relaxation and entertainment.

- Generally, users tend to switch their attention from TV to second screen for only a very short fraction of time. Second screen usage increases in breaks on TV content. Second screen usage related to TV programs is more frequent when the programs are being broadcasted compared to when they are not.

- Second screen users have a different behavioural characteristics. Some users are inclined to chat more on TV content via second screen, some are more interested in accessing additional information. Sometimes they use second screen to avoid the content on TV. Other times, they use it to supplement the TV content.

- Second screen increases cognitive load and this makes recalling content of TV more difficult.

- Sport fans increasingly use second screen and mostly during various breaks in the sports events. The nature of play also affects their second screen usage. They use second screen to access additional information related to the sports events and communicate with other viewers in different locations. They share their emotions, exchange jokes with rivals, and feel a sense of community through second screen.

- In 2014 FIFA World Cup, football audiences used the social media platform, *Twitter*, more when the matches were being played compared to the times when the matches were not. Their posts were more match-related when the matches were on. They also preferred quicker interaction on Twitter when the matches were happening.

- Bar charts seemed to be better than pie charts in comparing values. However, they seemed to be equally good in the perception of right proportions in the whole. Tables seemed to be better than bar charts and pie charts in terms of remembering the information accurately. They also seemed to work better compared to bar charts and line charts for interactive visualisation on tablets. Visually embellished bar charts seemed to be better than minimalist bar charts in terms of interpreting accuracy, short and long-term recalling and reader preferences.

- Grey scale colours in visualisations seem to be problematic due to lack of contrast. Colours in the yellow-blue scale can be perceived by almost everyone but this limits design considerations. Different background colour and colour saturations can alter how we perceive visualisations. Colours need to be meaningful on visualisations to clearly convey the message to the reader. The speed of understanding seems to be faster through a variety of multi-coloured visualisations compared to their mono-coloured counterparts.

- In low complexity information, coloured bar charts helped people make less errors in decision making compared to black and white bar charts. Such difference does not exist when the information becomes more complex. Colour in bar charts seemed to work better for women in terms of making less errors. For men, there was no such effect.

- Earlier work on sports information visualisation was mainly targeted at experts and general audience. The proposed visualisations seemed to enhance the level of experts' analysis and watching experience of an audience.

- Tapping seems to be the most popular and familiar interaction gesture whilst swiping seems to be a casual, less-accident prone and fun alternative for tapping in specific contexts such as when there is less need for the eye to focus on the screen and the need to pass through different data dimensions.

- Different gestures seem to put similar levels of cognitive load on users; however their usage seems to keep being task-oriented regardless of the circumstances.

3 Match-Related Information Seeking Behaviour & Mobile Football Apps and Websites

In the previous chapter, the literature review demonstrated that the earlier work does not inform us much with regard to how, why and when TV football audiences interact with their second screens during the act of watching football matches on TV. Moreover, the research shows little evidence regarding how second screen interaction affects experiences of football match viewers in detail. In addition, the expectations of football audience in this regard were not known. On top of that, it is uncertain what types of match-related information they seek during their watching activity. Therefore, the first part of this chapter is dedicated to the results of an online survey (Appendix 1) with seventy participants from different countries around the world and individual interviews (Appendix 2) with twelve people from Lancaster University and various cities from UK to show details as to how, when, why and how often people seek match-related information during their watching experience of football matches on TV. It is crucial to analyse the findings that reveal their motivations and patterns of information seeking behaviour whilst they were watching football matches on TV since any attempt to enhance such experience requires a broad understanding of this context. Furthermore, the first part of the thesis aims to shed light on the expectations of people regarding their ideal experience of match-related information seeking activity on additional media.

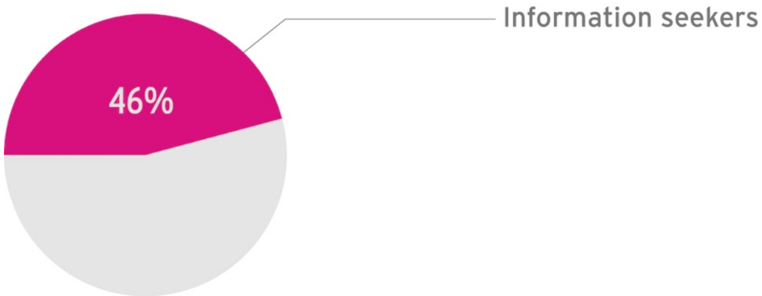
In the second part of this chapter, several mobile football apps and websites are reviewed. They are reviewed because they could be used for second screening although they were not built solely for such purpose. Secondly, they are one of the most important sources of information (Figure 3.6). The reviews are made with a focus on the type of visualisations that depict a certain type of match-related information. In addition to this, interaction gestures that are used to access the certain type of match-related information on those apps and websites are also considered. It should be noted that the decision of focus on the certain type of match-related information was based on the results of the online survey that revealed the frequency of accessing different types of match-related information.

3.1 Analysis of Match-Related Information Seeking Behaviour

3.1.1 Popularity of Seeking Match-Related Information on Additional Medium

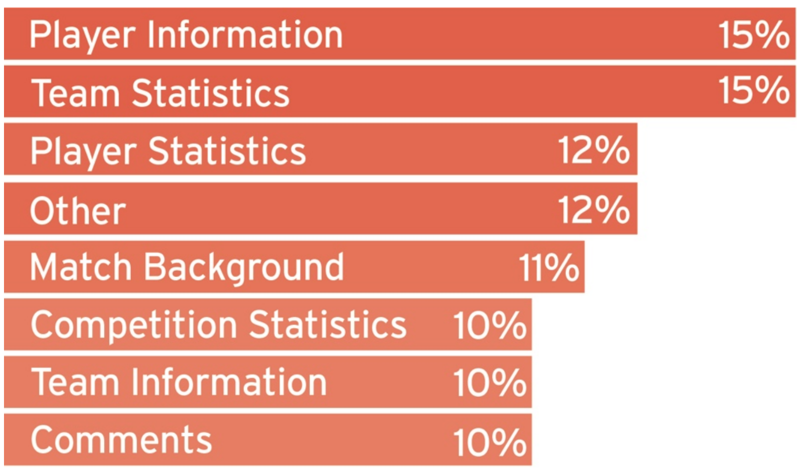
The frequency of replies (Fig 3.1) that favoured the use of an additional medium to retrieve information about matches viewed on TV unveiled a close figure (46%) to that seen in the work of Gantz et. al. (2012, p.71) who showed that around 50% of the American audience for soccer and American football declared that they utilised additional media in the form of second screen. However, the survey does not fully confirm (Fig 3.1) Mander's (2014) findings that depict almost 2/3 of football fans used additional media while watching the matches of FIFA 2014 World Cup on TV. The reasons could the following: First, Mander's study did not limit the role of extra medium to information seeking but included other aspects of it such as chatting with other people who watch the matches and generating content regarding the viewed matches. Secondly, such a popular event might have urged people to seek more information relevant to the matches due to its importance as it is well known that major sporting events such as World Cup and Olympics attract more viewers (Whannel, 2009, p.210); therefore, people who do not regularly follow football matches throughout the football season might have needed more information relating to the players and teams.

Figure 3.1: The ratio of participants who seek match-related information.



3.1.2 Types of Match-Related Information

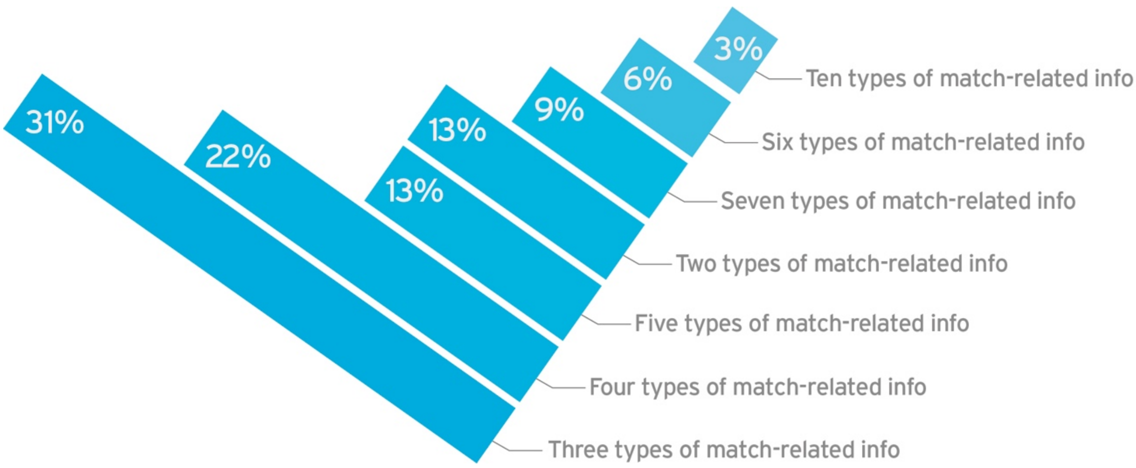
Figure 3.2: The distribution of sought types of match-related information.



The results (Fig 3.2) immediately reveal that the distribution of the preferred of types of match-related information does not inform us regarding any dominance of a particular type of information over the others. Another point of interest could be the popularity of in-game statistics as the combined player and team statistics cover a bit more than 1/3 of the whole set of various types.

It is worth to noting that none of participants who seek match-related information on an extra medium limit themselves with only one type of match-related information. In more detail, it should be highlighted that 28 of 32 (87.5%) declare that they look at 3 to 10 different types of content-linked information. The popularity of multiple types of information (Fig 3.3) along with the distribution in the variety of types (Fig 3.2) can be explained with the *bouncer* or *flicker* nature of today's digital consumer that was pointed out by Nicholas et. al. (2003, p.26).

Figure 3.3: The distribution of people and how many types of match-related information they sought.

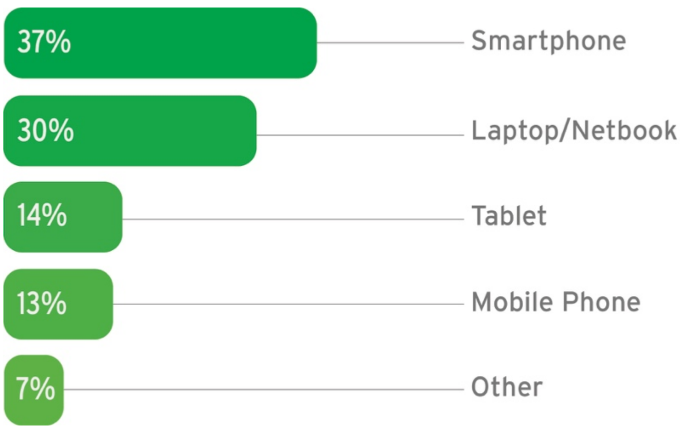


After looking at individuals' choices in more detail, it can be observed that all statistical match-related information composes a significant portion of the entire group of participants as 26 out of 32 people (81.25%) declared at least one type of statistics. Also, 90% (29) of those seeking information on additional media appear to have an inclination for at least one type of team-related information. Furthermore, 43% (14) of 32 participants declare *online comments of other people* as a type of match-related information that they look for on their additional media.

Overall, the need for statistical information and other people's opinions seem to be the popular choices for people who seek match-related information, and the former appears more often than the latter among the surveyed. The reason for such a difference could be correlated with the amount of time that is required away from the TV to focus on the companion medium to read and absorb the supplementary information; that is, reading a line of comment might take more effort and time compared to glancing down on a screen to check statistics.

3.1.3 Types of Additional Medium for Seeking Match-Related Information

Figure 3.4: The distribution of the types of additional media.

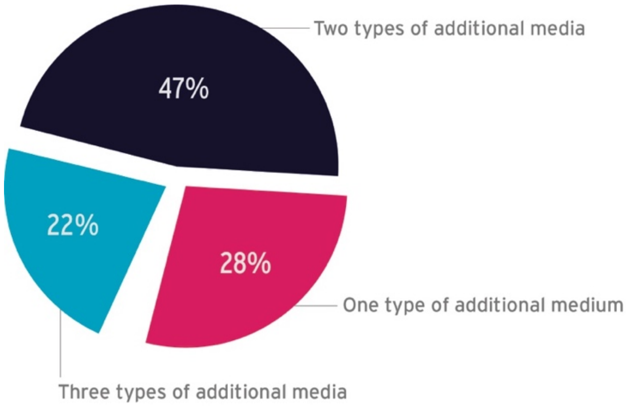


None of the survey responders appears to use a desktop computer as an additional medium for seeking match-related information (Fig 3.4). This could be highly related to the fact that many people may not prefer to have desktop computer in their living room. More than that, desktop computers do not offer the same level of comfort and mobility as smartphones and tablets do.

The number of selections for tablet use is considerably lower than smartphones and laptops. When this survey was made, it was reported by research carried out by *BusinessInsider* (Heggestuen, 2013), that the global level of tablet ownership was significantly lower than that for smartphones; therefore, such difference in figures in the test is not surprising. However, the same report highlights that *"…tablets show faster adoption rates than smartphones…"*; hence, at the present time and for the near future, the percentage of tablet usage as an additional medium in this context may change.

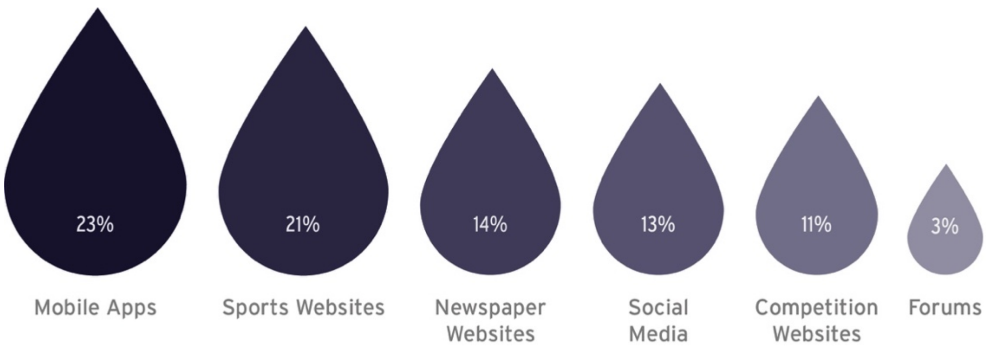
In addition to the findings (Fig 3.5), it was observed that 7 of 9 second screen users who preferred to use only one additional medium were smartphone users when the participants' choices were analysed on an individual basis. This finding, along with the leading figure of smartphone usage in this watching experience (Fig 3.4), could be reasoned as the supreme portability of smartphones that give them the edge over their rivals such as tablets and laptops in terms of comfort and ease of use. Additionally, it needs to be noted that, almost half of the respondents declared that they use two types of extra media for seeking information. One of the reasons why such a result was seen could be related to the relatively stronger than average purchasing power of the group over the world average since the majority of the volunteers were from first world countries. Another reason might be the known fact that people no longer use TV screens as their only medium to watch television programmes; hence, they might use two mobile devices in a way that one acts as the main screen to watch content and the other as a second to access supplementary information regarding the content. Furthermore, for people who use a number of additional media, it is uncertain when they prefer to use a particular device over another, for a specific purpose.

Figure 3.5: The distribution of the number of additional media that are used to seek match-related information.



3.1.4 Source of Match-Related Information

Figure 3.6: The distribution of the sources of match-related information.



One of the expected findings is the popularity of sport portals/websites among the survey respondents. Moreover, the popularity of mobile apps, which turned out to be the most popular source of information, can be correlated with the popularity of smartphones, that was highlighted in the previous subsection. On top of that, when the reported tablet usage is considered, such result is not surprising at all.

The low score in forum usage is an interesting outcome in that it appeared as the second least favoured source. There might be a few reasons for this: First of all, the layouts of many forums were designed before the emergence of smartphones; therefore, due to legibility issues related to screen size that required the extra effort of zooming in-out and scrolling, users might not have found them convenient for such activity that requires quick information retrieval. Secondly, the crowded structure of forums and their login requirements might have caused users to spend too much time accessing and navigating relevant match-related information and the aforementioned layout of them might exacerbate this difficulty. Finally, it is known that forums usually address people who feel stronger bonds to particular teams; hence, there could be a possibility that the majority of people who volunteered for the online survey were not dedicated fans but just occasionally watched football matches on TV and might not have been in the habit of checking forums for this purpose.

Figure 3.7: The distribution of the number of different types of information sources people preferred.

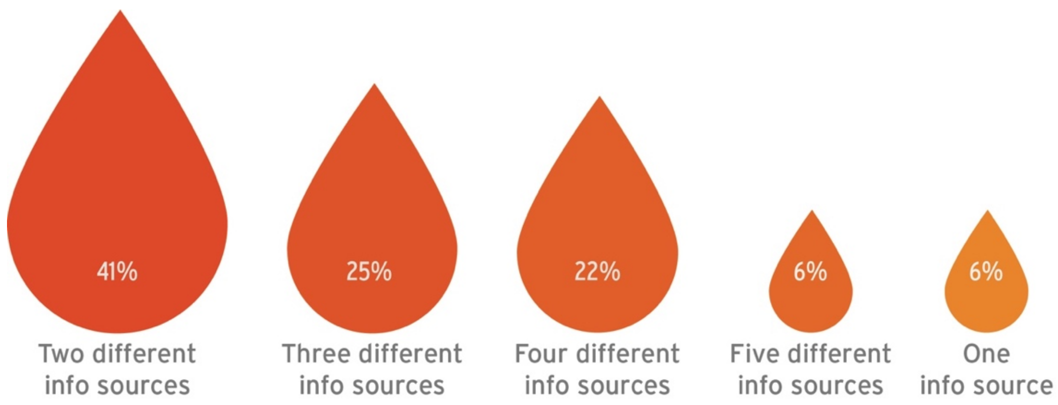


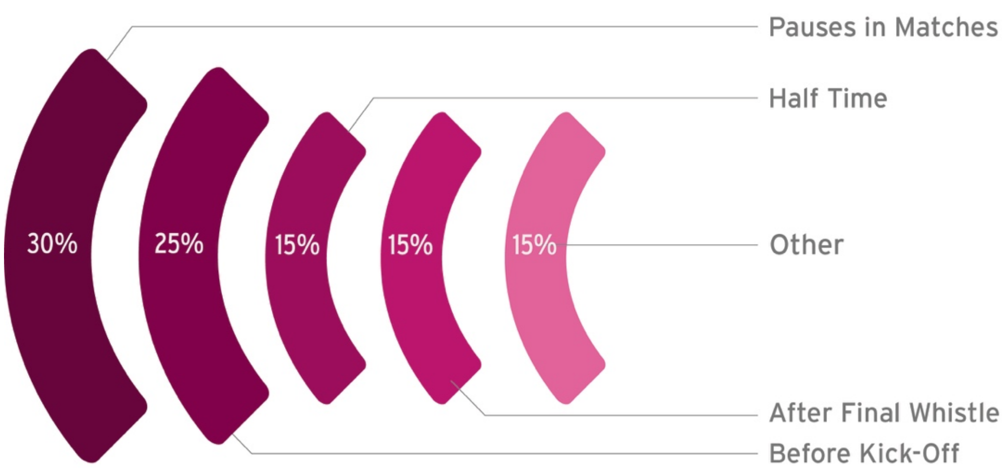
Figure 3.7 shows that 65% of the participants who sought information on additional media used 2 or 3 different sources of match-related information and a further almost 30% of them declared to check more; that is, people who just resort to one type of source are substantially low. This could be understood due to the fact that the different sources of information provide different types of data; for instance, personal details of an unknown player can be read off a general website such as *Wikipedia* whereas in-game statistics of a particular football match may require a quick glance on a mobile app. Apart from that, the percentage peaks for those accessing two types of information (Fig 3.7) and drops as the number of information source types increases. It could be explained through the fact people do not want to pay too much attention to the

additional media and for this reason they are not keen on looking at different sources whilst watching the matches on TV. Furthermore, it should be noted that all participants, except 1, declared that they use websites as their information source.

During the follow-up interviews, that were held separately from the survey, BBC and Twitter were underlined as sources for match-related information by all interviewees though they were not asked about such specificity. The BBC's appearance is not surprising since a remarkable number of participants were from UK and along with the Corporation's reputation, such level of reliance is expected. The reason for the use of *Twitter*, perhaps, could lie within one participant's preference as she said: *"I like the 160 characters… I like the short, pithy comments."* Along with its nature of briefness, Twitter can accommodate almost every variety of match-related information; therefore, it becomes a highly-rated source in such context.

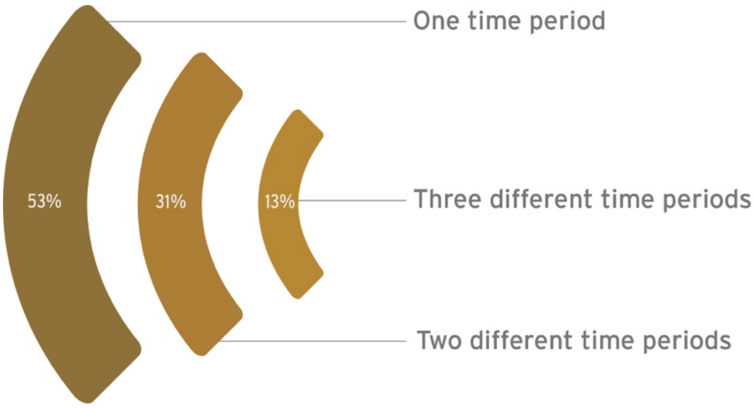
3.1.5 Time of Seeking Match-Related Information

Figure 3.8: The distribution of time periods for information seeking.



The survey suggests that people tended to look for additional match-related information more when the game play that they watch on TV stops due to any reason since 16 people of 32 (%50) declared this (Fig 3.8). The reason why the frequency percentage of aforementioned *time period* is lower than the percentage of people favouring it is because selections made in this respect by nine participants revealed that they were in search of information at other times, too (Fig 3.9).

Figure 3.9: The distribution of the number of different time periods that people seek match-related information.



During one-to-one interviews, five participants elaborated on the moments of pause that allowed them to retrieve match-related information on extra media:

> *"…Whenever the ball's go out for throw-in or someone's, you'll start sort of catching or updating… low points within the game where someone's down injured and commentator's just talking nonsense…"*

> *"…If there is an injury or there is a pause or there is a sloppy play, you might switch…"*

> *"…Especially when there is like a free-kick that is taking too long or a goal-kick or an injury…"*

> *"…Usually when there has been a break in play…"*

> *"I guess if somebody's injured and there is a spell where the game is paused then I might sort of go through…"*

Among the comments received from the interviewees, it is worth noting the factor of boredom. Boredom could be described as a moment of *pause* even while the match is playing due to several reasons, such as low speed of gameplay or a commentator's lack of drawing audience interest and therefore reduces the level of engagement to the main screen. As a result, it causes diversion of people's focus to additional media with the hope of finding something more interesting in content-wise.

The obvious reason why usage of additional media occurred mostly in in-match pauses compared to other moments should be linked with the fact that content on additional media, even if it is related to TV content, can be distracting during gameplay since it may increase the cognitive load. Connected to this, one of the earlier studies highlighted in the second chapter (Gantz et. al., 2006, p.110) remarked that sports audiences hate to be distracted when they watch matches on TV: *"[S]ports fans [have] keen interest in the action on the screen. [They] were likely to… tell people to be quiet."* Three interviewees confirmed that distraction could be an issue:

> *"…I don't want to interrupt the view of the game just in case something happens while I'm sort of checking…"*

> *"…If the game is exciting, you forget about that…"*

> *"…only as long as it's a quick check - I'd still want to be watching a game most of all rather than being overwhelmed with statistics..."*

Accessing game relevant information just before the kick-off seemed to be another noteworthy period of time for people; it is a favoured time span for thirteen survey volunteers (40%). A particular type of behaviour highlighted by three participants was that they check teams just before the kick-off:

> *"If I want to check the players, I just [do] before the starting the game…"*

> *"Team line-ups at the start of the match if missed on-screen…"*

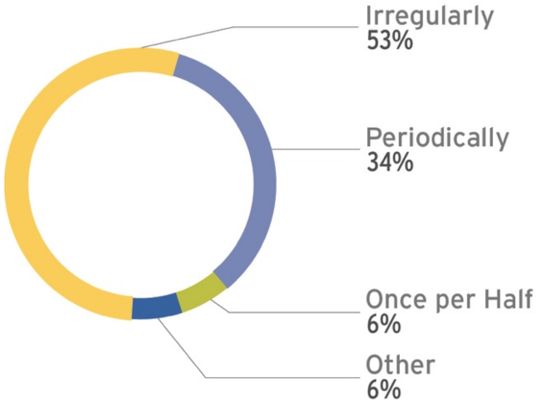
> *"At the beginning… Who's playing, who's on the bench…"*

The number of preferred time periods (Fig 3.9) shows that the majority of the participants (53%) sought match-related information on one particular period of time, such as before *kick-off* or *when the game pauses for any reason*. On top of that, significantly, almost all of them had preferred a period of time when the gameplay is disrupted with a pause or totally off. Only two of them declared that their only preferred time of checking information was when the game was played. Furthermore, among thirty-two people, twenty-five of them, regardless of the number of different preferred time periods they preferred, chose a single non-active gameplay moment or combinations of any type of such moments, such as *just before the game and after the final whistle* as their preferred time period of checking match-related information.

3.1.6 Frequency of Seeking Match-Related Information

One of the findings (Fig 3.10) that shows more than half of the information-seeker-on-additional-media participants' frequency of realising such activity aligns with the most frequent time period that is mentioned in the previous section of this chapter: *When the game pauses for any reason*. Additionally, since the timing of pauses in the game and the lengths of them occur randomly, it is no surprising to see *irregularity* as a prominent status of frequency in this regard. Moreover, another reason could be boredom in the game that could lead viewers to interact with an extra device to seek information. Football is a type of sport that accommodates dull moments as well as exciting instances for the viewer in an unsystematic manner; therefore, it cannot be easily predicted when viewers could seek match-related information in definite frequencies.

Figure 3.10: The distribution of frequency of seeking match-related information on additional media.



3.1.7 Reasons of Seeking Match-Related Information

The findings for this subsection in this chapter is based on the individual semi-structured interviews that were conducted with 12 people. Some reasons were highlighted more frequently than others by interviewees why they looked for match-related information. One of them was their curiosity regarding whether their own views towards players, teams and matches possessed similarities and/or differences with the opinions of other people for the same context:

> *"…I worry about what people think about the situation…"*

> *"…I like to see the view of other people regarding to situations in the game… I want to know, are other people seeing at the same way I am or is everyone disagreeing with me…"*

> *"…You wanna share your views with other to see if they resonate and see what other people thinking..."*

> *"…to compare my opinions on the game/specific incidents to that of certain journalists/bloggers."*

Apart from comparing views, improving any sort of knowledge and understanding of the game that was being watched appeared to be another important incentive for people to seek match-related information:

> *"…Reinforce the perceptions of the game…"*

"…[J]ust [to] have more understanding of what's actually going on…"

"…it is also good to see how the game is panning out…"

3.1.8 Reasons of Seeking Match-Related Information on Second Screen

Similar to the previous section, the reasons for seeking information on second screen that are mentioned in this subsection are derived from the aforementioned one-to-one interviews. People who were interviewed were clear about their preference of utilising second screen for seeking match-related information to limit the factors of potential disturbance of watching the matches on TV:

"…I don't switch my tabs on my sort-of-tablet to start looking at something else and I miss a goal cause often can happen… Switch over for minute and suddenly he scored or things like that. I think you want to be able to see the game whilst also keeping up to date…"

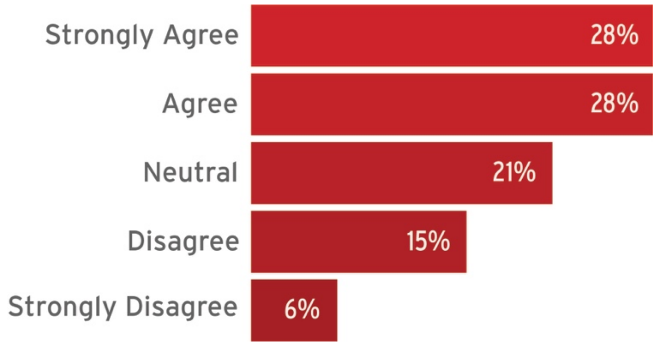
"…Twitter on my telly… would disturb my viewing."

"…On my cellphone I can still pay more attention to the match… if I divide the screen in two, sometimes at least for me it is a bit easier for me to get distracted… The time it takes for me to look from the screen to my cellphone screen it's, you know, very little so it sort of reduces the time so I can pay attention to both things…"

"…I use an additional medium because it's the most efficient (or the only) way of accessing the information I want without missing any of the match..."

3.1.9 The Effect of Seeking Match-Related Information on Second Screen on the Watching Experience

Figure 3.11: The distribution of people who stated their level of agreement or disagreement about whether seeking match-related information on second screen enhanced their watching experience.



The number of people who agreed that their act of seeking match-related information improved their watching experience compose a significant segment among the whole sample of information seekers imply that the positives of this action exceeds the negatives. It would not be wrong to assume that the pros and cons of the behaviour neutralised each other for those who seemed to be indifferent as to whether this act enriched their watching experience.

Although, unlike above, no rating system was used for interviews when people were asked whether they thought obtaining additional, not the type they received from the live TV broadcast, match-related information enhanced their experience of watching a football match on TV. Only one person out of twelve disagreed with the statement. The results of both studies evidently showed that the number of people providing positive feedback in this regard are reasonably larger than the ones who oppose the contribution factor of this sort of behaviour on their TV experience.

Interviewees and survey participants declared different ideas regarding how seeking match-related information on second screen improved their TV football match watching experience. First of all, according to some, the contribution of the aforementioned second screen activity was the increase in perception of the game in various aspects. For instance, a few people made comments about how such activity helped them to see the performance of individuals:

"…some of my friends make comments saying 'Oh, Gerrard's being awful today' and then you go, well actually, he's giving the ball away once out of seventy passes, things like that so it's good to see how he's performing individually well actually he might not look he's doing anything but he's just being in the right place. He's not giving the ball away. He's starting sort of movements, things like that…"

"…you think a player's having a bad game… and it is interesting to look at the statistics of that player in real time and see if… It is interesting to see how the statistics line up with your qualitative assessment…"

"…I feel it helps you see the impact of players during a game and in turn helps to allow you to judge their performance."

"…I like to sure on how a player performs, you notice more live at a match and so looking at stats help you fill the gaps…"

"…for example, I thought Mikel Arteta was having a bad game it would be interesting to look up his pass completion percentage and compare it to his season average."

Moreover, some others pointed out that they received a better overall perspective regarding the games:

"…I just have more understanding of what's actually going on…"

"It helps me understand the current match better…"

"It helps me get a more complete view of the match."

"…helping create a better perspective…"

"By attempting to establish some form of knowledge of the game, I attempt to reduce the risk in trying to understand whatever mechanics I can if I bet (money or otherwise)."

"…it allows for a more in-depth view on the game…"

"…I do appreciate how they can tell a story behind certain events…It helps understand the events or before the events take place it helps you imagine what might unfold..."

Furthermore, there were opinions voiced by a number of participants on how second screen helped them to socialise and simulate social environment as well as brought them some fun:

> *"…If you check Twitter, it's like you see the match with your friends or with some well-known person. So the joy of that is important for me…"*

> *"…I like the social interaction and viewing the different way people reacting responding to certain instances and the sort of thing that carries over into football…"*

> *"…You can replicate some of the experience of watching it in the stadium or watching it in the pub…"*

> *"…Social lubricant… If somebody makes a really funny comment on Twitter, that'd be something really would make it funny, something to laugh about you know…"*

> *"Yes, it does because I'm frequently amused by what people say."*

> *"…More information …can open discussion with friends while watching."*

> *"…Actually, I seek …comments just for fun..."*

3.1.10 Ideal Second Screen Experience

The analysis of this part is solely based on interview data. First of all, 3 participants expressed their belief that having a football-oriented social media feed would make their ideal second screen experience:

> *"…Maybe it can bring some live tweets about the game as well. I wouldn't want to see all tweets about that game. I would want to use it for example if some commentator, well-known, acclaimed person to see what he's saying about the game or I don't know maybe some football players who are playing in another team…"*

"…With Twitter you get everything about everything… A Liverpool game, rather than having to look at hashtags for Liverpool, just having all in one area… Make it more tailored to more specific areas you look at…"

"…Something like Twitter but it's dedicated entirely to football and not all the other rubbish you get… Twitter for football…"

Some volunteers showed their interest in various type of in-game statistics as part of their ideal second screen experience:

"…Statistics are very dull… If you drill down on what to see how players are doing, you get the masses of data. It'd be nice if you could visualise that kind of data in a meaningful way…"

"…additional statistics…"

"…the features should be in some way related more to player stats..."

"…basic stats, instantaneous player rankings…"

Few participants declared that they would favour all-in-one apps that have combined types of match-related information:

"…Something that pulls together different types of resources…"

"…It will be interesting to find an app combined sources in intelligent ways…"

"…updates from other matches, table positions, next matches coming… I can see a lot of features…"

"…I've nothing against the principle of an all-in one app…"

"…I think if I was going to use an app it would have to be very user friendly and also bring a lot of different things together to something that is really unique..."

Some respondents already seemed to be satisfied with their existing second screen experience:

"…Twitter is my ideal app, hashtags for a game."

"…I find the commentary on the Guardian website fine for what I needed for. It is easy just kind of scroll to the bottom and see the team and you can see who's fairly easily when substitutions are being made and things like that…"

"…There is enough information on reputable sources for me not to be seeking anymore…"

3.1.11 Summary of Online Survey and Interview Findings

- Additional media (second screen) usage to seek match-related information as part of the watching experience of football matches on TV seemed to be at a considerable level since almost half of the participants declared such usage.

- Participants seemed to prefer to seek a variety of match-related information. Based on the survey results, it cannot be claimed that a single type of match-related information dominated the participant preference. Having said that, statistical match-related information was one of the prominent types of match-related information sought.

- Most participants declared that they looked for more than one type of match-related information.

- Smartphones seemed to be the most used additional media to seek match-related information when football matches are watched on TV.

- Mobile apps and sports websites appeared to be the most used resources on additional media to seek match-related information whilst watching football matches on TV.

- People seemed to look for match-related information on additional media mostly when the gameplay was paused. In addition, in terms of frequency of accessing match-related information via additional media, most people did not seem to have any regular pattern.

- Most seen reasons for seeking match-related information through additional media seemed to be the curiosity of comparing own opinions with others as well as improving knowledge related to the match that was watched and understanding it. The reason why they used second screen seemed to be related to their feeling towards second screen's least distracting nature.

- Most of the people who declared that they used second screen to seek match-related information agreed that it enhanced their watching experience. Reception of overall view of the matches and enhanced perception for viewers regarding players' and teams' performance as well as simulation of social environment for viewers seemed to be the ways second screen enhanced their watching experience.

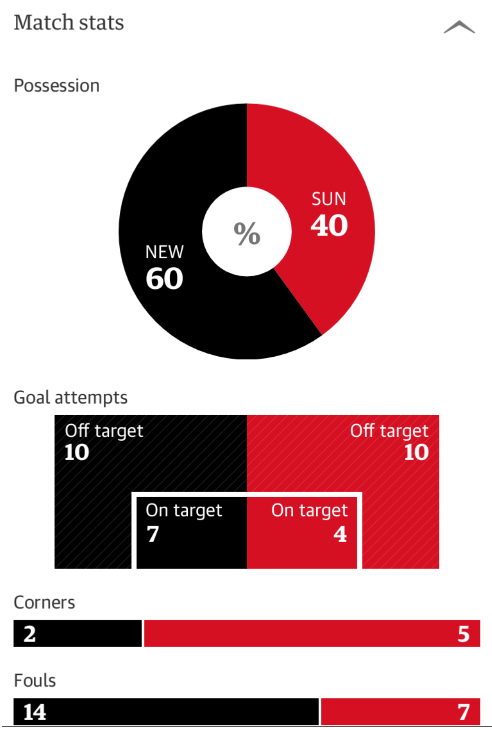
- Expectations from second screen varied. Some participants described their ideal second screen experience was obtaining full of in-game statistics while some others wanted football/match-oriented social media feed. Although, some wanted both.

3.2 Review of Mobile Football Apps and Websites

There is a plethora of football applications on the web that can address different needs of people who like football. For instance, some apps have geolocation services that can help people to find the nearest pubs to watch a live football match while others provide news related to teams, players and competitions. People may use them when they watch football matches on TV. According to the survey results, team statistics seemed to be one of the most prominent type of match-related information looked at by a football audience. The following examples are interface screenshots of different web-based and mobile football apps that display comparative team (match) statistics.

3.2.1 The Guardian

Figure 3.12: The Guardian's display of statistics from match played between Newcastle and Sunderland, 20 March 2016.



The Guardian's display of match statistics (Fig 3.12) is accessible through their website and mobile app via a few taps and scrolls. Moreover, the match statistics layout and the interaction gestures that are used to reach the match statistics screen are identical for both the mobile app and website. Although there are issues regarding the proportionate sizing of visual elements that represent the numerical values and text alignment, and the indifferent sizing between the black bar that represents Newcastle's on-target attempts and its red counterpart that illustrates Sunderland's on-target attempts, the general layout seems to be easy to read and allow the reader to differentiate between the sides.

The interface accommodates three different visualisations. First type is a *pie chart* that shows the ball possession percentages of each team. The second type is a visualisation that seems to be an adaptation of the simplest form of a *treemap* visualisation, that is used to depict hierarchical information (Johnson and Shneiderman, 1991). The adaptation seems to be the following: Unlike how a typical treemap visualisation depicts different types of information that were in the same hierarchical position (Johnson and Shneiderman, 1991), in the Guardian's visualisation, the rectangular shapes that depict *off target* and *on target goal attempts* are designed as if *on target goal attempts* is the subset of *off target goal attempts*. However, should the whole block of both black and red rectangular shapes are examined carefully, the white area that separate the *off target* and *on target goal attempts* delivers a *goal post view* that explains the positioning of the on target and off target attempts and as such look that on target goal attempts as the subset of off target attempts. There might be two issues regarding this sort of visualisation. First, such design might risk misdirecting the reader to perceive the large rectangle as *the total goal attempts.* Second it might not be easy to recognise the hidden goal post view to grasp the on target and off target visualisation at the first sight.

The last form of visualisation is bar charts that inform the reader regarding other in-game statistics such as corners and fouls. Alongside this, the visualisations carry each team's dominant colours, black for Newcastle and red for Sunderland in order to enable readers to differentiate between the information that is associated with teams and their shares of the aggregate statistics.

3.2.2 BBC Sport

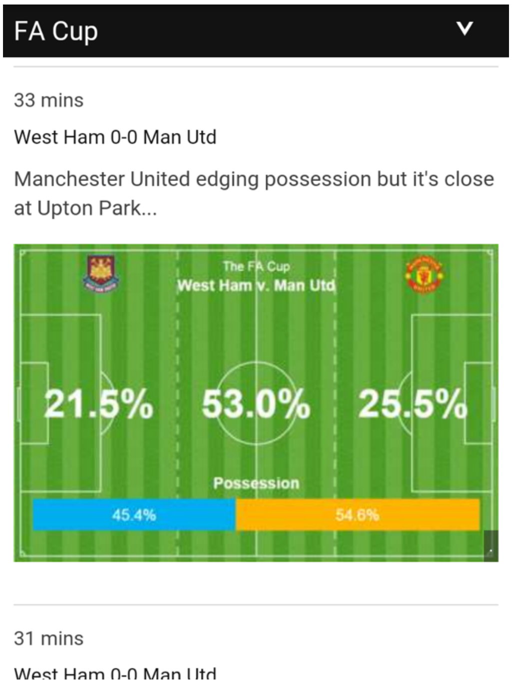
Figure 3.13: BBC Sport Website's display of match statistics for the match between Newcastle and Sunderland, 20 March 2016.

Similar to *The Guardian*'s interface, the display of statistics for a certain match (Fig 3.13) on *BBC Sport* is accessible with few taps and scrolls. The layout seems to be easy to read and the size of different coloured areas in the visualisations seem to reflect amounts proportionately.

Unlike *The Guardian*'s interface, the layout has only one type of visualisation: Bar charts. Similar to *The Guardian*, the numbers are located on the left and right edges of bars. However, the colours that represent the sides are not the colours that clubs identify themselves with; hence, the BBC needed to put labels at the top to identify the colours that differentiate statistics for each club. Apart from this, *BBC Sport*'s mobile app's interface that displays statistics for a match looks identical to the web app as well as the use of tapping and scrolling for interaction.

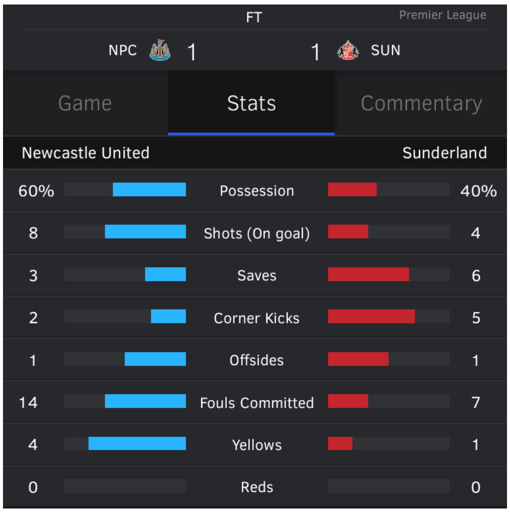
BBC Sport uses a different type of visualisation (Fig 3.14). The percentages are visualised with numbers on a rectangle that is a depicted as a football pitch where each percentage shows how much in-game action has taken place up to the minute in specific sections of the pitch. In addition, although the ball possession percentages were visualised in numbers with bar charts, the colours used in this depiction are not compatible with the green background. Plus, they do not represent the exact colours of both sides.

Figure 3.14: Display of percentages of action areas on the pitch for a cup clash between West Ham United and Manchester United, 13 April 2016 on BBC Sport.



3.2.3 Yahoo Sports

Figure 3.15: The distribution of in-game statistics for each team on Yahoo Sports' website for the match between Newcastle and Sunderland, 20 March 2016.

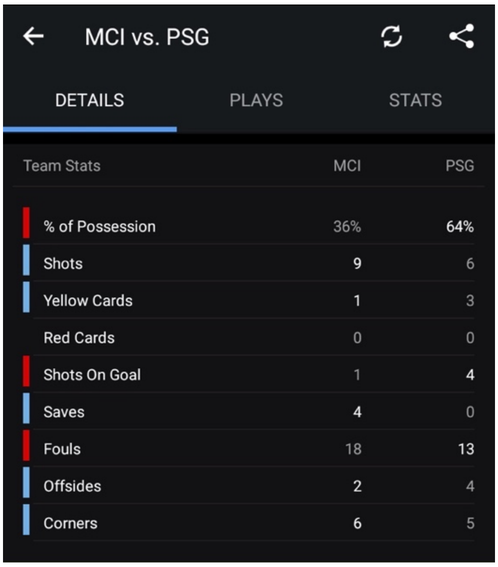


People need to apply taps to reach the layout of *Yahoo Sports* match statistics interface (Fig 3.15) on their mobile devices. Unlike the previous two examples, the information and related visual elements sit on a dark background. Dark backgrounds are usually good for the reader when the lighting levels in the reading environment is low e.g. night (Rempel et. al., 2011). Therefore, it is questionable whether this choice for the background is the best since according to a couple of previous studies (Hall and Hanna, 2004; Buchner and Baumgartner, 2007) dark text on a light background gives better readability. On top of that as Ware (2013, p.43) emphasised that due to *"…[c]hromostereopsis[,] [f]or most people, red seems nearer than blue on a black background… but some see the opposite effect."*. Apart from this, the interface provides a match score that is different than *The Guardian* and *BBC Sport*. The app has a clear look and it is easy to differentiate between both sides thanks to club-associated colours that helps the separation of statistics for each team.

Yahoo Sports chose to use only bar charts as their visual aid when it comes to depicting numerical values. The length of bar, like the 1st and 2nd website, is defined in relative proportions of each side's values in the same category of statistic. Unlike *BBC Sport* and *The Guardian*, the numbers are not placed on the bars but put nearby to them. The website has an attempt to colour the bars relevant to club colours; however, it only worked well for Sunderland but failed with Newcastle because Newcastle's black is not legible on a dark background.

Although there is no change in interaction style in order to reach the statistics; that is, a few taps on the screen lead the user to statistics, the mobile app of Yahoo Sports has a different style of visualising statistics though it preserves the colour scheme of the web version (Fig 3.16). Unlike the web app, plain numbers are chosen as a type of visualisation to depict statistics. In addition, different from the web version, colours are used to highlight the leading team in a particular statistic. In contrast to the majority of football apps, statistics labels are not centred between two sides but on the left edge of the interface. Such a decision may be a questionable choice since this layout may cause the readers' eyes to move around the screen more to identify teams and to find the relevant match statistics for each side and categories.

Figure 3.16: Depiction of statistical information for a Champions League fixture between Manchester City and Paris St. Germain, 12 April 2016, on the mobile app of Yahoo Sports.



3.2.4 Livescore

Figure 3.17: The key events timeline and statistics for the match between Barcelona and Arsenal, 16 March 2016, on livescore.com mobile site.

A single tap on a particular match on the mobile version of *Livescore.com*, one of most popular sites to check match scores, gives users the timeline of key events and a summary of statistics for the chosen fixture (Fig 3.17). The layout has a dark background and various textual and numerical information, as well as pictograms which have light colours of grey and yellow. Light coloured text on dark backgrounds are not the best for legibility except in an environment where the light is dim. Although the layout is clear and there is not any major problem regarding the typography, similar to the *Yahoo Sports* app, placement of stat labels is questionable since their off-centred location may not be the quickest option for users to read.

Plain numbers are used for the depiction of in-game statistics. Similar to sofascore.com, the leading numbers in each category are prioritised over the other with a yellow colour that shines on a grey-black-dense interface and a bold version of the same typeface heightens the visual hierarchy of better numerical values, compared to the worse ones that are coloured in light grey and depicted in thin typeface. This slight difference is colour and typeface might allow the reader to find better values quickly because those figures *pop out* in the environment they belong to, due to pre-attentive processing (Ware, 2013). The importance of pre-attentive processing is remarked as:

> *"…In displaying information, it is often useful to be able to show things 'at a glance.' If you want people to be able to identify instantaneously some mark on a map as being of type A, it should be differentiated from all other marks in a preattentive way." Ware (2013, p.153-154)*

The mobile app of livescore.com requires a few swipes to view statistics for a particular match after a single tap on the match. The app preserves the general colour scheme of its web version but utilises a different visualisation to display statistics: Numbers with bar charts (Fig 3.18). Similar to the web app, it has a clean design on a dark background and same colours are associated with leading and subordinate sides in particular categories. Compared to the web version, the statistic labels were put in between the sides.

Figure 3.18: The display of statistics for the match between Atletico Madrid and Real Madrid, 13 April 2016, on Livescore.com's mobile app.

3.2.5 ESPN

Figure 3.19: ESPN's depiction of general statistics for the match between Newcastle and Sunderland, 20 March 2016.

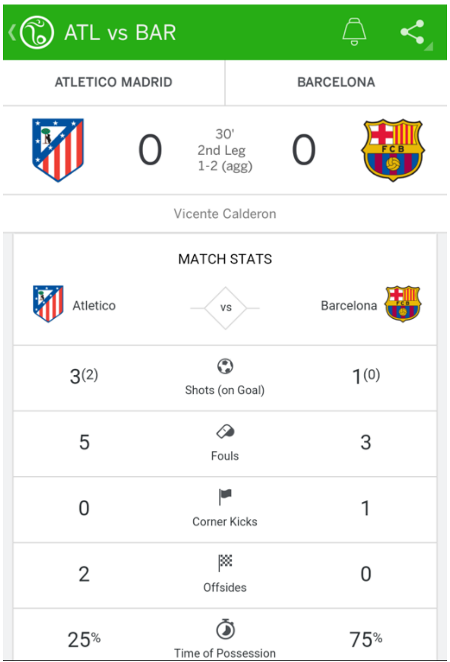
In order to view *ESPN*'s match statistics page (Fig 3.19) for a specific match, the visitor needs to tap several times on the relevant links. What they encounter is a clear overall look that host a few different visualisations for visualising match statistics. Similar to

The Guardian, three segments of statistics emerged due to the usage of distinct visualisations. The first segment is ball possession rates that were depicted as bar charts with round edges. The below of ball possession rates segment is for shots and tree-map visualisations are preferred for depicting shots. The last part that stays at the bottom is for the rest of the categories where plain numbers are used. Furthermore, the web-based app uses colours to identify statistics belonging each team. Moreover, in the shots division different tones of the same colour are used to keep *total shots* and *shots on goal* apart since the latter is a subset of the former.

The design of treemap visualisation is questionable in few aspects: The size of the black rounded rectangle that represents 8 *shots on goal* for Newcastle must be as big as 2 times of its Sunderland counterpart; however, it is bigger than double the size of Sunderland's. On top of that, the relative proportioning of the sizes of rounded rectangles that display total shots and shots on goal is inaccurate for example the light red rectangle for 14 total *shots on goal* for Sunderland is far bigger than 3.5 times of the smaller red one for *shots on goal*. Apart from that, the usage of the light grey area on Sunderland's size for shots may confuse the reader that it may signal the light red area as another subset although it probably is put as an aid for the reader to make an easier comparison with Sunderland and Newcastle.

The mobile version of *ESPN* does not host different sorts of visualisations to depict match statistics but only plain numbers though stat labels are supported with football icons (Fig 3.20).

Figure 3.20: Depiction of statistics of the game between Atletico Madrid and Real Madrid, 13 April 2016, on ESPN's mobile app.



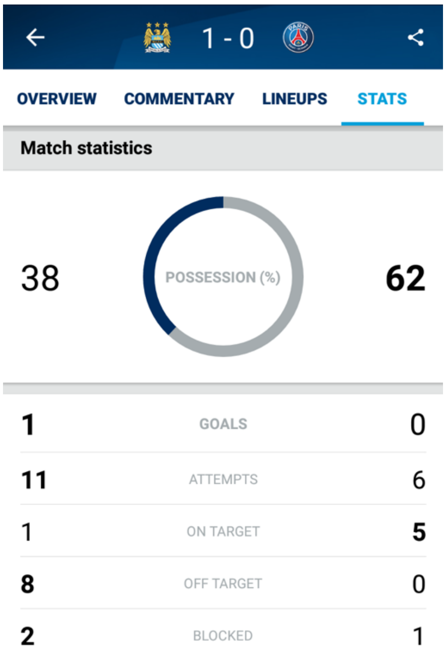
3.2.6 UEFA

Figure 3.21: The statistics of the match between Arsenal and Barcelona, 23 February 2016, on UEFA's mobile website.

The way of reaching statistics for a particular match (Fig 3.21) on UEFA.com is much the same as the previous websites that require tapping on the relevant links. The page has a clear layout on a light background similar to many of the previous app and websites and categories of statistics are divided with thin grey lines. Unlike the previous interfaces, UEFA.com provides visitors statistics only in the form of plain numbers. There is no colour-club association on the interface.

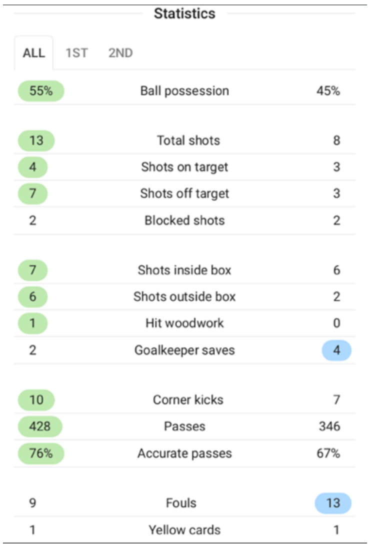
Usage of circle-type pie charts for displaying ball possession rate is the only difference in terms of visualisation between the mobile app of UEFA.com and its web counterpart (Fig 3.22).

Figure 3.22: The overall view of statistics for the Champions League match between Manchester City and Paris St. Germain, 12 April 2016, on the mobile app of UEFA.com.



3.2.7 Sofascore

Figure 3.23: The statistics for the match played between Crystal Palace and Leicester City, 19 March 2016, on sofascore.com



Statistics

ALL 1ST 2ND

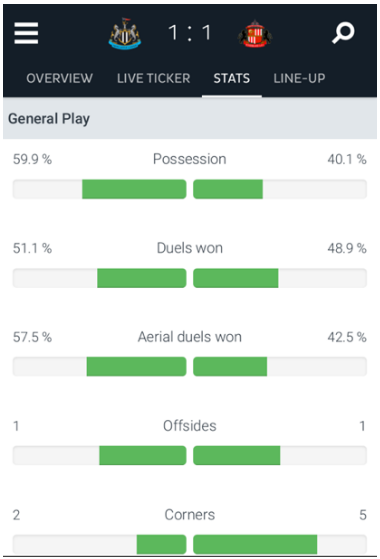
55%	Ball possession	45%
13	Total shots	8
4	Shots on target	3
7	Shots off target	3
2	Blocked shots	2
7	Shots inside box	6
6	Shots outside box	2
1	Hit woodwork	0
2	Goalkeeper saves	4
10	Corner kicks	7
428	Passes	346
76%	Accurate passes	67%
9	Fouls	13
1	Yellow cards	1

Users need to tap on the links to view relevant in-game statistics for a football match on sofascore.com's web display (Fig 3.23). The layout is plain and grey lines are used for the separation of the different types of match statistics.

Sofascore possesses coloured eclipse-shaped highlighters that accompany the numerical values therefore its plain numbers are slightly different than UEFA.com's display. The distinct colours that are used for each side are for separating the teams and highlight the superior side in a particular category such as corner kicks in terms of numerical value. If both sides occur to have the same numbers in a specific department, then the statistics that belong to each club are not placed in coloured eclipses. The colours are not associated with teams' colours. Apart from this, Sofascore's mobile app does not have any difference than the aforementioned version in terms of layout and the way of visualising match statistics.

3.2.8 Onefootball

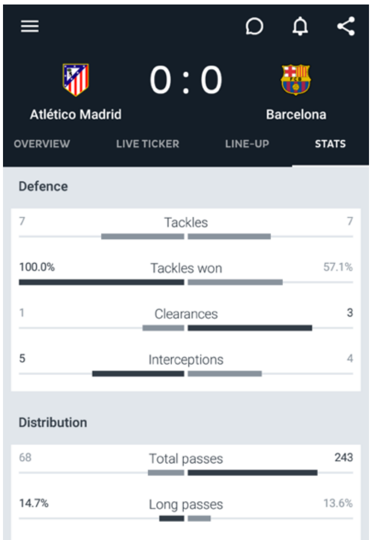
Figure 3.24: Onefootball.com's depiction of statistics for the match between Newcastle and Sunderland, 20 March 2016.



Readers need to tap for few times in order to pass through layers of menus on Onefootball's website to view various statistics for a match (Fig 3.24). The whole statistics do not fit the page of a smartphone with 768x1280 resolution; therefore, viewers need to scroll down to see the ones that could not be seen on the screen.

The web app provides the score on the top and defines each side of team statistics with their club crests. The section below is dedicated for in-game statistics and it seems to have good legibility. The preferred visualisation is bar charts; however, the colour of the bar charts has nothing to do with each team's colour but the corporate identity, green, of the firm who created the app. There are issues with the proportions of bar charts; for instance, the size of the bar for Newcastle's number of corners is less than 40% of the size of the bar of its Sunderland equivalent.

Figure 3.25: The display of statistics for the match between Atletico Madrid and FC Barcelona, 13 April 2016, in Champions League on Onefootball's mobile app.



The mobile app of the same company has slightly a different colour scheme and thinner bar charts although the core of design stays the same with statistics displayed in the form of numbers with bar charts (Fig 3.25).

3.2.9 Skysports

Figure 3.26: The statistics for the match between Newcastle and Sunderland on Skysports.com's mobile website, 20 March 2016.

The visitors to Skysports' website need to navigate around the menu with a few taps to view the statistics (Fig 3.26). Once they start viewing, they need to scroll to view further statistics as the whole match information does not fit the screen. The website's layout makes it easy to read the match-related content. Unlike some of the previous websites, the categories of match related information are two-layered in that there are separate sets (shots, overall) and subsets (total shots, on target, off target, blocked) of statistical information.

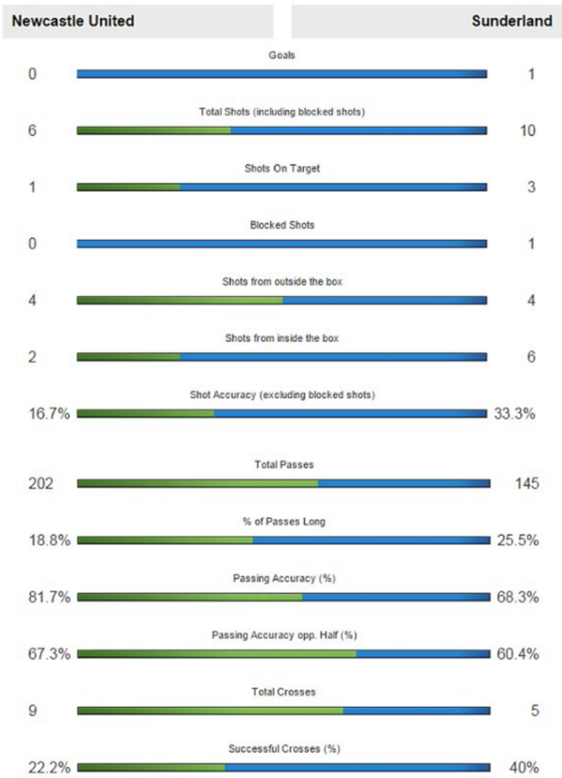
Bar charts is the only type of visualisation used to depict the in-game statistics. Similar to the other websites mentioned above, in each division of statistics, the bars are proportionately sized according to the numerical values, although there are issues in this regard; for instance, the bars in blocked shots are carefully sized against each other. In terms of colour selection, we do not see team-associated colours in bars. Instead, like Onefootball, a specific colour, navy, that symbolises the corporate identity of the company website is used.

Similar to its web app, participants need to tap a few times to reach the statistics for a particular match on Skysports' mobile app (Fig 3.27). In contrast to the web app, plain numbers are preferred to visualise in-game statistics on Skysports' mobile app.

Figure 3.27: Display of in-game statistics for the Champions League match between Manchester City and Paris St. Germain, 12 April 2016, on Skysports Live Score mobile app.

3.2.10 Daily Mail

Figure 3.28: The Daily Mail's display of in-game statistics for Newcastle vs Sunderland, 20 March 2016, on mobile screen.

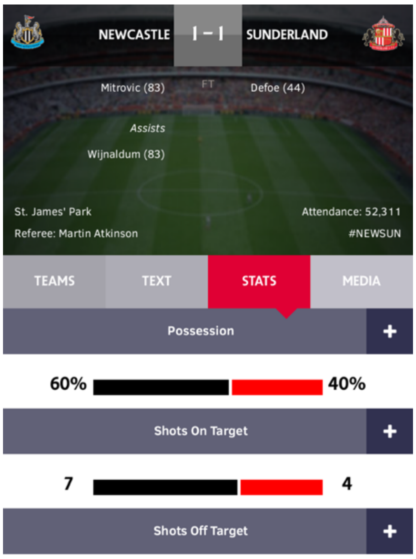


The mobile app of the Daily Mail does not show any match statistics; therefore, it is not mentioned here. On the other hand, Daily Mail's mobile website shows match statistics and tapping on the mobile screen is the key gesture of interaction to access the page that shows statistics for a relevant football match on the website (Fig 3.28). Although it holds an abundance of match-related information on a single page, the visual outlook is clear and there are no major issues, except gradient colours on bars, in terms of legibility of the displayed information.

Like most of the web apps, bar charts are the main and only sort of visualisation that are used to envisage a variety of numerical information for a certain match (Fig 3.28). Moreover, there are no sub categories for certain types of statistics, although there is a subtle spacing arrangement for the purpose of differentiating a group of statistics belonging to *passes* from another set that is for *shots*. Also, the bar charts are coloured differently to separate the teams, and coloured areas are proportionately sized according to the numbers they represent. However, each assigned colour is not associated with the colour of the team that they are attributed to, but they represent the colours that the website identifies itself with, in the relevant context. In addition to this, the tone of each colour gets darker from the point the separation of sides begins to the bar edges. This does not seem to be a good design proposition because using gradient tones of a colour on bar charts might create difficulty for the reader to perceive bar size since such gradient colouring of bar charts (Fig 3.28) is considered as a type of visual representation to depict uncertain data (Tak et. al., 2014).

3.2.11 Premier League

Figure 3.29: The in-game statistics that belong to the match played between Newcastle and Sunderland, 20 March 2016, on the official website of the Premier League.

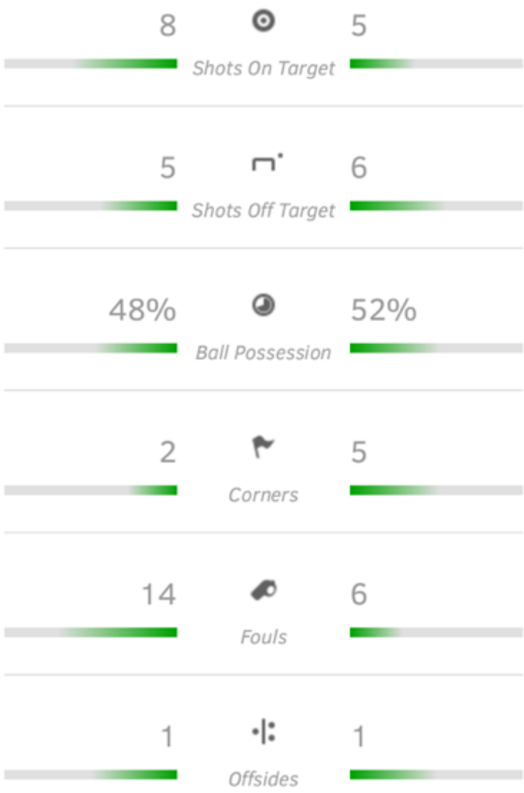


The visitors need to tap several times on the links of the official website of the Premier League but it does not have a dedicated mobile app of its own to see how a certain ongoing match is unfolding (Fig 3.29) in terms of important play events and match statistics. The layout of the statistics is plain and straightforward to read with options presented to readers on each type of statistic should they wish to elaborate further on a particular category.

Bar charts are used solely for visualising the statistics. Bars are sized and coloured differently in order to emphasise the amounts they illustrate and the sides they belong to respectively. The official league web app is designed to assign team colours to bar charts for identification of teams with relevant statistics.

3.2.12 FotMob

Figure 3.30: The statistics display on FotMob's mobile website for the match played between Japan and Afghanistan, 24 March 2016.



Tapping on the links of the FotMob's website is a requirement to display statistics for a relevant game (Fig 3.30). The web interface, similar to many other web apps, has an uncluttered look with a white background that does not create any concerns with regards to having a crowded look.

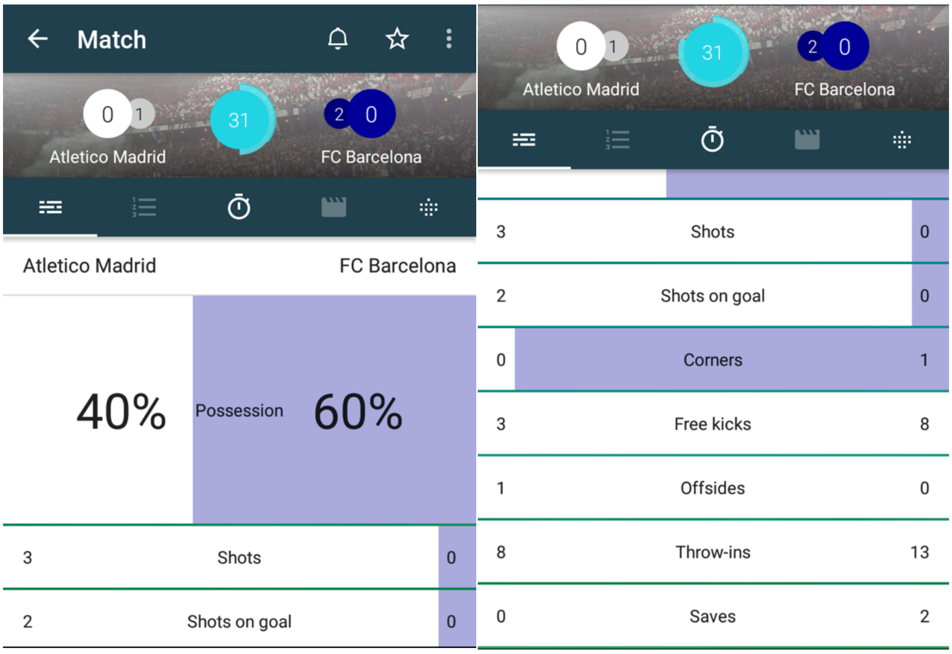
Bar charts appear to be the only style that is utilised for the depiction of in-game statistics on FotMob's web app. The bars are not coloured with each side's kit colours but the firm's corporate colour. Apart from this, icons are used to support labels of different sections visually, although their styles do not exactly seem to be in harmony with the plain visual language of the interface. On top of that, the positioning of the labels is awkward, the horizontal alignment of labels for the bar charts is not solid and creates problems of legibility. However, they do not pose the biggest problem on this app in the sense of visual outlook. The crucial concern lies behind the usage of gradient colour to highlight the numbers that the bars visualise, as was highlighted in the Daily Mail's display of match statistics on its mobile website. The use of gradient might put extra burden on readers' cognition and since second screening has to be quick and precise in terms of not missing much on the main screen, the ambiguity regarding the boundaries of bars caused by the usage of gradient colouring, might make viewers perceive the sizes with more difficulty.

The aforementioned issues seem to be resolved in FotMob's mobile application that uses the same type of visualisation to display statistics: Bar charts (Fig 3.31). First of all, gradient colours that could pose a readability problem are not used in bars. Secondly, different elements are not awkwardly aligned. On top of that, different sides are coloured according to team kits; hence, it may give viewers some ease to differentiate between sides.

Figure 3.31: FotMob's Mobile App's depiction of statistics for the match between Sunderland and Everton, 11 May 2016.

3.2.13 Forza Football

Figure 3.32: Forza Football Mobile App's display of statistics for the Champions League match between Atletico Madrid and FC Barcelona, 13 April 2016.

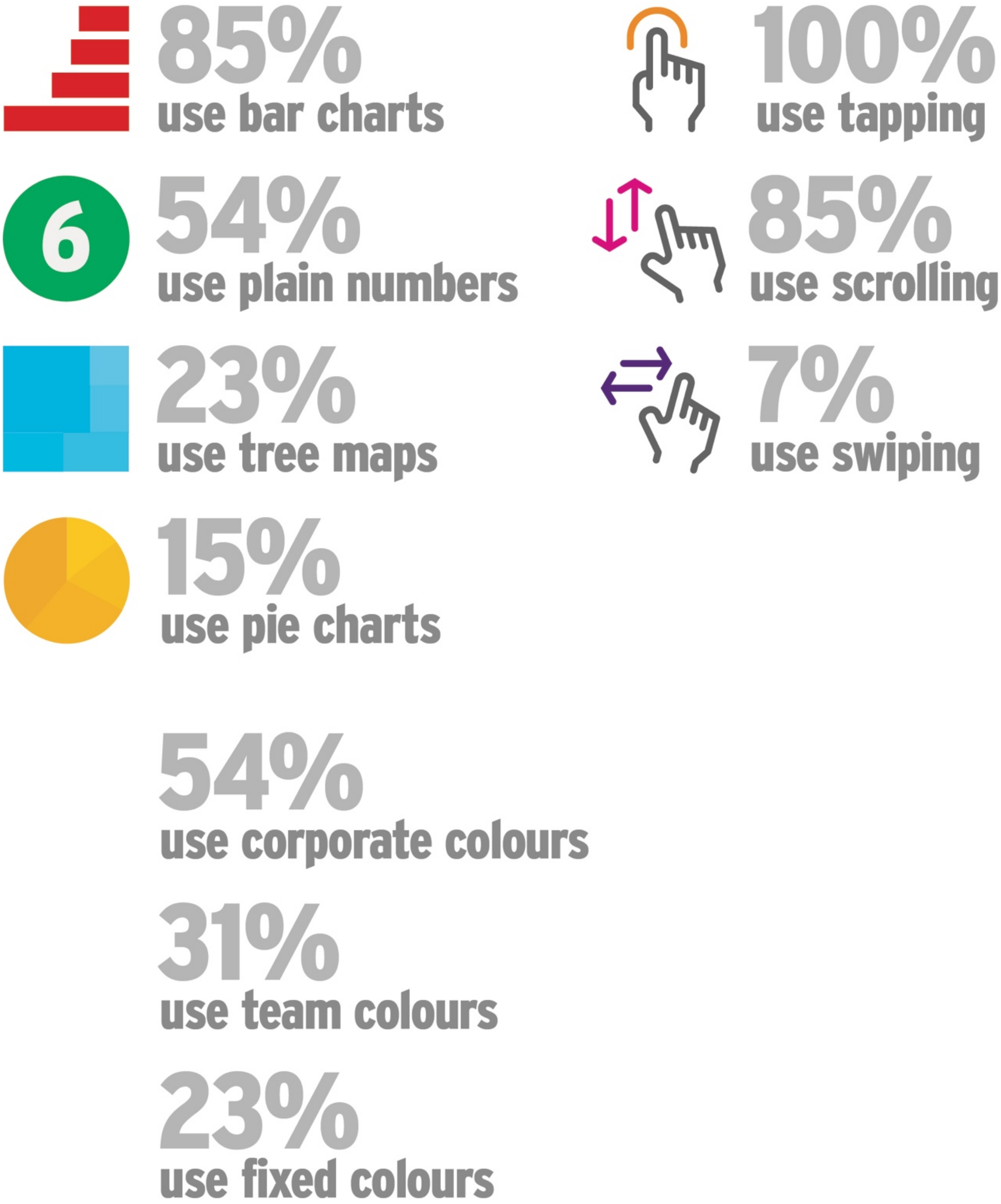


Forza Football does not have a web interface but a mobile app that provides live match information. Users can reach statistics for a specific match through taps via menus and they also need to scroll down and up on the same page to see different types of statistics (Fig 3.32). The form of visualisations and general layout do not possess any difficulties for users in terms of readability of the match related information.

Five different forms of visualisation are used for match statistics. The first one is a derivation of pie charts to display the elapsed time of the match, using light text on a turquoise background in the top middle between the names of the competing sides. Second, plain numbers with coloured rounds on their background are used to display the score as well as the first leg score that has smaller size of font and darker tones of colours used for each side. Thirdly, treemap visualisation is used to depict the ball possession percentages of both sides and the visuals in this regard are proportionately sized. The fourth type of visualisation is plain numbers and they are used to represent most of the rest of the statistics. Finally, some of the rest of match statistics are seen in the form of bar charts with numbers. Use of a particular sort of visualisation for the depiction of percentages can be understood in terms of differentiating them from the rest that are numerical values; however, using both plain numbers and bar charts with numbers for depicting numbers is not a consistent design decision; therefore, it may confuse the reader.

Colour selection is not based on any association with each side's kit colours but rather a choice related to the app's corporate identity. The use of different colours for one side for the visualisation of the number of goals and the rest of the statistics is an inconsistent feature, whilst using the same colour for the other team for depiction of number of goals and other information. On top of that, having four different colours with two additional tones for two of them in order to display match statistics is questionable since it may increase the likelihood of confusion on the screen, especially for second screening that already distracts user attention.

Table 3.1: Review summary of mobile football apps and websites.



3.2.14 Key Characteristics of Mobile Football Apps and Websites

- The reviewed mobile football apps and websites appeared to be designed in minimalist style. Most of them did not seem to have issues related to legibility and inconsistency in terms of their visual language.

- Most mobile football apps and websites that were reviewed used one type of visualisation to depict match statistics. Only a few apps and websites seemed to accommodate different types of visualisations for different types of match statistics.

- Bar charts and plain numbers were the most used types of visualisations to display match statistics in the reviewed mobile football apps and websites.

- There seemed to be no consensus among the apps and websites regarding the colour usage on the visualisations of match statistics. In some apps and websites, two different colours were used to differentiate between teams and the colours assigned to each team might not be team colours. Moreover, the corporate colour of the apps and websites were used in some apps and websites. In addition, data labels (numbers) regardless of whether they are depicted in bar charts or in plain numbers seem to be positioned on the left and right edges of the screen. Furthermore, match statistics were depicted in black and white in a few apps and websites.

- Tapping seemed to be the prominent interaction gesture that was used to navigate around the menus and to access the match statistics screen on the reviewed mobile football apps and websites.

4 Methodology

One of the vital elements of a research project is methodology. It is a vast area that hosts different approaches and methods to generate knowledge in varying fields of research. Methodology is crucial because it shapes the form, amount and validity of information. Since the content and scope of this project transcends a single discipline, choosing a method or a set of methods that would fit the requirements of the research questions requires careful examination, selection and adaptation of existing methodologies. In this section of the thesis, two approaches that built the framework of the methodology of the thesis are introduced and discussed firstly. Secondly, potential methods that could be applied to the thesis are reviewed; their advantages and disadvantages are discussed. Along with this, the reasons why a specific set of methods were chosen are elucidated. Finally, the selected methods applied in the research project are explained.

4.1 Methodology Approach

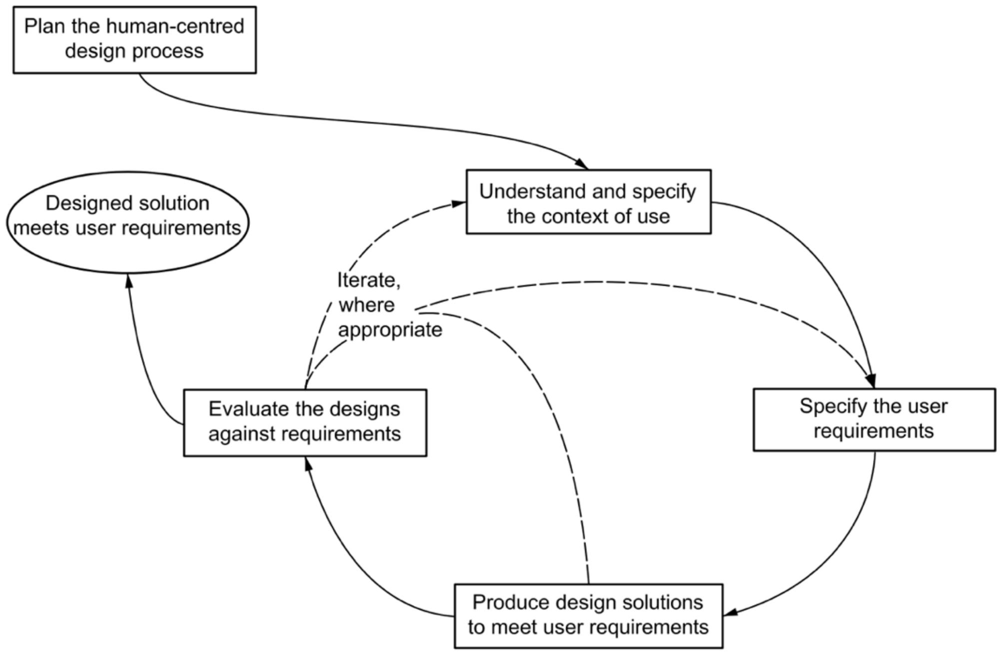
Before introducing and discussing potential methods that could be used in the thesis, it would be beneficial to explain the approaches that led to why the potential methods that are introduced in this chapter were considered. The thesis focuses effects of different visualisations of match-related information and interaction gestures to retrieve such information on second screen; therefore, it is important to understand the *second screen users* in the context of watching football matches on TV. In addition, without getting objective and subjective feedback from second screen users regarding the different visualisations of match-related information and interaction gestures to retrieve such sort of information, it would not be reasonable to understand how different forms of visualisations and interaction gestures shape their watching experience of football matches on TV. Therefore, *User-Centred Design* and *Participatory Design* were the approaches that were decided to follow in terms of choosing methods and how they would be applied.

4.1.1 User-Centred Design

User-Centred Design is an approach that shapes the methodology applied to this thesis. According to *International Organisation for Standardization* (*ISO*), user-centred design (UCD) is *"…an approach to systems design and development that aims to make interactive systems more usable by focusing on the use of system and applying human factors/ergonomics and usability knowledge and techniques."* (British Standards Institute, 2010).

Marcus (2016, p.145) summarised how UCD is composed of several processes as in a *"standard waterfall development model"* that was highlighted by Royce (1970) for software development: First, there is a needs analysis. Then, requirements for the product are gathered. Thirdly, a solution is implemented based on the needs analysis and requirements. Evaluation of the solution comes after this. Revision(s) in the solution is made in light of the evaluation and the revised solution is evaluated again. After a few iterations of revision and evaluation, the solution is finalised. The image below (Fig 4.1) by BSI describes a similar structure.

Figure 4.1: Schema of user-centred design activities (Source: BSI, Author: Unknown)



As Maguire (2001) stated, one of the key principles of this approach is consulting with users to satisfy their needs rather than imposing the solution on them. Maguire (2001) added that user-centred design is an iterative process that through primitive mock-ups and advanced prototypes users complete specific tasks that are based on real world practices. Feedback from users are used to develop and refine the design solution.

4.1.2 Participatory Design

The approach could be simply defined as involving all parties who are not designers, such as clients and users into the design process (Martin and Hanington, 2012). Robertson and Simonsen (2012) describe such involvement yields as a mutual learning. Different to user-centred design, participants act as participants and designers (Robertson and Simonsen, 2012) in that participants take part in co-design activities in the design process (Sanders et. al., 2010). Therefore, as Martin and Hanington highlighted (2012) the participants, through ways such as toolkits and workshops, can release their thoughts and ideas and lead the way to outcomes. Although their efforts are shared with the designers' experience and knowledge they do not have full control over the design process (Marton and Hanington, 2012). Compared to the *User Centred Design* approach, participants are more proactive in the *Participatory Design* approach.

4.1.3 The Approach for Method Selection

The selection of methods and how they would be applied were based on user-centred design rather than participatory design. There are two main reasons behind this approach. First, the effect of different visualisations and interaction gestures on the watching experience cannot be fully understood by just asking participants about them and letting them design what they want because they can only design and report what they think would work for them. The following explained the difference between what people think would work for them and what actually works for them:

> *"...Most behavior is subconscious and what people actually do can be quite different from what they think they do. We humans like to think that we know why we act as we do, but we don't, however much we like to explain our actions. The fact that both visceral and behavioral reactions are subconscious makes us unaware of our true reactions and their causes. This is why trained professionals who observe real use in real situations can often tell more about people's likes and dislikes—and the reasons for them—than the people themselves..."(Norman, 2004, p.81-82).*

Therefore, participants' involvement should be accompanied by objective measurements of how different types of visualisations and interaction gestures affect their watching experience.

The second reason for such choice was the availability of resources to conduct the research project. Ideally, in the whole research and design process, more involvement of second screen users would be preferred to enrich the variety of suggestions on the visualisations and interaction gestures; however, such involvement needs more resources to organise co-design sessions and convince people to join them. In that respect, as it is mentioned in the methodologies that were employed in the following sections, there were still traces of participatory design since there were few attempts such as design workshops and mini-interviews of the prototype experiments. In those activities, the aim was to get users involved more into the research and design process by encouraging them to express their expectations as well as depiction of their ideas regarding their second screen experiences.

4.2 Used Research Methods

4.2.1 Ethnography

The research questions require an understanding of the information seeking habits and behaviour of football TV audiences while they are watching football matches on TV. In addition to this, people's likes, dislikes, frustrations and expectations regarding the display of match-related information and interaction gestures for information retrieval on second screen need to be clarified. Such necessities inevitably drive the researcher to apply methods that focus on people who belong to such a specific group. In this regard, ethnography could be highly considered as a suitable method to elicit deeper insight regarding the behaviour and habits of viewers in terms of information retrieval on second screen when they watch football matches on TV. Ethnography is:

> *"…an iterative-inductive research (that evolves in design through the study), drawing on family of methods, involving direct and sustained contact with human agents, within their context of their lives (and cultures), watching what happens, listening to what is said, asking questions and… [respecting] the irreducibility of human experience…" (O'Reilly, 2005, p.3)*

The potential benefit from using ethnography in this project has been an enrichment of the information regarding viewers' behaviour and habits of match-related information seeking on second screen which was not covered highly in the literature. Therefore, it may offer insight regarding what type of visualisations of match-related information need to be tested in the further stages of research. Moreover, this method might also help us to understand viewers' feelings, emotions and thoughts regarding how different visualisations of match-related information and interaction gestures to retrieve such information work for them. Furthermore, this method could be applied in a variety of modes (Arnould, 1998; O'Reilly, 2005): *Observation*, *diary studies*, *focus groups*, *surveys* and *interviews*.

4.2.1.1 Observation

Participant observation is a method that needs a process of extended time (e.g. at least 6 months) of observing one person or a group of people who are considered as study subjects. In more detail, such a method requires a researcher to observe their way of living as well as participating in their lives while being able to hold a distance from them and keeping records of data within the process (O'Reilly, 2005; Fetterman, 2010). The benefit of observing a specific person or group of people is to notice any behavioural details and patterns relevant to the research. However, apart from getting too immersed into the community, difficulties can arise from observation such that accessing the environment may not always be straightforward for several reasons, e.g. trust issues, closed-groups of people, and even in some cases researchers must abandon their study (O'Reilly, 2005). Additionally it is important to document information and keep records in real-time because remembering details correctly can be problematic after a period of time (Murchison, 2010). Sound recorders and video cameras can be a solution to aid the memory; however, along with observation itself, presence of such equipment can scare the observed and may cause them to alter their behaviour in a specific situation (Murchison, 2010).

Observation could have been useful in this PhD study in order to gain an understanding of when and how people interact with their mobile devices during their act of watching football matches on TV. Also, through a monitoring app installed on their smartphones or tablets that they use as second screen, more details regarding their usage during their act of watching can be obtained. Nevertheless, not many people would be open to having an observer in their living room whilst they are practicing a leisure habit, watching football matches on TV. Apart from this, they may find the idea of having a monitoring app on their devices intrusive. Both concerns regarding privacy can lower the numbers of volunteers to participate and they may feel the need to alter their behaviour. On top of that, the need to travel to different places and arrange accommodation for observation that would take more time and demand more resources. Given the limited resources, such a method would not have been practical for this research.

Given the difficulties above, this thesis still benefitted from observation to understand how different interaction gestures affect people's information retrieval on second screen; and, their watching experience. With a camera mounted appropriately, without causing any intrusion to privacy of participants, their hands and gestural interaction on second screen was observed.

4.2.1.2 Online Surveys

Online surveys are the quickest and most practical solution to gather a considerable amount of data from different areas around the world in a short time period (Martin and Hanington, 2012). Online surveys are also convenient for analysis because large amounts of participant input can be stored instantaneously without any administration tasks such as collecting and transferring documents and the data can be systematised and catalogued by computer programs rapidly according to the researcher's needs (Evans and Mathur, 2005). Moreover, this method enables researchers to arrange a structure that holds a variety of questions such as multiple-choice, multiple-select, Likert-scale and open-ended ones (Martin and Hanington, 2012; Evans and Mathur, 2005). Such diversity allows them to extract disparate sorts of data (Martin and Hanington, 2012; Evans and Mathur, 2005).

There are a few disadvantages of online surveys. First of all, they may not perform well in terms of revealing participants' thoughts, views, behaviours and experiences accurately regarding the topics they are asked about as it is a self-reporting activity (Martin and Hanington, 2012). Moreover, sometimes they are not taken seriously by potential participants because they may be perceived as spam messages (Evans and Mathur, 2005). Besides, although the use of the Internet and mobile devices is increasing, there are still a fair number of people around the world who are not comfortable with the technology and this issue leads to the serious consideration as a problem that online surveys do not represent the total population (Evans and Mathur, 2005). Apart from this, motivation for online surveys can be low since it is not a human-to-human activity; therefore, participants can be reluctant to put genuine effort in to completing them (Evans and Mathur, 2005). This inhuman nature of such surveys can be a preventing factor for the researcher to 'dig deep' on open-ended questions (Evans and Mathur, 2005). Furthermore, if the instructions for answering questions are not clear, this lack of human communication can lead to misunderstandings of the questions as there is not human supervision to clarify the questions (Evans and Mathur, 2005).

Despite the disadvantages listed above, such methods seem to be one of the techniques that could be applied to this research, because reaching many people around the world with almost no cost might provide adequate sample depth; therefore, a strong insight regarding people's habits and behaviour in their information seeking on additional media could be achieved.

4.2.1.3 Interviews

Interviews are one of most applied research methods. It is a method that is best performed through face-to-face so that gestures and other details regarding the body language can be observed (Martin and Hanington, 2012). However, it can be conducted over the phone and via the Internet e.g. email and social media (Martin and Hanington, 2012).

Interviews can be done in rigid structures or follow looser forms; that is to say, interviewers may not go beyond a set of questions they plan to direct to interviewees or they can show flexibility and allow conversations with respondents when they talk whilst not losing the focus (Martin and Hanington, 2012). Interviews that use such a conversational style have the edge over the types that have strict flow because the former probably makes participants feel more comfortable than the latter (Martin and Hanington, 2012). Nonetheless, less-structured interviews have a few off-putting features, such as control of time keeping and questions are more difficult and analysing data requires more effort (Martin and Hanington, 2012).

Kuniavsky et. al. (2012) analysed structures of user experience interviews and identified six different phases that occur in the interview process. First, the interviewer introduces herself at the beginning. After this, the warm-up part begins and the interviewer starts to break the ice and orientate the interviewee towards the topic by asking her basic questions regarding herself and/or her connection with the product or service

(Kuniavsky et. al. 2012; Jacob and Furgerson, 2012). The third section mainly involves general questions with regard to the participant's experience of the product along with her expectations and assumptions about it (Kuniavsky et. al. 2012). After this, a product is introduced and the participant is expected to give details about their first impressions of the product; however, this part of interview may not happen if the purpose is exploration (Kuniavsky et. al. 2012). The section before wrap-up is dedicated for a wider evaluation of the product and it is different than the third section because the questions are related to how the new product would affect the experience mentioned in the aforementioned phase (Kuniavsky et. al. 2012). The interview is then finalised by informing the participants about how the research will advance and should there be any follow-up after the interviews (Jacob and Furgerson, 2012).

It is important throughout the interview process for the interviewer to be precise about her wording and avoid using expressions that can lead to misunderstandings and confusions (Kuniavsky et. al. 2012). In addition to this, the interviewer should be able to motivate people to talk freely and make them feel that they would not be judged; therefore, she usually needs to be a good listener (Kuniavsky et. al. 2012). Moreover, interviews need to be conducted at places where comfort, quietness and confidentiality are prioritised (Jacob and Furgerson, 2012). Apart from this, note taking and recording should be organised in an effective way; so that, the dialogue between the interviewer and the interviewee develops seamlessly (Jacob and Furgerson, 2012). On top of that, showing a genuine care for what the participant is saying and listening carefully are crucial to make them share more information regarding the interview subject (Jacob and Furgerson, 2012).

4.2.2 Design Workshops

Design workshops are activity-based research tools that are considered as convenient methods for *"...gaining an understanding of the user's world and establish design implications..."* (Martin and Hanington, 2012, p.62) and they can *"...quickly produce large number of insights and ideas."* (Polaine et. al., 2013, p.60). They are usually held at neutral sites that do not have any connection with the workspace of the stakeholders or organisers (Muller, 2009). Workshops can be formed from a few as four or can be as many as sixteen people in groups (Polaine et. al., 2013).

Different than focus groups, in workshops, participants do not just express their thoughts and opinions regarding a specific service or product in just a verbal way (Polaine et. al., 2013). They are encouraged to build their ideas through different ways, such as sketching, prototyping and making; therefore, they are not confined to the restrictions caused by a traditional way of thinking and the more dominant participants (Polaine et. al., 2013). Workshops are intensive, because they encourage different modes of thinking through various activities, but participants can enjoy themselves and have fun while generating ideas, evaluating concepts and providing insight (Martin and Hanington, 2012).

4.2.3 Lab Experiments

Since this research project is related to mobile devices that act as second screen and the notion of usability was one of the aspects that the research questions touched on, it was necessary to review methods used in studies related to mobile devices. Nayebi et. al. (2012) stated that lab experiments could be used for evaluating mobile usability. In laboratory experiments, there are people who take part in sessions in which they are instructed to carry out certain tests, such as interacting with a mobile app (Nayebi et. al., 2012). In this kind of tests, there are the following variables: *manipulated* (independent) and *response* (dependent) (MacKenzie, 2015). The manipulated variable means a property or feature that test subjects are exposed to in different arrangement or form (MacKenzie, 2015). For example, in this PhD research, it can be different sorts of visualisation of match-related information or gestures of interaction. The second variable refers to *"…any property of human behavior that is observable, quantifiable, and therefore measurable"* (MacKenzie, 2015, p.2). Memorability, for instance, can be considered such a parameter for this thesis.

Such experiments are conducted in environments that are regulated by the researchers; that is to say, any potential factor that is irrelevant to the context of an experiment and which could affect the outcome of it can be eliminated in lab settings (Nayebi et. al., 2012). This is one of the advantages of this method, because the ultimate control over the environment and variables give researchers the ability to fix everything except the elements they want to compare; as a consequence, they can receive precise results (MacKenzie, 2015; Nayebi et. al., 2012). However, this sort of isolated space can be a disadvantage too, because removed elements that belong to a natural environment may cause test subjects to feel different and lose their usual reactions towards a specific task or experience (MacKenzie, 2015; Nayebi et. al., 2012).

4.2.4 Prototyping

Prototypes which are defined as *"…first or preliminary version of a device or vehicle from which other forms are developed"* in the Apple Dictionary are widely used in lab experiments. As Martin and Hanington (2012) stated, they are varied in terms of their fidelity. Low-fidelity prototypes, which are usually in the form of sketches or storyboards, do not have any function but represent the proposed concept to be tested (Martin and Hanington, 2012). They generally take form of paper when the concern is related to software or interface design (Martin and Hanington, 2012). In paper prototypes, pages that represent screens of interface are handed over to users by the researcher, who acts as the interface mechanism when they describe what they want participants to do on each page in order to reach the goal they were assigned to achieve (Martin and Hanington, 2012).

There are a few reasons why low-fidelity prototypes are considered as useful tools. First of all, they are easier and cheaper to produce (Rudd et. al., 1996, p.80). Secondly, immediate feedback from users making rapid iteration and redevelopment can be generated through using them; therefore, they act as a step to refine ideas that are when carried to the next stages where actual products and services are made which incur relatively higher costs (Rudd et. al., 1996). Apart from that, low-fidelity prototypes have the advantage *"[w]hen the available prototyping tools do not support the components and ideas, which you want to implement."* (Sefelin et. al., 2003, p.779). Due to such advantages, they are the best tools when the goal is evaluation of design alternatives and illustration of concepts (Rudd et. al., 1996).

Low-fidelity prototypes do have a few disadvantages. Rudd et. al. (1996) state that paper prototypes lack authenticity because there needs to be a mediator to process the interaction. Moreover, they have different limitations that can pose issues in terms of evaluation (Rudd et. al., 1996). First of all, since they are in a raw state, error-checking is difficult through them. Secondly, since they are shown to users rather than letting users interact with them, the recognition of design issues is more problematic; hence, the user evaluation may not provide a sufficient level of insight (Rudd et. al., 1996). Over and above that, such prototypes can pose problems to coders, since they do not have clarity in detail regarding the user interface and mapping out of the interactions that a programmer, with little knowledge regarding the aforementioned topics, can end up implementing his bad design decisions in this respect (Rudd et. al., 1996).

High-fidelity prototypes have a more realistic outlook compared to low-fidelity mock-ups and they have complete or near complete functionality and are interactive in contrast to paper prototypes (Martin and Hanington, 2012; Rudd et. al., 1996). Such prototypes, which are mainly advanced models produced through computer programming and/or physical making, are presented to users at the later stages of design. Via tests, they provide information in connection with how they react to the product in terms of different aspects such as elegance, interaction and usability (Martin and Hanington, 2012). Unlike low-fidelity prototypes that aim to gain insight into user requirements for design via reception of quick feedback from a range of alternatives, high-fidelity prototypes are useful for detecting user interface issues, such as navigation and interactions (Rudd et. al., 1996). Since such prototypes mimic many functionalities of the finalised product, users are highly likely to experience the feeling of using the real product; therefore, they can deliver well briefed suggestions regarding the improvement of their experience and the product (Rudd et. al., 1996). In addition, since this kind of prototyping represents the actual product better, they are more efficient in terms of checking errors and variances in usage (Rudd et. al., 1996). On top of that, seeing an object that resembles the actual product engages test subjects more with the prototype; hence, the possibility of receiving more constructive and detailed feedback from them increases (Rudd et. al., 1996).

High-fidelity prototypes have some disadvantages. First, compared to the low-fidelity prototypes, they are costlier because they require more resources, e.g. technical staff, software and materials to build the protoype (Rudd et. al., 1996). Secondly, unlike paper prototypes, it may take considerably more time to make them (Rudd et. al., 1996; Sefelin et. al., 2003). Therefore, they should not be used for gathering information with regarding to general requirements or working on design alternatives (Rudd et. al., 1996). They should be used at a stage once the general design approach has been decided (Rudd et. al., 1996).

Van den Hoven et. al. (2007) highlighted that, although prototypes should not be evaluated as finished products, they can be recognised as objects with embedded propositions that possess adequate features for us to infer justifiable and linked judgements.

4.3 First Stage: Analysis of Information Seeking Behaviour

The low-fidelity and high-fidelity experiments would help us to understand how different visualisations of match-related information on second screen and interaction gestures for retrieval of this sort of information on second screen shape viewer experience. However, without reviewing existing practices and applications as well as the analysis of likes, dislikes, preferences, frustrations and expectations regarding consumption of match-related information through second screen, it is not possible to identify the prominent types of match-related information, visualisations and interaction gestures. Therefore, along with the review of existing football applications and mobile websites in the Chapter 3, the following methods were considered to analyse people's behaviour of match-related information seeking during their act of watching football matches on TV, as well as their expectations, ideas and thoughts regarding better second screen experience in this regard: *Online survey*, *in-person interviews*, and a *design workshop*.

4.3.1 Online Survey

An online survey was conducted in October 2013 with seventy participants living in eleven different countries. Fifty of them were male and twenty were female. The average age of sixty-seven participants was 33.4 (oldest 61, youngest 17, three participants avoided disclosing their age). The purpose of this survey was to learn details regarding football-match related information seeking behaviour of people during their act of watching football matches on TV (See Chapter 3) because the existing literature does not provide such details and they were dedicated to general sports or other sports from football. It would also be interesting to see whether the findings from previous research which encompasses the context of general sports would resonate with a study only covers the domain of football.

The online survey had three different sections (Appendix 1). The first part had only one question that all participants had to answer: *"When you watch a football match on TV, do you seek any kind of match-related information (e.g. in-game player & team stats, historical data of competition, comments of other people), apart from the kind provided by the commentary and TV graphics?"* The volunteers were presented three options in a drop-down menu below the questions: *"Yes"*, *"No"*, *"Don't Know"*. If a participant selected *"Yes"* as the answer, then they were directed to the second section that included seven different questions. If they selected *"No"* or *"Don't Know"*, then the process made them bypass the second stage and took her to the final segment of the survey that consisted of three questions regarding the participant's age, gender and country of residence.

The identities of participants are unknown as they were not asked to give their names. Moreover, none of them were deliberately picked for the survey. The *url* of the survey was shared through the email groups of the department (*Highwire Centre for Doctoral Training*) which had around 50 members at that time. Moreover, the link of survey was circulated to friends, family and acquaintances via email. Plus, the survey was shared on Twitter and other social media. Besides, *BBC Lancashire*, *Highwire* and the *School of Computing & Communications* of *Lancaster University* helped to circulate the survey by posting the link on their Twitter accounts. The online survey was open for two weeks.

4.3.2 Individual Interviews

Online surveys may not be the ideal tools to probe deeper into people's feelings, emotions and thoughts on products and services. Since further details in various aspects of information seeking behaviour on second screen during the act of watching football matches on TV were needed, a series of individual interviews were conducted to provide more depth in this regard.

Participants were recruited via *Highwire*'s email groups, posts on social media and fan forums of local and major football clubs: *Lancaster City FC*, *Morecambe FC*, *Preston North End*, *Blackpool FC*, *Everton FC* and *Liverpool FC*. However, the majority of participants (7) were students and staff from Lancaster University despite a lot of effort to get volunteers from outside of the university. Different from the online survey, there was one criterion for the selection of participants: Only people who were using second screen to retrieve football match-related information while they were viewing matches on TV were allowed to participate to the interviews. Moreover, since there was a filtering mechanism to recruit people, no payment for their contribution and limited time for the interviews, the number of volunteers was just twelve (nine males, three females). In addition, the average age of participants was 34 (oldest 54, youngest 25). Furthermore, six of them were interviewed in person, five via email and one on the phone.

Volunteers were asked thirteen questions in total (Appendix 2). In face-to-face interviews, to clarify points mentioned by the interviewees, and maintain the conversationalist style of in-person interviews, some additional inquiries that were related to the main questions were addressed on top of the main questions. The aim of the first five questions were to make the participants feel comfortable. For instance, they were asked their frequency of watching football matches on TV and whether they preferred to watch them alone or with other people, such as family. After this part, they were asked six questions that delved into the details of their information seeking practices on second screen during their viewing of football matches on TV, such as types of match-related information. They were then asked the reason(s) why they did not use any specific mobile application to seek match-related information on second screen. Participants were then requested to roughly describe the features of a potential app that they would like use on their second screen for this purpose. The final step was questions for demographic purposes and they were requested to tell their age, nationality and level of education.

The combined results of the online survey and the interviews, which were the first part of Chapter 3, were published as a work-in-progress paper at 1st ACM International Conference on Interactive Experiences for Television and Online Video that was held in Newcastle-upon-Tyne, UK, 25-27 June, 2014.

4.3.3 Design Workshop

To explore potential usages of second screen that might improve viewer experience of watching football matches on TV, a half-day workshop that was funded by *Digital Economy Network UK* was run. The event took place from 1.30pm to 4.30pm on the 5th December 2014 in London, UK as part of *Fifth Annual Digital Economy All Hands Meeting*.

The participants were four students (two *PhD*, one *Masters* and one *Undergraduate*), a senior academic and a research technologist from the *BBC*. During this activity, they worked in two groups of three and stayed in the same groups for the whole event. Each group was assigned a certain user persona to focus on during the workshop. These user personas were derived from findings of the online survey and interviews. The persona given to the first group was someone who was interested in checking match statistics on second screen, and the second persona was a character who followed social media on the additional device while viewing matches on TV.

The workshop was held in three stages. The first two of them were for ideation. During these, the groups were encouraged to brainstorm, discuss and generate ideas on specific briefs for their assigned personas. For instance, the brief for the first group was creation of a second screen scenario that included a specific time interval of checking match statistics, the way of interaction on second screen, the type of match statistics looked at and how they would roughly look on the mobile device. The instructions for the second group was same, except to look at different match-related information and they had to apply them according to their assigned character. The persona for the second group was a football watcher who checks match-related information on social media via second screen. In addition to this, both groups were supposed to consider the social setting as *home alone* while performing ideation. Apart from this, they were required to write down their ideas and, if necessary, draw or sketch them on flipcharts. In the second ideation session, the instructions remained same for each group; however, both groups were asked to work within the following social setting: *With friends at pub*. The reason for changing only social settings and keeping the user personas and briefs the same for groups was to see the effects of different social settings on potential solutions for improving the watching experience through second screen. The time limit for each ideation session was twenty minutes. In the end of each ideation session, each group gave a five-minute presentation of their ideas.

The final part of workshop was dedicated to prototyping. The participants were assigned the task of creating paper prototypes on given briefs. In their briefs, they were supposed to create a mock-up design of the interface of a second screen device, tablet or phone, that allowed access and interaction with their persona-related match-related information on the extra screen. Additionally, they were expected to design visualisations for their persona-relevant match-related information on second screen. At this stage, they were provided with basic tools, such as paper templates of mobile devices (tablet and phone) and pens. They had forty minutes to produce the paper prototypes and similar to the prior stages they had five minutes to present them. Unlike the previous couple of sessions, they were not bound to any specific social setting.

Before and during the organisation of this event, there were a few difficulties that hindered potential benefits to the thesis. First of all, the funding for participants was restricted to PhD students and other people in the *Digital Economy Network*; therefore, the event was limited to a specific group of people with a high level of education. This limitation was not ideal for sample variety. Apart from this, the initial plan was to have 12 people for the workshop and there would be 3 groups of 4. The third group would have been assigned to work on a persona that had the broad range of interest for all types of match-related information. Moreover, each group with 4 might have resulted in more productive sessions since 2 people had to leave in the middle of the event and the number of people in each group dropped to 2.

Although the workshop produced several outcomes, the output was not fully relevant to the focus of this study. The main reason could be the fact that participants were not given specific scenarios via the briefs, that could channel their effort mainly on the focus of thesis but they were expected to create the scenarios of second screen interaction from scratch and imagine a second screen experience for their scenario.

Consequently, the output of the three-hour event produced interesting and diverse results. However, the workshop output did not yield any specific direction regarding the types of visualisation that the PhD project needed to focus on. In that respect, the workshop briefs should have been more specific so that specific match-related information. For instance, comparative team statistics as match statistics and comments on social media as social media information could have been given in the briefs as focus points for participants; therefore, the workshop might have yielded more narrowed down results of visualisation that could inspire the research to focus on for prototype experiments. Videos from football matches could also have been displayed on screens in the workshop venue; therefore, participants might have engaged more to their briefs whilst they were working on them.

4.4 Second Stage: Prototype Experiments

The next phase after the interviews and the online survey was developing and testing prototypes. Although the aforementioned phases and the workshop yielded plenty of information regarding people's current second screen usage during their act of watching football matches on TV, and what they wished to have as second screen experience in this regard, there was a lack of focus on the details of the prototype and the prototype experiment for the investigation of an enhanced watching experience via second screen. At this phase of research, there were some ideas regarding prototypes (Fig 4.2), planning of the prototype experiments and even a pilot prototype experiment; however, the research direction was not certain. There were too many types of match related information (Fig 4.3) and visualisations of them to consider (Fig 4.4). First, since there was an abundant variety of match-related information from comments on social media to match statistics, what type of match-related information should be taken into consideration? In addition, visualisations for match-related information vary greatly, too; then on what sort of visualisations should the thesis concentrate on? Indeed, the focus of thesis needed to be narrowed down since a pilot experiment had already been conducted with the purpose of comparing a lesser-seen visualisation of statistical match-related information, to a more common type without narrowing down the focus on visualisations. However, there is more than one type of lesser-seen and more common visualisations for a particular type of match-related information. Since they all cannot be compared within the limited duration of a thesis, it was thought that limiting the scope of the study to the identification of the two most common visualisations might be the most realistic target to see the effects of visualisations.

Figure 4.2: One of the early prototype designs.

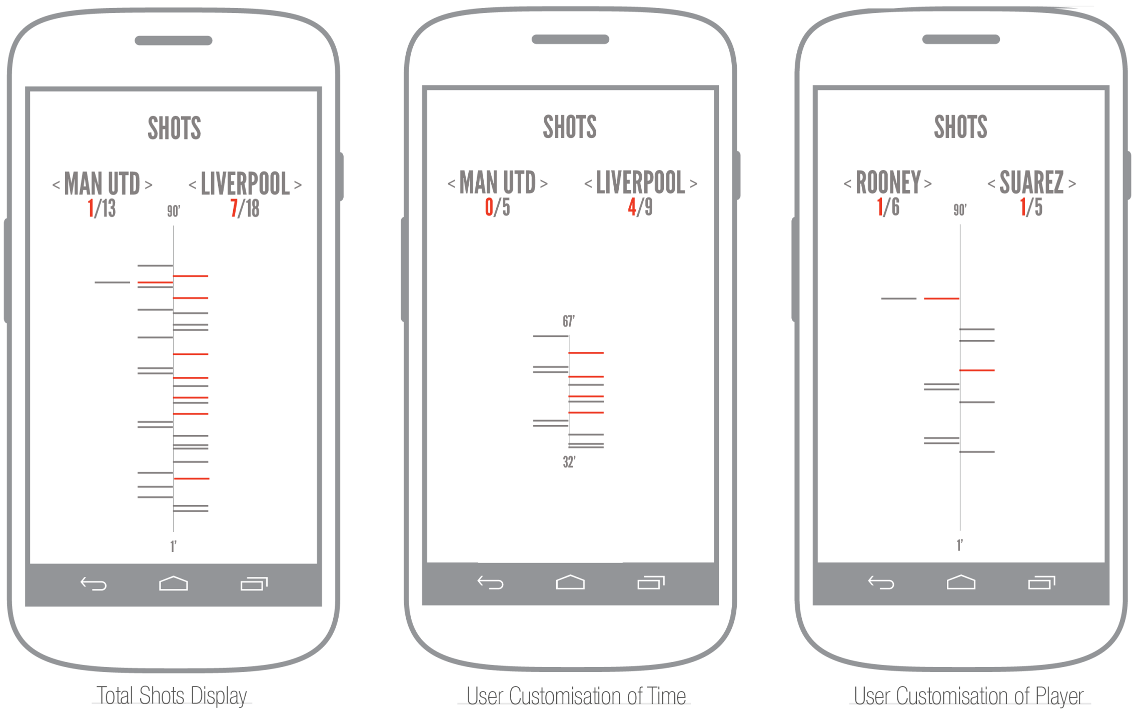
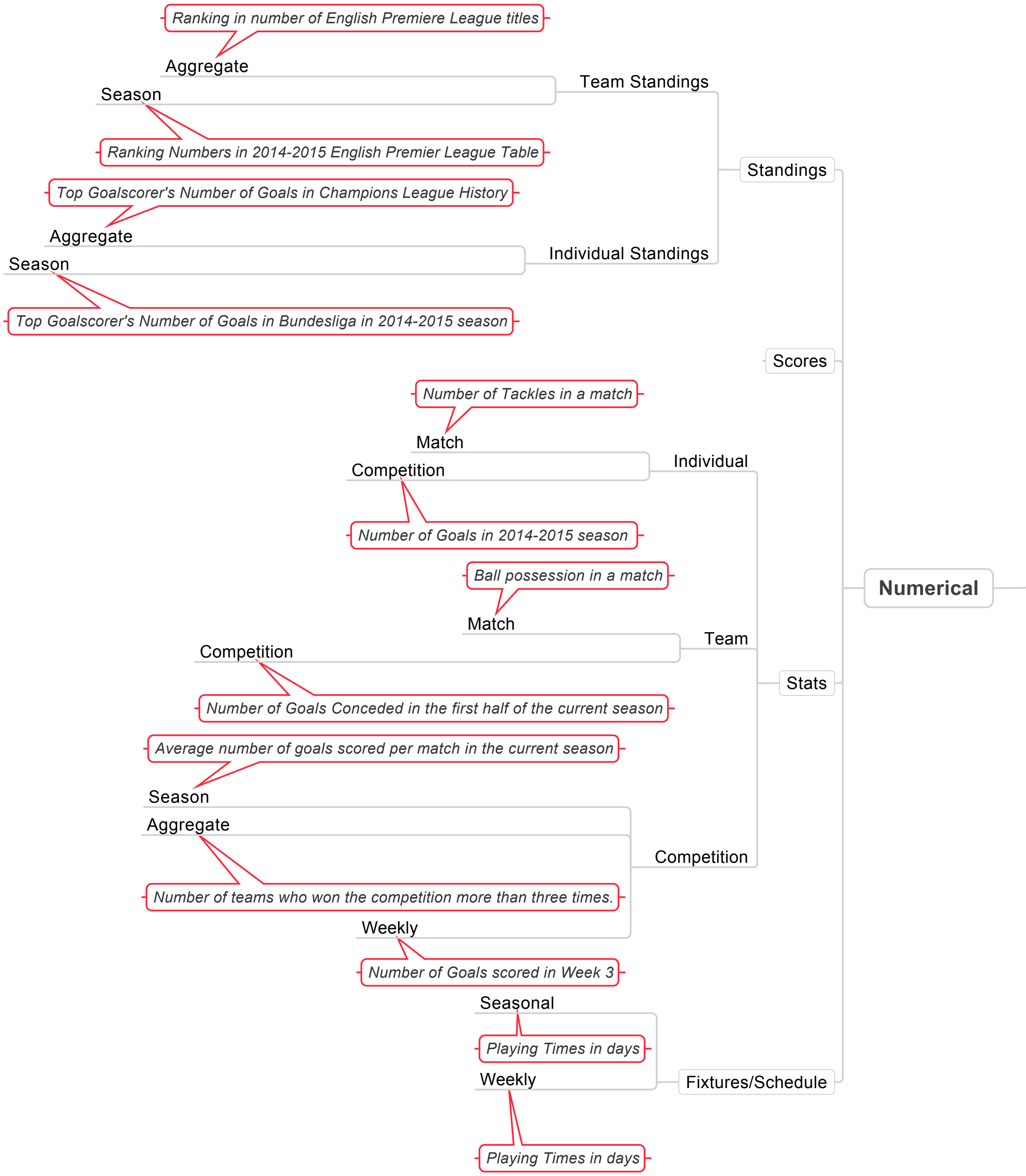
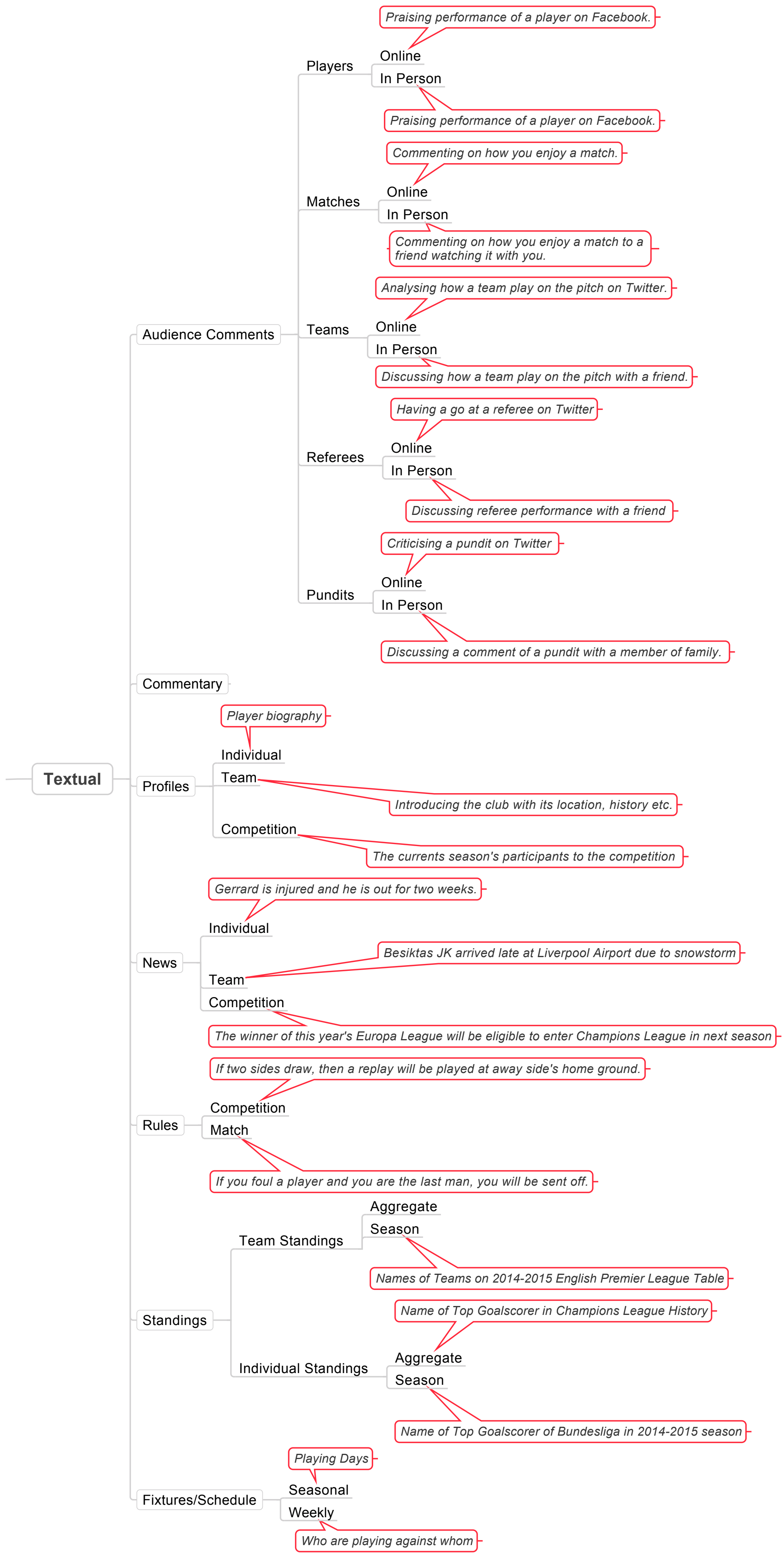


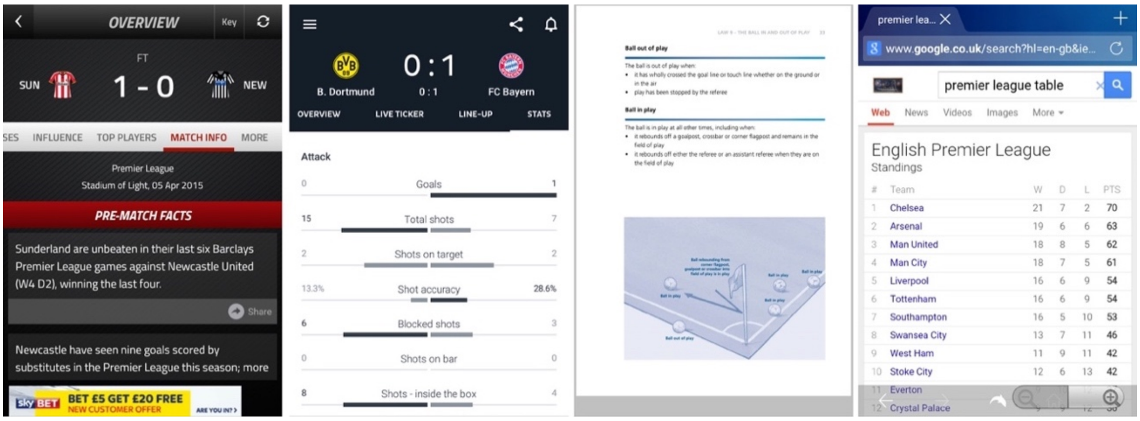
Figure 4.3: Schema to show classification of match-related information and examples.





Textual
Audience Comments
Players
Online
Praising performance of a player on Facebook.
In Person
Praising performance of a player on Facebook.
Matches
Online
Commenting on how you enjoy a match.
In Person
Commenting on how you enjoy a match to a friend watching it with you.
Teams
Online
Analysing how a team play on the pitch on Twitter.
In Person
Discussing how a team play on the pitch with a friend.
Referees
Online
Having a go at a referee on Twitter
In Person
Discussing referee performance with a friend
Pundits
Online
Criticising a pundit on Twitter
In Person
Discussing a comment of a pundit with a member of family.
Commentary
Profiles
Individual
Player biography
Team
Introducing the club with its location, history etc.
Competition
The currents season's participants to the competition
News
Individual
Gerrard is injured and he is out for two weeks.
Team
Besiktas JK arrived late at Liverpool Airport due to snowstorm
Competition
The winner of this year's Europa League will be eligible to enter Champions League in next season
Rules
Competition
If two sides draw, then a replay will be played at away side's home ground.
Match
If you foul a player and you are the last man, you will be sent off.
Standings
Team Standings
Aggregate
Season
Names of Teams on 2014-2015 English Premier League Table
Individual Standings
Aggregate
Name of Top Goalscorer in Champions League History
Season
Name of Top Goalscorer of Bundesliga in 2014-2015 season
Fixtures/Schedule
Seasonal
Playing Days
Weekly
Who are playing against whom

Figure 4.4: A few types of match-related information and visualisations of them.



Another point of interest was whether a low or high-fidelity prototype would be suitable for the tests. As Rudd et. al. (1996, p.80) highlighted low-fidelity prototypes are *"limited function, limited interaction ...efforts ...constructed for illustrating concepts..."* whereas high-fidelity ones are fully interactive products that make users feel as if they are operating on a real product.

4.4.1 The Pilot Experiment

A pilot study (pilot experiment) could be defined as a trial using a small sample, a miniature version that resembles the main study with the purpose of identifying feasibility, required time, various costs, potential pitfalls and errors that could be encountered during the main study (Grady et al., 2013; Van Teijlingen and Hundley, 2002). Simply, by running pilot studies, researchers can recognise whether their plan for the main study seems to work or not for their research purposes in minimal hazard and maximum efficiency (Grady et al., 2013; Van Teijlingen and Hundley, 2002). However, with a small sample, it may not be possible to identify every potential shortcoming (Van Teijlingen and Hundley, 2002). For this PhD project, it was thought that such a type of study might help to understand how prototype testing could be run since I had not conducted such experiment before; therefore, it could be a valuable learning experience. Moreover, with a pilot prototype experiment, I might gain a better idea regarding as to whether adequate data could be generated through paper prototypes. Furthermore, such an experiment would show whether more than one parameter, both interaction gestures and types of visualisation, could be tested with individuals in single experiment. In this experiment, it was decided to use the low fidelity method and use paper prototypes because they were the quickest to produce and would allow rapid iteration and redevelopment. Given the fact that they provide instant feedback from participants, they functioned as a filtering mechanism for the next stage of experiments to be performed with more realistic prototypes (Rudd et. al., 1996).

Two people from *Highwire* volunteered for the pilot experiment. The experiment was conducted on an individual basis. In the experiment, participants were asked to watch two short videos of a pre-recorded football match between Manchester City FC and FC Barcelona that was played on the 24th of February 2015. Each video was two and a half minutes long. After they had watched the first video, the participants were instructed to check *duel* statistics belong to a player, *Vincent Kompany*, via second screen (Fig 4.5). *Shots of Barcelona* was the type of statistical information that they were asked to check after they had watched the second video (Fig 4.7).

Participants were told that they were only allowed to *tap* on the paper prototype to check the relevant stats. The researcher acted as *the computer* that helped the interaction. When participants tapped on the right button on the interface, they were given another ‘paper screen’, which was supposed to be the linked screen on the prototype (Fig 4.5).

Figure 4.5: The prototype screens showing each step that volunteers had to follow.

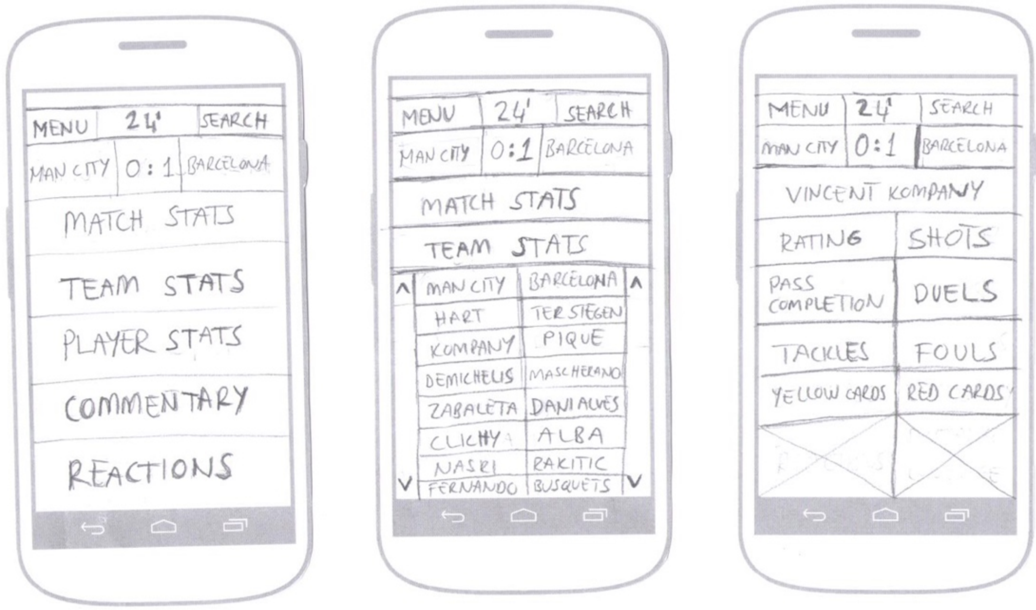
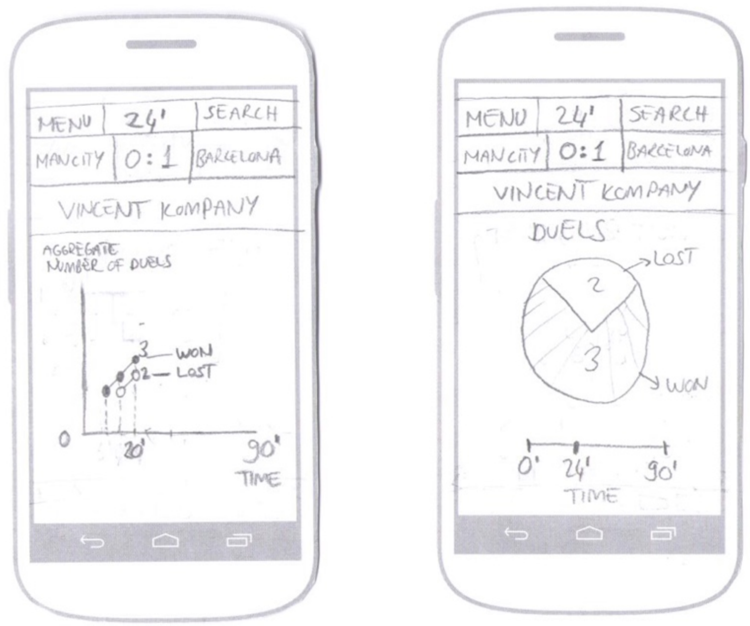


Figure 4.6: The visualisation options that were offered to the participants.



Participants had to tap three times (Fig 4.5) to access the player's statistics (Fig 4.6). Prior to using the prototype, they were not told which links led to the relevant statistics that they were supposed to access. Therefore, in every screen they had to figure out their way to reach the statistics screen, through tapping on the right button to proceed to the next screen. In addition to this, had they not tapped on the right button in every screen, they would not be allowed to proceed to the next screen but given more time to find the right button. Furthermore, they were asked to *think aloud* whilst they were interacting with the prototype. This was considered as an important aspect in such an experiment because through *think-aloud*, participants could express their feelings, emotions and frustrations regarding their interaction with the prototype in every step and therefore, design issues related to the prototype could be identified (Martin and Hanington, 2012).

Participants were faced with two options of visualisation for player statistics when they tapped on the player link of the prototype. One of the visualisations was a time series graph and the other was a pie chart (Fig 4.6). Besides, the participants were told that the statistics that they viewed on the prototype were real. The reason why a time series graph and pie chart were used in comparison was because the first type of visualisation is not seen in the most of football applications and websites, whereas pie charts, as highlighted in the previous chapter, are common in several football apps and websites. Therefore, it was considered worthwhile to test a rare form of visualisation against a familiar type on second screen to see whether the rare type could provide a better experience since familiar visualisations are easy to recognise and understand but lack novelty (Iliinsky, 2010).

After they had viewed the second video, the participants were instructed to interact with a paper prototype again to check certain in-game statistics. Different to their previous interaction with the prototype, they were only allowed to *swipe* (from right to left on the buttons) on the prototype to access the relevant statistics. However, like they did after they had watched first the video, they needed to go through three screens to reach the information that they were asked to retrieve (Fig 4.7). Plus, they were offered to select one of the two different visualisations for the same type statistics and the visualisations were in the same kind in their first interaction respectively (Fig 4.8).

Figure 4.7: The prototype screens showing each step that volunteers had to follow.

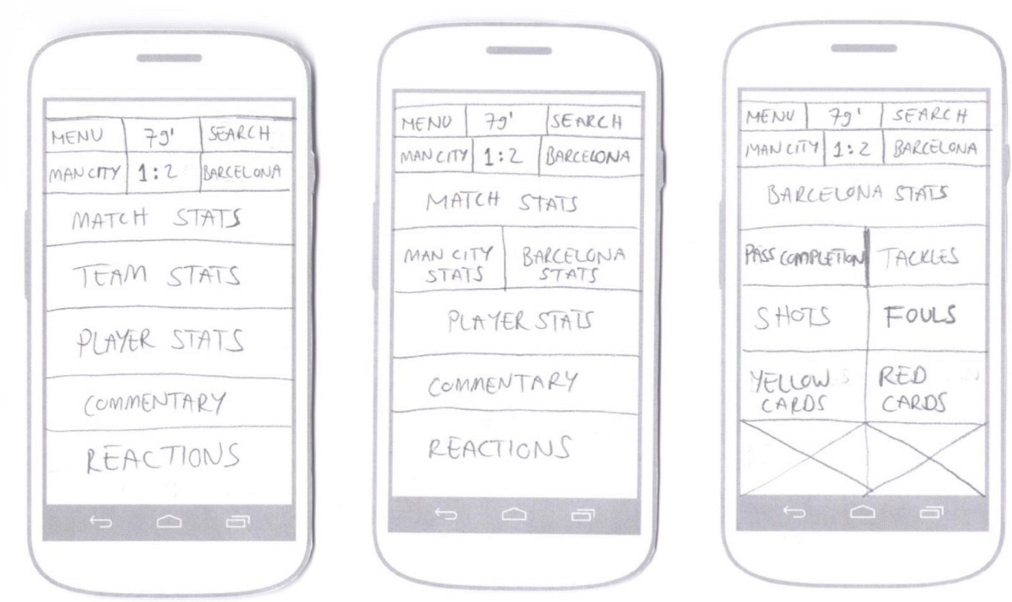
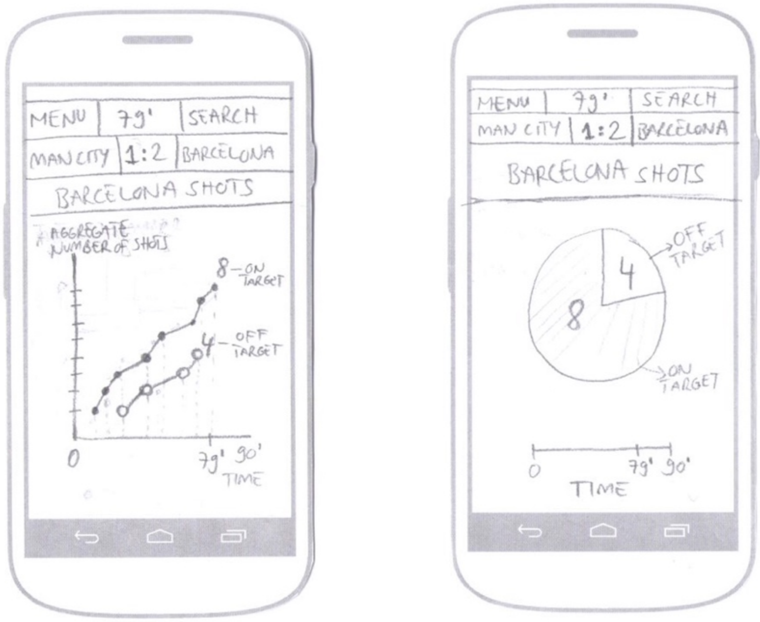


Figure 4.8: The visualisation options that were offered to the participants.



After they had watched the second video and chosen one of the visualisations, they were asked whether they preferred *tapping* or *swiping*. Their answers were noted and then they were given a questionnaire that had eight Likert-scale questions. The first four questions were related to their chosen interaction gesture. They were asked to decide to what extent their favoured gesture was intuitive, learnable, easy to remember and effective. The fifth, sixth and seventh questions regarded their preferred visualisation in both instances of interaction. They were also asked to rate how easily their favoured type of visualisation was to understand, remember and contributed to their understanding of the match. In the final question, participants were asked whether their preferred gesture and visualisation of the prototype enhanced their watching experience.

The questionnaire was followed by a short interview, in which participants were asked their likes and dislikes regarding their preferred gesture and visualisation as well as their ideal gesture and visualisation for this sort of information. These interviews were deemed necessary so that, participants could provide more details on their likes and dislikes, as opposed to questionnaires which are not as efficient as interviews in this respect. With the same reason, they could also describe or identify their expectations better in an interview. The reason why participants were asked about their preferred gesture and visualisation in the questionnaires and mini-interviews was because those details were considered important as they relate to the *subjective (enjoyment)* part of their watching experience.

A few issues arose with the pilot experiment. First, although paper prototypes were practical to provide ideas regarding the likes, dislikes, preferences and frustrations of second screen users in a rapid fashion, the screen transition was not smooth due to the nature of researcher acting as the computer. In addition, as Andrews (2006) highlighted, *thinking-aloud* seemed to alter their behaviour and experience of interaction. Plus, the visualisations on the prototypes had legibility issues that might affect participants' feelings and opinions on how they perceived them. Experiencing such issues that highly likely disrupted the authenticity of the interaction and display of statistics which might have created bias in the results. Such issues were encountered when the participants interacted with the prototype after they watched the video and it could be assumed that they would have caused more problems had the participants interacted with the prototypes when the videos were on.

Another issue that emerged during the experiment was related to how the experiment was conducted. Exposing participants to more than one variable could complicate the results since findings for a variable should be independent from the potential influence of another. Therefore, such experiments that compare two different types of a variable should have been conducted with only one parameter; therefore, separate tests would be needed for types of visualisation and interaction gestures respectively. Additionally, such separation would work better for participants since their focus would not be diverted from one parameter to another in the same experiment.

Lack of an objective measurement regarding the usefulness of visualisations and interaction gestures appeared as another problem after the experiment was conducted. The results that were derived from questionnaires and interviews were based on participants' opinions, feelings and emotions towards the gestures and visualisations; however, they were subjective. The questions were related to enjoyment part of watching experience through second screen but did not give any insight with regard to how effective and memorable they were. Since effectiveness and memorability of a visualisation and effectiveness of an interaction gesture formed the other part of the watching experience they needed to be understood. For instance, without having an objective evaluation, it was not possible to understand whether a type of visualisation was more memorable than another type. In this respect, participants could have been asked questions about whether they could remember the statistics.

4.4.2 The Experiments

After the pilot experiment, the online survey and individual interviews that were conducted to investigate match-related information seeking behaviour (Chapter 3) were reviewed to decide what type of match-related information and which type of visualisations of the match-related information needed to focus. Via the analysis of match-related information seeking behaviour based on the online survey and interviews, it was observed that team statistics should be the focus of the thesis since this sort of match-related information was one of the prominent types of match-related information that people sought during their act of watching football matches on TV. After a review of mobile apps and websites that display team statistics (Chapter 3), it was seen that bar charts and plain numbers appeared to be most used type of visualisation for such match-related information.

In those mobile football apps and websites, users mostly need to use a *tap* gesture to access the match statistics through their mobile devices. There were other means of interaction, such as scrolling and swiping, though they were not utilised as often as tapping was. Since swiping has been used in a few popular mobile apps such as *Snap Chat* and *Tinder*, and it was reviewed as a casual way of interaction in earlier research, it was wondered ever such casual fashion for retrieval of match statistics through second screen while watching football matches on TV might improve the watching experience (Anderson, 2015; Pierce, 2015).

The pilot experiment led me to conduct simpler experiments for understanding how different visualisations and interaction gestures influenced the watching experience. In both visualisation and interaction experiments, participants watched two short videos and interacted with second screen prototypes. In addition to this, they took part in follow-up questionnaires and mini interviews. In the following sections, details regarding how visualisation and interaction experiments were conducted are presented. Furthermore, more realistic prototypes were used in the experiments since paper prototypes that were used in the pilot experiment were not appropriate to understand the effects of different visualisations and interaction gestures on the watching experience due to their lack of realism.

4.4.2.1 Visualisation Experiments

Five visualisation experiments were conducted in between September 2015 and January 2017. Seventy-four people (fifty-four males, twenty females) were recruited for the visualisation experiments. They were mainly undergraduate and postgraduate students and staff at Lancaster University from different nationalities and cultural backgrounds.

Moreover, their average age was 31.5 (SD: 10.9). The youngest participant was 14 and the oldest was 67. In addition to this, their level of fandom, interest in the watching of matches on TV and second screen usage during their act of watching football matches were varied; that is, not all of them were frequent watchers of football matches on TV and users of second screen whilst they were watching. However, they all declared that they had a certain interest of watching football matches on TV and most of them were using second screen occasionally or often. Furthermore, they were not paid for their participation in the visualisation experiments.

The participants undertook the visualisation experiments on an individual basis. During the experiments, each of them were asked to watch two short videos from a pre-recorded football match. Each video had the duration of two and a half minutes. Depending on the experiment, they interacted with a second screen prototype when they were watching the short videos.

The majority of the participants stated that they had not watched the matches shown before the experiment and the rest declared that they did not remember the matches though they had watched them previously.

The experiments were conducted in two identical meeting rooms at the *LICA* Building of *Lancaster University*. During the experiments, participants watched the short videos on a Dell 2213 model monitor that acted as *TV*. The monitor was positioned on the meeting room table and each participant was seated in front of it with an approximate distance of 1.5 metres. Apart from that, a *Macbook Pro Retina Display* laptop that was connected to the monitor was used to play the videos.

The second screen prototype that participants interacted with whilst they were watching the videos or after they had watched the videos was a realistic interface that displayed match statistics on a *Google Nexus 4* smartphone. The smartphone's screen size and resolution were 4.7" and 768x1280 pixels respectively. This smartphone was used to host the interface that displayed the match statistics instead of a tablet computer or laptop since, as the findings from the first part of the previous chapter, *analysis of information seeking behaviour*, smartphones appeared to be the most popular mobile device used as second screen to seek match-related information. On top of that, a mobile app, *Pop*, was used to display the realistic interface that allowed participants to interact with and view match statistics on the smartphone.

After participants had watched each short video and interacted with the prototype, they were given questionnaires to complete. The questionnaires (Appendix 3) had two group of questions. The first group had two questions that related to the statistics that the participants had checked on the prototype. The second group were four Likert-scale questions which asked participants to rate the visualisations in four different aspects. A short interview with each participant followed the completion of second questionnaire. In the mini-interviews, participants were asked four questions regarding their preferences, second screen experiences and expectations in the context of visualisations of match statistics that they had encountered during the experiments. These interviews were conducted in a semi-structured fashion with extra questions asked to participants to make them clarify their answers if their answers were not clear.

The visualisation experiments were in two categories. In the first category, *grey bar charts* (*GBC*) used to depict match statistics were compared to grey plain numbers (*GPN*) used for the same purpose. This category had 3 different *GBC vs GPN* experiments. The first experiment was *GBC vs GPN, On-Play, Fixed Order* experiment. *GBC vs GPN, On-Play, Random Order* and *GBC vs GPN, Off-Play, Fixed Order* experiments followed the first experiment.

In the second category of visualisation experiments, there were two experiments. In these experiments, bar charts with two-colour schemes, *coloured bar charts* (*CBC*) and *team-coloured bar charts with repositioned numbers* (*TCBC*), were compared to *grey plain numbers* (*GPN*). Using the results of the first group of experiments in which *GBC* and *GPN* were compared, the direction of iteration for further experiments appeared as *colour* and *relocation of data labels (numbers) on bar charts*. Hence, this second group of experiments were conducted. In the first experiment of the second category of the visualisation experiments, *CBC,* which are bar charts with three different two-colour schemes (*bar charts in team colours*, *bar charts in colour-blind-safe team colours* and *bar charts in warm-cold colours*), were compared against *grey plain numbers* (*GPN*). In the second experiment, *team-coloured bar charts with repositioned numbers* (*TCBC*) were compared to *grey plain numbers* (*GPN*).

4.4.2.1.1 Grey Bar Charts (GBC) vs Grey Plain Numbers (GPN)

As it was stated above, grey bar charts (GBC) and grey plain numbers (GPN), were used as match statistics visualisations, and were compared in three different experiments. The three experiments differ from each other in two aspects: Time of second screen interaction and order of visualisation. First, in two of three experiments, participants interacted with the second screen prototype while they were watching the short videos. Therefore, the two experiments were named as *GBC vs GPN, On-Play, Fixed Order* and *GBC vs GPN, On-Play, Random Order*. The phrase *On-Play* was used to show the reader that in these two experiments, participants had to interact with the prototype to view match statistics while they were watching the match. Likewise, the third experiment was named as *GBC vs GPN, Off-Play, Fixed Order* as participants used the prototype to access the match statistics after they had watched the short videos. The *GBC vs GPN, Off-Play, Fixed Order* experiment was conducted because second screen interaction occurs during periods of time that is not in the game-play but still in the watching experience such as *just before the kick-off*, long breaks in the match e.g. *half-time* and *just after the final whistle*.

The second feature that differentiates these three experiments was the order of visualisations that participants were faced with. In two experiments, participants viewed the match statistics in fixed order. In *GBC vs GPN, On-Play, Fixed Order* and *GBC vs GPN, Off-Play, Fixed Order* experiments, participants always viewed the match statistics in *grey bar charts* (*GBC*) on second screen while they were watching the first video or after they had watched it. The people who took part in these two experiments always viewed the match statistics in *grey plain numbers* (*GPN*) while they were watching the second video or after they had watched it. Therefore, the phrase *Fixed Order* was added to those experiments to clarify that participants, in the *GBC vs GPN, On-Play, Fixed Order* and *GBC vs GPN, Off-Play, Fixed Order* experiments, viewed the match statistics on second screen in a fixed order of visualisations. On the other hand, in the *GBC vs GPN, On-Play, Random Order* experiment, half of the participants viewed the match statistics in GBC whilst they were watching the first video and GPN for the second video and the other half viewed the match statistics in the reverse order GPN during the first video and GBC when they watched the second video. The order of what the participants were exposed to the visualisations was randomised. For instance, the first participant saw the order as *GBC first, GPN second* whereas the following 4 participants viewed the match statistics in *GPN first, GBC second* order. The *GBC vs GPN, On-Play, Random Order* experiment was conducted to see whether the learning factor due to fixed order of visualisations would create significantly biased results of the other two visualisation experiments in which the order of visualisation was fixed.

4.4.2.1.1.1 GBC vs GPN, On-Play, Fixed Order

Fourteen people were recruited for this experiment. They watched short videos from a pre-recorded match between *England* and *Switzerland* that was played on the 8th of September 2015 as part of the *Euro 2016* tournament qualification. The first video from this match that was viewed was the segment between 25’30” and 28’00” from the first half of the match. The second video that they watched was the part between 70’30” and 73’00” from the second half of the same match. Those short videos were shown because of the following reasons: First, they belonged to different parts of the match; therefore, the match statistics that belonged to each video were different. Secondly, each video accommodated both dull and exciting moments of gameplay. Since viewer engagement to TV content varies in terms of interest, using short videos that have a mix of in-game events was thought to help to sustain authenticity in the watching experience.

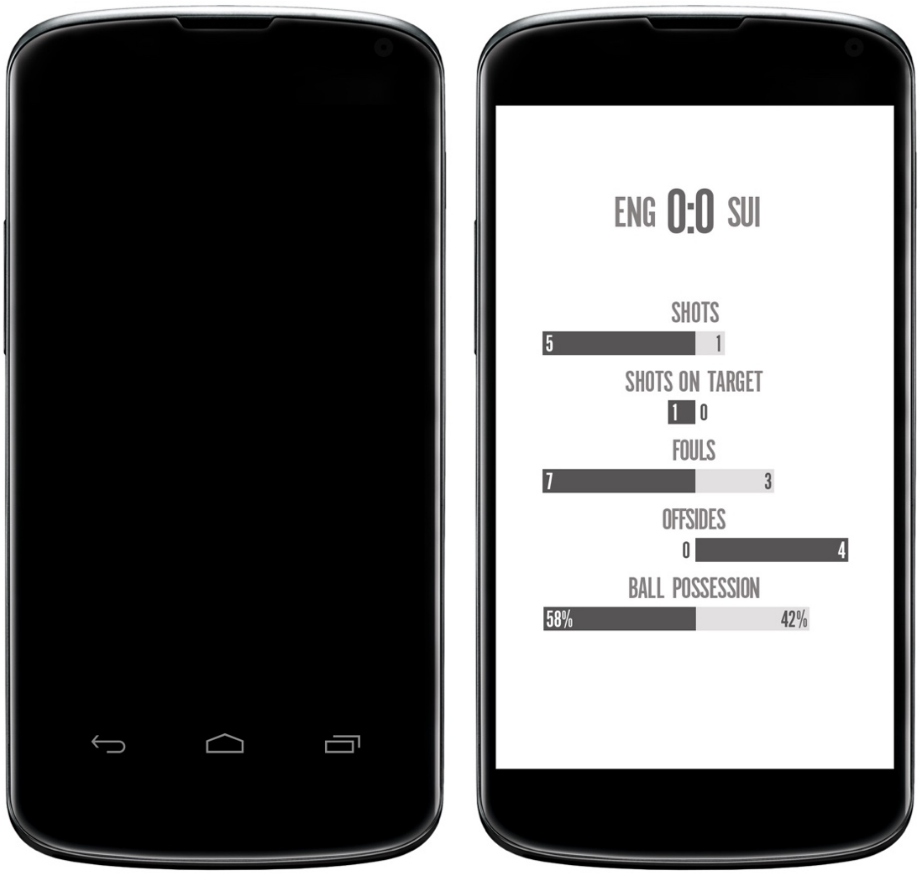
Prior to watching the first short video, participants had been instructed to interact with the second screen prototype to check 2 types of match statistics, *the number of shots made by England and Switzerland* and *the ball possession percentage of each team*. In addition, before they watched the second video, they had been told to use the prototype to access the following types of match statistics: *number of fouls* and *off-sides of England and Switzerland*. Other than that, along with the instructions of the type of statistics that participants needed to access via the prototype, they were told not to try to memorise the statistics but learn them. Furthermore, they were told not to focus to much on second screen and try to keep their focus mainly on the TV since this is the natural behaviour of football audiences. They simply were required to keep to their natural watching behaviour and not be obsessed with the match statistics whilst they were watching the match and using second screen.

The prototype that showed the match statistics to the participants was designed to allow participants to have an easy interaction experience since the focus of the experiment was to compare two different visualisations. Hence, participants could view the match statistics with a single tap on the phone each time they were watching the videos (Fig 4.9, 4.10).

Before they watched the videos, participants had been told that they could access the match statistics at any time whilst they watched the videos. However, in addition, they had been informed that they could retrieve the match statistics only once while they were watching the videos. For instance, P8 could choose to use the device at 25’45” to see statistics of the game but after that moment, another interaction with the device was not permitted. The reason was to recreate a sense of real-time synched match information. Otherwise if a user wanted to interact with the prototype another time within the duration of the same clip e.g. 27’36”, she would see the same numbers; therefore, the authenticity of accessing real match statistics access would be lost although putting limitation to interaction is not sound realistic either. Such disadvantage caused by this limitation could be tolerated for short videos, as from early work it is evident that viewers mainly concentrate on the TV (Holmes et. al., 2012).

As it was explained before, participants were given a *Google Nexus 4* smartphone to access the match statistics while they were watching the short videos in the experiment. Whilst watching the first video, they saw the match statistics in *grey bar charts* (*GBC*) (Fig 4.9). Moreover, before they started watching the first short video, they had been given the smartphone in *black screen state* (Fig 4.9) and they were told to ignore the buttons of the operating system that were at the bottom of the screen (Fig 4.9). In addition, they were instructed that the whole of the black screen, excluding the buttons at the bottom, was the hotspot and a single tap anywhere on the black screen would take them to the match statistics screen (Fig 4.9). Such black screen state, which could be perceived as *unlocking the phone*, was included to add realism to the interaction mechanism of accessing information on second screen. It should be noted that the black screen was included in all five visualisation experiments for participants to tap and display the match statistics.

Figure 4.9: The 'unlock' screen (left) and match statistics screen (right) for the first short video in *GBC vs GPN, On-Play, Fixed Order* experiment.



It was important to follow a minimalist style when designing the match statistics screen to reduce any bias. To ensure this, elimination of subjective factors was essential. Therefore, use of different colours and any decorative visual elements was minimal. Only two different tones of grey were used to depict bar charts to highlight the leading side in number. Regarding to typography, a condensed type of sans-serif typeface, *Alternate Gothic* was preferred because it was considered as a proper "…*display face [and]… [it] embraces loud and excitable aesthetic of twentieth-century newsmedia."* (Lupton, 2014, p.17-18). Moreover, since it is a condensed variant of *Franklin Gothic* typeface, it preserves the generic and solid visual look of *Franklin Gothic* that offers no association with any context and a good standard of legibility to readers (Fonts.com, 2017; Ayiter, 2005). Also, the number of types of match statistics were limited to five since Clark and Bolt (2010, p.60) highlighted: *"...a bar chart works best with four to six categories; attempting to display more than six categories on a bar graph can lead to a crowded and confusing graph…"* Additionally, the bars that depicted higher values in each type of match statistic were in a darker tone of grey and the bars that displayed smaller values were in a lighter tone of grey. This was due to the following that was pointed out by Ware (2013, p.117): *"...[S]tronger visual effects should be used to show greater quantities. If using color saturation to encode numerical quantity, use greater saturation to represent greater numerical quantities…"* Furthermore, the numbers were positioned on the edges of bars to make the figures more distinguishable from each other using the Gestalt principles of *proximit*y and *similarity* as it was highlighted:

> *"According to the Gestalt law of proximity, items that are relatively closer to one another in the visual field tend to be grouped together… According to the Gestalt law of similarity, items that are similar tend to be perceptually grouped together…" (Coren and Girgus, 1980, p.406)*

After participants had watched the first short video and viewed the match statistics while the video was playing, they were given a questionnaire containing six questions to answer. In the first couple of questions, participants were asked whether they could remember verbatim match statistics and comparison of match statistics, that they had been instructed to check via the prototype, while they were watching the first video. Apart from these two questions, there were four other questions that were Likert-scale questions in which participants were asked to evaluate GBC in the following aspects:

understandability, *memorability*, *contribution to the understanding of the match* and *the level of enhanced watching experience provision*.

After they had completed the questionnaire, participants were asked to watch the second short video from the same match, and interact with the prototype to view match statistics while they were watching the second video. Whilst watching the first video, the participants could check the statistics through the second screen at any time during the video but only once. This time, they were asked to check *the number of fouls and off-sides* that each team had. Similar to their way of interaction during the first video, a single tap was enough to display the match statistics on the prototype (Fig 4.10). This time, the match statistics were depicted in grey plain numbers (Fig 4.10).

Figure 4.10: The *unlock* screen (left) and *match statistics* screen (right) for the second short video in *GBC vs GPN, On-Play, Fixed Order* experiment.

After they had watched the video and viewed the match statistics during the video, they were given another questionnaire that was identical in structure to the first questionnaire. The type of questions that participants were asked were the same. Participants were told to check specific match statistics and in the first couple of questions they were asked whether they could remember them and be able to compare them. The other four were Likert-scale questions that required participants to evaluate grey plain numbers (GPN) in the aforementioned aspects.

Mini-interviews followed the completion of the second questionnaire. First, participants were asked whether they preferred GBC or GPN. The following question requested their likes and dislikes for their preferred visualisation. In the third question, they were expected to elaborate on their reasons for their answer given in the sixth question of the questionnaire about their preferred visualisation. For example, if a participant preferred GBC and circled *4* (*agree*), she was supposed to tell her reasons why she gave that answer. At the end of the interviews, they were required to answer whether their choice would be their ideal visualisation. If it was not, they were asked to state whether they could imagine any form of visualisation as their ideal for in-game information.

4.4.2.1.1.2 GBC vs GPN, On-Play, Random Order Experiment

GBC vs GPN, On-Play, Random Order was conducted almost identically to the previously explained experiment, *GBC vs GPN, On-Play, Fixed Order*. There was only one difference between this experiment and the *GBC vs GPN, On-Play, Fixed Order* experiment. In *GBC vs GPN, On-Play, Fixed Order* experiment, participants always saw the match statistics in *grey bar charts* (GBC) whilst they were watching the first short video. They viewed the match statistics in *grey plain numbers* (GPN) during their act of watching the second short video. Unlike the *GBC vs GPN, On-Play, Fixed Order* experiment, in this experiment, the order of visualisations was randomised so that some participants saw the match statistics in GPN when they watched the first video. They encountered the match statistics in GBC when they watched the second video (Fig 4.11). The rest of the participants saw the visualisations in the order that was seen in *GBC vs GPN, On-Play, Fixed Order* experiment (Fig 4.12). In addition to this, it should be noted that half (seven) of the participants in this experiment saw GBC first and GPN second, the other half saw GPN first and GPN second. Furthermore, the structural details of the *GBC vs GPN, On-Play, Random Orde*r experiment was same as the structural details of *GBC vs GPN, On-Play, Fixed Order*, e.g. the type of match statistics that participants were instructed to check, the short videos, the content of questionnaires, mini-interviews etc. were identical to the *GBC vs GPN, On-Play, Fixed Order* experiment.

Figure 4.11: The order visualisations for half of participants in *GBC vs GPN, On-Play, Random Order* experiment.

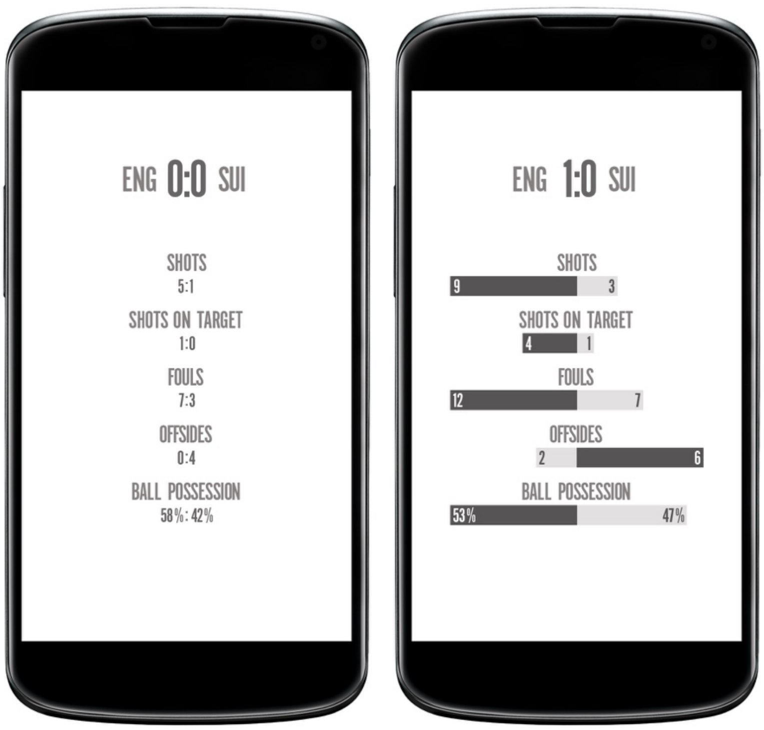
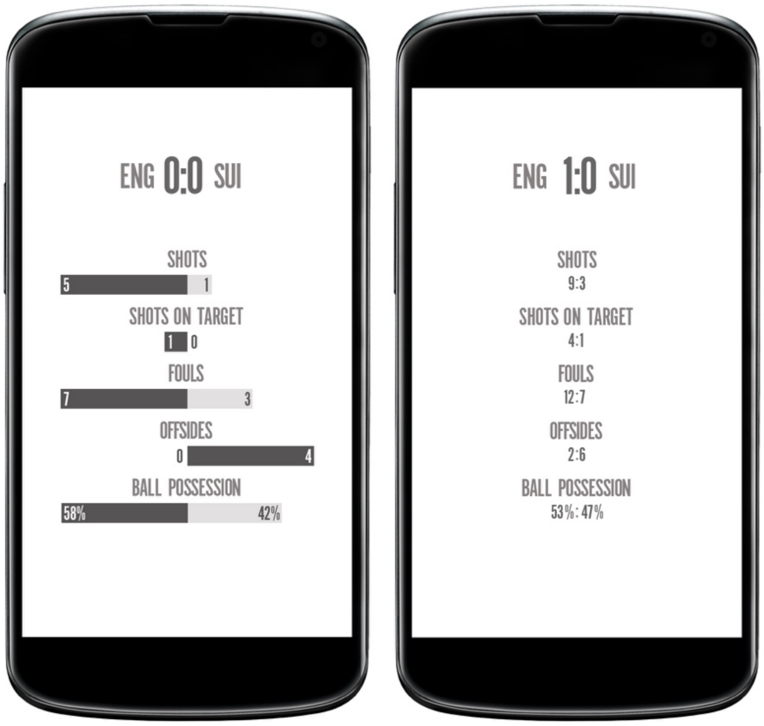


Figure 4.12: The order visualisations for the other half of participants in *GBC vs GPN, On-Play, Random Order* experiment.



4.4.2.1.1.3 GBC vs GPN, Off-Play, Fixed Order Experiment

As explained above, the only difference between the experiments, *GBC vs GPN, On-Play, Fixed Order* and *GBC vs GPN, On-Play, Random Order* was the order of visualisations that participants were faced with. The only difference between this experiment and *GBC vs GPN, On-Play, Fixed Order* is the timing of accessing match statistics on second screen. In this experiment, unlike the *GBC vs GPN, On-Play, Fixed Order* experiment, participants used the prototype to access the match statistics *after* they watched the short videos. Other than this difference in timing of interaction, this experiment was identical to *GBC vs GPN, On-Play, Fixed Order* experiment including the fixed order of visualisations (Fig 4.9, 4.10), the types of match statistics that the participants had to check, the questionnaires, mini-interviews etc. The following table shows the differences between these three experiments in which *grey bar charts* (GBC) were compared to *grey plain numbers* (GPN).

Table 4.1: The differences between 3 experiments.

Visualisation Experiment	Order of Visualisations	Viewer Interaction with Second Screen
GBC vs GPN, On-Play, Fixed Order	Fixed: GBC first, GPN second	During the act of watching the short videos
GBC vs GPN, On-Play, Random Order	Random	During the act of watching the short videos
GBC vs GPN, Off-Play, Fixed Order	Fixed: GBC first, GPN second	After the act of watching the short videos

4.4.2.1.2 Two-Coloured Bar Charts (CBC) vs GPN, On-Play, Random Order

This experiment was conducted in the same manner with *GBC vs GPN, On-Play, Random Order* experiment. The number and length of the short videos that were shown to the participants in this experiment were same as with the *GBC vs GPN, On-Play, Random Order* experiment each participant watched two short videos and each video was two and a half minutes long. However, the short videos were from a different match, England vs Russia that was played on the 11th of June 2016. The first and second videos were the gameplay moments between 22'00" and 24'30" and 80'00" and 82'30" respectively. These short videos were selected for the same reasons that were highlighted before: Each video held different statistics and both had a mix of boring and exciting in-game events.

Compared to the *GBC vs GPN, On-Play, Random Order* experiment, in this experiment, the types of match statistics that participants were asked to access and learn in each video were slightly different. In the *GBC vs GPN, On-Play, Random Order* experiment, participants checked the number of shots made by England and Switzerland and the ball possession percentage of each team, using the prototype when they watched the first video. Plus, they checked the number of fouls and off-sides of England and Switzerland whilst they were watching the second video. However, in this experiment, participants had been instructed to check number of *off-sides* and *shots* of England and Russia whilst they were watching the first video and *ball possession rates* and *number of fouls* of both teams for the second video. Similar to the *GBC vs GPN, On-Play, Random Order* experiment, participants could check the statistics anytime during the videos but only once.

Different than *GBC vs GPN, On-Play, Random Order* experiment, in this experiment, there were eighteen participants. Another difference between this experiment and *GBC vs GPN, On-Play, Random Order* was the colour scheme of bar charts. Six participants saw the match statistics in team-coloured bar charts and grey plain numbers (GPN) (Fig 4.13), another 6 in colour-blind-safe-team-coloured bar charts and grey plain numbers (GPN) (Fig 4.14) and the rest in warm-cold-coloured bar charts and grey plain numbers (GPN) (Fig 4.15). Similar to GBC vs GPN, On-Play, Random Order experiment, they saw the visualisations in random order. Furthermore, they had to tap once on the black screen state of prototype to display the match statistics, previously explained for the *GBC vs GPN, On-Play, Fixed Order* experiment.

Figure 4.13: Team coloured bar charts vs grey plain numbers (GPN).

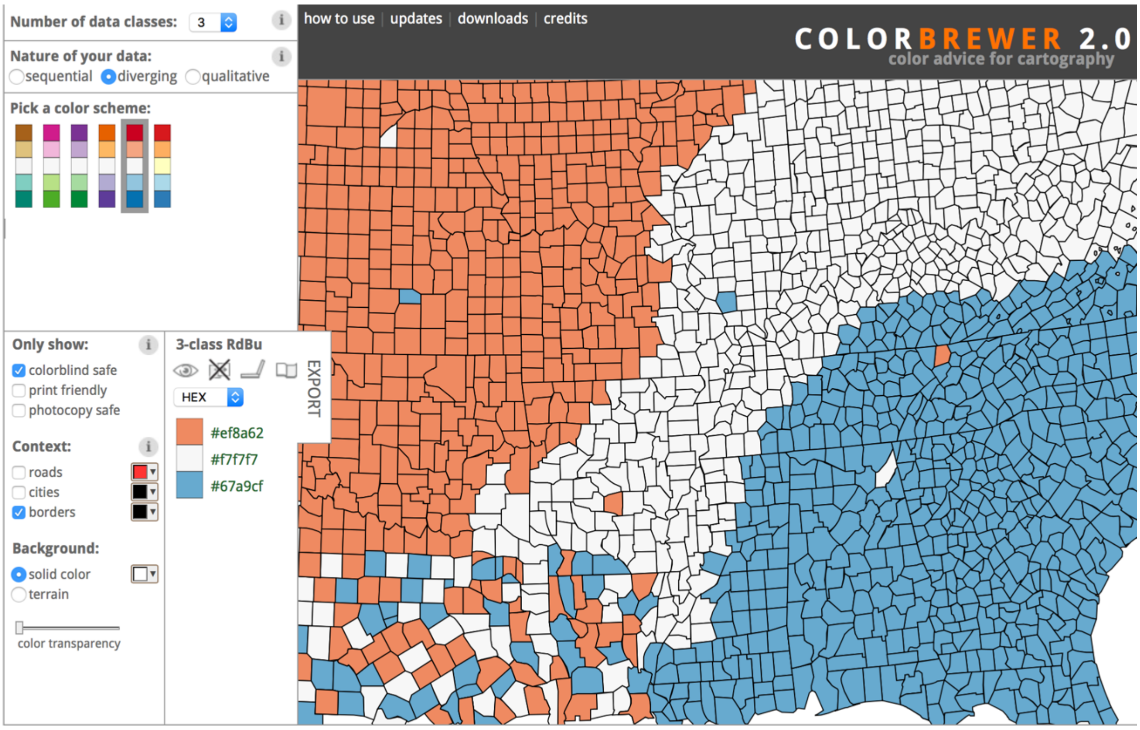
Figure 4.14: Colour-blind-safe-team-coloured bar charts vs grey plain numbers (GPN)

Figure 4.15: Warm-cold coloured bar charts vs grey plain numbers (GPN)

The reason to compare team coloured bar charts and GPN was due to the participant feedback for GBC in the *GBC vs GPN* experiments.

The reason to use colour-blind-safe-team colours on bar charts (Fig 4.14) was to see whether participants who were not colour-blind would react negatively towards the colour-blind-safe team colours because those colours were for colour-blind people. Basically, it was a way of seeing whether colours that were close to team colours on bar charts would provoke any reaction. Colour-blind-safe team colours used on the bar charts in this experiment were adapted through an online application, *ColourBrewer*, which was created as a colour advice tool for cartography. First, the nearest colour scheme among the *diverging* options for England vs Russia was selected so that the colour scheme differentiated the sides. Second, the number of data classes were chosen as the minimum: *3*. Then, the colour-blind safe filter was selected and the 3-colour-scheme appeared as the result that could be used on the bar charts in this experiment (Fig 4.16).

Figure 4.16: Colour-blind-safe team colours that were gathered via *ColorBrewer*.



The following reasons were considered to apply a warm and cold colour scheme on bar charts to compare it against GPN (Fig 4.15): First, there are certain types of statistics that could be considered as positive and negative. For instance, fouls have rather negative connotation compared to ball possession. Since Clarke and Costall (2008) found that warm colours, such as yellow, evoked more positive feelings and according to Birren (1961), blue might be associated with more negative feelings, such as sadness. It was wondered how certain types of match statistics for both teams associated with warm and cold colours would affect the perception and enjoyment of participants. Besides, such colour scheme was considered because Ware (2013, p.124) pointed out: *"…Almost everyone can distinguish colors that vary in a yellow–blue direction."*

4.4.2.1.3 Team Coloured Bar Charts with Repositioned Numbers (TCBC) vs Grey Plain Numbers (GPN)

This experiment was almost identical to *CBC vs GPN, On-Play, Random Order* experiment with two exceptions. Unlike the *CBC vs GPN, On-Play, Random Order* experiment, there were less participants (fourteen) and there was only one type of bar charts that was compared to grey plain numbers (GPN) (Fig 4.17). Apart from that, the short videos, the types of match statistics that were checked by participants in each video, questionnaires, mini-interviews and other elements that formed the experiment were the same as the *CBC vs GPN, On-Play, Random Order* experiment.

Figure 4.17: Team-coloured bar charts with repositioned numbers (TCBC) vs grey plain numbers (GPN).

The differences between *CBC vs GPN, On-Play, Random Order* and *TCBC vs GPN, On-Play, Random Order* experiments are summarised in the table below.

Table 4.2: The differences between *CBC vs GPN, On-Play, Random Order* and *TCBC vs GPN, On-Play, Random Order* experiments.

Visualisation Experiment	Number of Participants	Type of Bar Charts
CBC vs GPN, On-Play, Random Order	18	*Team coloured bar charts (6 participants), *Colour-blind-safe team coloured bar charts (6 participants) *Warm-cold-coloured bar charts (6 participants)
TCBC vs GPN, On-Play, Random Order	14	*Team coloured bar charts with repositioned numbers

In this experiment, team colours were used on bar charts based on participant feedback on CBC in the previous experiment, such a colour scheme on bar charts seemed to be less problematic than the other two colour schemes. In addition, data labels on bar charts i.e. numbers were repositioned to the centre of the prototype screen. Such repositioning was done for two reasons. First, one participant from *GBC vs GPN* experiments complained regarding the placement of numbers on bar charts that he had to look right and left to read the values. Second, bar charts in the *CBC vs GPN, On-Play, Random Order* experiment did not yield a superior recalling performance against grey plain numbers (GPN); therefore, it was thought that adding two-colour schemes would not be enough for bar charts to make a significant difference over GPN in terms of recalling match statistics. Consequently, repositioning the numbers on bars to the centre of the screen, having a similar positioning as GPN on the screen was thought to increase the participants' recalling performance of match statistics in bar charts against GPN.

4.4.2.2 Interaction Experiments

In this section, details regarding interaction experiments are presented. Similar to the visualisation experiments, the interaction experiments had three phases: Prototype experiments, questionnaires and mini interviews. The experiments were conducted inbetween October and December 2015. Twenty-eight (Twenty-one male, seven female) unpaid volunteers participated in the research. Their average age was 30.9 (SD: 10.2). The youngest participant was 21 and oldest was 58. They were a mix of undergraduate and postgraduate students, and members of staff at Lancaster University. They had different nationalities and cultural backgrounds. Similar to the visualisation experiments, their level of fandom, interest to the watching football matches on TV and second screen usage during their act of watching football matches were not same. Some of them were frequent watchers of football matches on TV and users of second screen whilst they were watching and others were very infrequent watchers and users. However, they all declared that they have a certain interest in watching football matches on TV and most of them were using second screen occasionally or often.

4.4.2.2.1 Swiping vs Tapping, On-Play, Fixed Order

The structure of the *Swiping vs Tapping, On-Play, Fixed Orde*r experiment is almost identical to the *GBC vs GPN, On-Play, Fixed Order* experiment. For instance, each participant watched the same number (two) of short videos as the participants watched for the *GBC vs GPN, On-Play, Fixed Order* experiment. Moreover, the short videos that participants watched in this experiment were the same videos that people viewed in the *GBC vs GPN, On-Play, Fixed Order* experiment. Additionally, the length of each short video in the *Swiping vs Tapping, On-Play, Fixed Order* experiment was same as the *GBC vs GPN, On-Play, Fixed Order* experiment: Two and a half minutes. Besides, similar to the people who participated to the visualisation experiments, none of the participants declared that they had watched the match or that they remembered the match before the experiment.

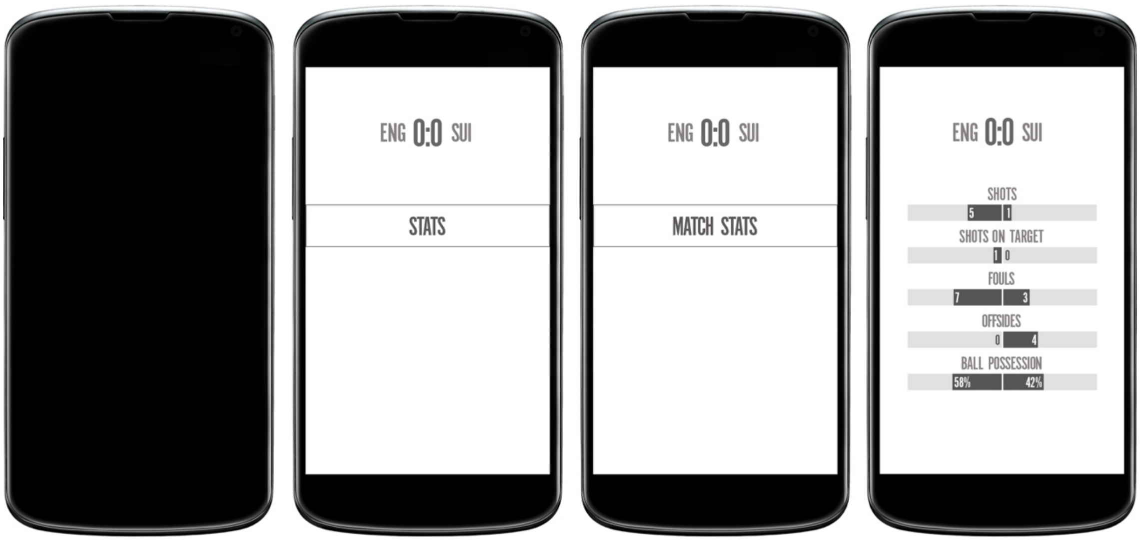
Similar to *GBC vs GPN, On-Play, Fixed Order* experiment, 14 participants were recruited for this experiment. Other similarities between this experiment and *GBC vs GPN, On-Play, Fixed Order* are the following: During this experiment, first, the participants watched the first short video. Whilst they were watching this short video, they interacted with a second screen prototype to access match statistics. Moreover, they could interact with the prototype to check match statistics at any time during the video but only once. After the viewers had watched the video, they were given a questionnaire to complete. After the questionnaire, they watched the second short video and interacted with the prototype to retrieve match statistics at any time they chose but again only once. In addition, prior to watching each video, participants had been told to access specific match statistics. The type of match statistics that they were supposed to check through the prototype were the same types in the *GBC vs GPN, On-Play, Fixed Order* experiment: For the first video, it was *number of shots* and *ball possession rate* for England and Switzerland. In the second video, they checked *number of fouls* and *off-sides* for same both teams. Similar to the *GBC vs GPN, On-Play, Fixed Order*, they were told not to memorise the statistics that they were supposed to check, but learn them while keeping their main focus on the match because football audience generally do not want to be distracted while they are watching football matches on TV.

There is a significant difference between this experiment and the *GBC vs GPN, On-Play, Fixed Order* experiment. In *GBC vs GPN, On-Play, Fixed Order* experiment, participants just needed to *tap* once on the prototype to retrieve the statistics whilst they were watching the short videos on TV. In *Swiping vs Tapping, On-Play, Fixed Order* experiment, participants were expected to retrieve the statistics through second screen by using one of the gestures (swiping or tapping) to navigate through menus whilst they were watching the short video on TV. For instance, P1 needed to only *swipe* from right to left on the prototype screen to pass through the menus and view the match statistics during the first video. She needed to navigate around the menus with *tapping* on the prototype to view the statistics whilst she was watching the second clip.

In the visualisation experiments, a *Google Nexus 4* smartphone was used by participants as second screen to access the match statistics. In this experiment, *Swiping vs Tapping, On-Play, Fixed Order*, the same smartphone was used by participants to access the match statistics. Unlike the visualisation experiments, another prototyping app, *Marvel*, was used to accommodate the interface of match statistics since it worked better in menu transitions compared to *Pop* which was used in the visualisation experiments. The layout of menu and match statistics screens were designed by the researcher.

All participants had to *swipe* from right to left on the buttons for three times to reach the match statistics screen while they were watching the first video (Fig 4.18). The navigation was designed in a way so that they needed to pass through 3 screens (Fig 4.18) to reach the match statistics, since in mobile football apps and websites, the users needed to go through a few screens to reach a similar type of match-related information. As the image below (Fig 4.18) shows, participants had to swipe from right to left anywhere on the black screen first. When they swiped, the screen with the *stats* button appeared (Fig 4.18). On this screen, they needed to swipe from right to left on the *stats* button to view the next screen (Fig 4.18). Next, they saw the *match stats* button and needed to swipe from right to left on this button to view the match statistics (Fig 4.18). As a result of this interaction, they finally reach the match statistics (Fig 4.18).

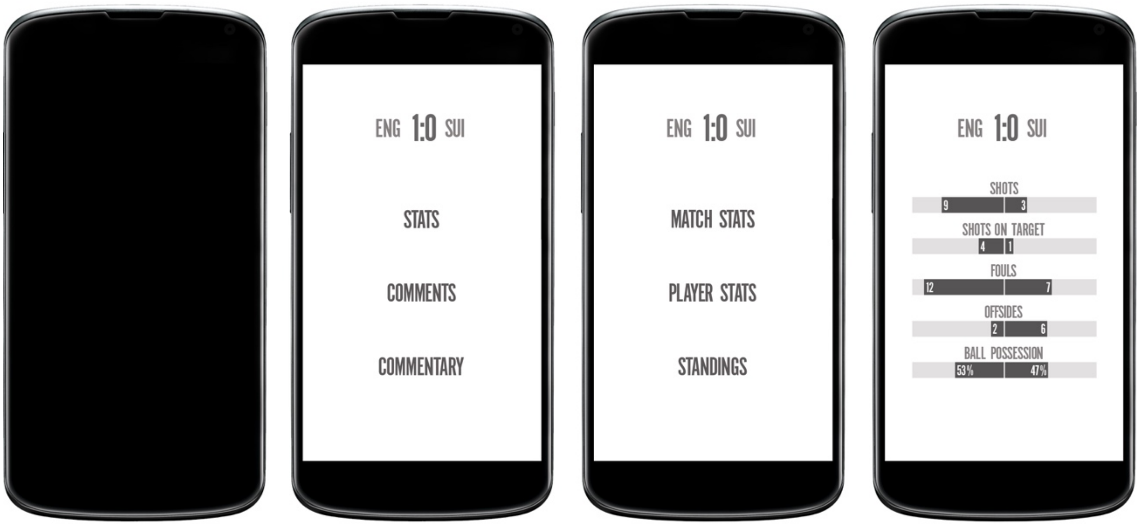
Figure 4.18: The navigation to the match statistics on the second screen prototype.



The participants in this experiment needed to *tap* on the prototype three times to retrieve the match statistics whilst they were watching the second video (Fig 4.19). Similar to the previous navigation in the image above (Fig 4.18), the navigation was designed to lead participants to pass through 3 screens to view the match statistics since they needed to tap on a few links to reach statistical information on mobile football apps and websites (Fig 4.19). Participants first had to tap on the black screen to see the menu that had the links of *stats*, *comments* and *commentary* on the following screen (Fig 4.19). Then they needed to tap on the *stats* button and view the next screen that had the buttons of *match stats*, *player stats* and *standings* (Fig 4.19). When they reached this screen, they needed to select the *match stats* to view the match statistics (Fig 4.19)

One difference between the two navigation systems (Fig 4.18, 4.19) was that their menus were different. The reason why they were different was to keep the authenticity of menu styles at the most viable level as each interaction gesture suits a different style. In the reviewed mobile football apps and websites, tapping was used mostly for *selecting among choices* and swiping for *changing the dimension from a different set of match-related information to another*.

Figure 4.19: The navigation to the match statistics on the second screen prototype.



Similar to the visualisation experiments, in this experiment, the *Alternate Gothic* font was used for buttons, labels and match-related information. The match statistics were visualised in grey bar charts since it was assumed that such visualisation would work better than grey plain numbers. The visualisation was in grey tones of colour for the reason of avoiding any potential participant bias against a colour scheme.

Participants were asked to complete a questionnaire after they had watched each short video. Each questionnaire had 8 identical types of questions. In the first question, participants were asked whether they remembered a match statistic that they checked whilst they were watching a short video. In the next question participants were asked to guess how much one team had more/less than the other team for another type of match statistic that they checked. The following five questions were Likert-scale questions. In those questions participants were asked to rate the interaction gestures, swiping for the first questionnaire and tapping for the second, in terms of *ease in application*, *understandability*, *learnability*, *quickness* and whether they caused *not too much distraction from TV*. These aspects were important since they are related to user experience goals (Preece et. al., p.19) and user experience is the focus of this thesis. In the final question, they were asked whether the gesture to retrieve match-stats on second screen enhanced their experience. Furthermore, they were asked to write down their reason briefly for their answer (*Yes/No/Don't Know*) on the questionnaire paper.

Short interviews with participants followed their completion of the second questionnaire. During the interviews, they were asked questions regarding the following: Their preferred gesture (*swiping* or *tapping*), their likes and dislikes regarding their preferred gesture. Additionally, they were asked if they could elaborate on the reasons why they thought their preferred gesture improved their watching experience or not. Finally, they were asked whether their preferred gesture was their ideal gesture. Depending on their answer, they were asked what their ideal gesture in that case would be.

While participants were watching the short videos, their interaction with the second screen prototype was recorded via a webcam mounted on the monitor that showed the videos. Harris (2016, p.19) highlighted that *"…[v]ideo data can be analyzed for …visual content (to isolate and analyze multiple perspectives on the participants' behavior)."* Video recordings of participant interaction were made to understand whether participants had seamless interaction with the prototype and the specific interaction gestures or not, because having the least level of frustration whilst interacting with second screen is crucial to reach the match-related information at ease.

4.4.2.2.2 Swiping vs Tapping, Off-Play, Fixed Order

This experiment was almost identical with the previous experiment, *Swiping vs Tapping, On-Play, Fixed Order*. There was only 1 difference between these 2 experiments: Timing of interaction on second screen for the retrieval of match statistics. In the *Swiping vs Tapping, On-Play, Fixed Order* experiment, participants used the prototype to access the match statistics whilst they were watching the short videos. In this experiment, they retrieved the match statistics through the prototype after they had watched the short videos. Other than this difference, the content and the structure of the experiment as well as the questionnaires and interviews were same in both interaction experiments.

4.5 Summary

- Methods that were used in this research were selected based on the following approaches: User-Centred Design and Participatory Design. User-Centred Design emphasises an iterative approach that creates and improves solutions based on usability measurements and user feedback. In participatory design, users become more pro-active that they are involved in the process of designing solution.

- User-Centred Design was used as the main approach due to the following reasons: First, without objective measures, we could not fully understand what worked for the users since they report what they think they would work for them. Second, methods that have the participatory design approach required more resources.

- Since User-Centred Design and Participatory Design were the main approaches, the following research methods were considered to use: Observation, Online Surveys, Interviews, Diary Studies, Focus Groups, Design Workshops, Lab Experiments and Prototyping. Diary studies and focus groups were not used due to limited resources.

- An online survey was conducted with 70 participants from different countries. The aim of the survey was to identify details regarding people's behaviour of football match-related information seeking on second screen. In addition, 12 people were interviewed to elaborate more in this regard.

- A design workshop was organised to explore expectations from second screen usage that might improve the watching experience of watching football matches on TV. 6 participants worked on how to visualise statistical match-related information and match-related information on social media. The results of the workshop was diverse that the briefs should have been narrowed down to more specific type of match-related information.

- A pilot prototype experiment was conducted with 2 participants to compare the effects of a common and a rare visualisation of match-related information on the watching experience.. The experiment also compared the effects of a popular and a novel interaction gesture for match-related information retrieval via second screen on the watching experience. Participants interacted with paper prototypes after they had watched two short videos of a football match. The pilot experiment showed that the following should be considered regarding the future prototype experiments: First, the experiment structure should be simpler that only one parameter should be tested because testing more than one parameter in the same experiment might bias the results. Second, more realistic prototypes should be used to preserve the authenticity of second screen interaction. Third, participants should interact with second screen in On-Play and Off-Play situations. Fourth, participants should be asked a combination of subjective and objective questions to measure effectiveness and enjoyability of the vsiaulisations as well as level of seamless interaction.

- Five different prototype experiments were conducted to understand how two of the most common types of match statistic visualisations on second screen affect the watching experience. In the first three experiments grey bar charts (GBC) were compared to grey plain numbers (GPN). In the fourth experiment, bar charts in different two-colour schemes (CBC) were compared to GPN. In the last experiment, team-coloured bar charts with repositioned numbers were compared to GPN.

- During the visualisation experiments, participants watched short videos of a recorded match and interacted with a realistic second screen prototype to access match statistics while they were watching videos except one experiment. In one of the *GBC vs GPN* experiments, they interacted with the prototype after they had watched each video. After watching each video and interacting with the second screen prototype, participants completed questionnaires. Via the questionnaires, participants were asked whether they remembered the match statistics. In addition, they were asked to evaluate each type of visualisation that they encountered with Likert-scale questions. Finally, each participant was interviewed and asked four questions regarding their preferred visualisation; likes and dislikes regarding their preference as well as their description of ideal visualisation.

- Two different protoype experiments were conducted to see how a popular interaction gesture and an emerging type of interaction gesture for match-related information retrieval affect the watching experience. In two experiments, same type of interaction gestures were compared but in one of them, second screen interaction occurred after participants had watched each short video. The setup of experiments were almost same to the setup of visualisation experiments with few exception: First, unlike the visualisation experiments, the interaction gestures were compared and the match statistics visualisation was fixed. Second, there were more Likert-scale questions in the questionnaires and their content was different since participants evaluated interaction gestures. The interviews were similar to the visualisation experiments. Participants were asked their preferred interaction gesture, likes and dislikes regarding their preferred gesture and description of ideal interaction gesture.

5 Analysis of Experiments

In the 4th chapter, the *Methodology*, the prototype experiments for testing effects of different forms of visualisation and interaction gestures on the watching experience of football matches on TV were described. Moreover, the reasons behind the structure of those experiments and the application of quantitative and qualitative measures were stated. In this chapter, the results of the prototype experiments are presented. First, the results of visualisation experiments are unveiled. The results of the visualisation experiments in which bar charts were coloured in grey tones (GBC) and the visualisation experiments in which bar charts were in two colours (CBC and TCBC) are presented separately. Then, a general discussion for the visualisation experiments follows this. After the presentation and discussion of the visualisation experiment results, the interaction experiment results are introduced and discussed.

The results in both groups of visualisation experiments as well as the interaction experiments are quantitative and qualitative: First, the participants' recalling performance from the first the two questions of the questionnaires are shown as graphs. This is followed by listing the main outcomes and trends from the recalling performance results that are depicted in the graphs. Moreover, to understand whether differences in recalling performance under different visualisations and interaction gestures were statistically significant, brief results of *McNemar* tests, that were applied to the results of those two questions regarding recalling performance of the participants, are given (Details of McNemar tests are not given in this chapter but in the Appendices).

The reason why McNemar tests are used to assess participants' recalling performance is the following: First, the results of recalling performance are dichotomous (success and fail). Second, each type of visualisation and gesture are tested comparatively; however, each participant group that were recruited for testing a type of visualisation or gesture is composed from the same sample of people. Thus, McNemar tests are recommended for analysis to see whether any differences between such paired data are statistically significant (Lowry, 1998; Yatani 2014).

The second type of quantitative results are based on participants' evaluations of different types of visualisations and interaction gestures through the *Likert-scale* questions of the questionnaires. *Wilcoxon Signed-Ranks* tests are performed on the results of the Likert-scale questions to understand whether participants' evaluations for each type of visualisation and interaction gesture differ significantly and the results of the tests are mentioned and compared to the outcomes of recalling performance (Details of participants' evaluations for each type of visualisation or gesture in each test are displayed in Appendices).

Wilcoxon Signed-Ranks tests are used to see whether the differences between participants' evaluation of each visualisation and interaction gesture are statistically significant because through such tests, the statistical significance of differences between evaluation rankings of each type of visualisation and gesture can be measured when each participant evaluated two different types of visualisation or interaction gesture (Lowry, 1998; Yatani, 2014).

Qualitative results, through the content analysis of interviews in both visualisation and interaction experiments, are gathered under the following aspects: Participants' preference of visualisation and gesture. Their likes and dislikes regarding their preferred visualisation and gesture. The reasons whether their preferred visualisation and gesture enhanced their watching experience or not. Their descriptions for ideal visualisation and gesture. Qualitative results are used in two ways. First, participants' preference of visualisation and gesture are compared with their recalling performance and evaluations. Second, highlights of the interview content are used to explain the reasons underlying the recalling performances.

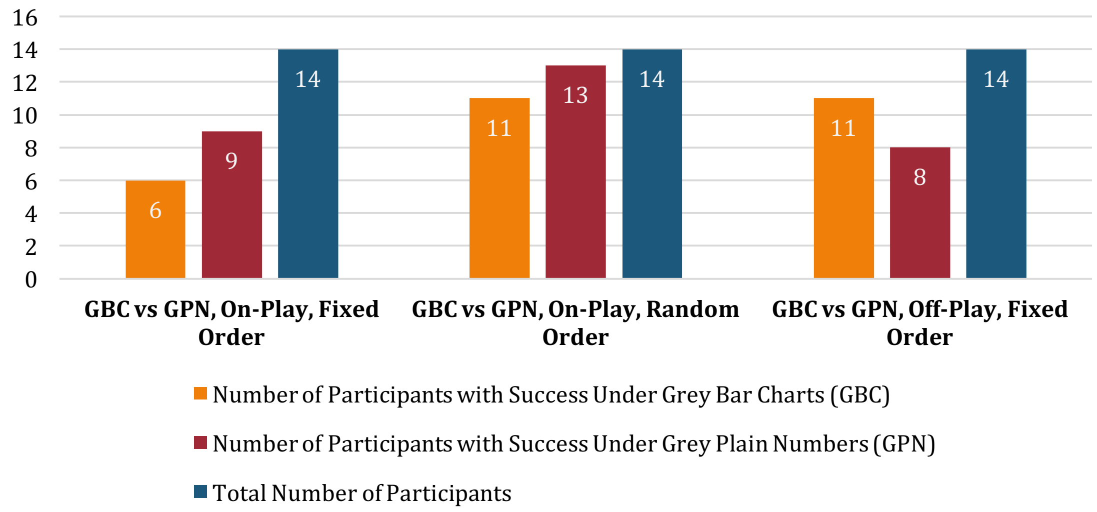
5.1 Visualisation Experiments

This section is dedicated to presenting the results of visualisation experiments. The results are unveiled in the following order: First, the recalling performance of participants in different visualisations are depicted in graphs and the main outcomes from the graphs stated. Next, a summary of participants' evaluations for different types of visualisation are presented and compared with their recalling performance under different types of visualisations. After this, participants' visualisation preferences are illustrated and their preferences are compared to their recalling performances under different visualisations and their evaluations for different visualisations. Then, the differences between participant performances, evaluations and preferences are explained by highlighting the content derived from the interviews and related literature. Each set of results is presented in two main categories of experiments as the main difference between such categories is whether the bar charts were in monochrome colours or not: *Grey bar charts* (GBC) versus *grey plain numbers* (GPN) and *2-coloured bar charts* (CBC and TCBC) versus *grey plain numbers* (GPN). At the end of this section, the results of visualisation experiments are discussed.

5.1.1 Grey Bar Charts (GBC) vs Grey Plain Numbers (GPN)

5.1.1.1 Recalling Verbatim Match Statistics

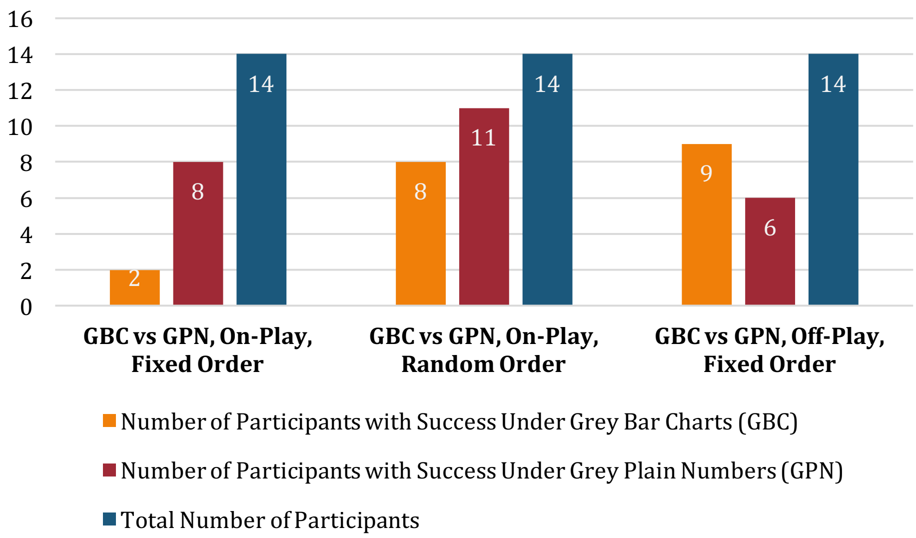
Figure 5.1: The distribution of participant success of recalling verbatim match statistics in three different experiments of GBC vs GPN.



The graph above (Fig 5.1) shows the number of participants who recalled verbatim match statistics successfully after they encountered the match statistics that were visualised in grey bar charts (GBC) and grey plain numbers (GPN). The first outcome from these experiments is the following: Compared to GPN, bar charts in monochrome colours (GBC) did not yield a better performance in recalling verbatim match statistics when participants accessed the match statistics through second screen during the act of watching a football match on TV. However, in a situation when the second screen interaction occurred during a long break in the match, GBC seemed to be better than GPN in this respect. To see whether there is a significant probability that participants' recalling performance of verbatim match statistics under different visualisations differ in each experiment, McNemar tests were applied to the results of each experiment (Appendix 4). The results of the tests revealed that there is not a significant probability that participants recalling performance of verbatim match statistics differ in GBC and GPN.

5.1.1.2 Recalling Comparison of Match Statistics

Figure 5.2: The distribution of participant success of recalling comparison of match statistics in three different experiments of GBC vs GPN.



The graph above (Fig 5.2) shows the number of participants who recalled a comparison of match statistics successfully after they had seen the match statistics that were visualised in grey bar charts (GBC) and grey plain numbers (GPN). Similar to the trends observed in the previous graph (Fig 5.1), participant performance of recalling a comparison of match statistics were lower under GBC when participants accessed the match statistics during gameplay, and such performance was better under GBC when the second screen interaction occurred during a long break in gameplay. McNemar tests, which were performed on the results of recalling verbatim match statistics, were used to see whether such differences in the performance of recalling comparison of match statistics under GBC and GPN are statistically significant. The calculations revealed that there is not a significant probability that participants recalling performance of comparison of match statistics differ in GBC and GPN (Appendix 5).

The lower success rate of *grey bar charts* (GBC) in *GBC vs GPN, On-Play, Fixed Order* could be due to the fixed order of the visualisations, GBC and GPN, in this experiment. Since each participant in that experiment interacted with GBC first and GPN later, the learning factor could have created bias on the results. However, the success rate of GBC was still lower than GPN even when participants interacted with the visualisations in random order during the experiment of *GBC vs GPN, Random Order*.

5.1.1.3 Participants' Evaluation for GBC and GPN

As stated in the Methodology chapter, after each time the participants had watched the short videos and interacted with second screen, they were given a questionnaire. In the questionnaires, apart from questions that were related to recalling verbatim match statistics and comparison of them, there were Likert-scale questions to evaluate GBC and GPN in terms of their *understandability*, *memorability*, *contribution to the understanding of the match* and *the level of enhanced watching experience* provided by them.

The four aspects above were selected for the following reasons. Understandability is related to ease of learning that was highlighted as one of the usability goals by Preece et. al. (2005, p.18-19). It is vital because a type of visualisation that is difficult to understand would likely frustrate second screen users and distract them more from the TV. As one of the participants mentioned in the first part of the Chapter 3, analysis of information seeking behaviour, he did not want to be overwhelmed by the statistics. Memorability was selected because, as Ware (2013, p. 377) put it, visualisations extend our memory, and according to Preece et. al. (2005, p.182) it is a criterion for the usability of a visualisation system, such as calendars. As stated in the third chapter, it is known that people might use statistical match-related information to support their opinions regarding the performance of teams or players. In addition, participants were asked to evaluate visualisations' contribution to the understanding of the match, since in the third chapter it was highlighted that participants used second screen to have a better overall perspective regarding the matches they watched. Furthermore, an enhanced watching experience through visualisations was put as another criterion to evaluate the visualisations, because it was wondered whether they found the visualisations enjoyable and helpful, as Preece et. al. (2005, p.19) stressed enjoyment and helpfulness are part of the user experience goals.

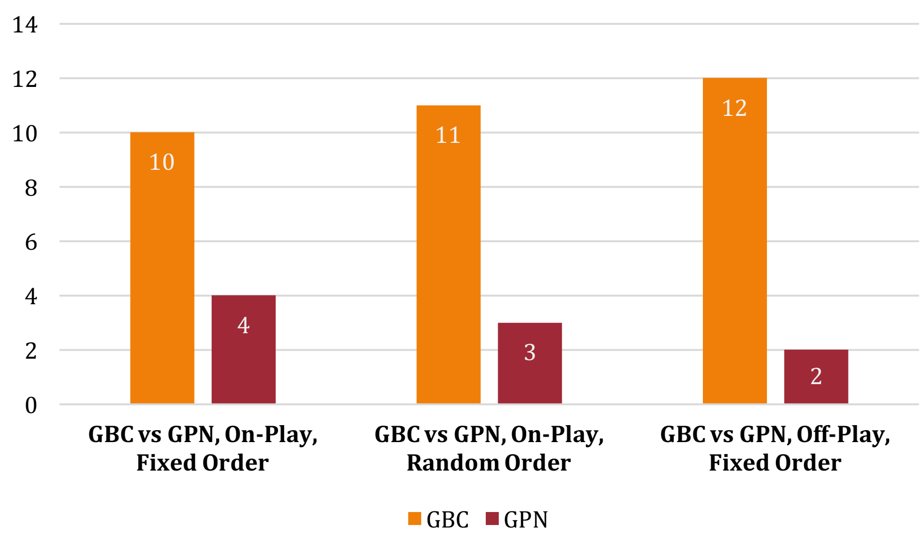
The results from Wilcoxon Signed-Ranks tests, that were applied to the answers of Likert-scale questions (Appendix 6), revealed that there is no evidence to support the probability of participants' ratings for GBC and GPN are significantly different in terms of *understandability*, *memorability* and *contribution to the understanding of the match*, as well as *the level of enhanced watching experience provision* in these three experiments.

Along with the statistically indifferent recalling performance of match statistics under GBC and GPN, the following outcome can be stated: Participants' statistically indifferent recalling performance of match statistics in GBC and GPN on second screen are reflected in their evaluations of GBC and GPN in the aspects of understandability, memorability, their contribution to the understanding of match and their provided level of enhanced experience, since the ratings for the visualisations in such aspects do not significantly differ.

5.1.1.4 Participants' Visualisation Preferences

As mentioned in the Methodology chapter, participants were asked whether they preferred GBC or GPN at the beginning of the mini-interviews held after they had finished watching their second short video and completed the second questionnaire.

Figure 5.3: The distribution of participants and their preferred visualisation in three experiments of GBC vs GPN.



The results of participants' recalling performance under GBC and GPN and their evaluations for GBC and GPN in 4 different aspects become more interesting when the distribution of participants' preferences across the experiments are revealed (Fig 5.3). The graph displays the number of people and their preferred type of visualisation. It indicates a dominance of GBC over GPN since 78% (33/42) of participants in these 3 experiments preferred GBC over GPN. Therefore, the second outcome of these experiments is the following: Although GBC was significantly preferred over GPN in 2 experiments in which the cognitive load is higher, participants' recalling performance of verbatim match statistics and comparison of them under GBC was not better than GPN in those experiments. In addition, despite GBC being significantly preferred over GPN in the experiment in which the cognitive load is lower, participants' recalling performance of verbatim match statistics and comparison of them under GBC was not significantly better than GPN in that experiment.

5.1.1.5 Analysis of Results

In this section, the results of the recalling performance of verbatim match statistics and comparison of them in these three experiments are analysed through the themes derived from the content analysis of the mini-interviews held with participants after they had watched the second video and completed the second questionnaire. The content extracted from the interviews will be used to explain the reasons why there was such a contradiction between the high preference rate of GBC and GBC's lack of superiority over GPN in terms of recalling performance of match statistics and four aspects of evaluation.

5.1.1.5.1 Lack of Colour

A possible explanation for why participants did not have a better memory performance with GBC in the two experiments, might be linked to colour, since 6 of 21 (28.5%) people who preferred GBC in these experiments mentioned lack of colour as their dislike for GBC. One of them was P5, a participant from *GBC vs GPN, On-Play, Fixed Order* experiment who highlighted potential roles of colours and meaningful colours on bar charts: *"Colours would help so that you could see the contrast instantly and team related colours would help to navigate information more easily."* P12, from the same experiment, although she managed to remember verbatim match statistics and comparison of them in bar charts stated another potential role of colour that *"…[Were] bar charts colourful, it would have been easier to memorise."*

Although in the Off-Play experiment, GBC yielded a better recalling performance over GPN, the difference between the two visualisations in this sense was not significant.

The monochrome colour scheme on bar charts might be a cause for this insignificant difference since a third of 12 participants who preferred GBC in this experiment mentioned lack of colour as their dislike for GBC. Although she could remember the match statistics and comparison of them in bar charts, P13, from *GBC vs GPN, Off-Play, Fixed Order* experiment, underlined the following confusion and implied that it was causing delays of reception: *"...most of the dark colours were on the England side… It wasn't clear right away."*

Via the quotes above, it may be concluded that lack of colour might have created difficulties in the memorability of visualisation; however, a note of caution is due here since although those 10 participants mentioned lack of colour as dislike, only 30% of them failed to recall verbatim match statistics and 50% of them failed to recall comparison of match statistics in GBC. It seemed the monochrome colour scheme on GBC had an adverse effect on people's watching experience by distracting their attention from TV at less desirable levels.

A potential catalyst that might help to increase bar charts' speed of information reception and memorability of information could be the addition of team colours on bar charts, since 8 of 33 (24%) people who preferred GBC in these three experiments mentioned team colours in their ideal visualisation (5 of 8 mentioned bar charts in team colours as part of their ideal visualisation). Interestingly, all 8 were successful in recalling verbatim match statistics and only 3 of the 8 failed to recall comparison of match statistics in GBC. Given such a success rate, this finding suggests colour may have a bigger effect on the speed of information reception rather than the memorability of information. Another possible effect of colour on bar charts could be related to enjoyment and desire to have a better engagement with the content on the main screen.

5.1.1.5.2 Perception vs Memory

During the mini-interviews, participants were asked what they liked regarding their preferred visualisation, and they were asked their reasons whether they thought their preferred visualisation enhanced their watching experience. Participants who preferred GBC over GPN in those three experiments mentioned certain likes and reasons that were related to *ease in information reception through GBC*; however, not all of them could recall verbatim match statistics and the comparison of them. Their reasons for why they liked GBC were *convenience in comparison* and *quick reception of information*. In addition, many participants who preferred GBC in these experiments highlighted that through GBC, they got a *sense of the match* as their reason why GBC enhanced their watching experience. The details of their likes and reasons in this respect might shed light on why people's performance of recalling verbatim match statistics and comparison of them in GBC were not significantly different than their recalling performance in plain numbers.

The first preference related to ease in information reception through GBC was *convenience of comparison*. It was mentioned as a like for GBC by 18 of 33 (54%) participants who preferred GBC in the three experiments. For instance, P6 who was in the *GBC vs GPN, On-Play, Fixed Order* experiment said: *"It makes it easier to understand the numerical size, what is more or less. Helps comparison."* However, interestingly, 8 of 18 (44%) failed to recall comparison of match statistics in GBC. A recurring detail, which is *less focus* on numbers and reliance on visual cues in bar charts, was mentioned by 9 participants who preferred GBC and liked it due to its *convenience in comparison*. The views of 3 of them who failed to recall a comparison of match statistics may help us understand the failure of participants in recalling comparison of match stats. One of them was P2 who partook in *GBC vs GPN, On-Play, Fixed Order* experiment. He stated there was no need to memorise numbers with GBC, implying that he received more of an impression: *"I just look at it and I get the data, or at least the information."* P3 who was in *GBC vs GPN, Off-Play, Fixed Order* experiment echoed P2's views: *"…With bar charts you have a clearer image of what is more what is less even if you don't' know the exact specifics…"* Although he managed to recall comparison of match statistics but failed for verbatim match statistics in bar charts, P13, from *GBC vs GPN On-Play, Fixed Order* experiment, through his explanation of what he liked about bar charts, might explain the relationship between *less focus* on numbers and failures in recalling match statistics:

> *"You don't fully have to concentrate on the numbers. You can just see visually who has more shots for example without seeing specifically what number that is. You don't have to completely divert your concentration onto the phone as opposed to, still having one eye on the match."*

Another like within the theme of *ease in information reception through GBC* was *quick reception of information* since 13 of 33 (39%) participants who preferred GBC mentioned this during the interviews. Although 6 of 13 stated *convenience of comparison* along with *quick reception of information* as their like for GBC, some mentioned only *quick reception of information*. For instance, P6 from *GBC vs GPN, On-Play, Random Order* experiment said: *"When I just wanna capture the numbers, if I am just glancing down, the visual is easier for me."* P10 from *GBC vs GPN, On-Play, Fixed Order* experiment mentioned similar details: *"You get quick instant impression. You can glance a line and you can see quickly."* However, only 4 of 13 could remember both verbatim match statistics and comparison of them. These participants might have benefitted from rapid information accession; however, their failures of recalling match statistics might be rooted from the GBC's aforementioned nature that gave participants an impression rather than exact values. In this respect, P3's views on his like for bar charts may tell us how GBC works:

> *"You just want a quick glance, you don't wanna lose any action on the game which means you need a quick visual impression that you don't have to look through all the numbers."*

A third (11) of participants who preferred GBC in these three experiments felt that their watching experience was enhanced by GBC because they thought they received a *sense of match* through GBC. P5 from *GBC vs GPN, Off-Play, Fixed Order* experiment said: *"[It] gave me an idea of what had happened… The extra information having visualised in a way that makes sense of what was happening on the screen."* However, only 36% (4) of them could remember both verbatim match statistics and a comparison of them. Perhaps, the following details that were highlighted by P12 who took part in the *GBC vs GPN, On-Play, Random Order* experiment could explain the reason for low rate of memorability: *"…You understand the parts of the game a bit better… The visualisation gives you lots of information in quick glance…"* Similar to the previous couple of paragraphs, GBC might be quick enough for people to receive an impression which might enough to satisfy some; however, this visualisation might not be the best for remembering exact values.

Briefly, a considerable number of people who preferred GBC emphasised that GBC facilitated *ease in information reception*. The reason for this emphasis could be related to GBC's practicality in delivering information that reduced their concern about being distracted from the TV and they seemed to be satisfied with the reception of impression. However, the trade-off in this regard might be losing memorability of the exact information. In fact, research highlighted the following:

> *"…there is a trade-off between the ability to accurately perceive specific quantitative facts and the ability to get a more qualitative gist of relationships depicted in the data. A table, for example, allows people to get single point values most accurately but provides the least integrative information." (Guthrie et. al., 1993, p.209-210)*

Another study elaborated on the difference between long-term memory and recall; therefore, it might explain this trade-off:

> *"…The dominant theory about how long-term memories are physically stored is that they are traces... Recall consists of the activation of a particular pathway… As visual information is processed through the visual system, it activates the long-term memory traces of visual objects that have previously been processed by the same system. In recognition, a visual memory trace is being reawakened. In recall, it is necessary for us to actually describe some pattern, by drawing it or using words, but we may not have access to the memory trace. In any case, the memory trace will not generally contain sufficient information for reconstructing an object..." (Ware, 2013, p.388)*

5.1.1.5.3 Nature of Grey Bar Charts (GBC)

GBC might have eased information reception for participants through its nature; however, it might be seen as a relatively more crowded type of visualisation to access numerical values for some people; therefore, the less crowded look of plain numbers on the screen might be one of the reasons why GBC never dominated GPN significantly in recalling match statistics. 9 of 42 (21%) participants preferred GPN in 3 visualisation experiments. More than half of them (5) mentioned *clarity of information* as their like for GPN. They highlighted simplicity of the layout in GPN and praised the existence of fewer visual elements on the second screen and usually complained about bar charts being the opposite. P9 in *GBC vs GPN, On-Play, Fixed Order* experiment said: *"...I wanted to find numbers. No complexity. No over-information. Just the information I required."* Such like could be one of the reasons why GBC and GPN did not pose any superiority over each other in terms of participants' recalling performance of match statistics and their evaluations. However, such interpretation must be done with caution since only 4 of 9 could remember verbatim match statistics and comparison of them in GPN.

Clarity of information through GPN might be considered important by the participants due to their concerns with regards to spending the minimum amount of time on second screen. P8, who was in the same experiment as P9, suggested a correlation between a less busy screen and rapid information access: *"It was less busy on the screen. I was trying to look at things quickly."* In addition to this, *P5 in GBC vs GPN, On-Play, Random Order* experiment shared a similar view and compared the process of acquiring information in GPN with bar charts:

> *"...Because you're trying to look fast in between watching the match, it is easier to see a number... ...it is easier rather than having a look along a bar chart."*

The last words in the previous paragraph suggests that GBC's orientation on the screen might have created difficulties for the participants in terms of accessing information quickly. P7 who was in GBC vs GPN, On-Play, Random Order experiment pointed out:

> *"...In the current position, it is actually difficult to see which one is longer, especially for ball possession. In that case, it doesn't give me the big picture quick enough. They could be next to each other."*

P4 who was from the same experiment described similar orientation for bar charts as he wanted *stacked bar charts* as his ideal visualisation. Even such orientation of GBC might be desired when viewers have a lower cognitive load. P10 who participated in *GBC vs GPN, Off-Play, Random Order* experiment implied this issue in her description of ideal visualisation: *"...A bit clearer bar chart in terms of separating the sides... Stacked bars on top of each other could be better to compare sides."*

P8 who participated in *GBC vs GPN, Off-Play, Fixed Order* experiment highlighted a different concern that placement of numbers was problematic: *"It doesn't take all in one go. You have to look left and right to two numbers which isn't comfortable..."* Perhaps, placement of numbers on rectangular visual elements (bars) of GBC might have caused issues related to receiving information quickly. More than that, such placement of numbers might be a concern even participants who had more time to focus on second screen.

5.1.1.5.4 The Need for Other Types of Visualisations

12 of 33 people who preferred GBC in three experiments declared that they wanted the inclusion of pie charts in their ideal visualisation. Interestingly, 9 of 12 failed to recall comparison of match statistics in GBC; therefore, such detail might hint why GBC did not have any superiority over GPN in recalling comparison of match statistics. For instance, P12, in *GBC vs GPN, On-Play, Fixed Order* experiment, felt pie charts would be better because according to her: *"…You don't even worry about checking lengths..."* P4 from the same experiment elaborated on P12's emphasis: *"For this quick glancing down, it might work better because you're watching a match, you want something quick and ready."* Hence, it could be hypothesised that the need for *quick reception of information* through second screen played a major role in shaping participants' descriptions of their ideal visualisation since such a point was highlighted in the previous sections of the subchapter. In addition, such desire was even valid for situations where the exposed level of cognitive load was lower. For example, P7, from *GBC vs GPN, Off-Play, Fixed Order* experiment, implied that information through pie charts would be quicker to perceive: *"Pie charts because you can 'just see' which one is bigger than the other compared to bar charts."* Besides, a third (4) of them explicitly stated that they wanted bar charts solely for the display of ball possession. P10 from *GBC vs GPN, On-Play, Random Order* experiment specified his reason as: *"Pie charts for percentages because it is much quicker compared to horizontal bar chart."* Such detail may be essential even for second screen interaction that happens when the cognitive load is lower because P14, who participated to *GBC vs GPN, Off-Play, Fixed Order* experiment expressed a similar opinion: *"Pie charts might work better because*

they are easier to read percentages." Apart from that, another explanation for why pie charts for ball possession were preferred by a significant number of people could be related to familiarity. P14, who was involved in the same test as P10, highlighted the following: *"...For possession, pie charts would be better because it is what I used to have."*

A minority of participants (12%), 4 of 33 who preferred GBC in these 3 experiments declared that they wanted more human-recognisable visual elements in their ideal visualisation. P8, who volunteered for the *GBC vs GPN, Off-Play, Fixed Order* experiment, wanted a virtual football pitch, a sort of heat-map in his ideal visualisation because:

> *"…[it] mimics the sort of look of the pitch, the field what I'm looking at already… and if I look at something else, I still have got the image of the pitch, sideways pitch and I look down the phone and I still carry that the lines of the pitch to carry that in my very short term memory and then to pick that up again on the screen might be quite nice… rather than [having] very sort of typographic stuff from… [I want] [s]omething that when my eyes leave the screen, it picks up again on the screen down there, something like a memory trace… It would make it comfortable to have the transition…"*

Perhaps, with more visually embellished elements on GBC, viewers might have a smoother transition from TV to second screen. Such transition might speed up information reception and memorability. However, the role of visual embellishments on bar charts in terms of increasing the recalling performance is not certain because although half of the participants who wanted such visual embellishments in their ideal visualisations could remember both verbatim match statistics and comparison of them in these experiments.

P9, who took part in the same experiment as P8, wanted more concrete visual elements, too, but she added that they should not have complicated the outlook:

> *"You need to keep it super simple… What I would be really tempted to do was… I would make it more 'footballish'… I would have probably green background… kinda emulates the idea of a football field, the fouls might be red and yellow because it would be directly linked with the idea of yellow card, red card… the colours on visualisation that links the game itself…"*

5.1.1.6 Summary of Findings

- Football match statistics that were visualised in GBC seem to be less memorable than match statistics that were depicted in GPN when the second screen interaction occurred during the act of watching football matches on TV. However, such a difference between GBC and GPN in participant recalling performance is not statistically significant.

- Football match statistics that were visualised in GBC seem to be more memorable than match statistics that were in GPN when the second screen interaction happened during a long break of watching football matches on TV. However, the difference is not statistically significant.

- Participants' evaluations for GBC and GPN in terms of their *understandability*, *memorability*, *contribution to the understanding of the match* and *level of enhanced experience provision* were not significantly different in statistical terms in any of the experiments.

- Although both visualisations did not significantly differ in objective (participants' recalling performance of match statistics) and subjective (participant evaluations of the visualisation in the four aspects in the article above) measurements, a significant ratio of people (78%) preferred GBC over GPN.

- The following factors might be the reasons why considerably more people preferred GBC over GPN although GBC did not have any superiority over GPN in terms of recalling performance of match statistics and participants' evaluations in aformentioned aspects.
    - Lack of colour on GBC might have had mitigated effects on the memorability of match statistics and speed of reception of such information.
    - GBC might have shifted participant focus on the presentation of content rather than the information itself; therefore, it might have made the statistics less memorable compared to GPN when participants were faced with a higher cognitive load.
    - The match statistics that were visualised in GBC might have been perceived as having a crowded look; therefore, it might be one of the reasons why participants did not have a superior recalling performance with GBC over GPN.
    - Opposite orientation of rectangular visual elements of GBC for different teams might have delayed participants' access to match statistics. In addition, placement of numbers on the edges of rectangular shapes might have mitigated quick reception of match statistics.

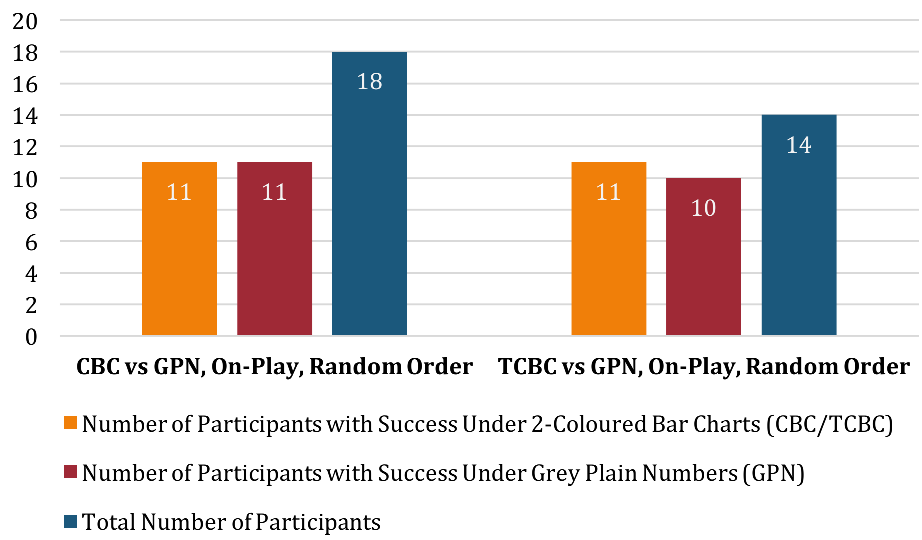
- GBC might not have been the most effective, quickest and least distractive in match statistics comparison, since there was a popular demand for pie charts.

- Lack of visual embellishments, i.e more human-recognisable elements on GBC, might have inhibited effective transition between TV and second screen and such transition might have negated the memorability of match statistics.

5.1.2 Bar Charts with Specific Two-Colour Schemes (CBC) & Team-Coloured Bar Charts with Repositioned Numbers (TCBC) vs Grey Plain Numbers (GPN)

5.1.2.1 Recalling Verbatim Match Statistics

Figure 5.4: The distribution of participant success of recalling verbatim match statistics in the experiments of CBC vs GPN and TCBC vs GPN.



This graph (Fig 5.4) reveals the number of participants who recalled verbatim match statistics successfully after they had seen the match statistics in bar charts in two-colour schemes (CBC), team-coloured bar charts (TCBC) and grey plain numbers (GPN). The immediate deduction from the graph is the following: The combination of bar charts in team colours, colour-blind-safe team colours and warm-cold colours (CBC) and grey plain numbers (GPN) performed equally for the recollection of verbatim match statistics. In addition to this, team-coloured bar charts with repositioned numbers (TCBC) seemed to perform better than grey plain numbers (GPN) in this regard.

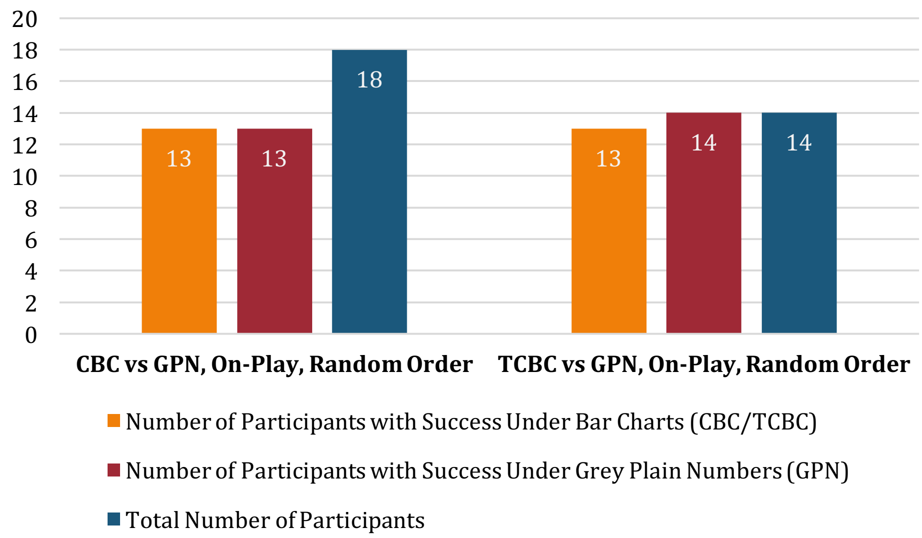
Similar to what was performed on the results of the previous group of experiments in which bar charts were in grey tones, McNemar tests were applied to the results of each experiment to see whether there is a significant probability that participants' recalling performance of verbatim match statistics differ under CBC/TCBC and GPN (Appendix 4). The results of the tests revealed that there is not a significant probability that participants recalling performance of verbatim match statistics differ in two-coloured bar charts and GPN.

Having found that the differences are not significant, when the graph above (Fig 5.4) is compared to the equivalent graph of the previous group of experiments (Fig 5.1) that showed the recalling performance of verbatim match statistics under GBC and GPN, the following results could be claimed: First, compared to GBC, addition of specific two-colour schemes on bar charts' increased participants' performance of recalling verbatim match statistics against GPN; however, such addition of specific two-colour schemes on bar charts did not make them superior over GPN in terms of recalling verbatim match statistics. Secondly, compared to GBC and bar charts with the combination of specific two-colour schemes (CBC), addition of team colours and repositioning numbers on bar charts (TCBC) seemed to increase bar charts' performance against GPN for recalling verbatim match statistics. The level of improvement was to such an extent that for the first time in all the experiments, bar charts were better than GPN for recalling verbatim match statistics. It should also be noted that these trends could be asserted for the *On-*

Play situation that puts higher cognitive load on participants since they interacted with second screen while watching a football match on TV.

5.1.2.2 Recalling Comparison of Match Statistics

Figure 5.5: The distribution of participant success of recalling comparison of match statistics in the experiments of CBC vs GPN and TCBC vs GPN.



The graph above (Fig 5.5) illustrates how many participants in each experiment successfully recalled a comparison of match statistics after they had seen the match statistics visualised in CBC/TCBC and GPN. Similar to the previous graph (Fig 5.4), the combination of bar charts in team colours, colour-blind-safe team colours and warm-cold colours (CBC) and grey plain numbers (GPN) performed equally in recalling comparison of match statistics. However, unlike, the graph that reveals results of recalling verbatim match statistics (Fig 5.4), team-coloured bar charts with repositioned numbers did not produce a better participant performance of recalling comparison of match statistics over GPN.

McNemar tests were applied to the results of participants' recalling performance of comparison of match statistics to understand whether, the performance differences under different visualisation in 2 experiments shown in the graph (Fig 5.5), were statistically significant (Appendix 4). The tests showed that there is no significant probability that the differences mentioned in previous paragraph were different.

Two other outcomes could be derived from these two experiments: First, similar to the results of recalling verbatim match statistics, addition of specific 2-colour schemes on bar charts' increased participants' performance of recalling verbatim match statistics against GPN when the performance of GBC against GPN is considered. However, such an addition of specific two-colour schemes on bar charts did not make bar charts perform better than GPN in this regard. Second, unlike the results of recalling verbatim match statistics, compared to GBC only, addition of team colours and repositioning numbers on bar charts (TCBC) seemed to increase the performance of bar charts against GPN for recalling comparison of match statistics. Nevertheless, such a trend is not seen between TCBC and CBC since CBC's performance of recalling comparison of match statistics against GPN's is better than TCBC's performance against GPN's.

5.1.2.3 Participants' Evaluation for CBC, TCBC and GPN

Similar to the previous three experiments in which GBC was compared to GPN, in these two experiments in which CBC and TCBC were compared to GPN, participants were given a questionnaire after each time they had watched the short videos and interacted with second screen. In the questionnaires, similar to the GBC vs GPN experiments, participants were asked to evaluate CBC, TCBC and GPN in terms of their *understandability*, *memorability*, *contribution to the understanding of the match* and *the level of enhanced watching experience provided by them* through Likert-scale questions after they had answered questions related to the recollection of match statistics.

The results from Wilcoxon Signed-Ranks tests that were based on participants' answers (Appendix 6) to the Likert-scale questions indicated the following outcomes: First, in the *CBC vs GPN, On-Play, Random Order* experiment, there was no evidence that participants' evaluations for CBC and GPN significantly differed in terms of their *understandability*, *contribution to the understanding of the match* and the *level of enhanced experience provided by them*. However, there was a significant probability that the ratings between CBC and GPN (CBC's ratings were better than GPN) in terms of memorability of visualisations differed. Moreover, in the *TCBC vs GPN, On-Play, Random Order* experiment, the participants' evaluations for TCBC and GPN did not significantly differ in the aforementioned aspects.

When the results in the earlier paragraph are reviewed with the results of recalling performance, it is interesting to see the following result: Given the statistically insignificant differences between CBC and GPN in terms of recalling match statistics, the differences of participants' evaluation for both visualisations that were in favour of CBC in terms of memorability seemed to be significant. Interestingly, bar charts in team colours with repositioned numbers (TCBC) were not rated differently to GPN in a significant level in terms of memorability, but the combination of bar charts with different two-colour schemes (CBC) was.

In the earlier group of experiments in which grey bar charts (GBC) and grey plain numbers (GPN) were compared, the statistically indifferent recalling performance of match statistics under GBC and GPN were reflected in the participants' evaluations in that both visualisations were not rated significantly different in any of the aspects mentioned in the paragraph above. Although a similar claim could be made for the current group of experiments, there is one exception: The significant difference between CBC and GPN in their memorability ratings in the *CBC vs GPN, On-Play, Random Order* experiment.

5.1.2.4 Participants Preferences of Visualisation

Similar to the earlier group of experiments in which GBC were compared to GPN, participants who took part in *CBC vs GPN, On-Play, Random Order* experiment were asked whether they preferred CBC or GPN and participants who were in the *TCBC vs GPN, On-Play, Random Order* experiment were asked whether they favoured TCBC or GPN at the beginning of the mini-interviews after they had watched the second short video and completed questionnaires in both experiments.

Figure 5.6: The distribution of participants and their preferred visualisation in the experiments of CBC vs GPN and TCBC vs GPN.

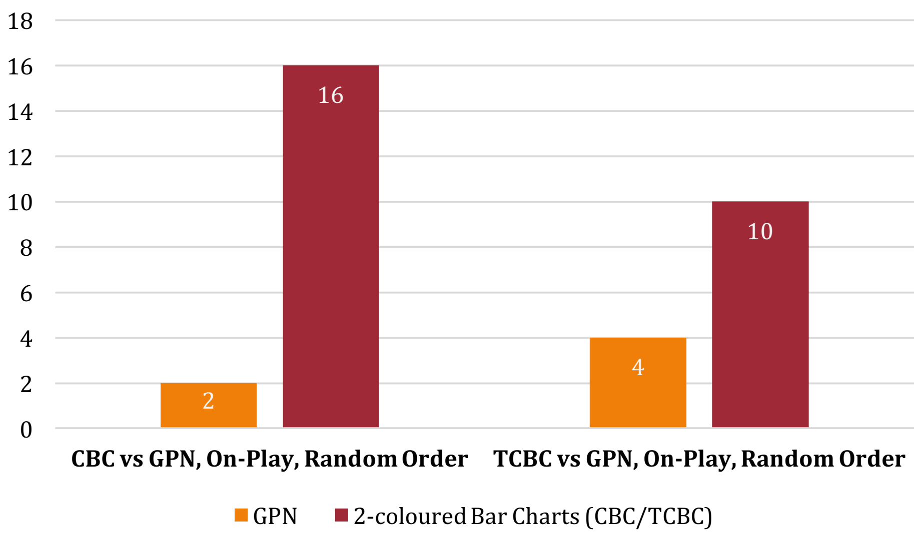


Figure 5.6 depicts the number of people and their preferred type of visualisation. This graph (Fig 5.6) shows similarities with the graph that displayed how significantly GBC was preferred over GPN (Fig 5.3), since according to the distribution that is shown above, 88% of participants in the first experiment preferred CBC over GPN and 71% of participants in the second experiment preferred TCBC over GPN. 81% of participants in these 2 experiments preferred 2-coloured bar charts (CBC/TCBC) over grey plain numbers (GPN).

Therefore, the following outcome of these experiments need to be stated: Although CBC and TCBC were significantly preferred over GPN in 2 experiments in which the cognitive load is higher, participants' recalling performances of verbatim match statistics and comparison of them under CBC and TCBC were not significantly better than GPN in those experiments. In addition, interestingly, the preference rate of CBC (combination of bar charts in team colours, colour-blind-safe team colours and warm-cold colours) was higher than the preference rate of team-coloured bar charts with repositioned numbers (TCBC). Given the exception stated in participants' evaluations, that there was a significant difference between CBC and GPN in terms of memorability, such a difference was not seen between TCBC and GPN in the same aspect. This difference in the rates of preference between CBC and TCBC is not surprising.

5.1.2.5 Analysis of the Results

In this section, similar to the earlier group of three experiments (5.1.1), the results of the recalling performance of verbatim match statistics and comparison of them in these two experiments are analysed using the themes derived from the content analysis of the mini-interviews held with participants after they had watched the second video and completed the second questionnaire. The reasons why there was such a contradiction between the high preference rate of two-coloured bar charts (CBC/TCBC) and their lack of superiority over GPN in terms of recalling performance of match statistics and most of the evaluations are also discussed.

5.1.2.5.1 Perception vs Memory

Similar to the earlier group of *GBC vs GPN* experiments, during the mini-interviews, participants who preferred CBC/TCBC over GPN in these two experiments disclosed certain likes and reasons that were related to *ease in information reception through CBC/TCBC*. However, like their counterparts in *GBC vs GPN* experiments, not all participants who felt *ease in information reception through CBC/TCBC* could recall verbatim match statistics and comparison of them in CBC/TCBC. Unlike *GBC vs GPN* experiments, *colour* appeared to be the most observed like for CBC/TCBC from participants who preferred CBC/TCBC and felt *ease in information reception through CBC/TCBC*. Moreover, similar to *GBC vs GPN* experiments, *convenience in comparison* and *quick reception of information* appeared as frequently seen likes for CBC/TCBC from participants who preferred CBC/TCBC. Furthermore, like GBC vs GPN experiments, the most seen reason for enhanced experience through CBC/TCBC for participants who preferred CBC/TCBC and thought CBC/TCBC enhanced their watching experience was getting a *sense of match* through CBC/TCBC. These highlighted details, regarding such likes and the reason could explain the contradiction between overwhelming majority of preference for CBC/TCBC and their insignificantly superior, inferior or equal performance against GPN in recalling match statistics.

In the earlier group of GBC vs GPN experiments, *convenience in comparison* was mentioned as a like for GBC by more than half of participants who preferred GBC. In these two experiments, less than a quarter (23%) of participants who preferred CBC/TCBC said that they liked CBC/TCBC for its *convenience in comparison*. However, they were more successful (67%) than their counterparts (56%) from GBC vs GPN experiments in recalling comparison of match statistics. Although the frequencies of such like and success rates of recalling comparison of match statistics differ between the group of experiments, details from participants regarding such like seem to be parallel in the earlier group of three experiments and these two experiments. For instance, in *GBC vs GPN* experiments, a repeated detail in *convenience in comparison* which was less focus on exact numerical values and reliance on visual aid in bar charts seemed to appear in *CBC/TCBC vs GPN* experiments. For instance, P3 who was in *CBC vs GPN, On-Play, Random Order* experiment said: *"…Very intuitive to* *understand who's doing better in each category."* P6 from *TCBC vs GPN, On-Play, Random Order* experiment seemed to explain what P3 was highlighting: *"...It gives you a stronger indication, not a precise but a stronger indication for who has more (offsides etc)."* It might be implied that, similar to GBC, CBC/TCBC might deliver impression of match statistics to viewers better than exact values.

Quick reception of information was observed as another frequent like for bar charts from participants who preferred CBC/TCBC in the latter group of two experiments. Nonetheless, it was mentioned less often in these experiments compared to the earlier group of GBC vs GPN experiments, in recalling both verbatim match statistics and comparison of them. The success rate (87%) of participants who mentioned such a liking for bar charts in these experiments was more than the success rate (31%) of the participants who mentioned the same like for bar charts in the earlier group of GBC vs GPN experiments. Given such differences, unsurprisingly, the details given by participants in these experiments regarding this theme show similarities between the details given by participants regarding the same theme in GBC vs GPN experiments. Many of them explicitly highlighted that *quick reception of information* was vital in second screen experience because they all wanted to be distracted from the TV as little as possible. Likewise, similar to the *GBC vs GPN* experiments, one of the reasons why CBC/TCBC did not have a superior performance of recalling match statistics, might be the *quick reception of information*. People might have been satisfied with just obtaining an impression rather than getting exact values. For instance, P14 who took part in *TCBC vs GPN, On-Play, Random Order* experiment said: *"...I don't want to stare long at it to understand. I just want to get information quickly and not to be distracted too much."*

In the experiments of *CBC/TCBC vs GPN*, 26 participants preferred CBC/TCBC. 7 of them thought CBC/TCBC enhanced their watching experience through allowing them to get a *sense of match*. Although their ratio (27%) to the whole group of CBC/TCBC favourers is slightly less than the ratio of their counterparts to the whole group of GBC favourers in the GBC vs GPN experiments, they gave similar details regarding receiving *sense of match* through bar charts (CBC/TCBC) as the participants from the earlier group of experiments (*GBC vs GPN*) did. For instance, P3 from CBC vs GPN, On-Play, Random Order experiment explained how CBC enhanced his watching experience:

> *"I was able to understand what was going on in the game, who was doing better. Bar charts allowed to me understand quickly about what was going on. For plain numbers, it took me a while to figure out who was doing what whilst it took me a lot less time with bar charts and I was able to continue watching the game without losing any detail. For plain numbers, I lost a bit action."*

However, their success rate (71%) of recalling both verbatim match statistics and comparison of them is quite higher than their counterparts' (36%) in GBC vs GPN experiments.

In earlier paragraphs, it was found that most frequent likes for bar charts (CBC/TCBC) and the reason for enhanced experience through bar charts (CBC/TCBC) around the theme of *ease in information reception* in *CBC/TCBC vs GPN* experiments, were similar to the most seen likes for bar charts (GBC) and the reason for enhanced experience through bar charts (GBC) in the *GBC vs GPN* experiments. Moreover, the recollection of match statistics performances of participants who had similar likes for bar charts and reason for enhanced experience between the two groups of experiments were compared, and the participants in the experiments in which bar charts were in two-colour seemed to do better than the participants who took part in the experiments of

GBC vs GPN. The addition of two-colour schemes on bar charts might play a role in such a difference since *colour* in *CBC/TCBC vs GPN* experiments, as mentioned in the *influence of colour* section, was liked more than colour in *GBC vs GPN* experiments. Such colour schemes might be one of the reasons for improvement of *ease in information reception* whilst reducing the loss of memorability. However, such a claim should be made cautiously since it could be argued that increase in recalling success of match statistics through CBC/TCBC in *CBC/TCBC vs GPN* experiments might be due to the fixed order of visualisations in one of the *GBC vs GPN* experiments and repositioned numbers in *TCBC vs GPN* experiment.

5.1.2.5.2 Influence of Colour

Compared to the earlier group of *GBC vs GPN* experiments, there are less colour-related concerns for CBC and TCBC that were reported by people who preferred CBC or TCBC in the experiments of *CBC vs GPN, On-Play, Random Order* and *TCBC vs GPN, On-Play, Random Order*. During the mini-interviews of *GBC vs GPN* experiments, 10 of 33 (30%) participants who preferred GBC highlighted concerns regarding *lack of colour*. However, when participants were asked what they disliked for their preferred visualisation in this group of experiments in which bar charts were in two colours, 6 of 26 (23%) who preferred CBC/TCBC felt that *colour* was problematic on bar charts.

3 of 6 people, who preferred CBC/TCBC and mentioned colour as an issue regarding their preferred visualisation, saw bar charts in team colours. Two of them highlighted that although they recognised the colours on bar charts as team colours, they thought those colours were not the exact team colours. As they saw England in a white kit on the videos, they thought dark blue on bar charts did not truly associate England's statistics with England. However, as it was mentioned in the methodology chapter,

such a dark blue colour had to be used instead of white on bar charts because bar charts in white on a white background is less legible compared to dark blue bar charts.

The third person, P2 from *CBC vs GPN, On-Play, Random Order* experiment, came up with an issue that had not been thought would be an issue prior to the experiments. She said there was not enough contrast between different colours and felt that colour distinction was not clear in different angles of viewing. In fact, dark blue and maroon that represent England and Russia respectively are not contrast colours. With a different angle of viewing the second screen, the level of low contrast between the colours might even be reduced so much that viewers could not distinguish the sides easily. Therefore, such a problem might cause more distraction from TV.

The other 3 of 6 participants who preferred bar charts and emphasised colour as an issue did not see bar charts in team colours but colour-blind-safe team colours and warm-cold colours. Moreover, unlike the previous 3, these 3 participants did not have a perfect score in recalling match statistics from bar charts. 2 of them stressed concerns regarding the colours and thought that they lacked meaning. P9 who saw the bar charts in colour-blind-safe team colours felt that the colours were not representing the sides. For her, if the team colours had been used, it would have helped her to identify the sides on second screen. In addition to this, P14, who viewed bar charts in warm-cold colours, found the colours *random* and felt that they should have *purpose*. The warm-cold colour scheme on bar charts might have created a confusion for him that was similar to the confusion that P13, from *GBC vs GPN, Off-Play, Fixed Order* experiment, faced with. P13 said: *"…most of the dark colours were on the England side… It wasn't clear right away."* Two different colours (yellow and blue) that had two tones seen in both sides of screen layout might have created a delay in distinguishing sides and processing the information.

Compared to the previous group of experiments of *GBC vs GPN*, colour was seen more of a like rather than dislike for bar charts in the experiments of *CBC/TCBC vs GPN*. Only 4 of 33 (12%) who preferred bar charts in the 3 experiments of *GBC vs GPN* mentioned *colour* as a like for bar charts. The number rises to 30% since 8 of 26 who preferred bar charts pointed out *colour* as their like for bar charts. 2-colour schemes on bar charts seemed to help them to access the information with relative ease. For instance, P1 who saw bar charts in team colours in *CBC vs GPN, On-Play, Random Order* experiment marked colour as a catalyst to process information: *"…it is easier for me to understand automatically to relate stats for each side…"* P18 who was from the same experiment as P1 explained why such aid of colour was crucial:

> *"…If I see them all in black and white, then I need to process the information. With just plain numbers, it would take more time to understand which side has better and might miss the action on the screen."*

Moreover, P4 who saw the bar charts in team colours with repositioned numbers gave details on how colour differentiation worked for her: *"…because you see where it splits like where the difference was. Guess it's more useful than if they are on the same colour… because then you have to look really for it, process that information…"* She agreed with P18 that it sped up the process: *"…It is faster so you spend less time trying to work it out so you can get back watching and get less distracted."* In addition, 2 other participants who preferred TCBC, highlighted colours' contribution to memorability. P9 argued: *"…The choice of colour which is distinct so that within a second we can just memorise the stat."* Furthermore, interestingly, only 1 of 4 participants who preferred GBC in the 3 experiments of *GBC vs GPN* and mentioned *colour* as a like for GBC could remember both verbatim match statistics and comparison of them whilst 6 of 8 participants who preferred bar charts (CBC/TCBC) in the latter 2 experiments and mentioned *colour* as like for CBC/TCBC succeeded to recall both verbatim match statistics and comparison of them.

Given the differences between the rates of likes and dislikes related to colour in both groups of experiments, and the slight increase in participant recalling performance of match statistics in bar charts in the experiments in which CBC and TCBC were compared to GPN, it seems that colour on bar charts might have a positive influence on the memorability of match statistics and the level of distraction from TV. Besides, there were 10 participants who preferred bar charts but who did not see bar charts in team colours in four experiments (among all participants in three GBC vs GPN experiments and 2/3 of participants in the CBC vs GPN experiment) wanted team colours in their ideal visualisation. However, bar charts did not pose any dominance in participants' recalling performance of match statistics over GPN in the *TCBC vs GPN, On-Play, Random Order* experiment; therefore, the impact of team colours on bar charts might not make a significant difference in this respect. The impact of team colours on bar charts might be on the speed of reception of match statistics rather than memorability of them. Compared to other experiments, only 10% (1 of 10) of people who preferred bar charts in *TCBC vs GPN, On-Play, Random Order* experiment wanted a different colour in their ideal visualisation. This could suggest that use of team colours might be seen as more suitable than other colour schemes on bar charts since even the person who wanted a different colour scheme in this experiment implied that he wanted team colours, too: *"…colours could be more appropriate."*

5.1.2.5.3 Nature of Coloured Bar Charts (CBC) and Team-Coloured Bar Charts with Repositioned Numbers (TCBC)

Although they were not widespread in two experiments as they were in *GBC vs GPN* experiments, design related concerns for CBC and TCBC were mentioned by participants who preferred them over GPN during the mini-interviews. In the earlier of group of experiments, participants who preferred GPN over GBC mentioned *clarity of information* mostly as their like for GPN. Although, the number of people who preferred GPN were considerably less than the number of people who preferred GBC, from the feedback of people who preferred GPN and had this liking for GPN, it was thought that GBC looked crowded on the second screen by some participants; therefore, this more crowded look compared to GPN might have inhibited GBC's memorability of match statistics and its speed of exact reception by viewers. However, it was added such interpretation might not have a solid ground since less than half of participants who preferred GPN and liked it due to its clarity of information could remember both verbatim match statistics and comparison of them.

Similar to the *GBC vs GPN* experiments, in *CBC/TCBC vs GPN* experiments, the number of people who preferred GPN (6) over CBC/TCBC were remarkably less than the number of people who preferred CBC/TCBC (26). However, as observed in the *GBC vs GPN* experiments, the most seen liking for GPN by participants who preferred GPN over CBC/TCBC is *clarity of information*. For instance, P1 who took part in the TCBC vs GPN experiment elaborated his like for GPN as follows:

> *"It is easy to focus on what you want because every representation on the screen can make you get involved in more on the screen. I don't need the analysis of the numbers. I just need the information."*

P5 from the same experiment with P1 echoed similar views and added the factor of being less distracted from TV: *"It is simple, plain and basic, not filled with bars and colours. It is straightforward. I can keep watching the game."* Furthermore, all participants who preferred GPN over CBC/TCBC and had this like for GPN were observed in *TCBC vs GPN, On-Play, Random Order* experiments.

Similar to *GBC vs GPN* experiments, orientation of bar charts was seen as an issue by a couple of participants who preferred CBC/TCBC in the experiments of *CBC/TCBC vs GPN*. P14 said horizontal orientation of CBC was a problem and he implied a different orientation would make bar charts deliver information more quickly: *"If you wanna make the differences in amounts processed, they need to be displayed vertically."* P6 who was from *TCBC vs GPN, On-Play, Random Order* experiment was not happy with the current orientation of TCBC and suggested: *"Bar charts could be consecutive, one onto each other, stacked."*

5.1.2.5.4 The Need for Other Types of Visualisations

As stated before, during the mini-interviews in all experiments, participants were asked to describe their ideal visualisation of match statistics. 12 of 33 (36%) people who preferred GBC in the experiments of *GBC vs GPN* declared that they wanted pie charts as their ideal visualisation for all or some match statistics. In addition, 9 of 12 could not recall comparison of match statistics in GBC. On the other hand, in *CBC/TCBC vs GPN* experiments, 6 of 26 (23%) participants wanted full or partial inclusion of pie charts in their ideal visualisation however, their specific reasons for this are not known. For instance, P14 who was in *TCBC vs GPN* experiment highlighted that he liked pie charts more than bar charts though he did not explain why. Moreover, 5 of 6 specified that they wanted pie charts for the depiction of ball possession rates. However, all 6 succeeded to recall comparison of match statistics in CBC/TCBC. Their rate of success suggests that pie charts might not always be necessary for recalling match statistics at a better rate. On top of that, the wish for pie charts might be related to receiving match statistics more rapidly thereby being less distracted from the match on TV, as some participants stated this in *the need for pie charts* part of the section of *analysis of results* in *GBC vs GPN* experiments.

In *GBC vs GPN* experiments, only 4 of 33 (12%) who preferred GBC wanted visually embellished elements in their ideal visualisation and 2 of them were successful in recalling both verbatim match statistics and a comparison of them. 5 of 26 (19%) who preferred CBC/TCBC in the experiments of *CBC/TCBC vs GPN* wanted visually embellished elements in their ideal visualisation. For instance, P11 who was from *CBC vs GPN, On-Play, Random Order* experiment wanted a more human-recognisable visual aid: *"Football balls can be used to visualise the number of shots. More concrete visualisations could be used."* Besides, 4 of 5 participants who preferred CBC/TCBC and expressed their desire to have visual embellishment in their visualisation could recall both verbatim match statistics and comparison of them. Therefore, such a desire might be more related to the need for quick access to match statistics due to the concern of missing action on TV. For example, P1 who volunteered for the *TCBC vs GPN, On-Play, Random Order* experiment wanted team flags on bar charts because he thought more clarification was needed for teams, implying that he spent more time than necessary on second screen. Furthermore, another reason for the demand for visual embellishments might be related to pure entertainment. P1 in *CBC vs GPN, On-Play, Random Order* experiment stressed enjoyment: *"…The design was very minimal which I personally like [it] but when it comes to sports because I have entertainment in my head, I would like to see more of a show."*

5.1.2.6 Summary of Findings

- Football match statistics that were visualised in a combination of two-coloured bar charts, CBC (bar charts in team colours, colour-blind-safe team colours and warm-cold colours), seem to be equally as memorable as football match statistics that were depicted in GPN when the second screen interaction occurred during the act of watching football matches on TV.

- In terms of recalling verbatim match statistics, football match statistics that were visualised in team-coloured bar charts with repositioned numbers (TCBC), seem to be more memorable than football match statistics depicted in GPN, when the second screen interaction happened during the act of watching football matches on TV. In terms of recalling comparison of match statistics, the opposite is true; however, the differences between TCBC and GPN in recalling verbatim match statistics and comparison of them are not statistically significant.

- Comparing the recalling performance of match statistics visualised in GBC against the recalling performance of match statistics depicted in GPN, the recollection of match statistics displayed in bar charts seem to increase against GPN with the introduction of colour.

- Participants' evaluations for CBC and GPN differed significantly in terms of *memorability* of visualisations. For the other aspects, *understandability*, *contribution to the understanding of the match* and *level of enhanced watching experience provision*, participants' evaluations for CBC and GPN did not significantly differ.

- Participants' evaluations for TCBC and GPN did not significantly differ in terms of *memorability*, *understandability*, *contribution to the understanding of the match* and *level of enhanced watching experience provision* of the visualisations.

- Although two-colour schemes and repositioned numerical values on bar charts were considered as catalysts that could increase the participants' recalling performance of match statistics in bar charts over GPN significantly, they did not seem to improve the performance significantly.

- Although participants' performance of recalling match statistics in 2-coloured bar charts (CBC and TCBC) and GPN did not significantly differ, the number of participants who preferred CBC and TCBC was more than four times that of participants who preferred GPN in the *CBC vs GPN, On-Play, Random Order* and *TCBC vs GPN, On-Play, Random Order* experiments.

- Although participants' evaluations for two-coloured bar charts (CBC and TCBC) and GPN did not significantly differ in most aspects, the number of participants who preferred CBC and TCBC was four times greater than the number of participants who preferred GPN in the *CBC vs GPN, On-Play, Random Order* and *TCBC vs GPN, On-Play, Random Order* experiments.

- The following could be the reasons for the indifferent participant performance of recalling match statistics in CBC/TCBC and GPN and the dominance of CBC/TCBC over GPN in participants' visualisation preferences.

    - Two-colour schemes on bar charts might channel viewers' perception in a certain way so that they receive rather quicker and more memorable impression of information than exact information, through helping viewers to have a better association of information when the cognitive load on viewers is higher.

    - Two-coloured bar charts (CBC and TCBC) might not be significantly more memorable than GPN due to having a more crowded look compared to GPN on second screen; therefore employing more visual elements might overwhelm viewers who are under higher cognitive load.

    - Orientation of bar charts (CBC and TCBC) might be detrimental to quickness of information reception and memorability of information.

  - Repositioning of numbers on team-coloured bar charts seemed to increase recalling performance of verbatim match statistics against grey plain numbers (GPN) compared to CBC's recalling performance against GPN. However, looking at CBC's recalling performance of comparison of match statistics against GPN, repositioning of numbers on team-coloured bar charts seemed to have a negative effect for the recollection of comparison of match statistics against GPN.

  - Two-coloured bar charts (CBC and TCBC) might not be the best for comparing match statistics since there were several participants who wanted pie charts for the depiction of certain type of match statistics to receive the statistics more rapidly.

- Lack of more human-recognisable visual elements on bar charts (CBC and TCBC) might just inhibit viewers' association of match statistics with teams but have no significant effect on the memorability of match statistics. CBC and TCBC with more concrete visual elements might increase the speed of information reception; therefore allow viewers to have less distraction from TV. Besides, visually embellished CBC and TCBC might be more entertaining.

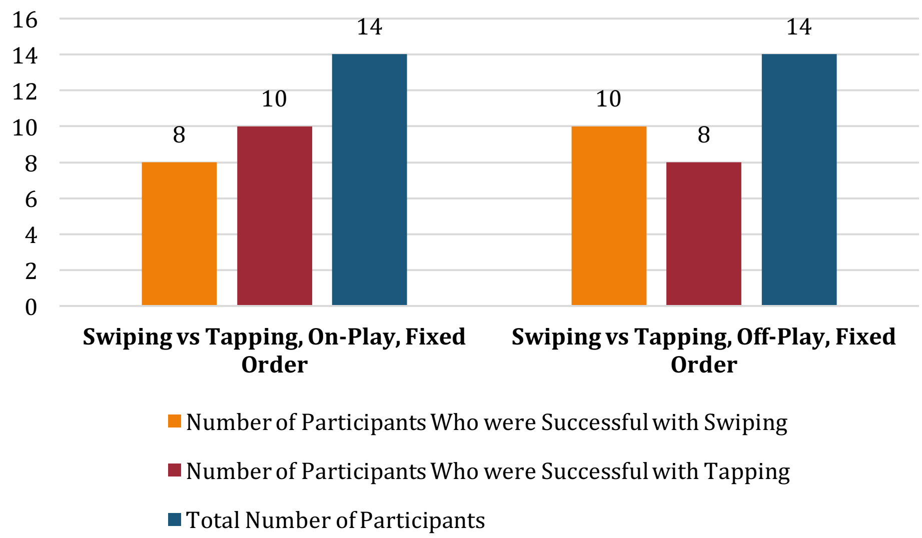
5.2 Interaction Experiments

In this section, the results of interaction experiments are presented. The results are revealed in the following order: First, the recalling performance of participants in swiping and tapping are shown in graphs and main outcomes from the graphs are deduced. A summary of participants' evaluations for swiping and tapping and comparison of this summary with their recalling performance with swiping and tapping follow this. Next, participants' interaction gesture preferences are depicted and their preferences are compared with their recalling performances for the two gestures and their evaluations for two gestures. Then, the differences between participant performances, evaluations and preferences are explained through the highlighted content that is derived from the interviews and recorded videos of participant interactions on second screen. Finally, the results of interaction experiments are discussed.

5.2.1 Swiping vs Tapping Experiments

5.2.1.1 Recalling Verbatim Match Statistics

Figure 5.7: The distribution of participant success of recalling verbatim match statistics in 2 different experiments of Swiping vs Tapping.

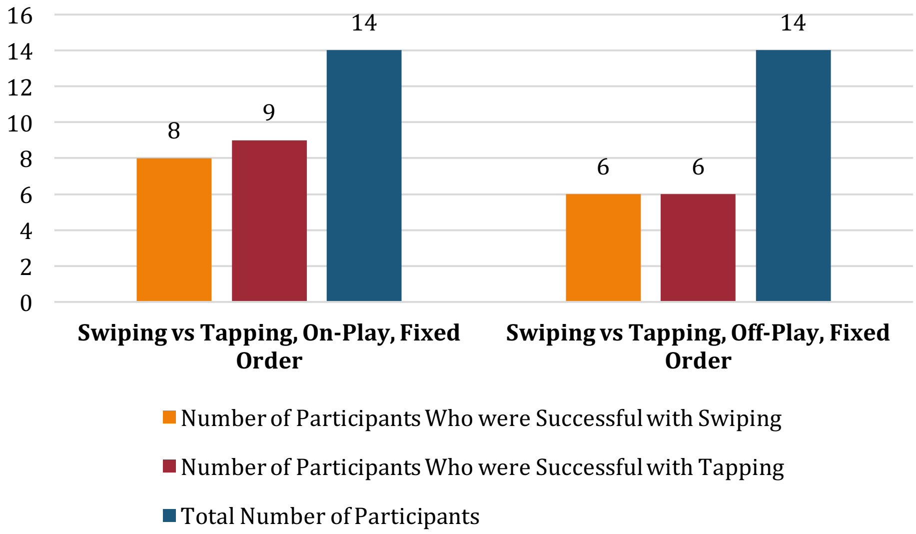


The graph above (Fig 5.7) demonstrates the number of participants who could recall verbatim match statistics after they had accessed match statistics via swiping and tapping on second screen. The first outcome from these experiments is the following: Compared to tapping, accessing match statistics on second screen through swiping yielded a worse participant performance of recalling verbatim match statistics when participants accessed the match statistics through second screen in *On-Pla*y i.e. during the act of watching a football match on TV. Nonetheless, the results are opposite in a situation when the second screen interaction occurred during a lengthy pause, *Off-Play*, in watching the match. In Off-Play, compared to tapping, information retrieval via swiping led to better participant recalling performance of verbatim match statistics. Like in the visualisation experiments, to see whether there is a significant probability that participants' recalling performance of verbatim match statistics with different interaction gesture differ in each experiment, McNemar tests were applied to the results of each experiment (Appendix 7). The results of the tests revealed that there is not a significant probability that participants recalling performance of verbatim match statistics differ with swiping and tapping in both On-Play and Off-Play situations.

In both interaction experiments, participants always accessed the match statistics on second screen through swiping during or after they watched the first video, and tapping during or after they watched the second video; therefore, the order of interaction gestures in both experiments were fixed. It is known that such fixation might cause bias in results due to the learning factor as mentioned in the first group of visualisation experiments; however, since fixation of visualisation did not seem to affect the trends in visualisation experiments, such disadvantage caused by non-randomisation might be tolerated to certain degree.

5.2.1.2 Recalling Comparison of Match Statistics

Figure 5.8: The distribution of participant success of recalling verbatim match statistics in 2 different experiments of Swiping vs Tapping.



The graph above (Fig 5.8) displays the number of participants who recalled comparison of match statistics successfully after they had retrieved match statistics via swiping and tapping on second screen. The first deduction from this graph (Fig 5.8) is as follows: Similar to the results of recalling verbatim match statistics (Fig 5.7), accessing match statistics on second screen through swiping yielded a worse participant performance of recalling comparison of match statistics compared to participant performance with tapping in *On-Pla*y. However, participant performances of recalling comparison of match statistics after reaching the statistics on second screen through swiping and tapping were equal. To see whether there is a significant probability that participants' recalling performance of comparison of match statistics with different interaction gesture differ in each experiment, McNemar tests were applied to the results of each experiment (Appendix 2). The results of the tests revealed that there is not a significant probability that participants recalling performance of comparison of match statistics differ with swiping and tapping in both On-Play and Off-Play situations.

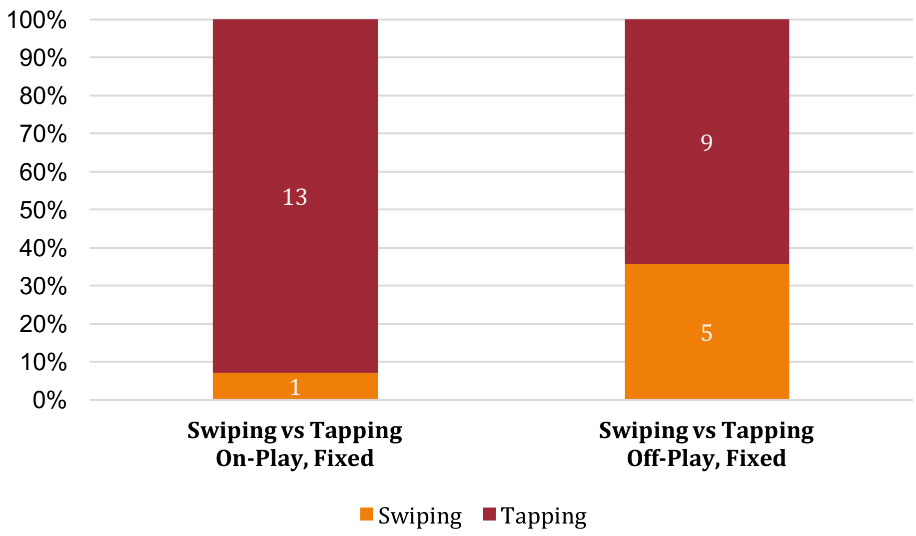
Similar to what was highlighted regarding the results of recalling verbatim match statistics, fixed order of interaction gestures in the experiments might have created a bias; therefore, it could be argued that due to such fixation participants did not have a better recalling performance with swiping compared to their recalling performance with tapping. However, as explained before, such potential bias may not be sufficient to affect the trends.

5.2.1.3 Participants' Evaluation for Swiping and Tapping

In the Methodology chapter, it was detailed that each time after participants had watched the short videos and interacted with second screen, they were given a questionnaire. In the questionnaires, different to the questions regarding recalling verbatim match statistics and comparison of them, participants evaluated swiping and tapping by answering Likert-scale questions regarding the following aspects: *ease in application*, *understandability*, *learnability*, *quickness and level of not distracting attention too much from TV*. In *ease in application*, *understandability*, *learnability*, *quickness* and *level of not being too distracting viewer attention from TV*, tapping was always rated higher than swiping in On-Play and Off-Play. However, Wilcoxon Signed-Ranks tests that were applied to the answers of Likert-scale questions (Appendix 9), revealed that there was evidence that such differences between tapping and swiping regarding *ease in application*, *understandability* and *quickness* are significant in On-Play whereas regarding *understandability* and *level of not being too distracting viewer attention from TV*, there was no evidence that the differences between tapping and swiping are significant in On-Play. For Off-Play, there is no significant probability that the rates reported by the participants for swiping and tapping differ regarding the aforementioned five aspects.

5.2.1.4 Participants' Interaction Gesture Preferences

Figure 5.9: The distribution of participants and their preferred interaction gesture in the experiments of Swiping vs Tapping.



When participants' performances of recalling match statistics with swiping and tapping are combined with their evaluation for swiping and tapping and their gesture preferences, the following statement could be made: Although participants' recalling performance of verbatim match statistics and comparison of them are not remarkably different with different gestures of interaction, their rates for each gesture in particular aspects and their gesture preferences show that tapping is slightly favoured. Surprisingly, the number of people who favoured swiping was more during Off-Play than the number of people who preferred it in On-Play.

5.2.1.5 Analysis of Results

In this section, the results of participants' recalling performances in both gestures, their evaluations for both gestures and their gesture preferences in these interaction experiments are analysed through the content analysis of the mini-interviews that were held with participants after they had watched the second video and completed the second questionnaire. In addition, observations from recorded videos of participant interaction during the experiments are presented to explain the results.

5.2.1.5.1 Convenience of Tapping

In both On-Play and Off-Play experiments, tapping was favoured significantly over swiping. In On-Play, the difference between the number of people who preferred tapping and the number of people who favoured swiping is much larger than the same difference in Off-Play. The reason could be explained with significantly better ratings of tapping compared to the ratings of swiping in *ease in application*, *understandability* and *quickness* in On-Play. Certain themes from participants that are derived from the interviews shed more light on them. For instance, 4 of 13 participants who preferred tapping declared that their like for tapping was its *intuitiveness*. P13 stated:

> *"…With the menu and the buttons laid out as they were, without any instructions one would have thought tap as opposed to swipe so it seemed more intuitive to tap than swipe."*

People's familiarity for tapping might be the factor why they thought it was intuitive. P6 gave more details and made connection with *intuitiveness* and *familiarity*: *"…you kinda have a first instinct when you go on something like that is the tap. It's very what you've been used to, have button pressed…"*

Another theme, *quickness*, might be related to why tapping was favoured remarkably since 6 of 13 who chose tapping mentioned it as their liking for this gesture. P12 described how quick tapping was for him compared to swiping: *"You don't need to make another movement on the screen, you just tap... It's quicker."* P3 had similar ideas for tapping: *"…For swiping, the finger movement takes longer, for tapping it is much quicker…"* P9 emphasised why quickness could be vital when he was explaining how tapping for information access enhanced his watching experience: *"…It is less time consuming and it is important because your main focus should on the football match.*

Tapping happens in a blink of an eye." In fact, when the video recordings of participants were watched, it was observed that 11 of 14 participants in On-Play experiments reached the match statistics in 6 or less seconds with tapping. However, this changed dramatically for swiping that only 2 of 14 participants in the same experiment accessed the statistics in 6 or less seconds with swiping. For most of them, information access with swiping seemed to take considerably more time.

Via highlighting *quickness* all of them imply that tapping caused less distraction for them and they did not need to spend more time than necessary on second screen. However, there are clues that tapping might not be the ideal in this sense. For example, P7 who preferred tapping stressed that although tapping was less distracting, the level of distraction that it caused was still high for him. P11's comment on tapping could explain P7's complaint on distraction that according to him tapping allows access to more options but requires more concentration. Tapping might be quicker; however, as P4 and P12 said, it may be more accident-prone and need more focus. P13 underlined such need: *"…You have to look at the screen to know what you tap."*

Control, the feeling that 3 participants received through tapping could be another reason why tapping was favoured more. P1 told how tapping improved his experience as follows:

> *"…By tapping, I felt like somehow that I was navigating the screen more comfortably… to have more control of what content I was actually accessing…Swiping is more of a casual movement so I don't feel like that… maybe I miss a couple of times."*

P2 made an analogy regarding how he felt in control with tapping:

> *"I'm more than a normal audience… I'm like the director of the whole match, choose whatever I want, whatever perspective of the match I want to see… I can check specific data."*

Considering the likes and reasons for tapping mentioned above, the following might be deducted: Compared to swiping, tapping's level of accident-proneness seems to be higher; however, the nature of its quicker application, its higher level of intuitiveness and the feeling of control with this gesture might offset the need for more eye focus for tapping on second screen. As a result, tapping might create a more seamless interaction than swiping; hence, people might get less frustrated to retrieve information through tapping, and such seamless interaction might cause them to lose their focus on the information and the game less likely. Therefore, it may lead them to prefer tapping considerably more than swiping. Furthermore, such seamless interaction might play a role in improving the recollection of both verbatim match statistics and comparison of them through tapping in situations that the level of cognitive load on viewers is higher; however, caution must be applied in this regard since participants' recalling performances in tapping and their likes for tapping do not yield a positive correlation. For instance, none of the 4 people who preferred tapping and liked it due to its intuitiveness nor the 6 participants who preferred tapping and liked it due to its quickness had a perfect record of recalling match statistics with tapping.

5.2.1.5.2 Usefulness of Swiping in Off-Play

Unlike the On-Play experiment, tapping did not yield better performances of recalling match statistics than swiping in Off-Play experiment. Such a trend occurred although even the numbers of people who preferred tapping was still more than the number of people who favoured swiping. However, the percentage of people (35%) who favoured swiping in the Off-Play test is larger than that of participants (7%) who preferred the gesture in the On-Play test. Such a rise and the comments of swiping favourers on their choice of gesture might give us hint regarding why swiping was better against tapping in recalling verbatim match statistics and more people preferred swiping in Off-Play experiment. For instance, swiping seems to be *intuitive* and *less distracting* for 3 of 5 people who preferred this gesture. P10 said: *"It's just easy, natural. You can keep looking at the telly while doing it. It doesn't disrupt your viewing."* P14 had similar thoughts: *"You can do it whilst you're looking at the screen. It distracts you a bit less… It is quite natural."* The comments about the less distracting nature of swiping might sound odd since in Off-Play, viewers' focus is relatively more on second screen; however, people may still watch TV, e.g. pundits or other content related to the match, in the long breaks such as half-time or end of match; therefore, retrieval of match statistics on second screen might still require a way of reach that is not too distracting.

Quickness was highlighted by 3 of 5 people who favoured swiping. This might be related to the menu design since participants saw only 1 option per screen to reach the match statistics when they interacted with second screen with swiping. On top of that, swiping's nature of being less accident-prone might play a role in why people found it quick. P7 who preferred swiping described it as follows: *"You're guaranteed that you will hit the right area; that is, you're less likely to make a mistake, hit the wrong button."* Thus, they might feel that swiping was quicker than tapping although the application of it might be slightly slower than tapping as mentioned by a participant in On-Play experiment.

5.2.1.5.3 Ideal Interaction Gesture

The main reason why participants who were content with their preferred interaction gesture had a lower ratio in On-Play experiment than Off-Play could be explained with the differences in cognitive load on participants between the experiments. In On-Play experiments, a higher number of participants highlighted different gestures for different tasks. For instance, P2, from the On-Play experiment, who preferred tapping over swiping, wanted the following as his ideal interaction mode: *"…Combination of tapping and swiping because tapping makes it easier to choose and swiping is quicker..."* P3, from the same experiment, who preferred tapping, too, echoed P2's views: *"…Tapping is preferable for choosing info….[and] when you have options. Before getting to options, I prefer swiping…"* Another couple of participants, from the same experiment, who preferred tapping as well, wanted only single-tap implying that the least number of interactions with menus was ideal for their second screen experience. Besides, the following statement of P4, who took part in the same experiment, could be considered as a valid explanation why such difference occurred across the experiments. Although he preferred tapping over swiping he refused to tell his ideal gesture of interaction and stated what could be his ideal gesture if the conditions were different: *"...If it was half-time, it would be tapping because I can easily navigate with my brain focus on the device…"*

5.2.1.6 Summary of Findings

- Tapping on second screen to retrieve match statistics seem to yield better participant performance of recalling verbatim match statistics compared to swiping when such activity of information retrieval happens during the act of watching football match on TV. On the other hand, swiping seems to better than tapping in this regard when viewers retrieved such information in a long pause of match on TV. However, both differences between gestures in recalling performances are not in significant levels.

- In terms of recalling comparison of match statistics, tapping on second screen to retrieve match statistics seem to yield better participant performance compared to swiping when such activity of information retrieval happens during the act of watching football match on TV. However, this performance difference between gestures in recalling performance of comparison of match statistics is not significant. In addition, both gestures performed equally in this regard when viewers retrieved such information during a long pause of the match on TV.

- Participant evaluations favour tapping more than swiping in both interaction experiments. However, only for *ease in application*, *understandability* and *quickness,* there was a significant probability that participant evaluations for tapping and swiping differed in On-Play experiment.

- The number of participants who preferred tapping and swiping in On-Play and Off-Play experiments seem to be correlated with participant evaluations in both experiments. In On-Play experiments, tapping was evaluated significantly better than swiping for the three aspects that were mentioned in the article above and 92% of participants in this experiments preferred tapping. However, in Off-Play experiments, tapping was not evaluated significantly better in any aspect and 64% of participants preferred tapping over swiping.

- The following themes were highlighted by participants who preferred tapping over swiping: *Intuitiveness*, *quickness*, *control*. These 3 themes imply that tapping allowed participants to have a more seamless interaction compared to swiping; therefore, such seamless interaction overcame any distraction caused by tapping's need for more focus on second screen compared to swiping due to its higher accident-proness compared to swiping. Recorded videos revealed that participants accessed the match statistics on second screen signifcantly more quickly via tapping than they did through swiping.

- Swiping was preferred by participants due to the following reasons: *less distraction*, *intuitiveness*, *less accident-proneness*.

- Tapping was preferred by an overwhelming majority in On-Play experiment. The number of people who preferred tapping in On-Play was more than the number of people who preferred tapping in Off-Play. However, the people who suggested different gestures or combination of gestures as their ideal interaction gesture were greater in the On-Play experiment than the Off-Play experiment. Several people in the On-Play experiment expressed their desire to have different gestures for different tasks. These might suggest that tapping may not be the convenient interaction gesture to retrieve match statistics when the cognitive load on viewers is higher.

6 Discussion of Experiments & Design Recommendations

In the previous chapter, the quantitative and qualitative results of visualisation and interaction experiments were presented. In this chapter, the results of those experiments are discussed. In addition, based on the experiment results, design recommendations regarding match statistics visualisations on second screen and interaction gestures to retrieve match statistics on second screen are listed.

6.1 Discussion of Visualisation Experiments

Prior to the visualisation experiments it was assumed that bar charts would result in a significantly better performance of recalling match statistics compared to grey plain numbers (GPN), especially in On-Play scenarios. The reason for this assumption is that it was believed that under the circumstances of being exposed to relatively more cognitive load compared to Off-Play, all visual aid such as shape, colour and colour tones in all three types of bar charts would increase information reception and make the statistics more memorable compared to GPN.

Firstly, the reason why such indifferences occurred in the memory performances of participants was thought to be the *lack of colour*. After the results of the experiments regarding memory performances between GBC and GPN were received, it was thought that bar charts with grey tones that were assigned to both teams might have been confusing to many participants. Also, such bar chart design with grey tones might not have allowed them to distinguish the sides easily but made them spend more time identifying the associations between the statistics and sides. This might be due to the fact that a considerable number of participants stressed that they suffered frustration due to colour scheme and *lack of colour*.

The addition of various colour schemes to bar charts did not add a significant advantage for bar charts in memory performance of participants in the experiment of *CBC vs GPN*, although *lack of colour* was raised as an issue by many participants in the three experiments of GBC vs GPN. Since the numerical values on CBC were at the opposite end of bars that, unlike the positioning of GPN, where numbers on bars were not vertically aligned with each other across the rows of bars; therefore, it was thought that the placement of numbers caused participants to spend more time to receive and process the information with relatively more difficulty. In the previous tests, people, who declared that the grey colour scheme was problematic for them, wanted team-coloured bar charts, the experiment of *CBC vs GPN* was a mix of colour schemes that included *team-coloured bar charts*, *bar charts with colour-blind-safe team colours* and *warm-cold coloured bar charts*. In conclusion, it was thought that perhaps the second (colour-blind-safe team colours) and third type (warm-cold colours) of colour schemes on bar charts were rather detrimental than helpful for the participants in recalling match statistics since few participants who saw bar charts in colour-blind-safe colours or warm-cold colours demanded team-coloured bar charts. One of those participants who saw bar charts in warm-cold colours explicitly stated that he perceived the colour scheme as random and not meaningful. As it was mentioned before, Few (2006) underlined the relationship between colour and meaning, i.e. that the assigned colours to data elements had to be meaningful because otherwise the readers would waste their effort and attention looking for associations that did not exist. In such a situation where cognitive load is relatively higher, it might be deduced that not having meaningful colours on visualisations could cause great distraction from TV and loss in memory.

The situation of indifference in recalling performances was preserved in the final iteration of the tests where team-coloured bar charts with repositioned numbers (TCBC) did not make a major difference over GPN, although it was the first time that participant performance in bar charts was better than their performance in plain numbers in terms of recalling verbatim match statistics. It could be argued that this might be due to the fact that colour contributed more to participants' enjoyment than their memory although compared to grey bar charts' (GBC) recalling performance against grey plain numbers' recalling performance, team colours on bar charts seemed to improve such performance. In addition, the notion of elegance might have distorted the attention to the shape rather than the information itself.

In general, the more numbers of visual elements on the mobile screen may have negated perception through increasing cognitive load more than users could cope with in this situation; therefore, such number of elements on mobile screen under relatively more challenging circumstances may not be beneficial for users to keep the exact information in their mind. In fact, many liked bar charts because of its nature of giving a general impression of how each team perform through allowing comparisons, reflecting sense of differences in glimpses, but not the exact values. Considering the number of participants who found bar charts quick and less distracting, as well as giving an overall picture, perhaps it is best to conclude that bar charts' strongest asset is the delivery of quick and memorable perception regarding matches. Given the majority of people who favoured it, the reception necessity of exact values may not be the highest priority for most viewers.

Another important outcome from the experiments was that although the number of people who preferred bar charts is more than 4 times the number of people who picked grey plain numbers (GPN), this was not reflected on the performance of bar charts recalling verbatim statistics and exact comparison of statistics. This tells us an important difference between how a type of visualisation works for people and how they see it as enjoyable. Therefore, it might be asserted that the second screen affects the watching experience more positively by creating an impression on viewers through abstract visual elements that support numerical information regarding matches rather than presenting exact statistics without any non-numerical visual aid. Perhaps the reason why bar charts did not work significantly better than plain numbers in recalling match statistics but preferred remarkably more was difference in the visual language of content of TV and second screen. For instance, lack of concrete visual elements on second screen might have mitigated the transition between the screen and second screen; therefore, abstract elements such as bar charts did not help people to associate the facts with the match shown on the screen strongly. A participant stated: *"Because it was the separate thing that I was looking on my phone, I felt like it was two different things. I didn't feel it was part of the viewing experience."* Since some participants mentioned that they wanted icons or visual embellishments, an improvement might occur through this way of representation.

6.2 Discussion of Interaction Experiments

In the light of the literature review, swiping was thought as a more casual gesture for interaction whilst tapping would require more user focus and precision on the phone to retrieve information. Hence, prior to the tests, it was expected that swiping would yield better results over tapping in terms of remembering and comparing statistical information in the On-Play setting and tapping would be better for Off-Play. The reason why such an assumption was not reflected in the results could be correlated with the fact that swiping from right to left on the screen took more time accessing the statistics for some volunteers. Therefore, such a nuisance might have caused some people not to benefit from swiping's casual nature and perhaps distracted them more than they were supposed to be. In fact, many participants placed emphasis on the quickness of tapping and the observation videos unveiled that they were much quicker accessing the statistics through tapping.

Difficulties in the application of swiping on the screen could be a crucial reason for why tapping was favoured by most of the participants and swiping did not yield better recalling performances, especially in the On-Play situation since the participant rates for both gestures in terms of ease of application, understandability and quickness have notable differences. Firstly, the difficulty might be related to habits. Familiarity with tapping might have played a role in this regard because the video recordings showed that several participants attempted to tap on the screen when they were supposed to swipe. Moreover, restricting the area on the screen for swiping to *button-size* might be another factor why swiping was not better than tapping in the matter of recalling and comparing statistics and it was favoured considerably less than tapping. It should not be forgotten that tapping was evaluated significantly better than swiping in *ease of application* in On-Play. In addition to this, the video recordings of participants revealed that around 7 of 14 in the On-Play experiment had issues with 'swiping on the button' and such a struggle might frustrate and distract them from the match and the information itself. Presuming that participants had all the screen area active to swipe, they might have had a better interaction experience. Therefore, they might also have had a better recalling performance.

Another striking point was the rise of the number of people who favoured swiping in the Off-Play experiment. Although the same number of people (9) struggled with swiping in both On-Play and Off-Play tests, the number of people who preferred swiping dramatically rose. Such a discrepancy could be attributed to the experience of the participants. They might realise that swiping's casual nature might give them more promise after they have learned how it worked.

Interestingly, the number of participants who failed to recall exact comparison of statistics in both gestures rose from 1 in On-Play to 5 in Off-Play and the ratio of overall success in recalling match statistics fell in Off-Play. Since, compared to Off-Play, cognitive load on participants is more in On-Play, this result was not expected. The reason could be that the participants' act of information retrieval in On-Play might have created a better complementary watching experience than the experience in Off-Play. Therefore, such a supportive experience might have offset the detrimental effects of a higher cognitive load in On-Play. The reason why the interaction in On-Play might have created a better complementary experience could be related to the fact that all links and match statistics coloured in grey had no meaningful connection with the clips. Such disconnection between second screen and TV in terms of colour might have played a negative role in such complementary experience.

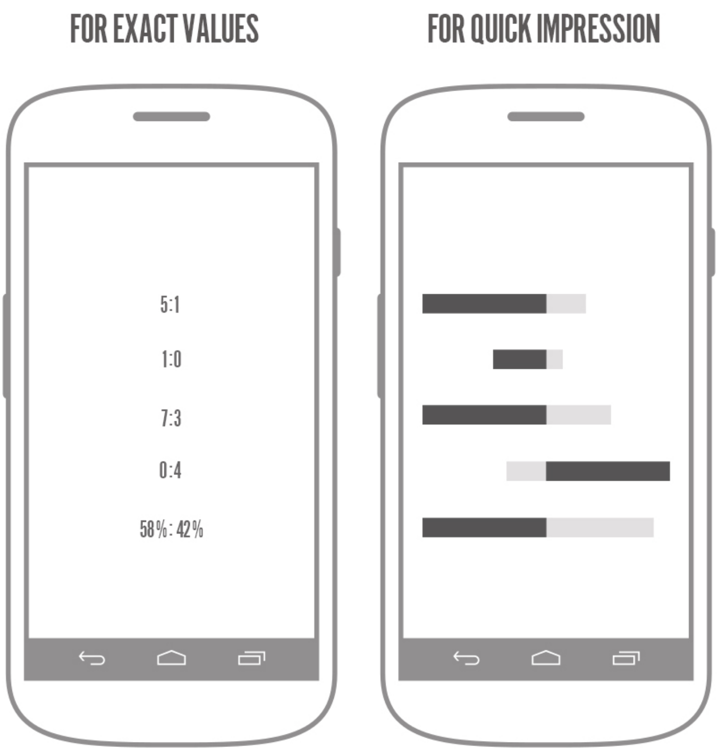
6.3 Design Recommendations

The following design recommendations are developed as a result of all findings from the visualisation and interaction experiments. It should be noted that the listed recommendations are developed as a result of the research discussion and findings presented in the fifth chapter. They do not form strict guidelines but recommendations on improving the viewer experience of interacting with second screen apps and websites whilst watching football matches.

6.3.1 Graphical Representation of Match Statistics

1. The mobile app and website developers might consider different visualisations for different purposes (Fig 6.1). For instance, should they aim to deliver a quick impression to second screen users, they might prefer bar charts over plain numbers to visualise the statistical match-related information. However, should the purpose be to convey exact values, plain numbers might be considered to visualise statistical match-related information, too.

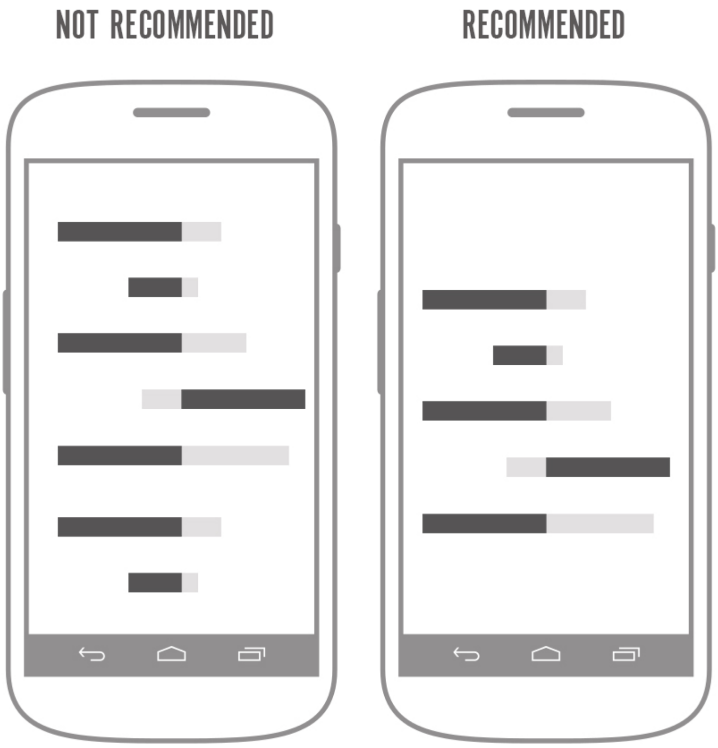
Figure 6.1: Visualisations for different purposes.



2. Bar charts should be designed in a way to avoid giving the impression of a crowded look (Fig 6.2). Therefore, bar charts should not take up too much space

on the second screen. Bar charts that have an overcrowded look on second screen might confuse and distract viewers significantly; especially, whilst they are using this during their act of watching matches on TV.

Figure 6.2: Overcrowded look vs Less crowded look.



3. Bar charts should be designed to facilitate smooth transition between TV and second screen.

    - Team colours might be used on bar charts to help viewers to associate match statistics with teams more easily; this might reduce time and effort for such association (Fig 6.3). However, colours that are used to associate match statistics with teams should be distinguishable and stand out from the background. Teams with the same colours may be differentiated by using the away jersey colour on bar charts so that associate match statistics could be associated with the away team. Using the same colour for both teams would create confusion. The level of confusion may be worsened should two different tones of colour be used to indicate the differences between teams (Fig 6.4).

Figure 6.3: Monochrome coloured (not recommended) vs team coloured (recommended) bar charts.

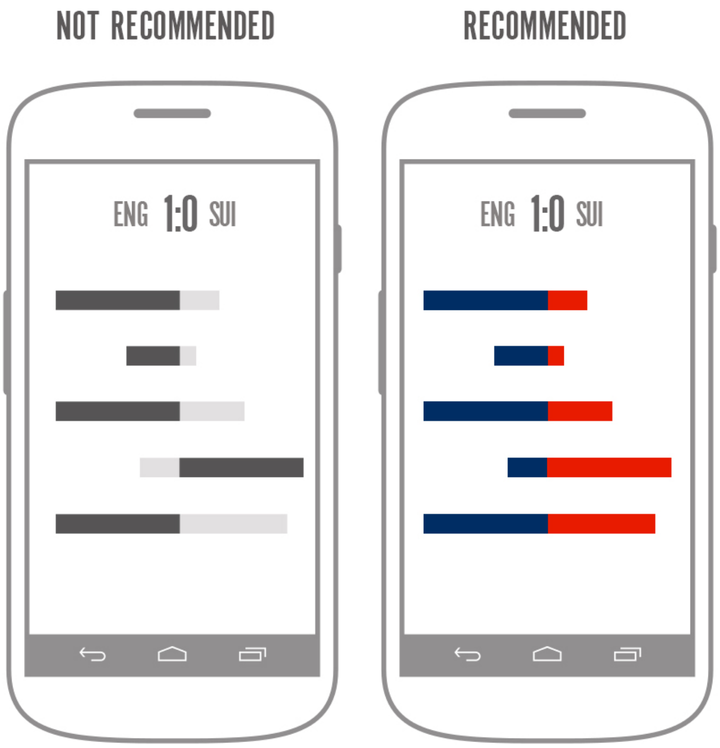
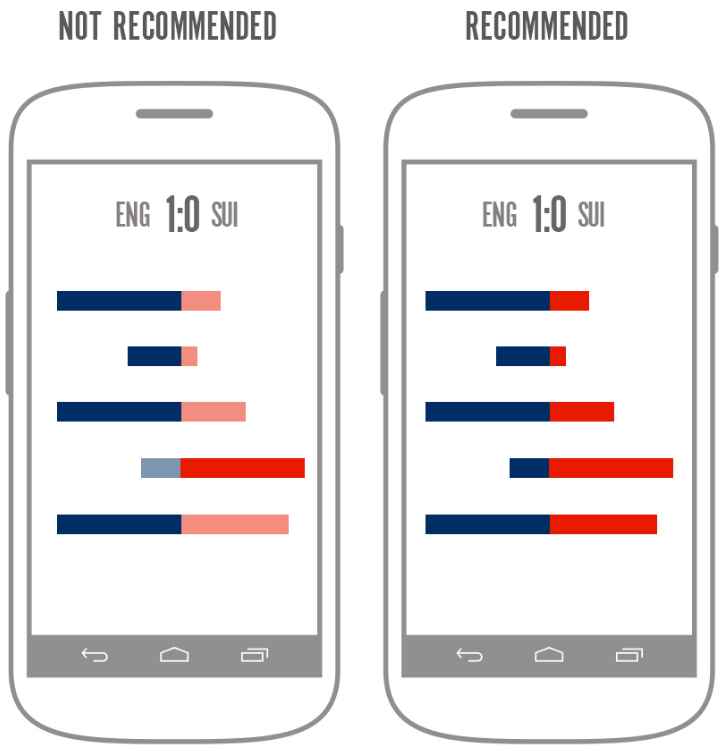
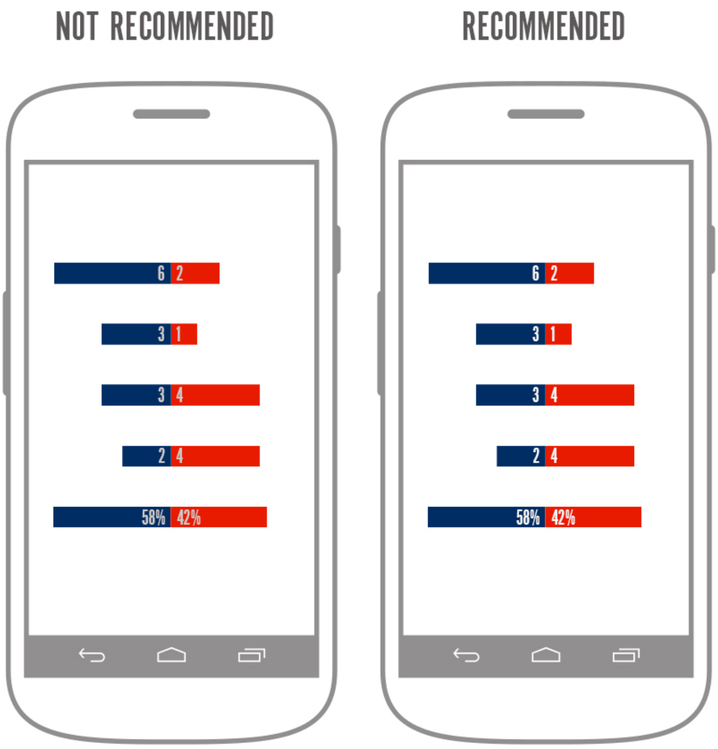


Figure 6.4: Colours with Different Tones (Not Recommended) vs Colours with Same Tones (Recommended).



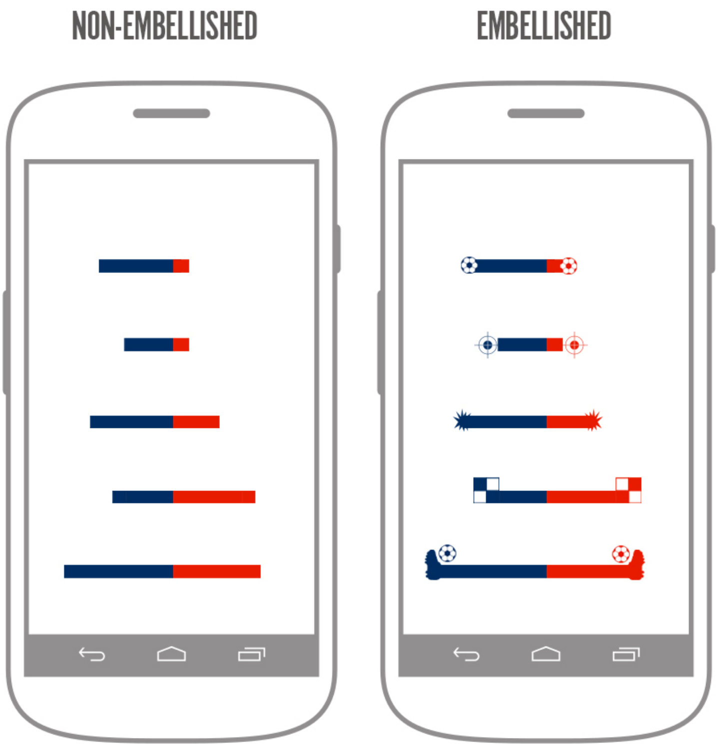
- Bar charts on the second screen should not overshadow the data labels, i.e. numerical values. To ensure this, data labels' colour contrast with bars' colour should be as strong as bars' colour contrast with background (Fig 6.5).

Figure 6.5: Overshadowed (Not Recommended) vs Not overshadowed (Recommended) Data Labels.



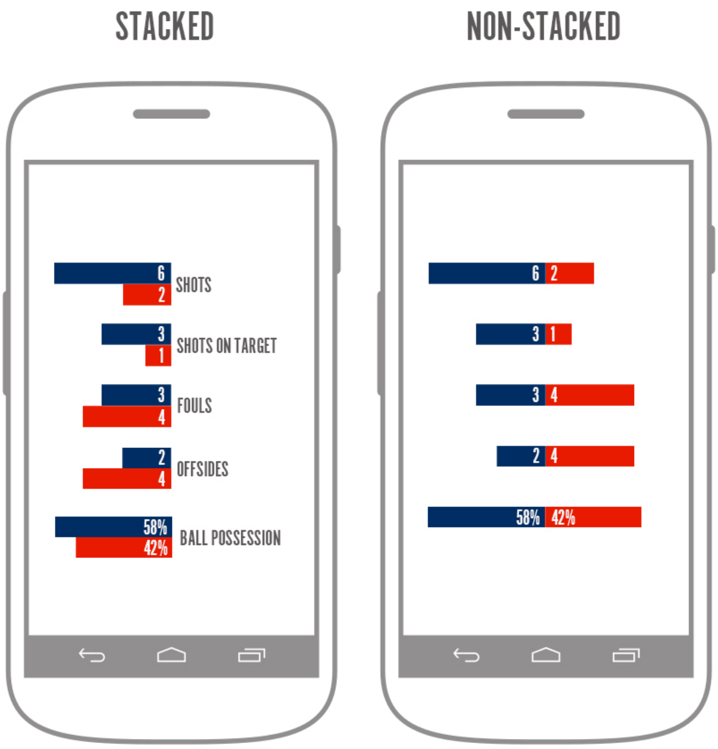
- Bar charts may need to accommodate additional visual cues such as more human-recognisable elements that allow viewers to have a better association of match statistics, type of statistics (Fig 6.6). However, visual embellishments should be informative to foster quick and memorable associations with statistics, their category of statistics and the team they belong to. They should not be overused to cause an overcrowded look on the screen.

Figure 6.6: Non-embellished vs embellished bar charts.



4. Orientation of bar charts associated with teams seems to be important for a quick comparison of match statistics. Bar charts that represent each team's statistics may be stacked next to each other to deliver match statistics to viewers most quickly (Fig 6.7).

Figure 6.7: Stacked vs non-stacked bar charts.

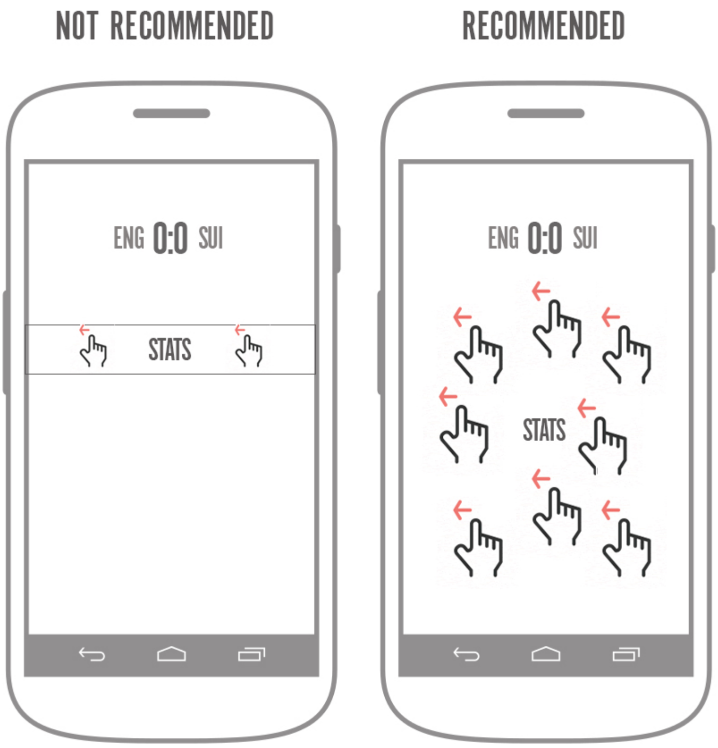


5. Developers and designers may offer second screen users the option of plain numbers for match statistics display, as a minority of people seem to prefer less visual elements on second screen and be interested in viewing match statistics in plain numbers.

6.3.2 Interaction Gestures for Information Retrieval on Second Screen

6. Swiping seems to be convenient for retrieving match statistics on second screen whilst the match is on, since it seems to be less distracting for viewers from the TV. However, hotspots for swiping should be unbounded on the screen; otherwise, swiping might be more distracting than tapping (Fig 6.8). The design of the menu to reach the match statistics through swiping should allow directional transitions; therefore, people could retrieve match statistics without a lot of glancing down at second screen.

Figure 6.8: Recommendation for swiping hotspot.

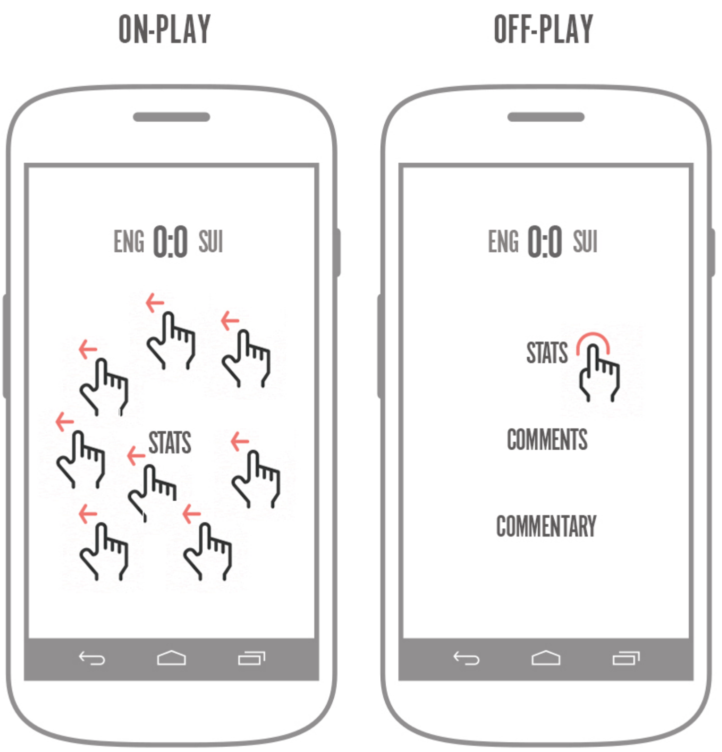


7. Tapping seems to be quicker, more intuitive and make viewers feel more in control of the content they want to access. However, compared to swiping it is more likely to cause accidental selection since tapping needs more eye focus on second screen, which is more distracting. Therefore, tapping seems to work best for Off-Play situations in which people can have more time to focus on second screen.

8. Apps and websites to display football match statistics could be designed in a smart fashion in that they should have a fluid navigation system (Fig 6.9). For instance, should viewers want to reach statistics when the gameplay is on, even if there were no short breaks, such as fouls and goal kicks, the menu might be in the dimensional form that viewers can reach different sorts of information through swiping in different directions. In addition, the menu on second screen might transform itself to a list of items when the match stops for a short break,

and viewers could interact with second screen via tapping to retrieve match statistics.

Figure 6.9: Menu and interaction gestures for On-Play and Off-Play.



7 Conclusion

The final part of the thesis is dedicated to presenting the summary of the following: First, why and how the thesis was formed. This is followed by the main outcomes, their implications and design recommendations for second screen interfaces (apps and websites) with regard to visualisations of match statistics and gestural interaction for the retrieval of such information. Then, it will be discussed to what extent the objectives set out in Chapter 1 have been achieved. Further, various challenges and limitations that were encountered during the whole process of the PhD journey are revealed in this chapter. In addition to this, how research on this topic could be extended with new directions is introduced.

7.1 Reasons and Methods

Football audience's habits of consuming football related information media has shifted in time, place and format due to an increasing number of Internet connected mobile devices. Therefore, nowadays, the practice of consuming any type and mix of textual, audio-visual content related to football games virtually, happens anytime and anywhere. Such consumption practice includes accessing different types of information about teams, competitions, players and matches, interacting with the governing bodies and players, socialising via sharing emotions and thoughts related to games, learning other viewers' reactions towards games, creating a sense of community and being connected to other people even if they are at remote locations. Consequently, novel non-linear ways of media access have given rise to a new phenomenon in consumption of football content; that is, watching the matches on TV and using a second screen. Despite the abundance of mobile apps and websites that have given auxiliary support to TV football audiences by allowing them to access statistical match-related information on second screen, there has been a lack of academic work pertaining to the effects of common visualisations of such match-related information and prominent interaction gestures for the retrieval of this type of information via second screen on the watching experience.

In order to investigate the effect of the aforementioned visualisations and interaction gestures, first, there was an initial need to understand viewer behaviour of seeking match-related information on additional media whilst they were watching football matches on TV. An online survey and interviews were conducted for this. After the online survey and interviews, a workshop was organised; however, the output was not specific enough with respect to the research focus. The issue was the large number of types of match-related information and visualisations for such information can take, and the results of the online survey did not show that a particular type of match-related information was preferred significantly more than others. For this reason, match statistics that appeared as one of the prominent types of sought match-related information on additional media from the findings of the online survey was chosen as the focus regarding the visualisation aspect of the thesis because time and resource limitations would not allow focus on the other types of information and the visualisations for them.

Several football apps and websites that display match statistics were reviewed in terms of how they displayed the match statistics and the interaction gestures for the retrieval of this type of information on them. Two different types of prominent visualisations, bar charts and plain numbers for match statistics were identified from the review. Thus, prototype experiments were setup to compare those visualisations. The visualisations were tested to look at their efficiency, memorability and enjoyment. Five different experiments were conducted with 74 participants in an iterative fashion to understand whether changes in colour scheme and positioning of data labels would make bar charts superior grey plain numbers another in all aforementioned aspects. Besides, it was observed that tapping was widely used in all reviewed apps and websites. Two prototype experiments were conducted to compare this type of interaction gesture with an emerging sort of interaction gesture, swiping, in terms of their efficiency and enjoyment.

7.2 Summary of Results

People who used additional media during the act of watching football matches on TV stated that they looked for more than one type of match-related information mainly via apps installed on their laptops and smartphones mostly during those periods of the matches when the gameplay was interrupted. In addition, a considerable number of people felt that the match-related information that they retrieved through second screen offered them an overall view of the match as well as the overall performance of players and teams. They also declared that second screen provided them a simulated socialisation experience and fun that they experience when they watched matches with other people. In addition, they seemed to have different expectations from second screen that some idealised it as full of tailored social media feeds whereas others demanded various statistical match information. Furthermore, some other people described their ideal second screen experience as all-in-one that they wanted both statistical in-game information and other people's comments via social media.

One of the most declared type of match-related information from the online survey was match statistics. The review of several football apps and websites revealed that bar charts and plain numbers were the two most used types of visualisation for depicting match statistics and tapping seemed to be most used interaction gesture to reach such information via those apps and websites. In addition, although they were generally designed in minimalistic style, their usage of colour in their visualisations were varied. Such variety in usage and design motivated the investigation of these elements with respect to how effective they are and how much this impacts on the enjoyment of the user.

The prototype experiments for visualisation showed that in most cases bar charts did not seem to yield better recalling performance of match statistics compared to plain numbers. Only in Off-Play experiment, grey bar charts (GBC) were better than plain numbers (GPN) in recalling both verbatim match statistics and comparison of them. In addition, team coloured bar charts with repositioned numbers (TCBC) performed slightly better than plain numbers in recalling verbatim match statistics. However, in all visualisation experiments, the differences between bar charts and plain numbers in participants' recalling performance were not statistically significant. Moreover, unlike the insignificant differences between visualisations in terms of recalling match statistics, most participants preferred bar charts over plain numbers. Furthermore, participants did not evaluate these two visualisations differently in all aspects and experiments except they rated coloured bar charts (CBC) significantly better than plain numbers in terms of memorability.

The visualisation experiments revealed that bar charts seemed to allow more rapid comparison of match statistics; hence, deliver a quicker impression of overall view of the match whereas plain numbers seemed to be better at the memorability of exact values. On top of that, most participants did not seem to be content with their preferred visualisation as they highlighted a variety of modifications for their preferred visualisations and mentioned other types of visualisations whilst they were describing their ideal visualisation in this context. Pie charts were one of the most seen types of visualisation that was emphasised in this regard.

The prototyping experiments for interaction gestures uncovered that recalling performance of match statistics after retrieving them via second screen by tapping seemed to be slightly better compared to swiping in On-Play situation. Moreover, the opposite was true when the experiment conducted in Off-Play scenario. However, the differences between the interaction gestures in both situations were not statistically significant. In addition, tapping was remarkably preferred by a majority of and in few aspects, it was rated significantly better than swiping. Furthermore, tapping seemed to be favoured due to quickness and intuitiveness whereas less distraction and less accident-proneness seemed to be reasons for people who preferred swiping.

7.3 The Contribution

The contribution of this thesis is a set of design recommendations for visualisations and interaction gestures on second screen to enhance the viewer experience of watching football matches on TV.

The contribution regarding the visualisations on second add certain angles to well-established design principles of data visualisations. For instance, Tufte (2001, p.92) highlighted the following as a principle: *"Above else, show the data."* With this statement, Tufte (2001, p.91) actually emphasised that *"[d]ata graphics should draw viewer's attention to the sense and substance of the data, not to something else."* Such principle implies clear outlook. Some of the design recommendations that are highlighted in this thesis are avoiding crowded look and overshadowing data labels. In this respect, the thesis confirms that such design principle made by Tufte applies to second screen context, too.

Tufte (2001) recommends the erasure of *"…non-data ink…"* (Tufte, 2001, p.96) and *"…redundant data-ink…"* (Tufte, 2001, p.100) for effective communication through visualisations. Moreover, a recent study stressed that *"[v]isualizations that contain pictograms tend to be better recognized and described."* (Borkin et. al., 2015, p.527). The thesis goes beyond them and recommends that even *data-ink* might be erased and just *numbers* would work best for some cases in second screen context.

The second contribution of the thesis is regarding the usage of interaction gestures on second screen. The difficulties that participants had with swiping on a restricted area on second screen led to a recommendation that swiping should be applicable to any part of the screen to maintain its casual nature. Therefore, viewers would be less distracted from the content on TV screen while retrieving information via second screen.

In the larger frame, the contribution of this thesis as design recommendations for visualisations and interaction gestures can be used as a strong reference for how information should be visualised and retrieved in multi-tasking environments for better perception, less effort and better well-being.

7.4 Discussion of Achievements

At the beginning, there were three main research questions and a list of objectives that were set to answer the questions. Within the time and resource frame, the objectives generally seem to be met. In addition to this, the findings seem to answer the levels of memorability, effectiveness and enjoyment of two prominent visualisations with a comparative approach. Two main issues could be stated as obstacles that prevented to obtain better answers for the research questions. First, the number of iterations in both visualisation and interaction experiments was not ideal to explore further such as the comparison of stacked bar charts in team colours versus plain numbers and combination of pie charts and bar charts versus plain numbers. Second, the results did not always yield clear patterns of data. For instance, it was apparent that a significant number of people preferred bar charts whilst their recalling performance in bar charts was not significantly superior over plain numbers. Such result was clear. However, many common points regarding different topics that were seen in the qualitative data did not dominate other common points in the same topic. Therefore, some design recommendations were given with more caution.

7.5 Research Limitations

7.5.1 Participants

During the whole process of the PhD, there have been challenges in participant recruitment. Reaching potential participants was one of the problems. Since seven different experiments were conducted considering different parameters of visualisation and interaction as well as considerations related to timing of interaction, over 100 people were needed to complete the experiments. The participants should ideally come from different cultures, have various level of education and interest to the research. Getting a sample of participants that could represent the diversity of football audiences was a daunting task. Most of the participants were from a certain level of education (high school level and more), and the number of participants who had at least an undergraduate degree was over half of the people who volunteered for the experiments.

It is an obvious fact that not all football viewers have high levels of education and they have a massive variety of occupations, life styles and income because football is the most popular sport in the world and its penetration is vast. In addition, the research on cognitive science shows childhood socioeconomic status affects the cognitive performance (Hackman and Farah, 2009). Therefore, it is unknown whether the research outputs might have been different had the participants come from more diverse socio-economical and educational backgrounds.

7.5.2 Watching Experience

Authenticity of the watching experience during the experiments was not ideal. First of all, the experiments were held in a lab environment, two identical meeting rooms at the university, which is not a genuine or natural environment for watching football matches on TV, such as participants' homes. Secondly, the participants did not watch a full match during the experiments but two short clips that could only represent a bit more than 5% of the whole match time. Third, the participants were instructed to retrieve information during or after watching the short videos. This could lessen the level of an authentic experience since the participants might not have had any desire to do so during those short videos. Fourth, the videos that were shown to participants might not have been found interesting by all of them since they were matches of England vs Switzerland and England vs Russia. Hence, the motivation of each participant for interaction on second screen was unknown. In summary, such limitations might affect the ecological validity of the research.

7.6 Further Research

For the investigation of different types of visualisation on second screen to understand how they influence the watching experience of football matches on TV, the following research directions may be pursued. First of all, since it was mentioned by several participants in their ideal visualisation, pie charts can be compared to bar charts and plain numbers. Besides, different combinations of two visualisation types e.g. bar charts and pie charts versus plain numbers and pie charts can be tested against each other. Apart from that, it may be interesting to add a further angle on the ongoing *Chart Junk Debate* (Tufte, 2001; Bateman et. al., 2010; Borkin et. al. 2016) through testing embellished bar charts against non-embellished bar charts in this second screen context since as Ware (2013, p.303) said: *"Often, object displays will be most effective when the components of the objects have a natural or metaphorical relationship to the data being represented."*

Comparison of embellished bar charts and plain numbers could be another suggestion to extend research in this context. On top of that, longer tests with a better environment that would simulate home settings could be performed were the resources to allow for it. Furthermore, various types of visualisations, especially the types that were mentioned above could be tested in different social settings such as pubs where people watch matches together. More ways of extending the research can be mentioned on top of the aforementioned suggestions; however, in broad sense, perhaps the main direction would be to find out whether there is any type of visualisation that can outperform other sorts in the following objective and subjective terms: *Effectiveness, memorability* and *enjoyment*.

Testing less commonly seen visualisations such as radial graphs, data maps and time series in second screen context seem to be another research dimension to focus on. These visualisations may depict other types of football match-related information that may be less popular than certain match statistics; however, as it was mentioned in Chapter 3, the types of match-related information that people sought on second screen vary and none of those types dominate the preferences of second screen users.

Therefore, it would be interesting to see how they affect the watching experience through their presence on second screen.

The main direction of further research regarding the effects of interaction gestures for information retrieval via second screen on the watching experience, could be to test combinations of gestures, whether they could yield notable better results against the existing gestures in objective performances i.e. recalling stats and subjective evaluations i.e. participant rates. Moreover, as it was mentioned in the previous paragraph, it would be worthwhile conducting research in a more authentic setting that participants would watch a full match at their homes. In such a case, participants could be left on their own in terms of retrieving match stats at any time and frequency that they would like to. The questions regarding recalling match statistics could be automated in line with participants' timing of interaction that the statistics would be synchronised to the match. Apart from that, how gestures affect the watching experience under different conditions, such as environment e.g. *home vs pub*, level of socialisation e.g. *alone vs with friends*, importance level of football match e.g. *friendly vs competitive* could be probed.

The research could be extended to a certain level to understand whether the effects of bar charts and plain numbers, as well as tapping and swiping on the watching experience demonstrate any changes with regards to longer and repeated use of second screen. In this regard, it might be an interesting investigation to conduct such research throughout a World Cup tournament that has 64 matches played in 1 month.

Another related area of research could be the visualisations that depict the summary of focused points on social media on second screen regarding the matches being watched. For instance, there was a visualisation project, *Emoto*, that aimed to visualise the emotional response based on Twitter feed towards 2012 London Olympics (Stefaner, M. et. al., 2012). Comparison of social media feed versus a visualisation summary of the feed regarding their effects on the watching experience, might be another interesting point of further research.

Apart from the aforementioned suggestions, it might be interesting to see whether the effects of same type of visualisations and interaction gestures on the watching experience varies in different sports. For instance, a tennis match seems to have more regular short breaks than a football match that might allow viewers to have more time to focus on second screen content. In addition, scoring in a basketball match occurs more often than a football match and this might make it more difficult for viewers to pay attention on second screen.

A future research direction could be the investigation of second screen experience in this context under different media, e.g. larger mobile devices, to understand whether the compared visualisations and interaction gestures in the experiments conducted for this thesis would yield different results in different media.

Using *augmented reality* (AR) as second screen might be another interesting aspect to extend the research. The reason why research on AR as second screen may be worth to pursue could be related to their potential of offering seamless experience to viewers. For instance, MIT's famous *6th sense* project aim was *"...to free information from its confines by seamlessly integrating it with the physical world."* (Mistry and Maes, 2009) via:

> *"see[ing] what the user sees and visually augments surfaces, walls or physical objects the user is interacting with; turning them into just-in-time information interfaces..." (Mistry and Maes, 2009)*

Moreover, Hardy (2014) in his PhD thesis investigated use everyday household objects and furniture as ubiquitous interactive displays and build a toolkit that allowed such transformation. The research (Hardy, 2014) showed that the toolkit could be used as an additional medium to enhance TV watching experience. Additionally, Fradet et. al. (2017) studied how an extended virtual screen operated by an AR device (tablet) affected TV watching experience and found out that the viewers appreciated the possibilities that such feature offered them. In another perspective, potential use of AR in stadiums as part of spectator experience such as receiving relevant in-game information or interacting with other spectators by directing a mobile device while viewing may be realised in the future; therefore, it could be an interesting research area (Miah, 2017). Briefly, such focus in this domain seems to be a promising future research direction.

Usage of *wearables* as second screen can be another research interest since Miah (2017) highlighted that wearable computing devices have become more and more involved in our lives such as *smart watches* and the excitement that *Google Glass* caused few years ago. As Miah (2017) pointed out wearable devices bring different experiences regarding how people interact with the digital content, it would be interesting to see how glancing down on the visualisations and using interaction gestures on them could affect the watching experience.

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9 Appendices

Appendix 1: Online Survey

Football Information Seeking Behaviour Survey Page 1

Hello, my name is Ege Sezen. I am a PhD student at Lancaster University. I need to have your answers for this mini survey that will contribute to the literature review of my PhD study. It is about football information seeking behaviour. Your help is much appreciated. Thanks.

*Required

1. When you watch a football match on TV, do you seek any kind of match-related information (e.g. in-game player & team stats, historical data of competition, comments of other people), apart from the kind provided by the commentary and TV graphics? *
Please select one from the drop-down menu.

This is a required question

Football Information Seeking Behaviour Survey Page 2

There are few questions, if your answer is 'yes' to the first question.

2. What kind of match-related information do you seek when you watch a football match on TV?
You can select more than one.

- Player Stats
- Player Info
- Team Stats
- Team Info
- Team Fixture
- Competition Stats
- Competition Info
- Competition Fixture
- Match Background/Preview
- Comments of other people
- Highlights
- Other:

3. What sort of medium do you use to seek information when you watch a football match on TV?
You can select more than one.

- Desktop PC
- Laptop/Netbook
- Tablet
- Smartphone
- Mobile Phone
- Newspaper
- Magazine
- Other:

4. If you use desktop PC/laptop/tablet/smartphone to seek information when you watch a football match on TV, what do you use as source of information?
You can select more than one.

- Newspaper Websites
- TV Websites
- Mobile Apps
- Sports Portals/Websites
- Competition Websites
- Offiical Team Websites
- Fan Websites
- Social Media (Facebook, Twitter, Instagram etc.)
- Forums
- Other:

5. In which moments of a football match do you seek information when you watch it on TV?
You can select more than one.

- Just before kick-off
- When the game pauses for any reason
- During half-time
- Just after the final whistle
- Other:

6. How often do you regularly use any kind of medium (e.g. laptop, tablet, smartphone or other) to get information when you watch a football match on TV?

- Not regularly
- Periodically (e.g. every minute/five minutes/20 minutes)
- Once for first half & once for second half
- Other:

7. When you watch a football match on TV, do you agree that any additional medium which you use to seek information help you to improve your understanding of game, performance of players & teams?

	1	2	3	4	5	
Strongly agree	○	○	○	○	○	Strongly disagree

8. When you watch a football match on TV, how do you think an additional medium develops your sense of perception of the match and performance of players & teams?

Football Information Seeking Behaviour Survey Page 3

Please state your basic information.

How old are you? *

What is your gender? *

Would you please state your country of residence? *

Submit

Never submit passwords through Google Forms.

33% completed

Powered by Google Drive

This form was created inside of Sabancı University.

Report Abuse - Terms of Service - Additional Terms

Appendix 2: Interview

Participant Information Sheet

Participant Information Sheet

LANCASTER UNIVERSITY

Investigation of Using Additional Devices (e.g. mobile) to Find Football Match-Related Information While Watching Football Matches on TV

Brief Description:

Do you like watching football matches on TV? I would like to invite you to take part in my PhD research study which is all about football. Research has shown that when watching football matches on the TV, many people often use another device e.g. laptop or tablet or mobile phone, to find event-related information, such as player statistics and other people's comments. The aim of this study is to find out more about how people use such additional devices to find more information on football matches shown on TV.

What is expected of you:

If you would like to participate in this study, you need to answer a few questions about your experiences of watching football on TV and the information you usually are interested in finding about football while watching a game on TV. This will take place at mutually agreed public place such as a pub or the university campus. If you are not available to be interviewed in person, then the interview can be conducted via phone, email or the internet. The interview will not take more than half an hour. Phone, in-person and internet interviews are recorded by audio recorders. The results of the interview will be used in my PhD thesis and a few academic papers that I will write. The interview data will be protected by the researcher and it can be shared with the participant should the participant request it.

Even if you agree to take part now, you can still change your mind at any point and stop participating without having to tell us why. If you stop participating, the data will be destroyed and not used and included in the study. You can also withdraw your participation up to two weeks after the interview takes place and your data will be destroyed and not used and included in the study but after this point the data will remain in the study. All personal information provided about yourself will remain confidential and no information that identifies you will be made publicly available.

1

If you are interested in one or more parts of the study please fill in the info below and send it to:

Name: Ege Sezen

Address: HighWire Doctoral Training Centre
The LICA Building
Lancaster University
Lancaster
Lancashire
LA1 4YW
UK

Phone: +447530243836

Email: e.sezen@lancaster.ac.uk

If you have any complaints regarding to the study, please contact my supervisor.

Supervisor Name: Dr Emmanuel Tsekleves

Address: ImaginationLancaster
The LICA Building
Lancaster University
Lancaster
Lancashire
LA1 4YW
UK

Phone: +441524510794

Email: e.tsekleves@lancaster.ac.uk

2

Participant Consent Form

STUDY: INVESTIGATION OF USING ADDITIONAL DEVICES (E.G. MOBILE) TO FIND FOOTBALL MATCH-RELATED INFORMATION WHILE WATCHING FOOTBALL MATCHES ON TV

Participant Consent Form

Name: ....
Address: ....
....
....
....

Initial

1. I agree to participate in this research ....

2. This agreement is of my own free will ....

3. I have read the participant information sheet pertaining to the study and have been given the opportunity to ask any questions ....

4. I realise that I may withdraw from the study at any time, without giving a reason and without any adverse effects ....

5. I have been given full information regarding the aims of the research and have been given information with the Researcher's name, contact number and email address if I require further information. ....

6. All personal information provided by myself will remain confidential and no information that identifies me will be made publically available ....

1

Signed: .... Date: ....
(*by participant*)

Print name: ....

Signed on behalf of researchers

Signed: .... Date: ....

Print Name: ....

1 copy to participant, 1 copy for researcher

Interview Questions

1) Do you support any football team?

2) How often do you watch live football matches?

3) On which medium do you watch live football matches?

4) Where do you watch live football matches?

5) Do you watch football matches alone or with friends/relatives/acquaintances?

6) Could you please identify the types of match-related information (in-game player & team stats, historical data of competition, comments of other people etc.) that you seek during your act of watching football matches on TV?

7) When do you think you seek such kind of information when you follow the matches on TV?

8) Why do you seek match-related information when you watch a football match on TV? Why do you seek such kind of information via an additional medium?

9) Do you regularly check this sort of data on your additional device? If so, how regularly do you check?

10) What kind of match-related information sources do you look for game relevant information when you use your additional medium during the act of watching the games on TV? Websites? Portals? Blogs? Forums? Specific Apps? Social Media? Facebook? Twitter? Anything else?

11) Do you think obtaining additional (not the type you receive from live TV broadcast) match-related information improves enhances your experience of watching a football match on TV? If so, how?

12) If you do not use any dedicated app that delivers you match-related information, why do you think you do not use it? What sort of an app would you be willing to use? What should be the features of the app that you would like to use?

13) May I please ask your age? nationality? level of education?

Appendix 3: Prototype Experiments

Participant Information Sheet

Participant Information Sheet

Lancaster University

Second Screen & Live TV Football Prototype Testing

Brief Description:

Do you like watching football matches on TV? I would like to invite you to take part in my PhD research study which is all about football. Research has shown that when watching football matches on the TV, many people often use another device (second screen) e.g. laptop or tablet or mobile phone, to find event-related information, such as player statistics and other people's comments. The aim of this study is to find out more about what people prefer to have as ways of interaction with 'second screen' that allows them to access and interact with match-related information as well as types of display of match-related information on their second screens during their act of watching football matches on TV.

What is expected of you:

If you would like to participate in this study, you need to watch two clips of a football match at most for ten minutes. After/during watching, you will be asked to interact with a paper prototype or realistic one to find a specific type of match-related information based on a scenario that I will tell you.. The paper prototype is the interface of a smartphone or tablet application that is drawn or sketched on a piece of paper that has a shape of a smartphone or a tablet. The realistic mock-up prototype is the interface of a smartphone or a tablet application that mimics the functioning of them. The latter's interface is placed on a real smartphone or tablet. Both prototypes do not have any capability of real-time and real-task functioning. Whilst you are interacting with the prototype, I will observe how you interact with the prototype and in order to catch all details in this regard, I may use a camera to record your interaction with prototype. After each time of your act of watching and interacting, I will ask you to fill out a questionnaire with a few questions related to the way you interact with the prototype and/or the display of information on it. Filling out the questionnaire will not take more than five minutes. After the second questionnaire, I will conduct a mini interview with you. During the interview I will ask for your comments regarding your interaction with the prototype and/or display of information on the prototype format. This interview will take at most ten minutes. I may need to record the interview with a sound recorder. The study, all steps of watching, answering the questionnaires and taking part in the interview, will take place at the university campus and it will not take more than thirty minutes of your time. There will be no compensation for your travel costs to the campus for this study. The results of the whole testing process will be used in my PhD thesis and a few academic papers that I will write. The data will be protected by the researcher and it can be shared with the participant should the participant request it.

Even if you agree to take part now, you can still change your mind at any point and stop participating without having to tell us why. If you stop participating, the data will be destroyed and not used and included in the study. You can also withdraw your participation up to two weeks after the interview takes place and your data will be destroyed and not used and included in the study but after this point the data will remain in the study. All personal

1

Lancaster University

information provided about yourself will remain confidential and no information that identifies you will be made publicly available. Your data will be secured in an external hard drive that will be kept in my password-protected personal locker at HighWire Lab, B06 of The LICA Building, Lancaster University.

The study as received ethics approval from Lancaster University's Research and Ethics Committee.

If you are interested in the study please fill in the information below and send it to:

Name: Ege Sezen

Address: HighWire Doctoral Training Centre
The LICA Building
Lancaster University
Lancaster
Lancashire
LA1 4YW
UK

Phone: +441524510859

Email: e.sezen@lancaster.ac.uk

If you have any complaints regarding to the study, please contact my supervisor.

Supervisor Name: Dr Emmanuel Tsekleves

Address: ImaginationLancaster
The LICA Building
Lancaster University
Lancaster
Lancashire
LA1 4YW
UK

Phone: +441524510794

Email: e.tsekleves@lancaster.ac.uk

2

Participant Consent Form

STUDY: SECOND SCREEN & LIVE TV FOOTBALL PROTOTYPE TESTING

Participant Consent Form

Name: ....
Address: ....
....
....
....

	Initial
1. I agree to participate in this research.	....
2. This agreement is of my own free will.	....
3. I have read the participant information sheet pertaining to the study and have been given the opportunity to ask any questions.	....
4. I realise that I may withdraw from the study at any time during the study or in two weeks after the study, without giving a reason and without any adverse effects.	
5. I have been given full information regarding the aims of the research and have been given information with the Researcher's name, contact number and email address if I require further information.	....
6. All personal information provided by myself will remain confidential and no information that identifies me will be made publically available.	....

1

Lancaster University

Signed: .... Date: ....
(*by participant*)

Print name: ....

Signed on behalf of researchers

Signed: .... Date: ....

Print Name: ....

1 copy to participant, 1 copy for researcher

2

First Questionnaire (*GBC vs GPN, On-Play, Fixed Order*; *GBC vs GPN, On-Play, Random Order*; *GBC vs GPN, Off -Play, Fixed Order*)

1) What was the number of shots that England have taken when you checked the general stats?

2) The ball possession of England was…
   a) 16% better than Switzerland b) 16% less than Switzerland
   c) 6% better than Switzerland d) 6% less than Switzerland
   e) 12% better than Switzerland f) 12% less than Switzerland
   g) 8% better than Switzerland h) 8% less than Switzerland

3) Do you think the visualisation of match-related information was easy for you to understand?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

4) Do you think the visualisation of match-related information was memorable for you so that you can recall the facts later?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

5) Do you think the visualisation of match-related information contributed to your understanding of the match you watched?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

6) Do you think the visualisation of match-related information enhanced your watching experience?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

Second Questionnaire (*GBC vs GPN, On-Play, Fixed Order*; *GBC vs GPN, On-Play, Random Order*; *GBC vs GPN, Off-Play, Fixed Order*)

1) What was the number of fouls that Switzerland have committed when you checked the general stats?

2) The number of off-sides that Switzerland had…
   a) Three more than England b) Three less than England
   c) Four more than England d) Four less than England
   e) One more than England f) One less than England
   g) Five more than England h) Five less than England

3) Do you think the visualisation of match-related information was easy for you to understand?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

4) Do you think the visualisation of match-related information was memorable for you so that you can recall the facts later?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

5) Do you think the visualisation of match-related information contributed to your understanding of the match you watched?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

6) Do you think the visualisation of match-related information enhanced your watching experience?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

First Questionnaire (*CBC vs GPN, On-Play, Random Order*; *TCBC vs GPN, On-Play, Random Order*)

1) What was the number of "off-sides" that England made when you checked the general stats?

2) The number of "shots" England made was…
   a) 4 more than Russia b) 4 less than Russia
   c) 6 more than Russia d) 6 less than Russia
   e) 2 more than Russia f) 2 less than Russia
   g) Equal to Russia

3) Do you think the visualisation of match-related information was easy for you to understand?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

4) Do you think the visualisation of match-related information was memorable for you so that you can recall the facts later?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

5) Do you think the visualisation of match-related information contributed to your understanding of the match you watched?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

6) Do you think the visualisation of match-related information enhanced your watching experience?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

Second Questionnaire (*CBC vs GPN, On-Play, Random Order*; *TCBC vs GPN, On-Play, Random Order*)

1) What was the "ball possession" rate of Russia had when you checked the general stats?

2) The number of "fouls" that Russia committed…
   a) 3 more than England b) 3 less than England
   c) 7 more than England d) 7 less than England
   e) 10 more than England f) 10 less than England
   g) Equal to England

3) Do you think the visualisation of match-related information was easy for you to understand?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

4) Do you think the visualisation of match-related information was memorable for you so that you can recall the facts later?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

5) Do you think the visualisation of match-related information contributed to your understanding of the match you watched?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

6) Do you think the visualisation of match-related information enhanced your watching experience?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

First Questionnaire (*Swiping vs Tapping, On-Play, Fixed Order*; *Swiping vs Tapping, Off-Play, Fixed Order*)

1) What was the number of shots that England have taken when you checked the general stats?

2) The ball possession of England was…
   a) 16% better than Switzerland b) 16% less than Switzerland
   c) 6% better than Switzerland d) 6% less than Switzerland
   e) 12% better than Switzerland f) 12% less than Switzerland
   g) 8% better than Switzerland h) 8% less than Switzerland

3) Do you think using 'swiping' to retrieve match-related information was easy to apply on second screen?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

4) Do you think using 'swiping' to retrieve match-related information was easy to understand?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

5) Do you think using 'swiping' to retrieve match-related information was easy to learn?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

6) Do you think using 'swiping' was quick enough to retrieve the match-related information on your second screen?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

7) Do you think using 'swiping' to retrieve the match-related information on your second screen was not distracting your attention from the TV in a great degree?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

8) a) Do you think that using swiping to navigate in your second screen has improved your viewing experience today?

   Yes No Don't Know

   b) Why? (Please write down your answer below)

Second Questionnaire (*Swiping vs Tapping, On-Play, Fixed Order*; *Swiping vs Tapping, Off-Play, Fixed Order*)

1) What was the number of fouls that Switzerland have committed when you checked the general stats?

2) The number of off-sides that Switzerland had…
   a) Three more than England b) Three less than England
   c) Four more than England d) Four less than England
   e) One more than England f) One less than England
   g) Five more than England h) Five less than England

3) Do you think using 'tapping' to retrieve match-related information was easy to apply on second screen?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

4) Do you think using 'tapping' to retrieve match-related information was easy to understand?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

5) Do you think using 'tapping' to retrieve match-related information was easy to learn?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

6) Do you think using 'tapping' was quick enough to retrieve the match-related information on your second screen?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

7) Do you think using 'tapping' to retrieve the match-related information on your second screen was not distracting your attention from the TV in a great degree?

   Strongly Disagree 1 2 3 4 5 Strongly Agree

8) a) Do you think using tapping to navigate in your second screen has improved your viewing experience today?

   Yes No Don't Know

   b) Why? (Please write down your answer below)

Appendix 4: McNemar Test Results for Participant Performance of Recalling Verbatim Match Statistics in Visualisation Experiments

GBC vs GPN, On-Play, Fixed Order: McNemar's chi-squared = 1.5, df = 1, p-value = 0.2207.
GBC vs GPN, On-Play, Random Order: McNemar's chi-squared = 0.25, df = 1, p-value = 0.6171.
GBC vs GPN, Off-Play, Fixed Order: McNemar's chi-squared = 0.57143, df = 1, p-value = 0.4497.
CBC vs GPN, On-Play, Random Order: McNemar's chi-squared = 0, df = 1, p-value = 1.
TCBC vs GPN, On-Play, Random Order: McNemar's chi-squared = 0, df = 1, p-value = 1.

Appendix 5: McNemar Test Results for Participant Performance of Recalling Comparison of Match Statistics in Visualisation Experiments

GBC vs GPN, On-Play, Fixed Order: McNemar's chi-squared = 3.125, df = 1, p-value = 0.0771.
GBC vs GPN, On-Play, Random Order: McNemar's chi-squared = 0.8, df = 1, p-value = 0.3711.
GBC vs GPN, Off-Play, Fixed Order: McNemar's chi-squared = 0.8, df = 1, p-value = 0.3711.
CBC vs GPN, On-Play, Random Order: McNemar's chi-squared = 0, df = 1, p-value = 1.
TCBC vs GPN, On-Play, Random Order: McNemar's chi-squared = 0, df = 1, p-value = 1.

Appendix 6: Wilcoxon Signed-Ranks Test Results for Participant Evaluation of Visualisations

Understandability of Visualisations

GBC vs GPN, On-Play, Fixed Order: Median=4.0, 4.0, W=27, Z=0.99258, p=0.3672, r=0.18758.
GBC vs GPN, On-Play, Random Order: Median=4.0, 4.0, W=16, Z=0.37401, p=0.7656, r=0.07068125.
GBC vs GPN, Off-Play, Fixed Order: Median=4.0, 4.0, W=12.5, Z=0.14055, p=0.875, r=0.02656145.
CBC vs GPN, On-Play, Random Order: Median=4.0, 4.0, W=17, Z=0.42513, p=0.6562, r=0.070855.
TCBC vs GPN, On-Play, Random Order: Median=4.5, 4.0, W=22, Z=1.0596, p=0.2891, r=0.2002456.

Memorability of Visualisations

GBC vs GPN, On-Play, Fixed Order: Median=2.5, 3.0, W=25.5, Z=-0.57854, p=0.6777, r=0.1093338.
GBC vs GPN, On-Play, Random Order: Median=4.0, 3.5, W=13.5, Z=0.20365, p=0.9844, r=0.03848623.
GBC vs GPN, Off-Play, Fixed Order: Median=3.0, 3.0, W=13.5, Z=1.4444, p=0.1875, r=0.2729659.

CBC vs GPN, On-Play, Random Order:

Median=4.0, 3, W=76, Z=2.1504, p=0.0415, r=0.3584.

TCBC vs GPN, On-Play, Random Order:

Median=4.0, 4.0, W=30, Z=0.42744, p=0.7539, r=0.08077857.

Visualisations' Contribution to Understanding of The Match

GBC vs GPN, On-Play, Fixed Order:

Median=3.0, 4.0, W=14, Z=-0.66172, p=0.6016, r=0.1250533.

GBC vs GPN, On-Play, Random Order:

Median=4.0, 4.0, W=18, Z=0, p=1, r=0.

GBC vs GPN, Off-Play, Fixed Order:

Median=4.0, 3.0, W=48, Z=2.0919, p=0.05078, r=0.3953319.

CBC vs GPN, On-Play, Random Order:

Median=4.0, 3.0, W=27, Z=1.4009, p=0.2422, r=0.2334833.

TCBC vs GPN, On-Play, Random Order:

Median=4.0, 4.0, W=1.5, Z=-1.0766, p=0.375, r=0.2034583.

Visualisations' Ratings for Enhanced Experience

GBC vs GPN, On-Play, Fixed Order:

Median=4.0, 4.0, W=18, Z=0, p=1, r=0.

GBC vs GPN, On-Play, Random Order:

Median=3.5, 3.0, W=11, Z=1.2606, p=0.375, r=0.2101.

GBC vs GPN, Off-Play, Fixed Order: Median=3.0, 3.0, W=18, Z=1.6607, p=0.1875, r=0.3138428.
CBC vs GPN, On-Play, Random Order: Median=4.0, 3.0, W=18.5, Z=1.6787, p=0.1562, r=0.2797833.
TCBC vs GPN, On-Play, Random Order: Median=3.0, 3.5, W=6, Z=-0.44721, p=1, r=0.08451475.

Appendix 7: McNemar Test Results for Participant Performance of Recalling Verbatim Match Statistics in Interaction Experiments

Swiping vs Tapping, On-Play, Fixed Order: McNemar's chi-squared = 0.25, df = 1, p-value = 0.6171.
Swiping vs Tapping, Off-Play, Fixed Order: McNemar's chi-squared = 0.25, df = 1, p-value = 0.6171.

Appendix 8: McNemar Test Results for Participant Performance of Recalling Comparison of Match Statistics in Interaction Experiments

Swiping vs Tapping, On-Play, Fixed Order: McNemar's chi-squared = 0, df = 1, p-value = 1.
Swiping vs Tapping, Off-Play, Fixed Order: McNemar's chi-squared = 0, df = 1, p-value = 1.

Appendix 9: Wilcoxon Signed-Ranks Test Results for Participant Evaluation of Interaction Gestures

Ease in Application

Swiping vs Tapping, On-Play, Fixed Order: Median=4.0, 4.0, W=3.5, Z=-2.3804, p=0.02734, r=0.4498533.
Swiping vs Tapping, Off-Play, Fixed Order: Median=4.5, 5.0, W=6.5, Z=-1.6956, p=0.125, r=0.3204383.

Understandability

Swiping vs Tapping, On-Play, Fixed Order: Median=4.0, 5.0, W=0, Z=-2.7739, p=0.007812, r=0.5242178.
Swiping vs Tapping, Off-Play, Fixed Order: Median=5.0, 5.0, W=2.5, Z=-1, p=0.625, r=0.1889822.

Learnability

Swiping vs Tapping, On-Play, Fixed Order: Median=4.0, 5.0, W=0, Z=-1.7321, p=0.25, r=0.3273361.
Swiping vs Tapping, Off-Play, Fixed Order: Median=5.0, 5.0, W=3.5, Z=-1.2963, p=0.3125, r=0.2449777.

Quickness

Swiping vs Tapping, On-Play, Fixed Order: Median=3.0, 4.0, W=0, Z=-2.9231, p=0.003906, r=0.552414.

Swiping vs Tapping, Off-Play, Fixed Order: Median=4.0, 5.0, W=7.5, Z=-1.8782, p=0.07031, r=0.3549464.

Level of Distraction from TV

Swiping vs Tapping, On-Play, Fixed Order: Median=2.0, 3.0, W=8, Z=-2.0386, p=0.0625, r=0.3852592.
Swiping vs Tapping, Off-Play, Fixed Order: Median=3.5, 4.0, W=11, Z=-1.559, p=0.1562, r=0.2946233.

Appendix 10: Personal Limitations

Funding

One of the biggest challenges during the PhD process was insufficient funding. First, due to my nationality, I could not receive the full funding of tuition fees and annual stipend though I was awarded the full funding in theory. I had to use the majority of my stipend to pay the difference between international and EU/UK level of tuition fees. Unfortunately, such issue impeded the progress significantly due to putting more restraints on living expenses. Second, lack of funding hindered participant recruitment. Although I received equipment and travel funding from my department, I could not receive any funding to compensate efforts of participants for the online survey, interviews and prototype experiments. Consequently, the number of participants for all of them was less than expected and recruitment process was quite lengthy. For instance, it took more than 6 months to recruit around 40 participants for the last 3 experiments. In addition, plans for organising focus groups, diary studies and additional prototype experiments had to be abandoned. Furthermore, prototyping experiments could be conducted in more realistic social and technological settings to ensure a more realistic watching experience, if there was adequate funding to create a home environment (or realise the experiments in participants' homes) and technological infrastructure for a real-time second screen interaction, not a simulation.

Bureaucracy

One of the problems that I encountered during the PhD was the bureaucracy of ethical approval. Receiving ethics approval to conduct surveys, interviews and experiments took quite longer than I predicted. For instance, my prototype experiments were approved in more than 3 months after I had submitted my application regarding the experiments for an ethical review. In addition, approval for slight modifications to the application required long waiting times, too. Such bureaucracy created anxiety as I had to consider every detail regarding how I conduct an interview or an experiment that I would not be able to change quickly. I believe this was an important restriction for the progress of my research.

Another problem was the visa bureaucracy. Not only it was an issue to study in UK but also a complication for attending conferences and short courses in other countries in EU. The visa restrictions and requirements consumed considerable amount of time and were another source of stress.