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# **Enhancing Fan Experience During Live Sports Broadcasts Through Second Screen Applications**

Dissertação para obtenção do Grau de Doutor em Informática

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# Acknowledgements

It is curious that the first words that you are reading were the last ones that I wrote. I think that this closes a cycle – or better, a journey – that started almost 4 years ago. Finding a theme for a PhD thesis is not an easy task, but fortunately, I ended up studying a theme and a technology that I love. However, not everything was a walk in the park. This work involved countless hours and contributions from many individuals who deserve recognition. To those who have accompanied me in this journey, I would like to express my sincere gratitude. First, none of this would have been possible without the unconditional support and encouragement of my family and colleagues. My parents, who always gave me everything I needed. My better half for all the patience and understanding across the years. My colleagues both former and current members of NOVA-LINCS, in particular Rui Madeira and Bruno Cardoso with whom I worked in close collaboration and attended different conferences; Professors Rui Prada and Nuno Correia for their invaluable feedback; my colleagues at Viva Superstars, mainly Mário Franco for his endless technology knowledge and Diogo Cordeiro for his help with eSports; Bárbara Teixeira for the graphic design created on different prototypes, and Carlos Oliveira for having the patience to review this dissertation.

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## Resumo

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Quando os fãs de desporto assistem a eventos desportivos ao vivo, é comum participarem em experiências sociais com amigos, familiares, e outros fãs que apoiam os mesmos atletas. Contudo, os fãs que assistem ao mesmo evento através de uma transmissão televisiva, acabam por não ter a mesma ligação emocional com os atletas e os milhares de fãs que estão presentes no local onde o evento se realiza. Tendo em conta este problema, nós procuramos criar aplicações móveis que proporcionem experiências sociais enriquecedoras aos fãs remotos que assistem aos eventos desportivos através duma transmissão televisiva. Devido ao crescente uso de dispositivos móveis enquanto se assiste a transmissões televisivas, estas aplicações procuram explorar o conceito de *second screen*, o qual permite aos utilizadores interagir em tempo real com o conteúdo que está a ser transmitido. Neste contexto, apresentamos um conjunto de protótipos que foram desenvolvidos para testar os nossos conceitos, realizar testes de utilizador, e analisar como estes se podem adaptar não só a vários desportos, mas também a diversos programas de TV e desportos electrónicos. Finalmente, apresentamos também o conjunto de dificuldades que enfrentámos e as diretrizes que seguimos durante as diferentes fases de desenvolvimento dos protótipos, o que pode representar uma ajuda considerável no desenvolvimento de futuras aplicações *second screen* para eventos ao vivo.

**Palavras-chave:** Fãs de desporto, desportos ao vivo, experiência de utilizador, dispositivos móveis, aplicações *second screen*, entretenimento.

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# Abstract

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When sports fans attend live sports events, they usually engage in social experiences with friends, family members and other fans at the venue sharing the same affiliation. However, fans watching the same event through a live television broadcast end up not feeling so emotionally connected with the athletes and other fans as they would if they were watching it live, together with thousands of other fans. With this in mind, we seek to create mobile applications that deliver engaging social experiences involving remote fans watching live broadcasted sports events. Taking into account the growing use of mobile devices when watching TV broadcasts, these mobile applications explore the second screen concept, which allows users to interact with content that complements the TV broadcast. Within this context, we present a set of second screen application prototypes developed to test our concepts, the corresponding user studies and results, as well as suggestions on how to apply the prototypes' concepts not only in different sports, but also during TV shows and electronic sports. Finally, we also present the challenges we faced and the guidelines we followed during the development and evaluation phases, which may give a considerable contribution to the development of future second screen applications for live broadcasted events.

**Keywords:** Sports fans, live sports, user experience, mobile devices, second screen applications, entertainment.

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# 1

## Introduction

*From so simple a beginning...*

- Charles Darwin, The Origin of Species

Sports. This competitive physical activity has extended as far as the existence of humanity, with evidence dating back from the Neolithic age of 7000 BC showing a wrestling match surrounded by crowds [1]. It is this natural human drive to compete that has always pushed the athletes forward. Rivalries have been born, records have been shattered, and history has been written, only because athletes had a single goal in mind: to be the best of the best. Ali and Frazier, Prost and Senna, Armstrong and Ullrich, Bolt and Gay, Federer and Nadal, Ronaldo and Messi. These are some of the greatest rivalries that helped to create new standards in different sports for years to come.

Although not everyone practices sports regularly, watches live or broadcasted sports events frequently, or is aware of the latest sports achievements, the value of sports cannot be denied. Because sports often have a great impact on people's lives. They affect people's mood. They cause emotions. They create memories. Especially when people attend live sports events [2]. The stadium atmosphere involves sports fans in a unique experience, where the specific environmental features of the venue and elicited affective responses of the spectators act together to create amazing vibes, strong emotions, goose bumps, and general euphoria [3]. Unfortunately, sports are sometimes haunted by "fans" that go too far in their "support". Within football fandom, hooliganism is often associated with the clubs' organised groups of fans called the "ultras". These

groups may have a positive impact when supporting their clubs during matches, but they can also have a strong negative impact by inciting members to violence and brawling. This violent behaviour is often associated with keeping fans with families away from the venues, especially when there are important matches between rivals. Of course that it is not our goal to promote this kind of actions, but rather to promote positive feelings for fans watching a television broadcast of a sport event.

In fact, most fans do not have the chance to go to the venue due to factors like the ticket price, distance, the limited number of seats available or the above-mentioned violent behaviours. However, when those fans watch a sports event on TV they do not feel so emotionally connected with the athletes and the in-venue fans, as if they were watching it live where the event takes place. And since there are usually much more spectators watching a match through television than at the live venue (see [4], for example), we see this as a prominent area that should be taken into account by the entertainment computing community to create innovative and exciting experiences. To achieve this goal, first it is necessary to acknowledge what influences fans' behaviours to watch and support their favourite team and athletes. Only then, successful concepts can be materialized into computational applications that help to enhance the remote viewers' experience during broadcasted live sports events, like the venue atmosphere helps to improve the fans' immersion and emotional levels during live sports events.

## **1.1. Description and Context**

Our research work focuses on the enhancement of the fans' experience while watching broadcasted sports events on TV. We started by researching on the psychology of sports fans, in order to ascertain which factors influence fans' behaviours. Our findings led us to conclude that sports fans are influenced to attend and watch sports due to a combination of factors, not just a single one [5, 6], with group affiliation – the desire to be with others - being a top factor for becoming a fan [7]. Fans feel motivated to continuously support the team when in the presence of others, but cease their support if they do not feel the support of other fans, or in other words, if they feel they are alone supporting their team. In this sense, it is usual for fans to gather before, during and after sports events. For instance, in the United States it is common for American Football fans to discuss an upcoming game while having a meal with friends and family members in a parking lot (a phenomenon known as tailgating). In the United Kingdom, pubs are so rooted in the countries' culture that fans often gather



there to watch football matches, while drinking a pint of beer with friends and other unknown fans. Finally, when a team achieves an important accomplishment, fans from all over a country set out to the main cities' centres and emblematic monuments, to celebrate with thousands of other fans that share the same affiliation.

Next, we investigated what kind of elements we could exploit while fans watch live broadcasted sports events, in order to enhance their user experience. To that end, we broke down the activity of watching a live broadcast sport event, which we refer to as the remote fan experience. The remote fan experience is comprised of three elements: the venue where the event is taking place, the television broadcast that remote spectators are watching, and the social factors related with the sports event (Figure 1.1). The venue is, of course, the basis of the whole experience: it is where the action happens and where fans go to support their team. Within this context, one can promote remote fans' engagement in the in-venue fans' activities and the sport action, so that the remote fans can feel closer to the venue atmosphere. It is also possible to expand the interaction with mobile devices, by adding visual and audible elements to the television. This results in an enhanced experience where the mobile device and the television are entwined. Finally, as we saw before, the social aspects are important motivational factors to attend or watch a sport event. It is usual for fans to cheer, support, exchange opinions, and even brag about their teams with family members, friends or just simply unknown fans, during a sports event. Thus, it is crucial to make remote fans feel connected with others and provide them with an enhanced experience by creating the feeling that they are not alone watching the sport event.

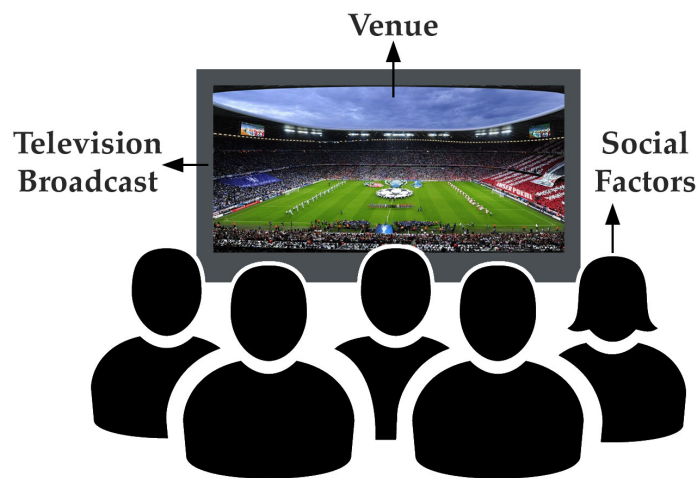


Figure 1.1: The three elements that play a part in the remote fan experience.

While watching live broadcasted sports events, fans can be prompted to interact through different multimodal systems. Thus, to deploy applications that seek to explore multiple human senses, it is necessary to integrate computational devices to the experience of watching television, in a seamless way. Such computational devices can range from traditional home computers (desktops and laptops), to mobile computers (tablets and smartphones), and even to wearable computers (smartwatches and optical head-mounted displays). In our work, we decided to focus on mobile computers (especially smartphones) although other computational devices are equally valid to conduct research in this area. Our decision was tied to the rapid growth of the mobile phone market and its technologies. In most developed countries virtually everyone has a mobile phone, with the majority owning a smartphone [8]. Today, mobile phones are probably the most personal and most loved technology in the world, since they are always by our side when we need them, and they advise us and entertain us anywhere (where and when) we want it [9]. Therefore, our target audience is set on the fans that often use (or have intention to use) mobile applications while watching a broadcasted sports event and that, for whatever reasons, do not attend the venue where the event is taking place. When such audience interacts with mobile applications, they have access to a second screen besides the primary one (television). The use of a second screen while watching television has become quite popular, to the point of new applications being developed solely designed to allow an interaction with TV broadcasts. These applications have been dubbed second screen applications, since they explore a second screen concept, as viewers are experiencing a TV broadcast through two screens (this concept is also applicable to other computational devices such as computers and smartwatches). Usually, the second screen applications aim to provide additional show-related information, access to social networks and interactive experiences synchronised with the program content, such as polls or quizzes. A survey conducted by Nielsen in the first quarter of 2013 [10], showed that nearly half of smartphone (46%) and tablet owners (43%) use their devices as second screens while watching TV every day, which depicts how this interaction concept is becoming widely adopted by TV viewers.

Finally, and taking into account the previous stages, we started evaluating which live sports themes were most suitable to study, through the deployment of second screen applications. We approached four different themes: fans' actions, live betting, social engagement, and broadcast delays (more about how these decisions were made on Chapter 3). Fans' actions refer to the activities that fans usually perform at the venue, either to support their teams and fa-

vourite athletes, or to discourage their opponents. Live betting is a popular theme on sports events, as fans are motivated to predict sports outcomes either due to its economic return or gamification feature. The social engagement refers to the interactions that fans have with each other and the strong emotional connections that they have with their teams. Finally, during our studies we became aware that television broadcasts delays can have a negative impact in the remote fan experience, as information about key moments can be known beforehand. Therefore, we also studied how viewers could synchronise at anytime a second screen application with any television broadcast, in order to provide an optimal user experience. Figure 1.2 summarizes the research process previously described. This process will be further detailed in Chapter 3.

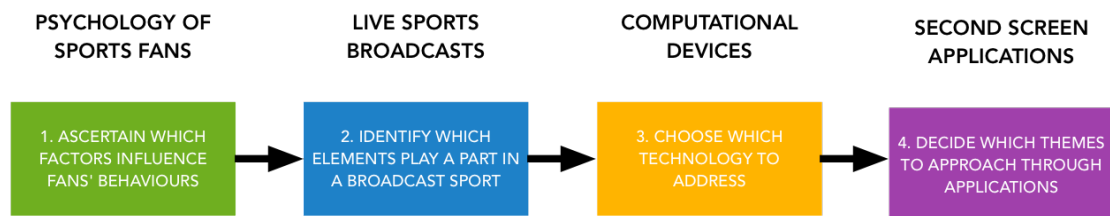


Figure 1.2: A summary of the conducted research process.

## 1.2. Research Goal and Questions

Our goal is to contribute to enhance the remote spectator experience during broadcasted live sports events through second screen applications. The idea is to encourage remote fans to participate in entertainment and social activities in order to enhance their experiences, all together with thousands of other fans supporting the same team and athletes. Thus, by exploring the use of technology to create new forms of social “liveness” [11], we hope to bridge the emotional gap between the sports stadium atmosphere and the remote users’ environment.

From our research goal, one main research question and three sub-questions arise:

- How to improve the remote user experience while watching a broadcasted live sports event?
  - What factors of the event contribute more to the fan experience?
  - How to create satisfying social experiences?
  - How should the user experience be designed?

To answer the main research question, it was necessary to take three different factors into account: first, the elements that can be explored during a sport event; second, the motives for watching a sport event with others, and third, the underlying - and sometimes invisible - design aspects, that allow for the creation of seamless second screen experiences. Such factors led to the formulation of the three sub-questions previously presented, to which we intend to have satisfying answers by the end of this document. With these questions in mind, we set out to develop and evaluate different mobile prototypes focused on football (soccer), although most concepts can be exploited in other sports or even other TV shows. We chose football because it is widely accepted as one of the world's most popular sports [12], it moves an incredible number of fans all over the world, and generates strong emotions. Thus, we saw it as a natural fit to study and apply our concepts.

### **1.3. Contributions and Publications**

This work provides the following contributions:

- Enhancement of the fan experience during broadcasted live sports events through competitive and non-competitive activities, by focusing on different live sports themes: fans' actions, live betting, social engagement, and broadcasts delays.
- Introduction of a set of concepts based on live sports themes that led to the development of four prototypes: applaud on key moments (WeApplaud), make live predictions (WeBet), share emotions and opinions with friends (WeFeel), and synchronise second screen applications (WeSync).
- A discussion on how the different prototype concepts can be applied beyond football, not only to other sports, but also to TV shows, and even electronic sports (eSports) broadcasts.
- A set of guidelines useful for the design and development of future second screen applications that rely on live broadcasts.

Our work produced the following publications:

- Papers
  - ✓ Centieiro, P., Romão, T. and Dias, A. E. 2012. Applaud Having Fun: A Mobile Game to Cheer your Favourite Sports Team. In Proceed-

ings of the 9th International Conference on Advances in Computer Entertainment (ACE '12). Springer-Verlag, 1-16.

- ✓ Centieiro, P., Romão, T. and Dias, A. E. 2013. Enhancing Remote Live Sports Experiences through an Eyes-free Interaction. In Proceedings of the 15th International Conference on Human-Computer Interaction with Mobile Devices and Services (MobileHCI '13). ACM Press, 65-68.
- ✓ Centieiro, P., Romão, T. and Dias, A. E. 2014. Bet without Looking: Studying Eyes-Free Interaction During Live Sports. In Proceedings of the 16th International Conference on Human-Computer Interaction (HCI International '14). Springer-Verlag, 581-592.
- ✓ Centieiro, P., Romão, T. and Dias, A. E. 2014. From the Lab to the World: Studying Real-time Second Screen Interaction with Live Sports. In Proceedings of the 11th International Conference on Advances in Computer Entertainment (ACE '14). Article 14.
- ✓ Centieiro, P., Cardoso, B., Romão, T. and Dias, A. E. 2014. If You Can Feel It, You Can Share It! A System for Sharing Emotions During Live Sports Broadcasts. In Proceedings of the 11th International Conference on Advances in Computer Entertainment (ACE '14). Article 15.
- ✓ Centieiro, P., Romão, T., Dias, A. E. and Madeira, R. N. 2015. Synchronising Live Second Screen Applications with TV Broadcasts through User Feedback. In Proceedings of the 15th International Conference on Human-Computer Interaction (INTERACT '15). Springer-Verlag, 341-349.
- ✓ Centieiro, P., Madeira, R. N., Romão, T., Dias, A. E. and Correia, N. 2015. In Sync with Fair Play! Delivering a Synchronized and Cheat-Preventing Second Screen Gaming Experience. In Proceedings of the 12th International Conference on Advances in Computer Entertainment (ACE '15) (in press).
- Journal
  - ✓ Centieiro, P., Romão, T. and Dias, A. E. 2015. Engaging Remote Fans in Live Sports. *Journal of Arts and Technology*, 8, 4 (2015), 325-345.
- Doctoral Consortium

- ✓ Centieiro, P. 2013. Bringing the Sport Stadium Atmosphere to Remote Fans. In Proceedings of the 21st ACM International Conference on Multimedia (ACM MM '13). ACM Press, 1063-1066.
- Book Chapter
  - ✓ Centieiro, P., Romão, T. and Dias, A. E. 2015. Enhancing Remote Spectators' Experience During Live Sports Broadcasts with Second Screen Applications. In More Playful User Interfaces – Interfaces that Invite Social and Physical Interaction. Springer-Verlag, 231-261.
- Posters
  - ✓ Centieiro, P., Romão, T., Dias, A. E. and Madeira, R. N. 2015. A Synchronisation Mechanism based on User Feedback for Second Screen Applications. In Proceedings of the 12th International Conference on Mobile and Ubiquitous Systems: Computing, Networking and Services (Mobiquitous '15) (in press).
  - ✓ Madeira, R. N., Centieiro, P. and Correia, N. 2015. Adaptation to TV Delays based on User Behaviour towards Cheating-free Second Screen Entertainment. In Proceedings of the 14th International Conference on Entertainment Computing (ICEC '15). Springer-Verlag, 424-432.
  - ✓ Centieiro, P., Romão, T. and Dias, A. E. 2015. Emotion Sharing During Live Sports Broadcasts: Studying its Potential and the Users' Preferences. In Proceedings of the 12th International Conference on Advances in Computer Entertainment (ACE '15) (in press).
- Demos
  - ✓ Centieiro, P., Romão, T. and Dias, A. E. 2012. When Away Applaud Anyway. In Proceedings of the 9th International Conference on Advances in Computer Entertainment (ACE '12). Springer-Verlag, 473-476.

Furthermore, during the elaboration of the research work presented in this document, we also participated in the design and development of two popular mobile applications: “Viva Ronaldo” and “Você na TV”. Viva Ronaldo is a unique entertainment, gaming and social following experience around Cristiano Ronaldo and his 150 million fans, where they can interact with Cristiano during a football match, among many other features. “Você na TV” is the official application of the popular Portuguese TV show with the same name. In this

application, viewers can interact live with the show, by visualizing extra content on their mobile devices, answering polls and trivia questions, and much more. Both of these applications incorporate guidelines and results from our research work and are being used by hundreds of thousands of spectators.

## **1.4. Document Organisation**

This document is organised in six chapters. The next chapter presents the more relevant work done in the research areas approached in this thesis. In Chapter 3, the different live sports themes are addressed, through the development of proof-of-concept prototypes. Chapter 4 discusses how the different prototype concepts can be applied beyond football, to other kind of TV broadcasts. Chapter 5 presents a set of challenges and guidelines for the design of second screen interactions during live broadcasts. Finally, Chapter 6 presents the conclusions and topics for future work that can be pursued.





# 2

## Related Research

*You can change your wife, your house, your car, but you can never change your team. Chairmen come and go, boards come and go, but the fans remain. They are the one true constant.*

- Edward Thomson, former Chairman of Dundee United Football Club

This chapter presents the state of the art of the main areas covered by this work. Subchapter 2.1 mentions important studies regarding the motivations and behaviours of sports fans, Subchapter 2.2 explores the remote user interaction during live events by pointing out the most relevant works, and Subchapter 2.3 presents significant studies and applications developed within the second screen research area.

### 2.1. Psychology of Sports Fans

In the world of team-based sports, fans (or supporters) are key elements for the definition of the sport itself. Imagine if there were stadiums and venues without seats, or if the events would not be broadcasted through television or radio. Sports events would be less exciting and engaging, and teams would not feel the extra support coming from the crowd, resulting in lower team performances than usual. Also, and since fan involvement plays a big part in the economics of clubs (global sports industry is worth between €350 billion and €450

billion [13]), many club features, like merchandising or premium club television channels, would simply not exist.

Thus, it is not surprising that companies invest on sports that draw huge numbers of spectators (either in-venue or through television), since the spectators' support of athletes and teams in the form of broadcast licensing fees and related merchandise has a high commercial value [14, 15]. Furthermore, sports arenas and stadiums are the number two most checked-in places in the US (only after airports) [16], a clear sign that fans like not only to attend sports, but also to show other people that they are supporting their team. This raises three simple but important questions: "How are fans connected with their favourite sports team?", "What motivates them to watch sports events?" and "Why do they attend sports events?". These questions are discussed next.

### **How are fans connected with their favourite sports team?**

Back in 1976, Cialdini et al. [17] introduced the definition of BIRG: Basking In Reflecting Glory. BIRG refers to one's desire to increase alliance with successful others, such as a team or a player. When a team is doing well, the fans feel happy and excited. On the day after a team's win, people feel better about themselves, they say things like "we won", when they really feel part of the team. The closer people are identified with their favourite sports team, the more likely they are to bask in reflecting glory. Madrigal [18] studied fan satisfaction with sports events as a motive for attendance. He proposed a "model of fans' satisfaction in which three cognitive antecedents are directly related to BIRG and fans' enjoyment that, in turn, affect fan satisfaction" [18] (Figure 2.1).

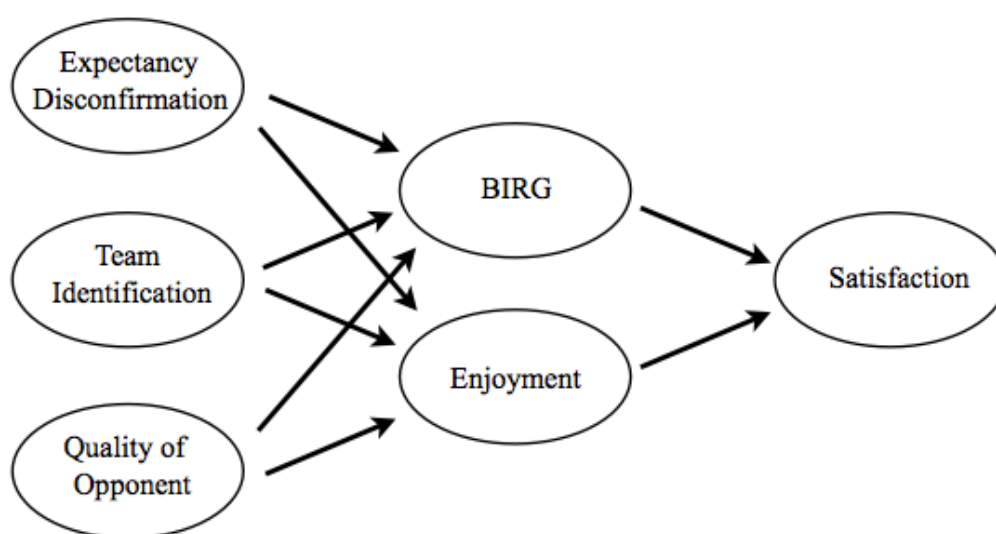


Figure 2.1: Model of Fan Satisfaction [18].

The expectancy disconfirmation, team identification and the quality of the opponent are the three factors that influence BIRG and enjoyment. The expectancy disconfirmation refers to the fans' feelings about the outcome of the sport event and whether it matches the expectations. Team identification represents fans' emotional attachment to a team or player and it has a positive relationship with BIRG, in which fans who have a stronger team identification tend to BIRG more than others [19]. Finally, a victory over a difficult opponent makes fans feel an increased enjoyment, as well as they become more likely to feel and show their association with their team.

In contrast to BIRG, there is CORF: Cutting Off Reflected Failure. CORF happens when fans attempt to decrease their association with an unsuccessful team [20]. In this case, fans refer to their team as "they" instead of "we", since they want to distance themselves from the team failures. This happens most frequently when there is not a strong relationship between the fan and the team, making a relationship that rises and falls according to the matches' results. On the other hand, fans with a strong bond with the team will still refer to them as "we", and will continue to support their team, by wearing jerseys or scarfs and by attending the following matches. These two aspects of the psychology of sports fans shed some light on how fans connect with their team and how they behave according to the outcome of a sport event.

### **What motivates fans to watch sports events?**

Social scientists have been studying the motivation of sports fans and spectators for many years. Whether fans go to sports events in stadiums, or whether they watch games on television or listen to them on the radio, individuals' usually have a combination of motivations, not a single one. In his research, Wann [5] introduced the Sport Fan Motivation Scale (SFMS), an instrument designed to illustrate the degrees of fan intensity that helps sports decision makers determine how to increase the fan involvement with the clubs. On further developments [6, 21], the SFMS revealed that fan motivation factors can be categorised into eight types:

- **Eustress:** defined as moderate or normal psychological stress interpreted as being beneficial for the experiencer (e.g. engaging in a challenge, playing sports or watching a scary movie). Many sports fans feel they do not get enough stimulation or excitement from their own life, but find it through watching sports events [21].
- **Self-esteem:** it is related to how fans connect with their teams. The BIRG and CORF concepts mentioned earlier have a strong impact

on the fans self-esteem [21]. If the team has a good performance, fans feel better about themselves.

- **Escape:** fans who are dissatisfied or bored may temporarily forget about setbacks and distress through sports by using it as a diversion from work and the normal, unexciting activity of everyday life [22].
- **Entertainment:** some fans just find watching sports to be an enjoyable pastime, like if they were watching a TV show, movie or playing a video game [21]. This may happen when our team or favourite players are not playing, but we still enjoy watching the game.
- **Economic/Betting:** gambling is also an important motive for some sports fans due to its economic return. As a site note, Trail and James [23] referred that this factor should be labelled betting or wagering, as the items evaluated in Wann's study [21] asked about these terms and not about economic influence.
- **Aesthetics:** some fans are "attracted to the beauty and grace found in the athletic performance of some players" [24], which is enough to motivate them to become fans of a sport, a team or an athlete [21].
- **Group Affiliation:** "reflects fans' desire to be with other people and involves a fans' need for belongingness" [24]. Individuals with high group affiliation are willing to participate in a sport as a fan because it provides an opportunity to spend time with others (excluding family members).
- **Family:** a similar motivation to group affiliation, the family factor involves one's desire to spend time with his/her family, especially for those who are married with children [25].

In several studies [21, 26, 27, 28], it was found that males have higher levels of eustress, economic/betting, self-esteem and aesthetic motivation while females were found to have higher levels of family motivation. No major gender differences were found in escape, entertainment, and group affiliation. Building on the SFMS, Trail and James [23] created the Motivation Scale for Sport Consumption (MSSC), comprised with nine motives for being a sports fan, six of them similar to the SFMS (aesthetics, escape, family, achievement/self-esteem, social/group affiliation, drama/eustress) and three new ones: knowledge (e.g. knowing records), physical attraction (e.g. watching physically attractive athletes), and physical skills (e.g. appreciation of the skills of athletes). In another study [29], it was suggested that sport attachment, dra-

ma, vicarious achievement and community pride have an impact in the level of viewership of Japanese football fans.

In [7], the authors showed that sports fans reported the group affiliation factor as one of the top reasons for originally becoming a fan. Fans feel motivated to continuously support the team when in the presence of others, but cease their support if they do not feel the support of other fans, or in other words, if they feel they are alone supporting their team. Wann et al. [30] showed that there is a strong relationship between social support and loneliness while watching sport matches. When watching sports events at the venue, fans felt more satisfaction for being with thousands of other fans, than when they watched the events alone at home. It was also identified a boost in social well-being when a fan encountered other fans with the same affiliation, distant to the locale where the team is located. That is why fans prefer to attend public spaces like a cafe to watch a sport event with friends, than to stay at home and watch it alone. In the same vein, the Director of Media Partnerships for Facebook, Nick Grudin, stated that sports can be fundamentally enhanced with social experiences [16], as fans are never fans alone.

### **Why do fans attend sports events?**

According to Wochnowski [31], the definition of atmosphere in the context of sport setting is “the totality of emotionally appealing environmental stimuli in a defined place”. Thus, the atmosphere of a particular place can only be determined by integrating information about the environmental features of the place, with information about the affective responses of the people located in that place. This means that the sport stadium experience can be tentatively defined, as “the relationship between perceptions of the specific environmental features of a sport stadium and the elicited affective responses of the spectators” [3]. To be a unique theoretical construct, it must be further specified in terms of its temporal (period of time in which a sport event takes place) and spatial (area inside the sport stadium) limits, as well as its character. Therefore, to specify a conceptually complete measurement model for sport stadium atmosphere, it is required “an exploration of the environmental stimuli in a sport stadium, as well as the typical affective states of the spectators” [3].

In order to further investigate these stimuli, and identify other possible factors that contribute to the unique atmosphere in sports stadiums, Uhrich and Benkenstein [3] conducted four studies. The fans inquired in these studies, showed that their presence in the stadium is motivated by four major stimuli: organiser, spectators, game action and stadium architecture. Each one of these

stimuli, has different environmental factors responsible for creating the unique atmosphere found in sport stadiums:

- **Organiser:** includes having an enthusiastic stadium announcer and playing the club's anthem at games.
- **Spectators:** this kind of stimuli is associated with sports fans, such as certain chants, enthusiasm when the home team scores, choreographic routines, the wearing of merchandise, and the exchange of chants between bleachers on opposite sides of the stadium (with fans of the same team or with the supporters of the opposing team).
- **Game Action:** the action of the game and the teams' performance provides suspense, thereby causing a response of arousal in the spectators. Further stimulation comes from players showing team spirit and a strong desire to win.
- **Stadium Architecture:** the direct proximity of the grandstands and bleachers to the field not only ensures that spectators have a good view of the game, but also makes them feel that they are an integral part of the action. Another important aspect of stadium design is the special acoustics, which make the sound in the stadium echo like in a covered hall.

Altogether, these factors result in the sport stadium atmosphere, which in turn result in amazing vibes, tremendous enthusiasm, strong emotions, goose bumps, a thrill in the air and general euphoria (according to the fans enquired in the studies, when asked what was so special about the sport stadium atmosphere), as shown in Figure 2.2.

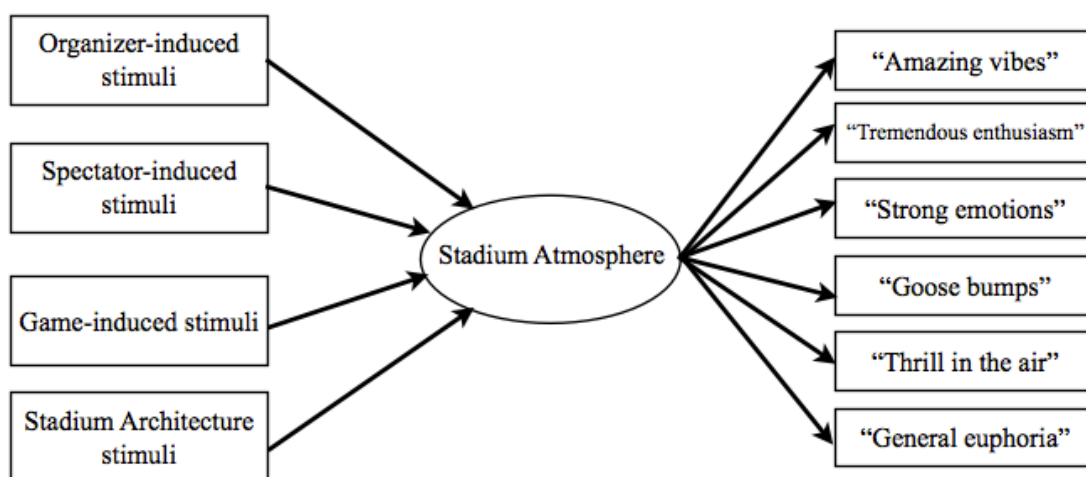


Figure 2.2: Model for Measuring Sport Stadium Atmosphere [3].

In a study conducted, by Stephanie Charleston [32], to explore the home stadium atmosphere in English professional football, participants ranked via a web survey the features of the stadium and aspects of match attendance that, according to them, most contribute for the atmosphere created during live matches. Participants could choose from cheering and singing, crowd size, history with opponent, connect with supporters, stadium size, away fan location, proximity to the pitch, opponent standing, pubs in ground and memorabilia location. Results showed that noise (singing and cheering) and crowd size (full capacity crowd, as opposed to stadium size) were the most important to fans, followed by history with an opponent, and feeling connected to other supporters. The higher noise level may represent increased feelings of belongingness amongst supporters, because they see themselves as part of one voice, the 12th player, which positively reinforces that aspect of their identity associated with the football club. The greater importance of the full capacity crowd/density suggested that empty seats may affect atmosphere more than the sheer number of supporters. For football supporters, attendance at a match with a sell-out crowd may add to the feeling that they belong to something others perceive to be quite special [33], thereby positively reinforcing their social identity. It seems that fans do not necessarily need a large stadium for the best atmosphere as indicated by the lower ranking of overall stadium size in the study, but do want a feeling of belonging or connectedness to be part of a community. This and other similar aspects have been the focus of some spectator crowd analysis studies, such as in [34, 35], where the authors concluded that the most important events of a match could be automatically detected by analysing the crowd's motion on the stands.

In summary, and to answer the three questions previously presented:

- Fans tend to connect with their favourite sports team in two ways: when they feel satisfied with it, they Bask in Reflecting Glory, referring to the team as “we”; however, if the team fails to match their expectations, they Cut Off Reflected Failure, referring to it as “they”.
- Fans are motivated by a combination of factors, not just a single one. Group affiliation (desire to be with others) is a top reason for fans to continuously support their team, being more satisfied when watching an event with others, than when watching it alone.
- Fan attendance in sports events is motivated by four stimuli: organiser, spectators, game action, and stadium architecture. Factors like noise (singing and cheering), crowd size, history with an opponent,

and connectedness to other fans most contribute for the sport stadium atmosphere.

As it will be presented in Chapter 3, we took into account some of these aspects in order to explore different concepts that allow remote viewers to experience live sports events in interesting and innovative ways.

## **2.2. Remote Live Experiences**

Not so long ago, watching television was a defragmented social experience. Viewers watched a TV broadcast from start to finish with no interruptions and, at the end of it, they phoned their friends and family members to discuss what they have just witnessed. Today, this rarely happens. As technology changes, so do viewers' behaviours. Today, watching television has become a full social experience, to the point of the social TV market being worth \$212.3 billion [36]. Since viewers use additional devices to communicate with others during a TV broadcast, some TV shows evolved into a bidirectional experience, allowing viewers to interact with them directly or through social networks such as Facebook or Twitter. In this sense, live video broadcasting through the Internet has become an area of intense interest. People from all over the world can broadcast themselves on daily activities, while viewers have the option to engage in polls and conversations not only with other unknown viewers, but also with the broadcaster, creating a participatory experience (see Periscope [37] or Twitch [38] for example). Moreover, through live video broadcasting, viewers can explore the world through someone else's eyes in real time, which can help to create unique experiences. This feeling of being elsewhere is the focus of telepresence, "the human experience of being fully present at a live real-world location remote from one's own physical location" [39]. Next, we present several examples on how participatory and telepresence activities can enhance the remote user experience in different kind of events.

### **Participating in Live Events**

It is possible to use different technology means to promote remote user interaction during live events. A simple, yet, powerful example is the use of chat rooms associated with live video broadcasts to create participatory experiences. These experiences are explored by Twitch [38], a live video-streaming platform for videogames where players gather to watch others playing. Broadcasters communicate with the audience through audio or video, while viewers share their opinions in a text-based chat room. In a study conducted by Hamilton et al. [40], the authors came to the conclusion that people like to engage in this ex-



perience for two reasons: they are drawn to the unique content of a particular broadcast, and they like to interact with others and participate in a broadcaster's community. In other words, people like to engage in social experiences. Sociability, "the sheer pleasure of being together" [41], becomes as much essential to the broadcast, as the videogame action being streamed. As such, as communities form around the broadcaster's content, a sense of community is created. This social psychology concept is defined by McMillan [42] as a "feeling that members have of belonging, a feeling that members matter to one another and to the group, and a shared faith that members' needs will be met through their commitment to be together".

An example of a community in Twitch, is Twitch Plays Pokémon. What started as a social experiment back in February 2014, has now become a popular stream of the platform, taking the boundaries of participatory experiences even further. The idea is simple: a script parses the text from a chat room and uses it as input into an emulator running a copy of a Pokémon game to control the game's character (initially the game was Pokémon Red). Viewers, also become players as they type in commands (e.g. "left", "right", "A", "B") and the one that has more votes after a short period of time (usually 20 seconds), is executed by the game. This experiment became immensely popular, reaching 55 million views with 1.16 million viewers participating, and a peak of 121.000 viewers simultaneously [43]. The first game was completed after more than 16 days of continuously gameplay. Commenting on the surprise success of this experiment, Twitch's Vice President of marketing Matthew DiPietro stated "by merging a video game, live video and a participatory experience, the broadcaster has created an entertainment hybrid custom made for the Twitch community" [44]. A study was conducted [45] to evaluate how the social dynamics developed within this novel gaming scenario, and the results are consistent with previous research [46, 47], demonstrating that in a social context with external and internal obstacles, a group is able to unite to overcome them and achieve its goals. Finally, WeGame [48] is a similar system that supports co-located group play by allowing multiple players to jointly control a single character in different games.

On a different note, there are also examples of applications that allow viewers to remotely interact during live events, without having direct consequences on the live action. This can happen quite often on competitive activities like in sports events or eSports tournaments, as external actions are prohibited. In this case, the idea is to support and cheer the performers, in order to boost their confidence, so they can hopefully achieve better results. Izumi et al. [49]

presented a simple computational tool that enabled users to cheer their favourite ice hockey team. Users watched an ice hockey game through a website, and used the tool to select one of three cheering options: “Go!”, “Nice!”, and “Defence!” (each with a different background colour: red, green and yellow, respectively). Then, every time someone chose an option, the corresponding word appeared on the 50-inch display screen at the rink side. For remote audiences to be able to perceive that their cheering option was shown to players and in-venue fans, the displayed word was also embedded in the streaming video. Another feature of the setup was the use of shock sensors to transmit the feedback of players hitting against the rink fence to remote users. When a shock was detected by a sensor, the video was reversed five times, to give a shocking feeling to remote audiences. Although the results of the user test were mixed, due to infrastructure issues and inappropriate details of design, the concept of remote cheering and improvement of awareness between players and remote viewers was received with positive feedback.

In a different study [50], the authors presented how motion-based activities can be deployed so remote fans can also interact during music performances, like if they were in the venue. A Microsoft Kinect was used to detect typical reactions when watching a music performance at the venue, such as: hand waiving (lift a hand and wave it to the rhythm of music), hand clapping (applaud synchronised with the rhythm), hand joggling (lift a hand and joggle it, without moving the arm), push up (raise a closed fist up and down synchronised with the music), and towel swinging (to swing a towel above the head). Then, animated reactions of remote fans were shown to the performers in real-time, without interfering with the show itself (in this study, the authors used a LCD display without sound to symbolize the reactions). The authors argued that presenting videos of the remote fans to the performers can have a negative impact in the experience, due to the bandwidth limits of uploading videos in real-time synchronised with the music, hence the use of animations to symbolize the reactions. Most recently on a different event, one of the biggest football clubs in the world teamed up with one of the most important technology companies, to bring a similar experience to life. Thanks to Google, Manchester United’s remote fans were able to cheer their team live by using the Google+ Hangout service in a feature dubbed “Front Row” [51]. Cheering videos appeared on the Old Trafford stadium's digital screens (next to the turf), visible to all players, in-venue fans, and remote fans, which helped to create an enhanced experience, where in-venue and remote fans could feel that they were together supporting their team.

Finally, besides remotely interacting through live video broadcasting websites, computational tools, motion sensing input devices, and communication platforms, mobile computing can also be explored to convey enhanced experiences for remote fans watching the same live event. We decided to conduct our research in this area, mainly due to two factors: first, fans are used to interact with mobile applications while watching TV broadcasts [10], and second, it is easier to materialize the developed prototypes in real applications, since the majority of fans have mobile phones. This topic is explored in more detail in Subchapter 2.3.

### **The Feeling of Being Elsewhere**

Since distance acts as a barrier when interacting with others, technologies were created to bridge this gap. The term telepresence was coined back in 1980 by Minsky [39], who envisioned a future where high-quality sensory remote experiences would be so similar to actually being there, that people would not be able to tell the difference. Since then, different commercial and academic applications were developed in different areas, such as sports [52, 53], health and education [54], and home environments [55]. Regarding sports, Huawei presented [52] a new concept called full field communications, which aims to take telepresence to the next level. As a proof-of-concept, a prototyped called MirrorSys was created consisting of a 220-inch display with 8K resolution and a 22.2-channel sound system. MirrorSys was carefully deployed in a room that had choreographed surround sound, so viewers could feel like what was to be in the scenario conveyed by MirrorSys. In the future, one of the goals of MirrorSys is to experience live sports events like if we were in the stands with thousands of other fans. Kirari by NTT (Nippon Telegraph and Telephone) [53] is a different, yet, also immersive telepresence concept, which aims to broadcast the Tokyo 2020 Olympic and Paralympic Games in unprecedented ways. Kirari uses advanced MMT (MPEG Media Transport), along with sensing technology, video and sound transmission technology at 4K and 8K resolutions, and it reconstructs remotely the in-venue action, according to different arrangements of hardware devices or size of each site. The data gathered on the venue can then be broadcasted to any place in the world in real-time, or played at a later time. In health and education, PEBBLES (Providing Education By Bringing Learning Environments to Students) [54] is an example on how video-conferencing can be used to make a real-time link between hospitalised children and their classroom. PEBBLES provided an opportunity for children who are in isolated situations, such as hospitals, to maintain a meaningful link with their regular educational and social environments, through telepresence video-conference. Results

indicated that PEBBLES had a very positive effect on both young and adult participants, which can serve as a motivation for future initiatives in this area. Regarding home environments, HomeProxy [55] is a prototype that explores supporting video communication in the home among distributed family members through a physical proxy. HomeProxy combines a form factor designed for the home environment with a no-touch user experience and an interface that responsively transitions between recorded and live video messages. Most users liked the video affordance, the easiness to access video messaging, and the home look and feel of HomeProxy (fabric enclosure, glowing lights, and sounds). Finally, Periscope [37] and Merkaat [56] are two examples of live video broadcasting applications that allow users to see the world from someone else's eyes, in a way that is raw, unfiltered, and unfettered. Users can make their videos public or private to certain users such as their friends or family members. While broadcasting, viewers can like the broadcast content (by sending "hearts") or comment it through a text-based chat room. Both applications have reached mainstream status, and it is usual for some celebrities to also broadcast themselves in order to deliver personal messages to fans.

As we can see, sometimes a television set is not enough to experience an event. Sometimes it is necessary to take part in participatory experiences and feel like being somewhere, to satisfy our need of experiencing an event.

### **2.3. Second Screen Interaction**

In recent years, many media devices have become a regular presence in the living rooms. This space, once used mostly to watch television, has evolved to a shared space where individuals use different devices like laptops, tablets, smartphones or gaming handhelds. Within this refurnished space, an innovative concept has become quite popular: the possibility to interact with the content watched on television, through an additional electronic device. This concept defined as second screen, provides several functionalities that improve the viewer's experience, usually by presenting additional show-related information, access to social networks, and interactive experiences synchronised with the program content, such as polls or quizzes. An early idea of second screen dates back to 1996, as Roberston et al. [57] presented a system where handheld devices were used to interact with the television. This system used a PDA in conjunction with interactive television to allow users to manipulate the TV broadcast. Besides controlling the TV broadcast, the first initiatives sur-

rounding the second screen interaction, also focused on electronic programming guides [58], commerce [59], and quiz games [60].

With the growth of the second screen concept popularity, in 2009 Cesar et al. [61] proposed a taxonomy for the different uses of the second screen in the TV environment. They classify use cases into three main categories: content control, content sharing and content enrichment. These cases focus on the possibilities of interaction between viewers and the TV content: to control it, to share it or to enrich it. In content control, users are given the opportunity to decide which content is appropriate to display either on TV or on the second screen device. Common actions of this category include player control functionalities (e.g., play/pause), and the possibility of transferring a running session from one device to another (e.g., from the television to the second screen device). Content sharing empowers the users to share their opinions and comments with others. Viewers might want to share their opinions publicly on social networks or privately, through chat-message services. Finally, content enrichment refers to the content manipulation that users can perform on either the TV or the second screen device. There are a number of sub-classes within this category such as fragmenting television content, generating new content, and enriching or annotating existing material. Table 2.1 presents a summary of these categories and their subclasses.

**Table 2.1: Taxonomy of the different usages of the secondary screen in the television environment [61].**

Category	Definition	Subclasses
<b>Content Control</b>	To decide what and how to consume television content	Select content
		Browse content
		Manage content
		Select path
		View extra material
		Video controls
		Session transfer
<b>Content Enrichment</b>	To actively manipulate the television content	Create content
		Annotate content
		Fragment content
		Enrich content

<b>Content Sharing</b>	To socially communicate with others	Share personal content
		Share media fragments

Today, as the second screen concept matured and developers became aware of what people sought in second screen applications, other authors proposed a categorization of typical activities when watching TV [62]. They divide it in three categories: social sharing, gamification and extras, and expanded experience. Next, we describe these categories, as we present several works in different TV broadcasts genres.

### **Multiple Genres, Multiple Possibilities**

Social sharing refers to the social interactions that we have with others, like when talking about a TV show with friends, or sharing broadcast-related content on social networks (human to human interaction). This is a topic of major interest within the second screen research area, which resulted in different studies. For instance, Geerts et al. [63] discussed the effect of TV genres on social TV activities like chatting or clip sharing. A study conducted by Buchinger et al. [64] concluded that news, soap operas, quiz shows, and sports were the genres during which participants talk the most while watching, making them highly suitable for social media use. Furthermore, in [65] it is presented that viewers were mainly motivated to tweet during television series due to their desire of connecting with a community also watching the same show. In a survey conducted by Nielsen [10], three in five of Twitter UK mobile users are on Twitter sending and reading tweets whilst watching television, as of November 2013. In fact, another example where we can see a shift in how television is consumed specially within the sport industry is the Super Bowl 2014 edition, which had 24.9 million related tweets (most of them done after exciting plays or touchdowns), edging out the 2013 edition by 800.000, and the 2012 edition by 11.2 million [66, 67]. This is a clear sign that spectators are starting to become more open to comment, interact, and cheer through electronic devices during live events, than they used to.

As the name implies, gamification and extras explores interactive activities such as placing bets and answering trivia questions, but also checking the TV programme and accessing movies and TV shows on-demand. In this case, users are the main drivers, while the application awaits user input (human to machine interaction). An early example that explores this category is the electronic programming guide developed by Cruickshank et al. [68]. In this case, a second

screen prototype was developed using a PDA to remove the need for interactive television services to use on-screen graphics, dramatically improving the possibilities for effective interaction and navigation. Users showed a strong preference for the second screen solution over conventional remote controls, due to the mobility of the PDA and its superior visualization of service information. More recent examples are the ones developed by television service providers. MEO GO [69] is a mobile application developed within the MEO triple-play subscription home telecommunications platform. This application allows users to watch a TV channel either on the mobile device or on the television screen, as well as control the TV by switching channels and volume, and even accessing special features, such as the MEO video club. XFINITY TV Remote [70] is a similar application that allows subscribers of Comcast to control their top boxes. Users can control the TV and DVR, schedule recordings, browse the on-demand library, check extra information about a channel programme, among other possibilities. Comcast subscribers can also download the XFINITY TV Go [71], which allows them to stream all the Comcast content directly on their mobile devices, without the need to be connected to a DVR. More interactive examples are the ones found in TV series and sports broadcasts. Popular TV shows with second screen applications like *Game of Thrones* [72], *X-Factor* [73], and *The Million Pound Drop* [74] have been downloaded by millions of people worldwide, allowing viewers to access extra information, and engage in live polls and trivia questions. Furthermore, the studies conducted in [75, 76] depict how second screen applications can help viewers to understand complex storytelling with multiple characters over a long arc TV series. This way, viewers that join the series at a later point in the story – or simply cannot watch all episodes –, can have access to story maps and events’ details, that make the narrative easier to follow. Regarding sports, due to its high level of unpredictability, it is easy to think on features that allow viewers to guess what will happen next. In fact, there are some applications that exploit this concept, like *Pre-play* [77] (for baseball and American football), *Viva Ronaldo* [78] (for football), and *NHL Connect* [79] (for ice hockey). However, as we experienced at first hand during our user tests, and as pointed out by Anstead et al. [80] in a study conducted with the Olympics second screen application, it is necessary to take into account the “liveness” and the impact of spoilers during a sports TV broadcast, otherwise viewers can have a frustrating experience. Until now, besides the possibility of predicting what will happen next, there have not been many other exciting interactions that a remote fan can perform through a second screen application. Furthermore, currently fans do not engage in rich social interactions other than through traditional text-based chats, which of course

is not the same as being with others on the same physical space. This motivated us to combine the gamification and extras and social sharing categories, in order to create interactive second screen applications that motivate users to engage in social interactions.

Finally, expanded experience refers to the activities where the second screen application is the driver and the human is the consumer (machine to human interaction). These activities include content generated algorithmically without explicit user input, such as related news or facts about the content of the TV show. In this case, the existent initiatives focused on newscasts and TV shows. For example, FanFeeds [81] is a second screen application that provides in-sync additional content-related media. FanFeeds relies on one's social circles to create contextual information for TV shows making the information feeds more personal and relevant to the primary content. Another example is the SentiTVchat [82], which allows users to chat on a mobile device about a TV show, analyse the chat-messages towards it, and plot the data on the TV screen to inform the viewer about the show popularity. In another study conducted [83], the authors used IntoNow [84] – a platform that enabled developers to identify TV shows through automatic content recognition – and the closed captions of a live TV newscast, to find online articles that matched the news being broadcasted. When a match was found, the article was immediately presented to the user, in order to give additional information about a specific news piece. Table 2.2 summarizes the previously described categorization.

**Table 2.2: Categorization of features of existing second screen applications as described in [62].**

Category	Interaction	Examples of Common Features
<b>Social Sharing</b>	Human-Human	Share and interact with social circles, comment on events in real-time, Twitter and Facebook integration, meme generation, and user-generated content.
<b>Gamification and Extras</b>	Human-Machine	TV guide, remote, behind-the-scenes looks, deleted scenes, polls, trivia, badges, rewards, and editorially generated content.
<b>Expanded Experience</b>	Machine-Human	In-depth on the content, music identification, related news, exploration of the cast, related content, recommendations, and algorithmically generated content.



### **Additional Devices, Additional Problems**

While second screen applications are designed to enhance viewing experience, the use of an extra screen results in a competition for users' attention. If attention is not appropriately directed between screens, the second screen could diminish rather than enhance engagement with the broadcasted content. Conversely, the television could distract from time-sensitive, interactive content on the second screen. This issue is studied by Holmes et al. [85], where the authors suggest that adding a synchronised second screen application to the television viewing experience has important impacts on the distribution of visual attention as indicated by point of gaze. In this study, the second screen garnered considerable visual attention during the viewing sessions of two television genres: a drama and a documentary. Considerable gaze time went to the tablet screen (30% of the total visual attention) even when there was no recent interactive content with the TV show and TV advertising. In other words, viewers started to look more frequently to the tablet during the television show, even when there was not any reason to interact with the second screen application. These results imply that there may be a fundamental impact on visual engagement with the television screen when another screen simultaneously competed for attention. On the other hand, in a study conducted by Brown et al. [86], results indicated that viewers focused strongly on the television screen, which may lead them to miss the synchronised content on the second screen device. Participants of the study watched a 15-minute clip of *Autumnwatch* (a BBC TV show that depicts the fortunes of British wildlife during Autumn), as they interacted with a second screen application on a tablet, featuring quizzes and complementary information. To monitor the attention given to each one of the screens, two eye-trackers were used (one for the TV and the other for the tablet). The TV eye-tracker detected activity between 57% and 91% of the time, while the eye-tracker monitoring tablet detected activity between 8% and 35% of the time. Furthermore, viewers shifted their attention from the TV to the tablet a few seconds (2s to 9s) after an update on the application's content. Other factors that appear to trigger attention shifts are changes in the television content: more people look at the tablet when the TV is showing the TV hosts speaking than when it is showing wildlife footage, and audio cues such as exclamations seem to bring viewer's attention back from the tablet to the television. As such, the authors hypothesised that shifts from the TV to the tablet are primarily visually driven, while those back to the TV are primarily driven by audio. These results were also observed in another study [87], as the authors found that users reacted quicker to fresh second screen content when alerted by

means of peripheral stimuli, such as sound. We think that these findings may be in-line with what happens in sports: viewers perform parallel actions during uninteresting moments (e.g., after a foul), but once sportcasters talk more enthusiastically, viewers are keen to shift their attention back to the broadcast. To conclude, the challenge here is to develop second screen applications that grab the viewers' attention at the right time to provide interactive content, i.e. when it is safe to shift the attention from the TV, without the loss of important events. To solve this problem, we designed second screen applications that get users' attention through audio or tactile cues (so users do not need to constantly look to the mobile device) during less relevant moments.

Another issue that needs to be taken into account is the effect of the TV delay when watching broadcasted live events. Since different TV providers have diverse types of connections and hardware, it is common for some viewers to receive events on second screen applications that are not synchronised with the TV broadcasts, which may spoil their viewing experiences. Mekuria et al. conducted a study [88] regarding the synchronisation between different TV service providers, and presented empirical evidence that relative delays encountered in digital TV degrade the football watching experience, especially when there are fans closer to each other (e.g. neighbours) watching non-synchronised TV feeds. In our research we have a similar problem, since we have to deal with the synchronisation between what is being watched on TV, and the content that is displayed on the second device. Both of these feeds have different sources (television broadcast and the server handling the second screen application), and they need to be synchronised to provide a non-disruptive experience. Moreover, as described by Kooij et al. [89], television providers have different broadcasting delays, making it more difficult to achieve a solution to this issue. In the authors' study, it was presented a variation of the playout delay up to 6 seconds in TV broadcasts, and more than one minute in some web based TV broadcasts. Within the second screen context this may affect the user experience of viewers in two ways. If a second screen application presents content earlier than the expected, it will spoil the users' experience since they will know what will happen next (e.g. a goal message appears before the user sees the goal on television). On the other hand, if the content is presented too late, it will not provide a meaningful experience, making the content obsolete (e.g. a message appears asking what will happen during a free kick, after it took place). Fortunately, this issue can be solved from a software-based perspective by either the TV service provider or the second screen application. In the first case, TV service providers can introduce synchronisation technologies and algorithms [90, 91] to diminish

the TV playout difference between viewers. In the latter case, developers can use automatic content recognition (ACR), such as audio fingerprinting (see the third-party API Entourage [92] for instance), to identify a given TV show and synchronise the second screen application with it. However, if TV providers do not agree to synchronise their broadcasts between them, or if third-party APIs cannot identify the TV show being broadcasted, these solutions will not work. This issue motivated us to develop a simple and universal synchronisation mechanism that allows users with different TV delays to receive synchronised events on their second screen applications, without disrupting their user experience (more details in Subchapter 3.4).

As it was demonstrated, the second screen concept can be explored in multiple TV broadcasts genres to create innovative and enhancing experiences, and connect the viewers around the world. However, the introduction of an extra screen competes for the users' attention, while the synchronisation between devices needs to be well designed in order not to disrupt the user experience.



# 3

## Bridging the Emotional Gap

*What I love about the creative process, and this may sound naive, but it is this idea that one day there is no idea, and no solution, but the next day there is an idea. I find that incredibly exciting and conceptually actually remarkable.*

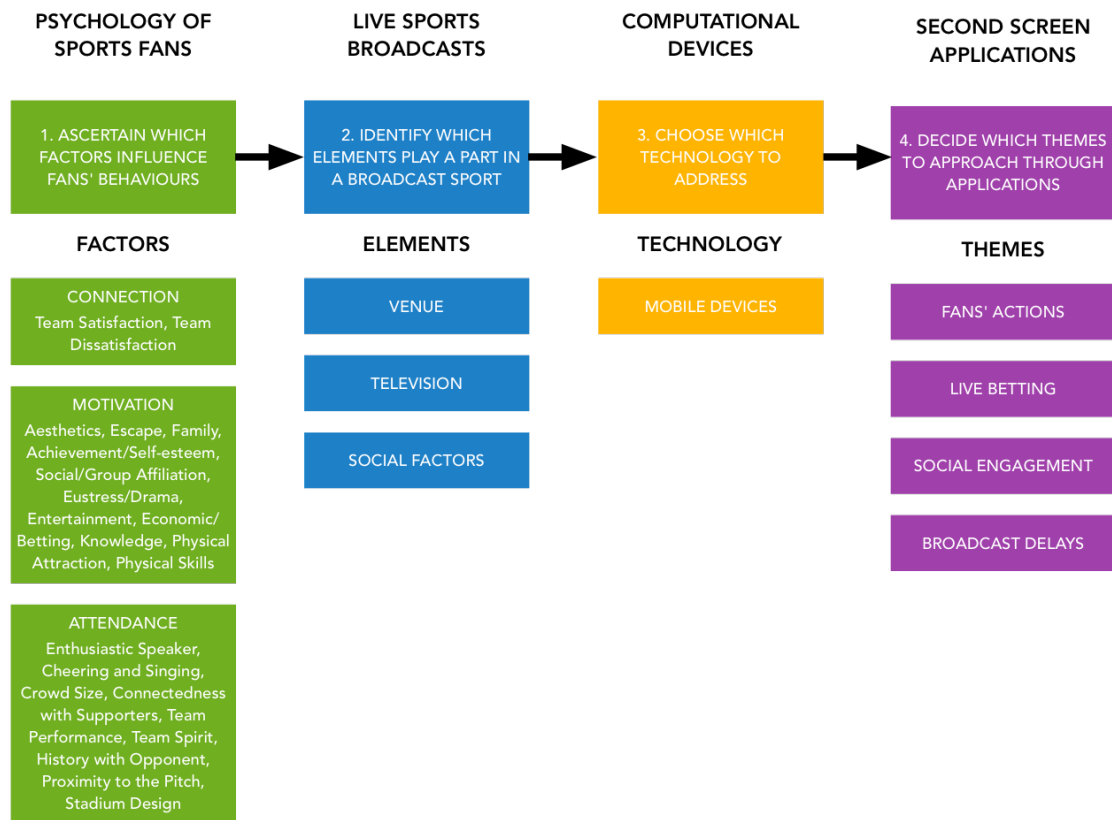
- Jonathan Ive, CDO of Apple Inc.

With the objective of investigating how to enhance the fan experience during broadcasted live sports events through competitive and non-competitive activities, we developed a set of proof-of-concept prototypes. These prototypes introduce new concepts of interaction during broadcasted live sports events, based on the findings from Subchapter 2.1 – “Psychology of Sports Fans”. Table 3.1 presents a summary of these results, by pointing out the factors that influence fans’ behaviours. Each prototype addresses several of these factors and the different elements that encompass the remote fan experience (the venue, the television, and the social factors), as presented in Chapter 1.

**Table 3.1: Factors that influence fans' behaviours according to the analysis of Subchapter 2.1 – "Psychology of Sports Fans".**

Question	Category	Factors that Influence Fans' Behaviours			
How are fans connected with their favourite sports team?	Connection	Bask in Reflecting Glory (BIRG)		Cut Off Reflected Failure (CORF)	
		Team Satisfaction		Team Dissatisfaction	
What motivates fans to watch sports events?	Motivation	Sport Fan Motivation Scale (SFMS)		Motivation Scale for Sport Consumption (MSSC)	
		Aesthetics			
		Escape			
		Family			
		Achievement/Self-esteem			
		Social/Group Affiliation			
		Eustress/Drama			
		Entertainment		Knowledge	
		Economic/Betting		Physical Attraction	
				Physical Skills	
Why do fans attend sports events?	Attendance	Stimuli			
		Organiser	Spectators	Game Action	Stadium Architecture
		Enthusiastic Speaker	Cheering and Singing	Team Performance	Proximity to the Pitch
			Crowd Size	Team Spirit	
			Connected-ness with Supporters	History with Opponent	Stadium Design

Taking into account these factors, we developed four proof-of-concept prototypes based on four live sports themes, as mentioned on Chapter 1: fans' actions, live betting, social engagement, and broadcast delays. Figure 3.1 presents an extended view of the conducted research process.



**Figure 3.1: The conducted research process detailing the different stages.**

The first prototype that we developed focused on the fans' actions, as it was a topic that we kept coming back after several brainstorming sessions. The possibility for remote fans to perform supporting actions like if they were in the stadium (Subchapter 2.1 – "Why do fans attend sports events?"), was very appealing to us, as we could connect the remote and in-venue audiences together. As such, we started by developing WeApplaud, a local multiplayer mobile rhythm game that prompts players to applaud their team (Subchapter 3.1). WeApplaud explores all the elements of the remote fan experience with special emphasis on the venue.

Next, motivated by the high interest of fans in live sports betting (Subchapter 2.1 – "What motivates fans to watch sports events?"), we explored a different approach on placing bets during an event. Traditionally, viewers predict events triggered by applications, but to our knowledge, so far there has not been any approach that dealt with user-triggered events. To study this concept, we developed WeBet, a game where players can place live predictions through eyes-free interaction (Subchapter 3.2). WeBet resorts to the social factors of competing with other fans in order to brag about who best knows their team.

Due to the strong emotional connection that fans have with their teams (Subchapter 2.1 – “How are fans connected with their favourite sports team?”), we felt compelled – in a good way of course – to study how remote fans could share their emotions with their friends and the audience watching the same event. Thus, we idealized and developed WeFeel, a system that allows users to share emotions and opinions through the television screen (Subchapter 3.3). WeFeel relies on the television broadcast and social factors to deliver a seamless user experience and a sense of community.

Finally, during our studies, we became aware that broadcast delays can have a major influence in the remote viewer experience. A common scenario is when fans hear a neighbour shouting goal, before they watch it in their television. While we cannot do much to solve this problem, we can solve the one in a second screen application context, where synchronised events are presented earlier than they are supposed to. Therefore, we created WeSync, an application that allows users to synchronise second screen events with the TV broadcast (Subchapter 3.4). WeSync explores the television element, and uses a synchronisation mechanism to deliver an optimal experience. As a summary, Figure 3.2 presents the set of proof-of-concept prototypes previously mentioned.

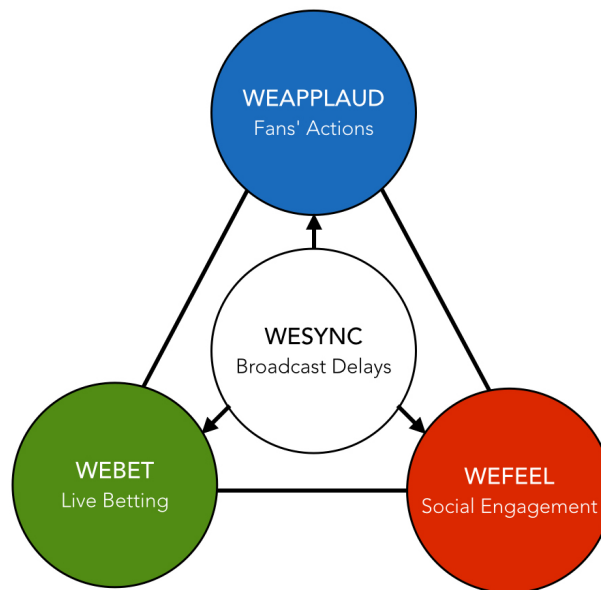


Figure 3.2: Set of proof-of-concept prototypes.

### 3.1. WeApplaud

The first concept that we idealized resulted from a brainstorming session where we asked ourselves an interesting question: “Wouldn’t it be great to connect the in-venue and remote communities together?”. Although there are se-



cond screen applications that exploit this concept (like the official X-Factor [73] and Rising Star [93] applications), we challenged ourselves to deliver an immersive and innovative experience to viewers. There is a wide range of actions that in-venue fans perform while watching a sports event, like shouting, applauding, chanting, and performing la ola (Mexican wave). However, remote fans are not so interest in performing such actions, as they know that it does not have an impact in the athletes' performances. Furthermore, both remote and in-venue fans do not share a social connection, resulting in defragmented social experiences. To address this issue, we conceptualized an experience where remote fans could perform supporting actions together with in-venue fans. As a proof-of-concept, we developed WeApplaud [94], a local multiplayer mobile rhythm game that takes users, sharing the same physical location, to participate in the applause happening at the stadium during a simulated football match broadcast. By doing that, we aim for users to become more engaged in the broadcasted event, increasing their fun and immersion levels, allowing them to feel and act almost as if they were at the event venue.

In Subchapter 3.1.1, we describe several fans' actions that are performed during live sports, and their impact on football matches. Next, we present several examples of rhythm games, and how sound effects like applauding can be detected (Subchapter 3.1.2). The WeApplaud prototype builds upon these concepts to prompt remote fans to support their teams during football matches, as described in Subchapter 3.1.3. One of the innovations of WeApplaud is how users interact, i.e. how they applaud, and this is detailed in Subchapter 3.1.4. In Subchapter 3.1.5, details about the implementation and architecture are explained. Finally, the evaluation tests conducted with WeApplaud are described in Subchapter 3.1.6, and the final conclusions are addressed in Subchapter 3.1.7.

### **3.1.1. Fans' Actions during Live Sports**

Sport always went hand-in-hand with fans. The first evidences of wrestling matches in 7000 BC, also depicted the existence of crowds watching the event [1]. Thus, it is not surprising there were already buildings constructed solely for the purpose of watching sports events, as back as 776 BC [95]. Since that year, the Olympic Games of antiquity were held in Olympia, Greece, which initially only consisted of a single event: a sprint along the length of the stadium. Fast-forward to today, and football matches in England are attended by almost 40.000 fans on average per week [96].

As mentioned in Subchapter 2.1 – “Why do fans attend sports events?”, stadium attendance is motivated by four main stimuli: organiser, spectators,

game action, and stadium architecture. Furthermore, factors like noise (singing and cheering), crowd size, history with an opponent, and connectedness to other fans are some that most contribute for the sport stadium atmosphere. There is no denying that singing and cheering are popular themes in sports. In football there are thousands of chants sang by different clubs, sometimes based on popular songs and classical music, others created specifically for the club. The Liverpool Football Club anthem “You’ll Never Walk Alone” is so widely known within sports fandom, that its words became featured in the club crest and on the Shankly Gate entrance to Anfield, Liverpool’s home stadium [97]. But cheering is almost as important as singing to create the sport stadium atmosphere. Fans can cheer their teams and favourite athletes through several forms like shouting when a goal is scored, or applauding after a good team performance, as a way to show appreciation. Imagine if singing and cheering was prohibited during a sport event. Imagine if we could only hear the athletes on the field. That would not be so exciting, right? Nor to the in-venue and the remote fans, nor to the athletes themselves.

Although these actions aim to encourage athletes, there are also other actions performed by fans either to entertain themselves, or to discourage opponents. Table 3.2 presents the typical fans’ actions during live sports events.

**Table 3.2: Typical fans’ actions during live sports events.**

Action	Description
Applauding	Clapping both hands together, during chants, or to follow a rhythm (e.g. before triple jump). Usually performed to show appreciation.
Booing	Screaming boo to show disapproval, frequently after an action.
Performing La Ola (Mexican wave)	Standing up and raising hands in turn, creating the illusion of a wave passing through the crowd. Usually performed when the whole venue shares the same affiliation and it is satisfied with the athletes’ performances.
Shouting	Screaming words like “yeah!” and “goal!” to show appreciation, or cursing to show disapproval (e.g. after an athlete’s miss).
Singing	Screaming along chants with a set tune. Usually performed to encourage a team or athlete.
Whistling	Producing sound by controlling the stream of air flowing through the mouth. In the United States, it is used to express appreciation, but in Europe whistling is used to express disapproval.

However, it is not usual for remote fans to perform these actions so often as if they were at the venue. Of course that is normal for remote fans to shout “goal!” or cursing words to the TV due to a refereeing error, but the fact is, fans do not feel motivated to sing along a chant or cheer their teams as if they were in the venue. We think that this happens for two reasons: one, fans are watching the event alone or with just a few people, and two, fans’ actions do not have an impact in the venue, and consequently in the athletes’ performances. With this in mind, we idealized a gaming experience where in-venue and remote fans would be performing the same action together. As such, we developed WeApplaud, a proof-of-concept rhythm game that – like the name says – prompts remote fans to applaud. The idea was to encourage remote fans to be more participative during a football match, promoting supporting actions, even if they were miles away from the venue. But before delving into WeApplaud, let us see how rhythm games can help uniting players’ senses, due to their motion and coordination requirements.

### **3.1.2. Playing Games by Interpreting and Reproducing Rhythmical Patterns**

Rhythm games challenge the player’s sense of rhythm. This genre has been widely popular in Japan where games like Dance Dance Revolution [98] and Bust a Groove [99] achieved mainstreamed popularity in 1998. Dance Dance Revolution challenges players to dance on pressure-sensitive pads in an order dictated by on-screen instructions. Bust a Groove features a similar focus on dancing but relies on a more conventional input method through the use of a gaming controller. In the United States, game series like Guitar Hero [100] and Rock Band [101] launched in the second half of the 2000s, became pop culture hits, as players used peripheral devices to play songs. Initially, Guitar Hero allowed players to use a guitar-shaped controller to simulate playing lead, bass guitar, and rhythm guitar across different songs. However, as new game iterations were released, new peripherals were added such as keyboards, drums and microphones, eventually leading to the release of Rock Band. The premise of Rock Band was to simulate the performance of a band by allowing four players to take the role of vocalist, bassist, guitarist, and drummer. But there are also examples of rhythm games for mobile devices. In Rhythm Heaven [102], players use a stylus to play through several rhythm-based levels, each with their own specific rules. Cytus [103] features three types of challenges where players used their fingers to tap an object in time, drag along a line, and hold over an

object according to the rhythm, in order to continue progressing in a level. In *Electroplankton Nanocarp* [104], players have to clap their hands or breath near the microphone to make the plankton form shapes. Finally, there are different approaches to rhythm games in academia research. *Headbang Hero* [105] prompts players to “headbang” to the rhythm of songs, by wearing a motion-sensing wig, as players are awarded with points. Wang and Lai [106] developed a mobile rhythm learning system based on a digital game-based learning companion, making the rhythm's learning anywhere and anytime possible. Charbonneau et al. [107] studied if rhythm games can be used as learning tools for the activity they simulate, by comparing a dance instruction video to a rhythm game interface. Lastly, Pertulla [108] modified *Frets on Fire* (a rhythm guitar game) to provide a new kind of collective experience for players. In this game's version, a new UI was added to promote social interaction, game controller mechanics were simplified, and collaborative gameplay features were designed to create a social, engaging, and enjoyable experience. *WeApplaud* builds upon these concepts to deliver an immersive and fun experience while watching a football match.

In summary, the majority of rhythm games are goal-oriented, with players hitting or missing a beat, to be rewarded with points and progress to the next level. Pichlmair and Kayali [109] conducted a qualitative analysis of music games and described the common features found in this genre: active scores, rhythm action, quantisation, synaesthesia, play as performance, free-form play, and sound agents. Active scores are scores that can be manipulated by the players and by the rules of the game, i.e. gameplay elements that react in real-time to the music. Rhythm action refers to the ability of interpreting and reproducing a pattern several times. Quantisation is the process of transforming the player's actions into musical notes (think of a music-box). Synaesthesia is a neurological condition where “sensory perception of any kind may manifest itself as sensory experience of another” [110], i.e. the tight synchronisation of acoustic and visual traits can help to deliver an immersive experience. Play as performance is a common element in games like *Guitar Hero* and *Rock Band*, which allows players to feel that they are performing instead of playing a game. Free-form play refers to the possibility of experiencing a game like an instrument, as the gameplay elements are cut back in favour of the instrument aspects, i.e. players have total freedom to perform as they desire. Finally, sound agents are visual elements that primarily exist for affect, emit, or accompany sound (e.g. plankton in *Electroplankton Nanocarp* [104]).

While some rhythm games are based on the input actions' timing (pressing buttons at specific times), sometimes it is necessary to rely on audio content analysis to detect if a specific sound occurs. In this case, there are several applications that use Acoustic Event Detection (AED). AED aims to detect specified acoustic events such as sirens, gunshots, explosions, applause, laughter, and cheer. It usually consists of three stages: a pre-processing stage to obtain low-level information; an event detection stage to derive mid-level contextual information, and a statistical modelling stage to formulate short-and long-time high-level semantics. Cai et al. [111] proposed an extensible framework to detect laughter, applause, and cheer, by using HMMs (Hidden Markov Model) and log-likelihood scores to make a final decision. Auditeur [112] is an acoustic event detection platform for smartphones, relying on tagged soundlets, short-duration audio clips recorded on smartphones along with two types of contextual information: user given tags and phone generated context. Finally, in [113], the authors presented an auditory training system to determine how users could clap their hands together within a classroom. This study focused on discriminating between near-field claps (originating in front of the microphones), and far-field claps (coming from other locations). To detect each clap, the authors used a fast and simple transient algorithm in order to minimize the complexity of the system. The clap detection in WeApplaud is based on a similar method, since we wanted to focus on the design of the game, and not on the development of a high accurate clap detection algorithm.

### **3.1.3. The Prototype**

WeApplaud is a local multiplayer mobile rhythm game where players are challenged to applaud at different key moments of a football match. WeApplaud was designed for fans that share the same physical location, either at home or at third places. Third places are “public places that host the regular, voluntary, informal, and happily anticipated gatherings of individuals beyond the realms of home and work” [114]. Typical third places are cafés, bars, and coffee shops. Like in third places, WeApplaud fosters sociability. In WeApplaud players compete between them for the glory of becoming their team's top supporters. This takes them to engage in further conversations, such as bragging about who is having a better performance, or discussing WeApplaud's mechanisms and the different key moments to applaud, which is similar to the social activity of watching a football match, as viewers comment the game's events, players' performances, and referees' decisions. In the end, WeApplaud's goal is to encourage remote fans to participate in the applauses happening at

the stadium. By doing that, we expect fans to become more engaged in the broadcasted event, increasing their fun and immersion levels, to the point of fans feeling that they are not playing a game, but supporting their team (the play as performance factor mentioned in the previous subchapter). Nevertheless, we need to take into account that this activity should be a complement to the football match, and not the main focus of the match. It is possible that some fans might get frustrated sometimes (when their WeApplaud's performance was not the best) but since their involvement in the match increased, our goal of improving the fans' affective responses has been fulfilled.

### Design and Development

When we were designing the interaction mechanism (how users should use their mobile phone to applaud), it was clear that it should be as intuitive and non-intrusive as possible, allowing users to just clap. Nonetheless, it is necessary to identify and count the claps made by the users. By using a mobile phone while clapping, for example by holding a mobile device in one hand, and then moving the device as if we would hit the palm of the other hand (Figure 3.3), it is possible to detect claps by combining accelerometer data and sound analysis (more details in the next subchapter). This can be done by using either the front or back side of the device while clapping, so users can applaud as they prefer.

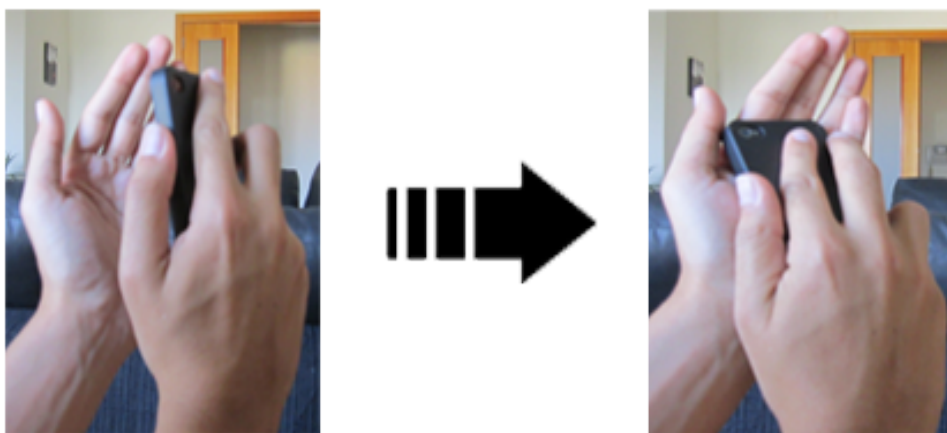


Figure 3.3: Clapping action.

To make the experience more engaging, we added two different kinds of applauses that create different challenges to users: free and synchronized applauses. During free applauses, players just need to keep clapping, like they would do in a normal applause action, to be rewarded with points (similar to the free-form feature of some rhythm games, as mentioned in [109]). During synchronized applauses, like in rhythm games, players' claps need to be syn-

chronized with a certain tempo to score points. Examples of synchronized applause are the slow clap (which happens quite often before a free kick in football or before a triple jump) and the claps that mark the rhythm of some football chants. These challenges should be triggered by the application at key moments of a match when fans at the corresponding event venue would start performing the same action. This version of WeApplaud, was tested during a recorded football match. So, the key moments were triggered automatically, according to the elapsed time of the video. In a real life environment (during a broadcasted football match), the key moments are determined by a human operator (who can be at the stadium to have a better perception of the crowd's actions). The operator can also define the number of key moments to include in the game, in order to not become tiring for the users. The key idea is that both of these actions make the remote fans synchronized with the in-venue fans, creating the feeling of a unique worldwide community connected through the event.

The developed prototype simulates a football match broadcast, displayed on a television screen, or projected on a wall, complemented with additional interface elements that point out when users should applaud, and display the corresponding feedback to the users' actions (Figure 3.4). The mobile devices are used for user interaction, allowing claps recognition and count. They are also used for input (so users can choose their teams), at the beginning of the game, as well as for visual feedback at the end of the game (teams and player total scores).



**Figure 3.4:** Game screen on the (a) main display and on the (b) mobile device.

Although in the future this game can have different configurations, this prototype version, which was conceived to test the concept design, allowed users to support one team (Portuguese national football team), competing for the

best supporters. This means that two teams of supporters of the same football team must be defined. So, before the game starts, each user must choose to play for one of the two teams of supporters (red or blue team) that will compete head-to-head. To create a real time competition between the two teams of supporters and promote group affiliation, both teams of supporters are challenged to applaud during the same key moments, which ends supporting the same sports team. Additional game configuration can be added in the future, allowing two teams of supporters, of the different football teams playing the match, to compete between each other. In this scenario, the two teams will be challenged to applaud during different key moments and should do their best to win the competition.

The goal of the game is to perform claps synchronized with the correct tempo (fans at the stadium), which we defined as correct claps. Each time a team member performs a correct clap, s/he and his/her team are awarded points and a consecutive streak count is started. In the free applause challenge every clap is a correct clap, while on the synchronized applause challenge a clap is only a correct one if it is synchronized with the tempo. Since it is very difficult to applaud at precise moments (we measure to millisecond accuracy), we have defined a threshold that allows users to get correct claps within a reasonable short interval (300 milliseconds, achieved after tries). The consecutive streak count is associated with a score multiplier, and it is intended to reward the team that is synchronized with the tempo during the period of time that the challenge takes place. Similar to games like Guitar Hero and Rock Band, we defined four score multipliers: two, three, four and five. Each of these multipliers is achieved by doing two, four, six and eight consecutive correct claps, respectively. If a team member claps when s/he should not, his/her team's score multiplier is restarted. If a team member does not clap, his/her team's score multiplier stays the same. To visualize the team's performance we added two score bars at the right and left sides of the display: one for the blue team and other for the red team. The score bars act as simple sound agents, as they increase each time users win points for their teams. The team that fills the score bar quicker wins the challenge. The required number of points for a team to fill its score bar is proportional to the number of team members. This way, if a team has fewer members than the opposite team, it will need fewer points to fill its score bar and consequently win the challenge. To win the game, a team needs to have more points than the opponent team, at the end of the broadcast. This is intended to motivate users not to give up, because there is always a chance to win, even after losing some of the challenges.



To alert users, in advance, when they need to applaud (meaning that a challenge is about to start), we use three kinds of feedback mechanisms: a text message on the top of the TV broadcasted match; the mobile device starts vibrating, so it can get the user's attention in a simple and seamless manner; and a hand inside a circle icon starts spinning on the mobile device display until the end of the challenge (Figure 3.4b). Therefore, users do not need to keep aware of their mobile devices during the whole match (nor they should, since the TV is the primary device that users should focus on). Furthermore, on the mobile device, a vibration is synchronized with the rhythm of the synchronized applauds (only during the first moments of the challenge). Therefore, when a synchronized applause challenge starts (which may be hard to follow in the beginning), every time there is a vibration, users know that they need to applaud on that instant. After sometime having the mobile device vibrating, users recognize the rhythm that they need to follow, since they perceive an action-reaction mechanism (ability of interpreting and reproducing a pattern mentioned before).

A typical game unfolds as follows:

- 1) Users are initially presented with the instructions on the main display (Figure 3.5a) and they can select one of the two teams of supporters on their mobile devices, red or blue (Figure 3.5b).
- 2) After everyone has chosen their teams, the game starts (either through an automatic algorithm or a human operator).
- 3) The simulated football match is displayed on the television screen. After a short time, the first challenge appears, and users are prompted to applaud after an attacking play. We started with a simple challenge, so users could understand the gameplay.
- 4) When the challenge ends, a message, stating which team won the challenge, appears on the television screen, while on the mobile device it is shown a message stating how many points the user won in the challenge.
- 5) The video keeps playing, until another challenge appears (either a free or a synchronized applause).
- 6) The process repeats until the match ends.
- 7) A final screen appears showing the final results, both on the main display and on the mobile device (Figure 3.6). The television screen shows more detailed information regarding both teams of

supporters, while on users' mobile devices they can see how many points they won for their team, as well as the team total score.

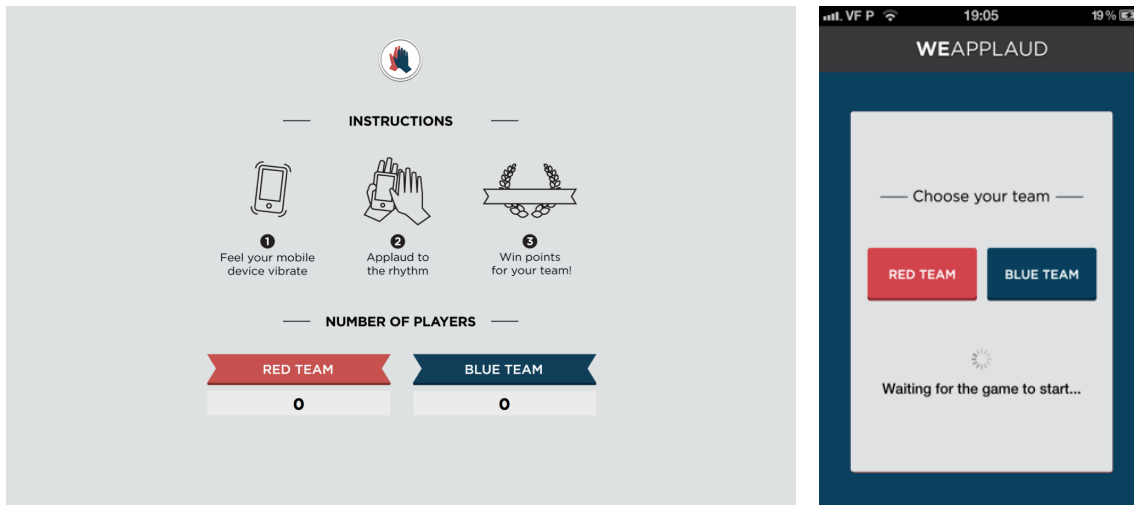


Figure 3.5: Start screen on the (a) main display and on the (b) mobile device.

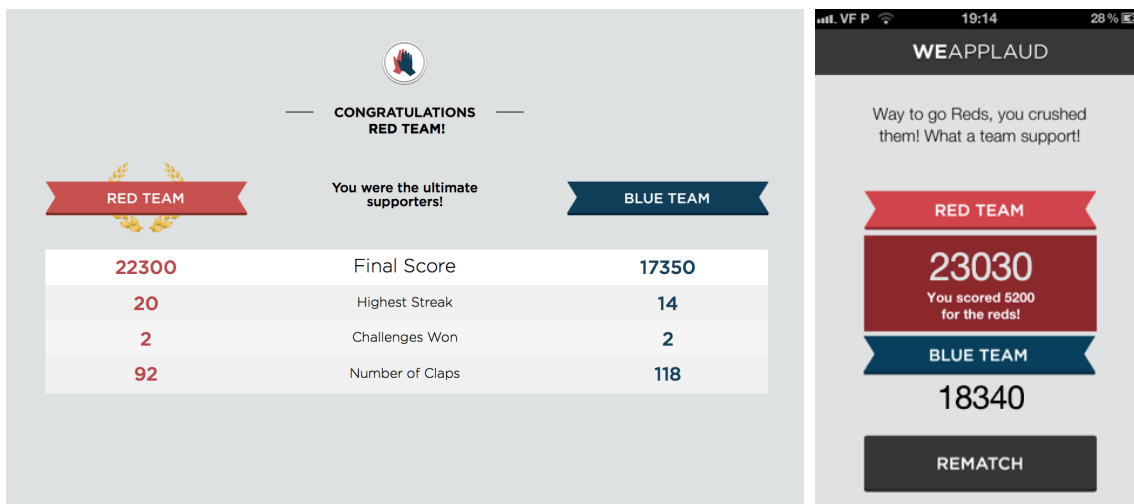


Figure 3.6: Final screen on the (a) main display and on the (b) mobile device.

### Influential Sports Factors

Taking into account Table 3.1 – “Factors that influence fans’ behaviours”, we designed WeApplaud to address five factors: cheering and singing, connectedness with supporters, group affiliation, entertainment, and escape. It is obvious that WeApplaud relies on the cheering factor to motivate remote fans to perform supporting actions, namely applauding. This is one of the most common action fans perform during live events and particularly during sports events, which we saw as a fitting activity to design a game around it. The connectedness with supporters is also at the core of WeApplaud. Remote fans only applaud when is meaningful, i.e. when an exciting action occurs and the in-

venue fans start applauding. We thought that the feeling that remote fans have when applauding together with the in-venue fans is a unique experience that contributes to the sense of community, where the in-venue and remote fans are connected. Since WeApplaud was designed as a local multiplayer game, it motivates fans to gather at each other's homes or at third places, in order to watch the football match and play WeApplaud. This, of course, leads to social experiences, which is something that sports fans desire (group affiliation). As a game, WeApplaud explores the entertainment factor that some fans have in watching sports. Therefore, WeApplaud motivates them to be further interested in a sport event, by applauding on exciting events. Similarly, some fans may also find in WeApplaud a diversion or an escape from their daily life, by supporting their team with other fans, rather than just watching the team playing. In Table 3.3 we present a summary of this discussion.

**Table 3.3: Influential sports factors addressed in WeApplaud.**

<b>Factor</b>	<b>Description</b>
Cheering and Singing	WeApplaud is a local multiplayer rhythm game that prompts remote fans to applaud like if they were in the venue.
Connectedness with Supporters	Remote fans can feel that they are applauding together with the in-venue fans, creating a sense of community.
Group Affiliation	WeApplaud was designed to create social experiences, as fans interact in the same physical space.
Entertainment	By playing WeApplaud, fans can be more entertained and more engaged in the football match, compared to just watching it.
Escape	Being a game, WeApplaud can help distracting fans that are bored or worried about personal setbacks.

### **Remote Fan Experience Elements**

With WeApplaud we sought to explore all the three elements that encompass the remote fan experience. By extracting aspects of the venue, we aimed to allow remote viewers to have an experience closer to the in-venue fans. In this case, we added the sound of in-venue fan applause at specific moments, so that remote viewers could perceive the rhythm of the applause in order to follow along. Next, we lowered the sound of the television broadcast at the different key moments and increased the sound of applause from the venue, so remote viewers could hear what was like to be there. This can be seen as an extra audio feed that replaces the one of the television broadcast, where sportscasters

give a running commentary of the event. We also added a custom interface to the television, by adding score bars for each team of players, as well as instruction and feedback messages. This has two purposes: first, it avoids users to shift their visual attention from the television to the mobile device (which would be the case if this information was displayed in the mobile device screen); and second, it enables audience members to also follow WeApplaud’s action, even if they are not playing. Finally, we designed WeApplaud to be played when people gather to watch sport events, either at home or at third places. As such, WeApplaud relies on the social factors existent in these places, to deliver a social, collaborative, and fun competition, as fans engage in conversations about the match and WeApplaud, and thrash-talk about each one’s performance. Table 3.4 presents an overview of the elements previously mentioned.

**Table 3.4: Remote fans experience elements explored in WeApplaud.**

Element	Description
Venue	WeApplaud uses the audio of the venue so viewers can perceive the rhythm of the applause in order to follow along.
Television Broadcast	<p>The television broadcast audio is lowered at different key moments and the sound of applause from the venue is increased.</p> <p>A custom interface was added to the television, with score bars, as well as instruction and feedback messages.</p> <p>By placing UI elements on the television, viewers do not need to shift their visual attention from the sport event, and enables audience members to follow WeApplaud’s action.</p>
Social Factors	WeApplaud relies on the social factors existent when people get together, to deliver a social, collaborative, and fun competition.

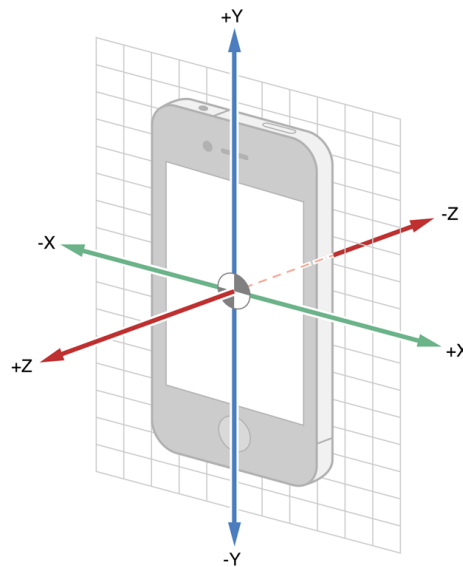
### 3.1.4. Clap Detection

We took three approaches to identify claps: sound analysis, accelerometer data analysis and a combination of both methods.

A proper clap generates a sound, so we decided to analyse the sound, captured by the mobile device microphone, to detect a clap. Like in the work of Lesser and Ellis [113], we used a fast and simple transient algorithm. This was essentially to minimize the complexity of the system, as it was not our goal to implement an acoustic event detection algorithm. As such, every time a volume peak was identified (value higher than -15 db, selected after multiple trial-and-

error sessions), we counted a clap. This allowed us to have a fast detection algorithm, which differentiated between near silence (-160 db) and full scale (0 db) in 100 milliseconds. However, this approach has its flaws, because a loud noise, like talking aloud, blowing into the microphone or snapping the fingers, would also be counted as a clap.

Thus, we implemented a different approach as developed in games like Mario & Sonic at the London 2012 Olympic Games<sup>1</sup>: we used the accelerometer to detect whether there is a movement in a particular direction. The device accelerometer reports values for three axes (Figure 3.7).



**Figure 3.7: Orientation of the device axes.**

Each axis has values in units of g-force, where a value of 1.0 represents acceleration of about +1g along a given axis. When a device is laying still with its back on a horizontal surface, each acceleration event has the following values:  $x = 0.0$ ,  $y = 0.0$ , and  $z = -1.0$ . To detect a movement that resembles a clap, we detected if there was an acceleration peak ( $y > 0.6$  and  $z > 0.8$ ), every 20 milliseconds (once again these values were selected after multiple trial-and-error sessions). If there was, then the algorithm stopped for 200 milliseconds (in order to prevent the detection of multiple claps), and after it resumed its normal operation. Still, this approach also allows users to do a “clap” just by wagging the mobile device in the air, without the need to hit the other hand. This behaviour is very common on motion games, where the player stops mimicking the pro-

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<sup>1</sup> Mario & Sonic at the London 2012 Olympic Games clapping interaction, <http://bit.ly/1UqwI72>

posed action, and starts performing a simplified version of it (i.e. in Wii Sports, bowling can be played on the sofa just by moving the wrist, without the need to stand up and perform the action like in a real bowling game).

In either approaches, it is necessary to find appropriate threshold values to tweak the algorithms and achieve high-quality rates for clap detection. Both approaches do not leave much room for error. If a player performs a rough clap, it might count as several claps, due to the high variation of new reads. In the contrary, if someone executes a smooth clap, the algorithm might not detect it, because it was created only to detect claps above a certain threshold. Furthermore, we wanted to design an interaction that resembled applauding as close as possible, so remote fans could applaud like if they were in the venue. As such, exploiting the interaction method (like mentioned previously) was not an option. Therefore, we decided to combine the two previous approaches, so they could complement each other. The resulting method works as follows: when the mobile device detects a volume peak, it checks if there was a recent movement (in the last 200 milliseconds). If so, then it counts a clap, otherwise it does not. Thus, we have a more flexible system, where we do not rely on a single threshold. Moreover, users will not be able to exploit the system in order to do something simpler than the supposed actions. They can still shout to the mobile device microphone while they mimic the clapping action without hitting the palm of the other hand, but, in this case, they are doing a more complex action, than the one they were supposed to. Table 3.5 presents the results from a small study conducted with 4 participants. Each clapped 50 times: 25 times on a 500 milliseconds interval and 25 times on a 100 milliseconds interval. We analysed how many claps were detected, how many of them were false positives or false negatives. Results showed that with small intervals (100ms), the algorithm has a 52% success rate, while with longer intervals (500ms), the success rate increases to 82%, which brings to a success rate of 67.5% overall. Although we acknowledge that these results are merely indicative, they can give a glimpse on the algorithm's performance, and what we can expect from deploying it on a real environment.

**Table 3.5: Clap detection success rates.**

	Time between claps		
	500ms	100ms	Total
Total Claps	100	100	200
Detected Claps	96	93	189
False Positives	5	17	22

False Negative	9	24	32
Success Rate	82%	52%	67.5%

### 3.1.5. Implementation and Architecture

WeApplaud was developed in Objective C and the client application was developed to be compatible with iOS 5.0 (or higher) running on all the most recent iPhone's and iPod Touch's. It can also run on iPad's, but it makes no sense to deploy it on this type of device, considering the WeApplaud interaction style. The server application was developed to be compatible with Mac OS X 10.7 (or higher). The computer running the server application can be connected to a video projector or a TV.

WeApplaud is based on a client-server architecture. We used Bonjour protocol to quickly identify the clients and the server. To keep the process simple and to avoid being dependent on third-party networks, the computer running the server application creates a wireless network for the clients to connect to. To handle the network communication between the mobile devices and the server, we used the UDP protocol through CocoaAsyncSocket (a TCP/IP socket networking library). This architecture can be very similar to the one deployed in a real environment, where users are playing remotely from their homes. The only difference is that instead of using Bonjour to identify the clients and the server, it is necessary to have a fixed IP associated to the server on the Internet, which the clients need to know in advance. Figure 3.8 presents the WeApplaud's architecture and the different devices necessary to deploy it.

To keep the mobile devices synchronized with the server, during a WeApplaud game, the server broadcasts a message with its clock time to all the client devices, so they can adjust their clocks if necessary. Then, the server starts a clock and sends a message to all clients when the video (football match broadcast simulation) begins to play. Mobile clients immediately start their clocks when they receive this message. This way, we keep all the mobile devices synchronized with the server, right before the key moments when users need to interact. This synchronization mechanism is required, because it is the mobile device, and not the server, that verifies if a user clapped within the correct time interval. The client mobile device only needs to inform the server each time the user performs a correct clap, and the server handles the rest (score, streak count and multipliers). This reduces dependency on network performance, which could have a negative impact on the user experience. We are still dependent on

the network performance, but only before each game starts, and not each time a user does a clap (which is larger by the numbers than the occurrence of challenges).

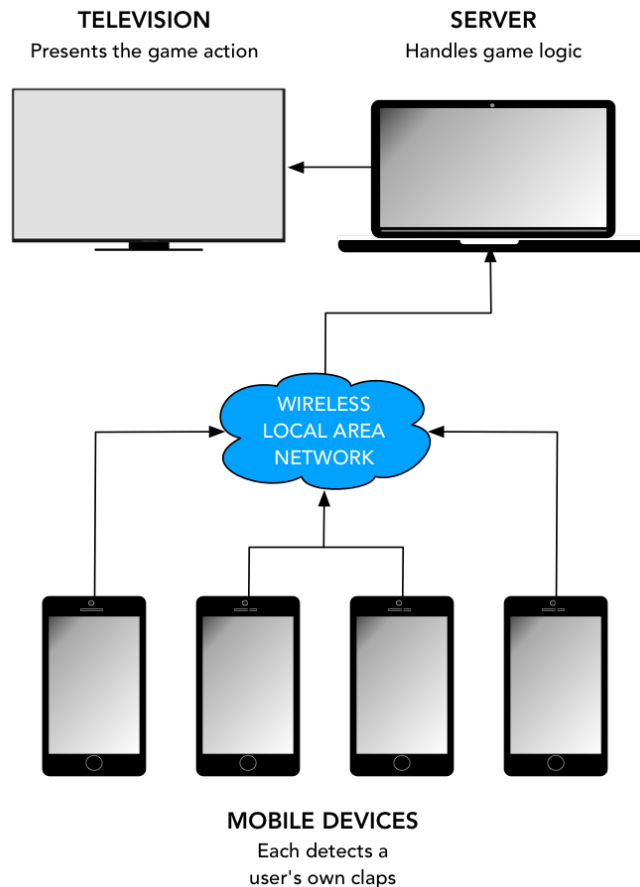


Figure 3.8: WeApplaud's architecture.

### 3.1.6. Evaluation

Users tests were conducted to evaluate the WeApplaud concept, guide the system's design and evaluate users' reactions. Furthermore, we also wanted to perform a technical evaluation concerning clap detection, regardless the way users hold the mobile device. All the feedback we collected enabled us to understand the main advantages of the prototype and to decide what can be improved.

WeApplaud was deployed on two different locations. In the first one, we setup WeApplaud in our University campus to conduct evaluation studies. Some time after it, we showcased WeApplaud during the ACE 2012 conference, in Nepal, which enabled us to collect feedback from people from different countries and cultures.



## Participants and Methodology

The evaluation studies were conducted with 16 voluntary participants (12 male and 4 female) aged 23-43 years ( $\bar{x} = 30.06$ ,  $\sigma = 5.22$ ). The tests took place in a meeting room in our University campus. A projection screen and a set of speakers were used, so users could see and hear the broadcast like they would do at home or at a public place (Figure 3.9). Of course, we were not expecting that most users have a projection screen at home, but the experience conveyed through this method is closer to a home setting, than the one experienced through a computer screen. Moreover, video projections are already used in numerous occasions for displaying sport events' broadcasts for a large number of people (e.g. in third places like bars or cafés), where our concept can be deployed.



**Figure 3.9: Participants interacting with WeApplaud.**

We conducted eight test sessions, each with two participants (hence sixteen participants). Each test session comprised a maximum of three games, which means each user participated in a best-of-three games, where one player played against the other until someone won two WeApplaud games. Thus, in each test session each participant played at least two games. In each test session, only two participants were admitted in the room, in order to keep the experience unique to each pair of participants. Before starting to use the application, users were informed about the objectives of the WeApplaud game. The test sessions were conducted by two researchers, who played the roles of facilitator and observer. The first one had a more active role, giving an initial brief-

ing and instructions to the participants and providing assistance for any problems that users might face. The second researcher focused on observing the way the tests unfolded, and how users reacted and interacted with the system.

The video content shown to the users during the tests focused on the Portuguese national football team. All participants were Portuguese, so it was natural that they would support their country's national team. We chose an important match between Portugal and Bosnia on November 2011, where Portugal needed to win to qualify to Euro 2012. The video was 5 minutes long and included four different challenges corresponding to four key moments of the match:

- 1) A free applause challenge after an attacking play.
- 2) A synchronized applause challenge, which consisted in a slow clap before a freekick.
- 3) A free applause challenge after a goal.
- 4) A synchronized applause challenge, based on a Portuguese chant.

At the end of each test session, users were asked to answer a questionnaire to evaluate their experience while using WeApplaud.

### **Questionnaire**

The questionnaire began with a group of questions related to the users' personal data, such as age and gender. It also included questions regarding the users' habits while watching sports events: how often do they watch live sports; how often do they watch them on television; which additional devices do they use while watching live sports events on television and which activities do they perform while interacting with them. Then, the questionnaire focused on usability and user experience issues, including general feedback about the experience, application's usability and ease of use, users' entertainment and emotional involvement, as well as users' suggestions and comments.

The questions related with the general feedback, and usability issues were based on the USE questionnaire [115]. This questionnaire helps to assess whether an interface is well designed and to define which problems should be considered with higher priority. Users were asked to rate statements, using a five-point Likert-type scale, which ranged from strongly disagree (1) to strongly agree (5). These statements (see Table 3.6) focused on the type of interaction and the different key moments that prompt users to applaud.

Users were also asked to rate two additional statements using a five-point Likert-type scale aiming at acknowledging whether users felt more involved in the stadium atmosphere, and if the competition enhanced their level of entertainment during the game.

To capture users' feelings and study their emotional involvement with the prototype, a question based on the Microsoft "Product Reaction Cards" [116], was included, since this method facilitates the measuring of intangible aspects of the user experience. Users were asked to select the words that best described their experience while using WeApplaud. They could select as many words as they wanted from a list consisting of about 60% of words considered positive and 40% considered negative.

In the end of the questionnaire, users could express any further suggestions and comments they had about the prototype and their experience while using it.

**Table 3.6: Statements, regarding general feedback and usability issues, rated by the users.**

Statements
<b>General Feedback</b>
<b>S1.</b> I liked to use WeApplaud.
<b>S2.</b> It is easy to learn how to use WeApplaud.
<b>S3.</b> It is easy to use WeApplaud.
<b>Usability and Ease of Use</b>
<b>S4.</b> The application correctly detects the clapping action.
<b>S5.</b> The way of applauding (how to hold the mobile device while clapping) is natural.
<b>S6.</b> The mobile device vibration helps to understand how and when to interact.
<b>S7.</b> I can use the application without exterior help.
<b>S8.</b> The feedback given by the application is useful.
<b>S9.</b> Free applauses, like the ones used after a dangerous play or a goal:
<b>S9a.</b> Are natural and suitable for the associated key moment of the match.
<b>S9b.</b> Are easy to perform.
<b>S10.</b> Synchronized applauses, like the ones used before a free kick:
<b>S10a.</b> Are natural and suitable for the associated key moment of the match.
<b>S10b.</b> Are easy to perform.
<b>S11.</b> Synchronized applauses, like the ones used during a chant:
<b>S11a.</b> Are natural and suitable for the associated key moment of the match.
<b>S11b.</b> Are easy to perform.

## Results and Discussion

Results showed that more than half of the participants in these users studies rarely watch live sports (56.25%). Some of them never watch live sports (12.5%), but 31.25% do watch live sports on a regular basis (25% weekly and 6.25% monthly). These results changed when participants were asked how often they watch sports on television. Half of the participants watch sport events on TV on a weekly basis, 12.5% on a monthly basis and 6.25% fortnightly. Still, 25% of the participants rarely watch sports events on television, and 6.25% don't watch them at all. From those who watch it, 60% uses additional technological devices during the sport event.

The favourite device used during broadcasted sports events, was the cell-phone/smartphone (89%), followed by the computer (44%) and finally the tablet (22%). From those who used additional devices, 89% performed activities related with the sports event and all of them performed other kinds of activities. Regarding the activities related with the event, browsing the web was the most common activity (67%), then sending SMS (56%), chatting (44%), accessing the social networks (33%) and making voice calls (22%). Regarding the activities not related with the sport event, accessing the e-mail was the most frequently performed activity (77%), followed by browsing the web (67%), accessing the social networks (33%), playing videogames (22%) and chatting (22%). These results showed that the majority of participants were used to interact with technological devices while watching live broadcasted sports. Moreover, almost all of the participants perform activities related with the event, and the cell-phone/smartphone was the most popular device used to perform those activities.

As shown in Figure 3.10, most participants agreed with the statements concerning the general feedback (statements 1, 2 and 3). Participants liked to use WeApplaud and found it easy to use and to learn. Participants' opinions regarding statements 4 and 5 were also very positive, showing that most of them had the feeling that the application correctly detects their clapping actions and consider the interaction with the mobile device (way of applauding) natural. We observed that sometimes users felt initially hesitant on how to applaud (they were reluctant to break the phone), but after noticing that the score bar (in the main display) was filling in while they were clapping, they started to feel more confident and had no problems in using their mobile phones while clapping. It was also grateful to see the different clapping styles (different ways to hold the mobile device while clapping) used by the participants, with no interference on the clapping detection.

In statement 6, the majority of the users agreed that the vibrations helped to understand how and when to interact. Although, some users suggested that we could use sound and vibration to help perceiving the rhythm. While we agree that it can work at a conceptual level, unfortunately we cannot develop such feature, as the microphone would detect volume peaks when it was not supposed to, due to the sound output. Therefore, to comply with such suggestion, a redefinition of the clap detection algorithm must be taken into account, or users need to use headphones while playing WeApplaud (which of course is not our intention). Nevertheless, the results were positive as 75% of users agreed with this statement (both 37.5% agreed and strongly agreed). Users seemed to be able to use the application without exterior help (statement 7) as they stated that the feedback given by the application was useful (statement 8).

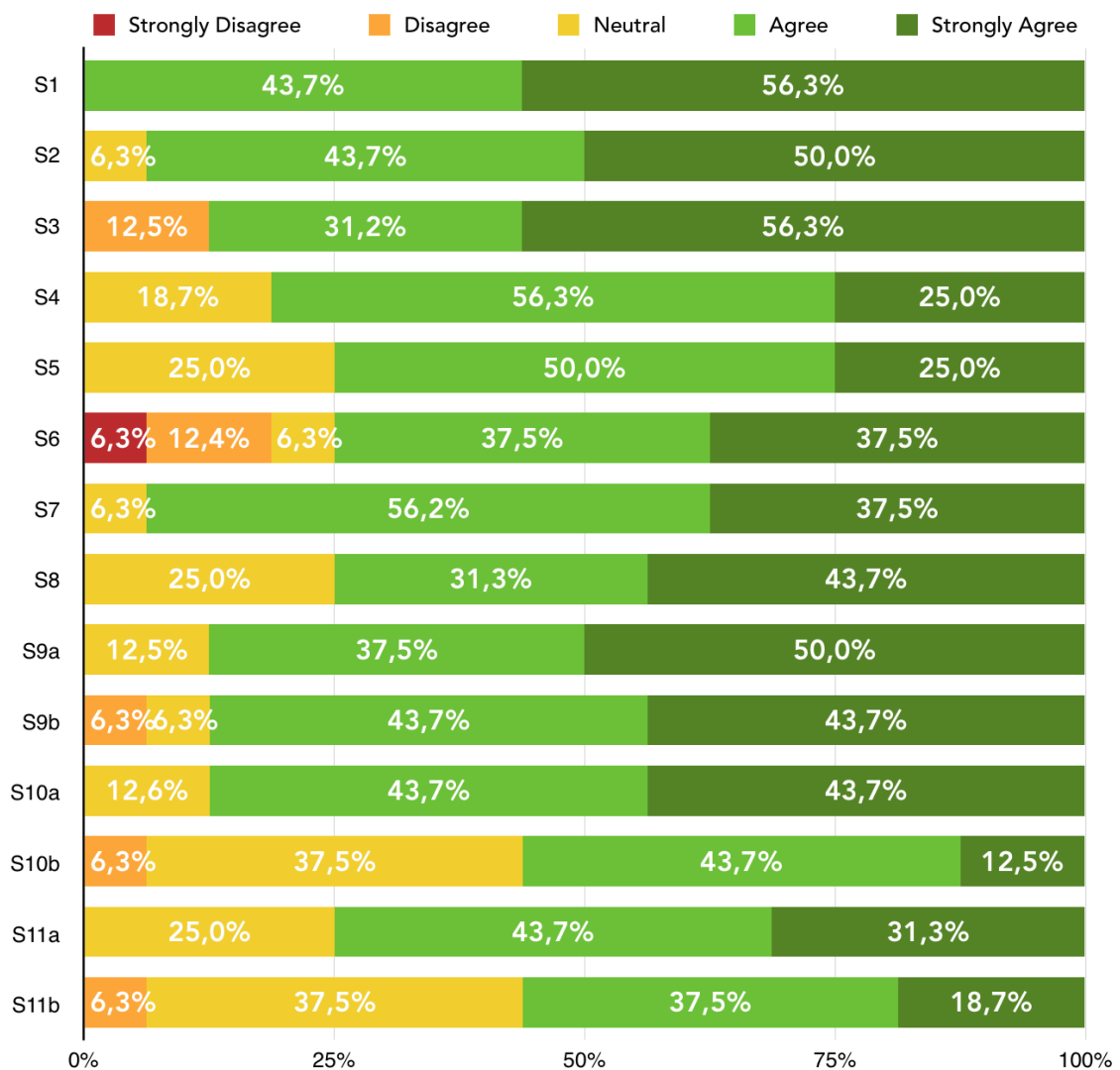


Figure 3.10: Summary of results from general feedback and usability.

Regarding the different key moments that prompted users to applaud, the results were mixed (statements 9, 10 and 11). The majority of participants agreed that the free applauds were natural, suitable to the associated key moments (a dangerous attacking play and a goal), and easy to perform (S9a:  $\bar{x} = 4.37$ ,  $\sigma = 0.71$  and S9b:  $\bar{x} = 4.25$ ,  $\sigma = 0.85$ ). They also felt that synchronized applauds (a slow clap and a chant) were natural and suitable to the associated key moments (S10a:  $\bar{x} = 4.31$ ,  $\sigma = 0.71$  and S11a:  $\bar{x} = 4.06$ ,  $\sigma = 0.77$ ), although they did not find them so easy to perform (S10b:  $\bar{x} = 3.63$ ,  $\sigma = 0.81$  and S11b:  $\bar{x} = 3.69$ ,  $\sigma = 0.87$ ). According to our observations, this happened because the goal of the challenge was not clear to the users the first time they used the application (i.e. users did not understand that it was necessary to follow a rhythm, and what was the rhythm). Once it was clear, the action itself was easy to perform.

Regarding the entertainment experienced by users and their engagement in the broadcasted football match, we asked participants to rate two statements: "Competition promoted by WeApplaud contributes to increase the level of entertainment during the broadcasted match" and "WeApplaud contributes to make me feel more involved in the stadium atmosphere". According to the participants' opinions, the competition promoted by WeApplaud clearly enhanced the level of entertainment during the broadcasted match (43.8% agreed and 50% strongly agreed). According to our observations, most participants were really having fun, engaged in the game and eager to become the best player (supporter). Regarding the second statement, feedback was also positive, although feelings were not so strong (31% were neutral, 63% agreed and 6% strongly agreed). This reveals that WeApplaud represented a contribution to immerse remote users in the real environment of the sports event, even if users were not watching a real broadcast (which may have contributed to reduce the immersion feeling). As we know, watching a live broadcast, where the match is exhibited in real time, is much more engaging than watching a recorded match that already took place.

By analysing the Microsoft "Product Reaction Cards" [116] questions, we concluded that all participants held positive feelings when classifying their experience with WeApplaud. The most selected word was fun (81%), followed by immersive (50%), pleasant and simple (44% each) and innovative and stimulating (37.5% each). We were already expecting the word "fun" to be one of the most popular ones, due to our observations during the tests. It was very frequent for participants to laugh, smile, get exalted and exchange comments about their opponents in order to discourage them. This also corroborates our goal of increasing users' fun while watching a sport event broadcast. While the

word immersive was not as popular as the word fun, it was the second most selected one, which we believe is still very positive.

Finally, we analysed the comments and suggestions given by the participants. Ten of the sixteen participants expressed their opinion in three different areas: interaction, visual feedback and scoring system. Concerning the interaction, some users stated that the rhythm of synchronized applauses was not very perceptible, and that they did not know when they should start or end clapping. As stated before, the use of sound instead of (or to complement) the use of vibrations can mitigate this problem, but it requires a redefinition of the clap detection algorithm. Regarding the scoring system, some users felt that those who are not clapping in the right tempo should be more penalized than they actually are, since it is easy to keep clapping from the beginning to the end of a synchronized applause challenge and still earn points. However, we believe that it is better to reward players than to penalize them (positive reinforcement), and thus, extra points can be awarded to those synchronized with the rhythm. Some users also expressed that the scoring system was not very clear, and we agree that it could have been easier to understand, as some details should have been added at the beginning of the game. Finally, a minority of the users expressed that it was not clear when a score bar was totally filled. This is something that we fixed shortly after the tests, by adding a “Great Job!” message on the top of the bar, as soon as it is completely full. This informs users that they can stop applauding, since they have already reached the maximum possible score.

### **Showcase at ACE 2012 conference**

During the showcase demonstration day at the ACE 2012 conference in Nepal, attendees were free to try WeApplaud. Many of them (14) played the game while the research team members observed them and informally interviewed them after playing. Participants were from different countries, such as Nepal, Japan and several European countries. Even considering the cultural differences between users and the fact that they have to support the Portugal national team (since the football match displayed by the video involved this team), the majority of the participants had great fun while using WeApplaud as corroborated by the observation made and the notes taken by our research team. Many exciting and fun moments occurred and participants were really enjoying the game (as can be seen in Figure 3.11). In two game sessions with four participants, two of them called other friends to play with them. This shows that this concept can be a success even when players just watch the football match for entertainment, without being emotionally attached to any of the



teams playing. Participants provided us with valuable feedback and suggestions. For instance, a participant stated that s/he would like to see the remote fans' contribution to support their teams on the stadium screen, which reinforces the idea that it is of major importance to connect both the in-venue and remote communities.



Figure 3.11: Users playing WeApplaud during the demo day at ACE 2012.



### 3.1.7. Conclusions

As we can see from the previous results, our first prototype gave us a lot of confidence to continue our research. Users had a great time playing WeApplaud, a clear sign that the promoted competition encouraged them to have a more active role during the match and increased their fun. Furthermore, it helped to demonstrate that influential sports factors like cheering, group affiliation, and connectedness with supporters can be addressed in computational applications, in order to further increase the level of entertainment during a broadcasted match.

However, we also acknowledge that some improvements can be made, specifically on three areas: applauding rhythm, television interface, and gameplay. As mentioned before, sometimes users did not perceive the applauding rhythm that was necessary to follow. This could either be because the vibration was not sufficient to interpret the rhythm pattern, or the in-venue applause were not clear enough. To solve the first issue, we can use sound cues to complement the use of vibrations to mark the tempo. Although, such design decision has an impact in the clap detection algorithm, as the microphone would detect volume peaks as false claps, due to the sound output. A solution would be to use specific and easy to identify sound cues, that could be distinguished from the sound of a clap. Regarding the second issue - and although we acknowledge that during a simulated broadcast it may be difficult to have access to audio samples that contain the clear sound of the applause - in a real environment, WeApplaud can benefit from the use of several microphones scattered throughout the venue to deliver an accurate sound stream. Regarding the television interface, we can do a lot of improvements. First, we can present a better feedback to each correct clap besides increasing the score bars. An example would be to add more interesting sound agents, such as a team's mascot becoming happier and applauding along with the remote fans, in order to teach them the rhythm pattern and to keep them motivated. Second, the TV broadcast should also be maximized to fullscreen, in order to highlight the match and not the game. However, to make this improvement, it is also necessary to redesign the interface, so the UI elements do not overlap important areas of the TV broadcast. Lastly, another improvement could be a picture-in-picture feature where users saw the stadium screen (or a simulated version of it) that showed how other remote fans were focused on supporting their team. Finally, regarding gameplay, the use of digital rewards (such as achievements or titles) can be important extrinsic motivators. At the moment, users compete due to intrinsic motivators: they want to prove that they are the best and they want to see their

rivals fail (*schadenfreude*) [117]. But the use of extrinsic motivators like the aforementioned, should also be equated to motivate fans on a long term. Moreover - and although this goes out of the scope of our work - clubs can also reward fans with physical prizes in order to thank for their loyalty.

We hope that it will be just a matter of time for future research to expand upon the WeApplaud concept. Imagine what would happen if WeApplaud was deployed on third places, and thousands of supporters in Oporto's cafés competed against the supporters in London's pubs, during a FC Porto vs Chelsea FC football match. Fans would engage in both a local and online experience, as they gathered on physical locations to collaboratively compete against fans in another city, for the glory of becoming the ultimate team supporters. Even better: picture the use of a stadium screen to present WeApplaud's feedback, so that players and fans at the venue could feel the encouragement coming from people watching the match worldwide. This is our vision for remote spectators to interact like they would do when watching a sport event live at the venue. This is our vision for connecting the in-venue and remote communities together.

### **3.2. WeBet**

Shortly after conducting the evaluation tests with WeApplaud, we started thinking about which theme we should tackle next. Since betting is an important motivational factor for fans to watch sports, and there is a historic high interest in sports betting [118], we decided to approach live betting. Companies like bwin [119] and bet365 [120] are known for being leaders of online gambling. They have millions of daily visits, are sponsors of multiple brands (clubs included), and operate in different areas from sports betting to online poker and casino games. On the other hand, Draft Kings [121] and Fan Duel [122] are daily fantasy sports games that become hugely popular in the last years. The easiness and the instant gratification of creating a team of players and win real money in the same day, attracts fans worldwide, and today, millions of entry fees are made per year [123]. Since we wanted to focus on live betting, we had two choices: create an interaction similar to the one found in bwin and bet365, where fans can bet on multiple options on the status of a match in the next minutes or at the end of a match, or we could try something completely different. And that is what we did. On one hand, we wanted to continue studying how tactile and audio feedback could be explored in second screen applications in order to inform and help users interacting, without the need to shift their attention from the television. But on the other hand, we also wanted to provide

exciting online experiences for those who are alone at home or cannot attend a third place, and participate in activities like in WeApplaud. Thus, we thought about allowing users to predict what was going to happen in the next seconds, in the next play. This way, the match's action becomes the canvas that we needed to paint the WeBet concept, as each dangerous play automatically becomes an event that players can interact with. However, as interesting as it may sound, this idea has a problem. If we are to allow remote viewers to predict what is going to happen next, they may miss the event they are about to predict. Fortunately, the use of tactile and audio feedback can help solving this problem. In order to study this concept, we developed our second prototype, WeBet. WeBet is a mobile game that prompts users to bet if a goal is about to happen during a football match broadcast, without requiring their visual attention on the mobile phone. We designed WeBet aiming to reinforce the connection between fans and their favourite sports teams, as WeBet allows them to score along with their team by predicting that a goal will result from a dangerous play.

In the next subchapter, we present an overview of sports betting. In Subchapter 3.2.2, we describe some difficulties, but also some guidelines, on how to design interactions that do not require users to look at their touchscreen devices. A brief description of the WeBet prototype is presented in Subchapter 3.2.3. The first development stage, aimed to evaluate the WeBet concept, is presented in Subchapter 3.2.4; the second development stage where we performed a comparison study with three interaction methods, is detailed in Subchapter 3.2.5, and the third and last development stage that addresses a study in a real life environment is described in Subchapter 3.2.6. The final conclusions are presented in Subchapter 3.2.7.

### **3.2.1. Sports Betting**

If sport always went hand-in-hand with fans, the same can be said regarding bets and fans. Many Roman emperors enjoyed gambling and for many years it was only legal to place a bet in Rome at the gladiator battles or at the chariot races [124]. In the early 19th century, pedestrianism was extremely popular in England, with enormous cash prizes being awarded both for athletes and gamblers. Consequently, it was not long until the Amateur Athletic Association was founded in 1880 to help stop race fixing and other devious schemes designed to influence the outcome of these events [125].

Today, sports betting are more controlled. There are many regulations in place around bookmakers and online services. Sports bets are now socially ac-

cepted. Daily newspapers publicize ads on sports betting, there are books focused on teaching fans how to bet and be profitable, and online services that allow fans to bet in real-time. Today, betting is also an important motive for fans to watch live sports, as mentioned in Subchapter 2.1 – “What motivates fans to watch sports events?”. In this sense, there are several types of sports betting. For instance, on football, the most popular types of bets range from match odds, match scorers, unders/overs, correct scores, Asian handicaps, to parlays (Table 3.7). All of these bets are based on odds. Odds are used to facilitate the varied possibilities of outcomes, as each club has different chances to win than others, due to the quality of the squad and the management team.

**Table 3.7: Most popular types of bets on football.**

Type	Description
Asian Handicap	A form of betting in which teams are handicapped according to their form, so that a stronger team must win by more goals for someone who bets on them to win.
Correct Score	In this case, a bettor only wins if s/he predicts the exact final result of a match.
Match Odds	The most common type of betting, as fans can predict the final outcome of the match (win, loss or draw).
Match Scorers	There are also bets where it is possible to predict which players are going to score in a match.
Parlays	A wager in which a bettor selects two or more different teams and wins only if every selected team wins.
Unders/Overs	Bettors can bet on whether the number of goals scored between the two clubs will go over or under a set total.

Nonetheless, there are also services that rely on gamification to engage fans in betting competitions. In this case, there are those who use real money, and those who use digital currencies such as virtual coins. For instance, in daily fantasy sports applications, fans pay an entry fee to draft a team of real world athletes, who then score fantasy points according to a set of scoring rules. At the end of the competition, fans with the top scores are awarded with money prizes. On the other hand, applications like Fulham Score Predictor [126] and NHL Connect [79], allow fans to engage in social gaming competitions, without spending real money. These rely on more interactive and exciting features, as there is not a concern on how real money flows during the competition (which

is something analysed extensively by either bookmarkers and regulatory agencies).

And so, it is within this scenario (real-time betting with no money involved) that we sought to introduce our second concept. Sometimes, fans are more motivated to watch sports events due to its potential return (monetary or not). Thus, we thought on exploring this motivational factor, in order to enhance the emotional connections that fans have with their favourite teams. Our idea is simple: in order to increase the drama and eustress originated from the outcome of dangerous plays, and reinforce the connection between fans and their sports teams, fans should be allowed to predict what will happen in the next play. This way, it is possible to predict at anytime if a goal is going to be scored, if a player will achieve a touchdown, or if a dunk will take place. To study this concept, we developed a prototype called WeBet. Early on we found out that we needed to create an interaction mechanism that would allow fans to place their bets without looking at the device, since the shift of visual attention from the television to the mobile device to place a bet at a crucial moment of a match, can result in a disrupting experience, as fans can lose important events. The next subchapter approaches this topic, as it presents several eyes-free interaction studies.

### **3.2.2. Interacting without Looking through Touchscreen Devices**

Today, although people are used to interact with touchscreen interfaces, it is necessary to have a high level of visual attention to interact with them, since the touchscreen lack tactile feedback. Thus, when performing a task that requires the user's visual attention, interaction with touchscreen devices becomes difficult, causing "situation impairments" [127], as it impairs the user's ability to interact with the device. Although this concept may be more of a concern to users with disabilities, there is a range of factors that can affect those without them, including: environmental factors, physical factors, and attentional factors [128]. Environmental factors are those caused by the environment that surrounds us such as sunlight, rainwater, or uneven terrain. For instance, sunlight impairs the way users interact, due to the low visibility to read content. Physical factors are related with the users' physical capabilities like impeding clothing, occupied hands, or movement. A common example is the use of gloves that restrains users to interact. Finally, attentional factors are caused by the users' sensory attention, like abrupt distractions, social interactions, or divided attention. This is exactly the problem that we face in using second screen applica-

tions, as users constantly deviate their attention from the television to the mobile device.

However, user interfaces can (and should) adapt to the users' contexts in order to reduce the effects of situational impairments. The low visibility to read content caused by sun exposure can be mitigated by automatically adjusting the screen brightness. When a user goes out for a run, the text can be enlarged in order to be easy to read. And as we described in Subchapter 2.3 – “Second Screen Interaction”, audio and visual feedback can help users to direct their attention when using second screen applications. In this case, users know when and where to look without being impaired by divided attention. As such, in order to avoid attentional impairments, we argue that eyes-free interaction techniques should be taken into account when designing second screen experiences. Oakley and Park [129] presented an eyes-free interaction literature review, focusing on history and scope, motivations, input and output modalities, as well as learning issues. A set of design principles to develop eyes-free interaction systems was also proposed: self-monitored input (expert users should be able to mediate their input actions with confidence); input reflects bodily constraints (the input actions should have in mind the user's body constraints); minimal interaction models (eyes-free interaction models should rely on a simple and understandable mapping); immediate output (an eyes-free interaction system should have output presented immediately or continuously), and seamless transition from novice to expert (novice users can use the system easily through a GUI, but experts should use it without requiring visual attention).

A mobile touchscreen eyes-free interaction system can explore different sensory cues. Audio is one of the most common ways to ascertain a system's state. By hearing a well-define sound, users immediately acknowledge that a trigger was set. Vibration is another important cue, as specific vibration patterns can inform users about a continuous state. Finally, and strange as it may sound, tactile feedback can also be explored in mobile touchscreen devices. For instance, by exploring bezel area surrounding the touchscreen display, it is possible to perform bezel-initiated gestures and interact with bezel menus that require minimum visual attention [130, 131]. Furthermore, the presence of the physical buttons on the side of the device and beneath the touchscreen should not be forgotten, as users can have a perception of where their fingers are just by sensing them. This and the previous factors were taken into account during the design of the eyes-free interaction method used in WeBet.

### **3.2.3. The Prototype**

WeBet is a mobile game that prompts users to bet if a goal is about to happen during a simulated football match broadcast, without requiring users' visual attention on the mobile phone. Through the use of eyes-free interaction that relies on tactile and sound feedback, WeBet aims to 1) reinforce the connection between fans and their sports teams, enhancing their experience when watching a broadcasted match (WeBet allows users to score along with their team when they preview, and bet for, a goal); and 2) provide an online experience, during which users can watch a live match, see real-time information, win badges, compete with their friends by bragging about who predicts more goals correctly, as well as with fans around the world battling for exclusive prizes. WeBet game concept can also be used for other sports where it makes sense (e.g. guess a goal on ice hockey or a touchdown on American football), while the interaction method can be applied on other kinds of events, such as contests that allow spectators to vote or answer trivia questions.

We devised WeBet development in three stages. In the first development stage (concept stage), we conducted user tests to evaluate if the WeBet concept conveyed an exciting user experience [132]. In the second stage (eyes-free interaction stage), we performed a user study to analyse what were the usage patterns and users' preferences regarding three different interaction mechanisms, designed to complement the users' experience while remotely watching a live event broadcast [133]. In the third stage (real environment stage), we collected the real users' feedback using the WeBet concept in a real world setting [134]. We cooperated with Viva Ronaldo [78] – which besides other features offers a second screen game for remote fans to guess what will happen during a Cristiano Ronaldo match - to introduce a new feature based on the WeBet concept, which allows Viva Ronaldo users to guess when a Ronaldo's team goal is about to happen during a live match.

### **3.2.4. Concept Stage**

In this stage we conceptualized the WeBet's game and developed a first version of the interaction method. WeBet featured a screen with information about a football match (time, result and teams), as well as a match report, which kept users engaged during uninteresting periods of the match. Users won points by predicting goals correctly, and lost when they did not, in order to discourage indiscriminate use.

### 3.2.4.1. Design and Development

The WeBet prototype version developed for the first study simulated two football match broadcasts. Once users open the application, they can choose one of the two football matches, and a highlight video of the corresponding match is presented on a television through AirPlay (using an Apple TV). While the user is watching the video, the application presents an in-sync report of the match (e.g. most important events, match time, result). Each video footage contains highlights of one match, and users are prompted to bet if each highlight or play can lead to a goal. WeBet scoring system rewards users for predicting a goal the earlier as possible, to a maximum of 10 seconds. The challenge is on knowing a team and its players, so when a player movement occurs, you know that a goal may be imminent. Thus, when a user places a bet, the system checks if a goal occurs in the next 10 seconds. If so, the user wins 100 points, and for each second that has already passed by s/he wins 50 extra points. This way, a user that bets earlier wins more points. However, if a goal does not happen when a bet is made, the user loses 50 points (except when s/he has no points). The idea behind this rule is to prevent users from betting that a goal happens in every dangerous play.

In order to have a better perception on how the first version of WeBet worked, a typical game session is presented next.

- 1) Users could hold their phones throughout the match to follow the information being provided or just grab it at certain moments. While holding the device, users could perform a gesture from outside to inside the screen and started pulling the special bet interface up as their fingers entered the bottom of the screen (Figure 3.12a). A quick upwards swipe gesture made the special bet interface go full screen immediately (Figure 3.12b).
- 2) As soon as the special interface was full screen, an upward sound (lasting 400ms) was played and the phone started vibrating repeatedly every 300ms, in order to inform users that they could now bet that a goal was about to happen with no need to look at the mobile screen.
- 3) To close the special interface, and return to the game report screen (Figure 3.13a), users just needed to swipe downwards anywhere on the screen, and a downward swipe sound was played (lasting 400ms). At this point, the mobile device stopped vibrating and no bet was made.



- 4) While the special interface was on full screen, users could touch anywhere on the screen to place the bet.
- 5) After that, the mobile device stopped vibrating, a selection sound was played (lasting 700ms), and a 10s countdown appeared (since there was not too much time since the start of a dangerous play and its outcome).
- 6) If there was a goal during those 10s, a cheerful sound was played (4s duration), the mobile device vibrated once and the screen changed to show how many points the user won.
- 7) If there was no goal during the 10s, the mobile device also vibrated once but played a different sound (a 2s disappointment sound), and displayed a different screen stating that the user lost points.

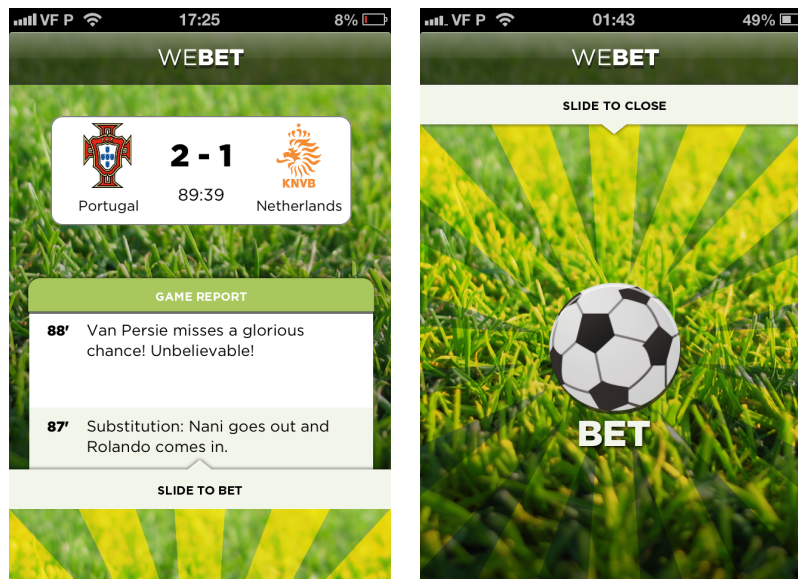


Figure 3.12: Performing a swiping upward gesture (a) that displays the special bet interface (b).



**Figure 3.13: The WeBet interface showing information about a match (a). Interaction with WeBet (b).**

In the first version of the interaction method, we aimed to create a two-state interaction mechanism, resembling a jet fighter shooting button, and enhance it with tactile and audible feedback. Inspired on previous work done by [129, 130], we decided to have a swiping gesture starting from outside of the screen's bottom, which then reveals a special bet interface that only requires the users to single touch the device screen to make a bet. This design decision was based on the idea that when users grab the mobile device, they have the perception of where their fingers are, and therefore they can accurately perform a swiping gesture from the bottom of the screen (e.g. by sensing the home button on an iPhone) without looking at the device. Moreover, we force WeBet to stay active, to prevent users from the need to unlock the phone when it enters an idle state (without having to look at the screen).

Vibration and sound features were added to provide users with an accurate perception of the state of the interface, without the need to look at it. Just by hearing and feeling the device, users know: if the swipe gesture was recognized and they are ready to bet; that a bet was effectively placed; and the outcome of a bet. For example, in noisy environments users may not hear the device's sound, but the vibration gives the feedback they need. On the other hand, sound helps to create a better experience, by playing sound effects naturally associated to the user's interaction. Together, vibration and sound complement each other, increasing user perception of the application's state, and creating a more sophisticated experience.

We also tried to use a gesture that users are familiar with, and the swiping gesture is something that iOS users perform quite often when accessing the Notification Center. In that case, the swiping gesture starts at the top of the screen and is made downwards. We did not want to use a swipe to the left or to the right, because these are usually made to access navigation menus (e.g. Facebook and Gmail applications).

### **Influential Sports Factors**

According to Table 3.1 – “Factors that influence fans’ behaviours”, WeBet aims to address five factors: economic/betting, knowledge, eustress/drama, group affiliation, entertainment, and escape. Like in any sports betting system, WeBet has a strong luck factor associated, but skill also plays a central role as the better knowledge players have about their team, and the more matches they watch, the higher the chances are to have better scores when playing WeBet. This way, we hope that WeBet can motivate fans to become more connected to their favourite teams, by watching multiple matches and by having a good knowledge on how the team plays and the different characteristics of the athletes. Psychologically speaking, the purpose of guessing a goal in the next seconds is to play with the users’ emotions: as soon as a bet is placed, users should start feeling anxious about the outcome of the play (since there are consequences associated), which only should rise as the bet countdown timer runs out. Then, there are two possibilities: either users become frustrated for not getting the bet right - and sometimes they blame the athletes, which is great because that means that they are more emotionally involved in the match -, or they become excited and smug because they just previewed that a goal was about to happen, and effectively, it happened. In this sense, WeBet tries to convey a psychological feeling that users are scoring along the team. As fans play WeBet, they also engage with others that share the same group affiliation, even if it is through a communication device. In this case, community-building features can be created around the WeBet concept, in order to bring together the remote fans watching the match. Finally, fans can find in WeBet, an entertainment activity that motivates them to be more aware of their teams’ matches, allowing them to forget daily issues, by engaging in a healthy and exciting gaming competition. Table 3.8 presents a summary of the most influential sports factors addressed in WeBet.

**Table 3.8: Influential sports factors addressed in WeBet.**

Factor	Description
Economic/Betting	WeBet is a mobile game that prompts users to bet if a goal is about to happen during a football match broadcast.
Knowledge	The better the knowledge players have about their team, the higher the chances are to have better scores when playing WeBet.
Eustress/Drama	WeBet plays with the users' emotions, as they become more anxious and expectant towards the end of plays.
Group Affiliation	WeBet was designed as an online game, where fans can play together while watching the match.
Entertainment	Like in any sports betting system, fans find WeBet entertaining, where they also can participate in a competition with other fans.
Escape	WeBet motivates fans to become more focused on the football match, which may further distract them from personal issues.

### Remote Fan Experience Elements

WeBet focus on the social factors of playing a game with others. Although WeBet did not feature an online option until the third development phase, our goal was always to provide an online social experience for those who are alone watching a sport event. Therefore, fans can talk with others through a text-based chat, check the game's rankings and interact with top fans, in order to further delve into the competition. Nevertheless, fans that share the same physical space are also free to play WeBet, as they can discuss dangerous plays in more detail and brag about each one's performances face to face. Table 3.9 presents a summary of the elements previously mentioned.

**Table 3.9: Remote fans experience elements explored in WeBet.**

Element	Description
Social Factors	<p>Fans that for any reason are watching a match alone, can play WeBet in order to engage in a competitive and social experience with other fans.</p> <p>Fans that are watching a match with others, can also play WeBet to engage in personal discussions.</p>

### 3.2.4.2. Evaluation

A preliminary user study was conducted to test the WeBet concept, guide the system design and evaluate user reaction. We aimed to evaluate the WeBet concept and the affective responses created by it, in order to know if it provided a good and fun experience.

#### Participants and Methodology

The user tests were conducted with 16 voluntary participants (11 male and 5 female) aged 12-43 years ( $\bar{x} = 28.50$ ,  $\sigma = 7.01$ ). The tests took place in a room at our University campus, with a researcher observing and taking notes. Since it was important to simulate a home environment, we used a television and a comfy sofa, so that users could watch the broadcast like they do at home (Figure 3.14). All the users held the device in their hands during the test.



Figure 3.14: Participant interacting with WeBet during the first development stage.

We conducted an initial briefing before each of the 16 individual test sessions stating the objectives of the application, and explaining what users were about to watch and which actions they could perform with WeBet. We selected two types of matches: a friendly match of Real Madrid during the pre-season of 2012 and, since the user tests were conducted in Portugal, an important match of the Portuguese national team during the Euro 2012. The purpose was to evaluate the WeBet concept on two different scenarios, where participants had different emotional connections with the teams playing. Therefore, in each session, each user watched two 5-minute videos from two football matches, Real

Madrid vs LA Galaxy and Portugal vs Netherlands. None of the participants had seen the first match before, and while many had seen the second (as expected), only one participant remembered some of the plays. Users played WeBet during both matches, allowing them to better understand how the application worked and enabling us to analyse how the interaction evolved as users got more used to it. In order to incite participants to play like if they were in a competition, we reminded them of the previous participants' scores before and during each game test session.

Lastly, at the end of each test session, users were asked to answer a questionnaire to evaluate the WeBet concept and users' emotional responses.

### Questionnaire

The questionnaire started with a group of questions related to the users' personal data, such as age and gender, and the users' habits while watching sports events. Next, the questions focused on usability and user experience issues, including general feedback about the activity, application usability and ease of use, and user emotional involvement. As presented in Table 3.10, users were asked to rate multiple statements based on the USE questionnaire, using a five-point Likert-type scale, which ranged from strongly disagree (1) to strongly agree (5).

A question based on the Microsoft "Product Reaction Cards" [116] was also included to capture users' feelings and study their emotional involvement with the prototype. Like in WeApplaud, users were asked to select the words that best describe their experience, where they could select as many words as they wanted from a list consisting of about 60% of words considered positive and 40% considered negative. In the end of the questionnaire, users could express any further suggestions and comments they had about the prototype and their experience while using it.

**Table 3.10: Statements, regarding general feedback, usability and entertainment issues, rated by the users.**

Statements
<b>General Feedback</b>
<b>S1.</b> I liked to use WeBet.
<b>S2.</b> It is easy to learn how to use WeBet.
<b>S3.</b> It is easy to use WeBet.
<b>Usability and Entertainment</b>
<b>S4.</b> The way of interacting (slide and then touch on the screen, without having to look at the device) is appropriate.

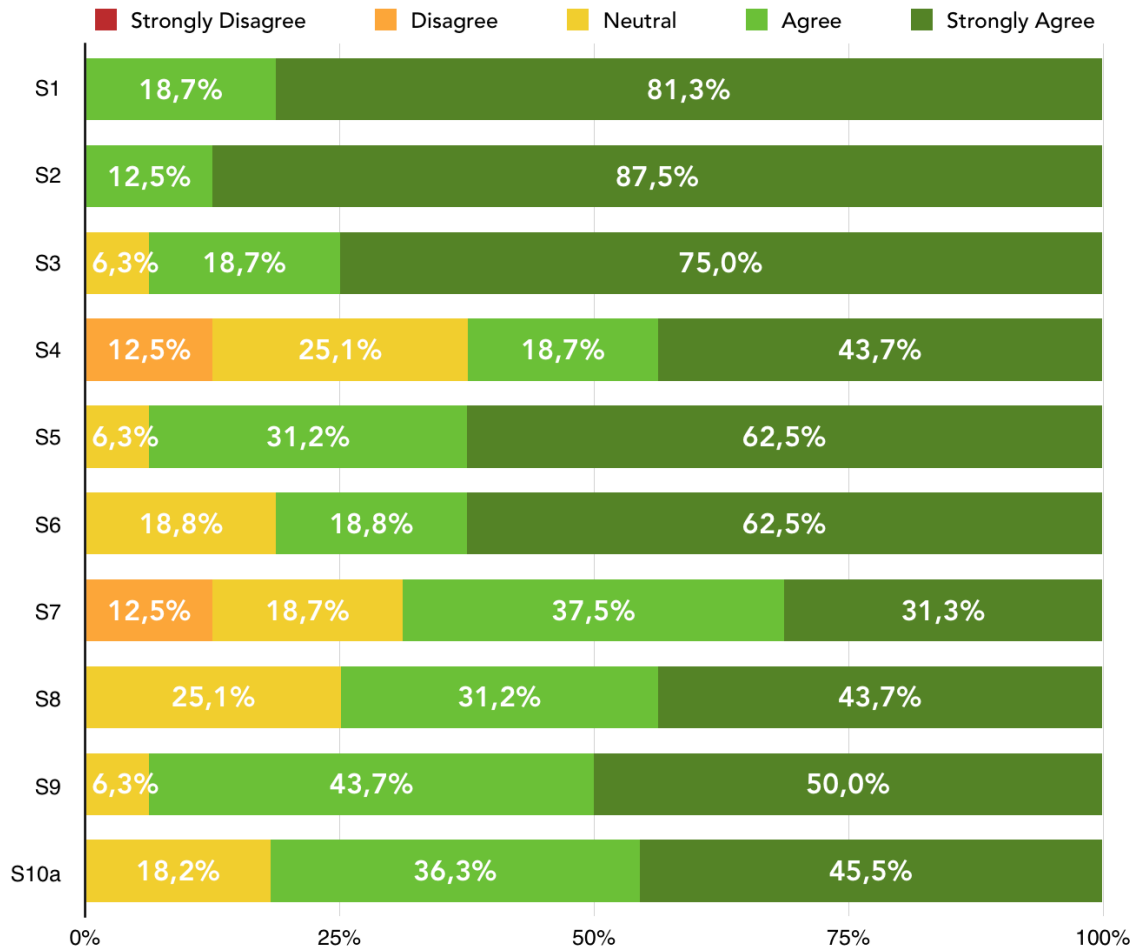
<b>S5.</b> The mobile device vibration helps to understand the state of the application.
<b>S6.</b> The mobile device sound helps to understand the state of the application.
<b>S7.</b> I can execute the betting action without looking at the mobile device.
<b>S8.</b> Watching a football match becomes more interesting using WeBet.
<b>S9.</b> I would use the WeBet concept during a real football match.
<b>S10.</b> If you perform parallel tasks while watching football matches on television, rate the following statement:
<b>S10a.</b> The WeBet concept contributed to be more focused on the match.

## Results and Discussion

Analysis of the results showed that 56% of the participants watch sport events on TV on a weekly basis, while 38% rarely watch it, and 6% do it on a monthly basis.

The feedback regarding the WeBet concept was extremely positive. Almost all participants liked to use WeBet, found it easy to learn, and to use (as depicted in Figure 3.15). However, the results decreased when users rated the statement 4, “The way of interacting (slide and then touch on the screen, without having to look at the device) is appropriate” ( $\bar{x} = 3.93$ ,  $\sigma = 1.03$ ) and statement 7, “I can execute the betting action without looking at the mobile device” ( $\bar{x} = 3.86$ ,  $\sigma = 1.06$ ). Although positive, these results motivated us to conduct a second development stage of WeBet (see the next subchapter), in order to analyse what were the usage patterns and users’ preferences regarding eyes-free interaction mechanisms. When asked if the vibration and sound helped to understand the application state, the answer was very positive, with both types of feedback having similar scores (vibration:  $\bar{x} = 4.56$ ,  $\sigma = 0.63$ ; sound:  $\bar{x} = 4.43$ ,  $\sigma = 0.74$ ).

Regarding the entertainment issues, participants rated “Watching a football match becomes more interesting using WeBet” (statement 8) and “I would use the concept on a real match” (statement 9) very positively, which motivated us to conduct a study in a real environment (Subchapter 3.2.6), where viewers could watch a live broadcast match. Finally, most of the users (69%) who said they usually perform parallel activities while watching a football match, also stated that WeBet contributed to make them more engaged in the match.



**Figure 3.15: Summary of results from general feedback, usability and entertainment issues.**

The analysis of the Microsoft “Product Reaction Cards” [116] question revealed that the most selected word was enthusiastic (75%), followed by fun (69%), pleasant (56%) and addictive and attractive (50% each). These results were very encouraging, as it showed that WeBet helped to further enhance the user experience during dangerous plays, by increasing the tension moments based on the uncertainty of the outcome. This was in-line with our observations, as participants became more expectant towards the end of a play, showing that their levels of concentration and emotion increased. It was also quite frequently for participants to get exalted when they bet a goal was about to happen and then it did not happen, even in a match where participants did not share any emotional connection with the teams (Real Madrid vs LA Galaxy).

Finally, two participants stated that they would be more motivated to play WeBet, if they were competing with others, either online or locally. One participant said that he would like to bet real money, since he often bets during live sports. Some participants (31%) commented that they had difficulties perform-



ing the swipe gesture without looking at the phone, so shortly after these tests, we increased the swiping area at the bottom of the screen to mitigate this problem. Moreover, as suggested by Oakley and Park [129], frequent use may lessen the need to look at the device, resulting in novice users becoming experts, who do not rely on visual glances to interact with it.

### **3.2.5. Interaction Stage**

Motivated by the results from the previous user tests, in the second stage of development we aimed to analyse what were the usage patterns and users' preferences regarding eyes-free interaction mechanisms used to play WeBet. Thus, we conducted a comparative evaluation study of three different interaction methods that allowed users to perform the betting action.

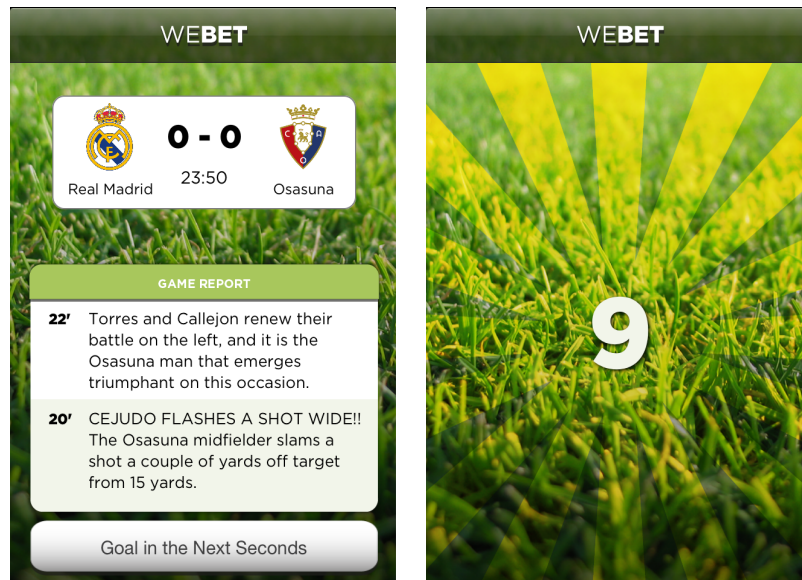
#### **3.2.5.1. Design and Development**

The WeBet version developed for the second stage presented three different interaction methods to predict a goal in the next seconds, during three different pre-recorded football matches. Once users selected an interaction method and a football match on their mobile device, a highlight video of that match was presented on a television through AirPlay (using an Apple TV). Like before, while users were watching the video, the application presented information about the match (time, result and teams), as well as a match report, which kept users engaged during uninteresting periods of the match. Each video footage contained highlights of one match, and users were prompted to bet if each dangerous play could lead to a goal.

We broke down the eyes-free interaction mechanism presented in the first stage - with the corresponding tweaks mentioned in the results section - into two simpler interaction mechanisms, and we compared them with the original one. The first interaction method was called "touching", and it worked as follows:

- 1) Users touched the button at the bottom of the interface (Figure 3.16a).
- 2) Next, the application played a selection sound (lasting 700 ms) and the mobile device vibrated, so the user could acknowledge that the bet was made without the need to further look at the mobile device.
- 3) Then, a 10s countdown appeared on the screen (Figure 3.16b).

- 4) If a goal happened within the 10 seconds, a cheerful sound was played, the mobile device vibrated once and an outcome screen appeared to show how many points the user won. However, if no goal occurred, the mobile device also vibrated once but it played a different sound, and displayed a different outcome screen stating that the user lost 50 points (like in the previous WeBet version).



**Figure 3.16: Touching interaction method: touch a button on the bottom of the screen to place a bet (a) and the countdown screen after placing a bet (b).**

The second interaction method was called “swiping”. Here is a quick walkthrough on how it worked:

- 1) Users started by doing a swiping gesture, from outside to inside the screen, to reveal a new screen that immediately placed a bet once it reached full screen (Figures 3.17a and 3.17b). A quick upwards swipe gesture could also trigger this action. As in the previous method, the selection sound was played and the mobile device vibrated once a bet was made.
- 2) While users were doing the swiping gesture (and had their fingers on the touchscreen) they could perform a downward swiping gesture to cancel the bet, and a downward swipe sound was played accordingly (lasting 400 ms).
- 3) Once a bet was made, the application played a selection sound, the mobile device vibrated, and the 10s countdown started like in the previous interaction method.

- 4) Finally, the outcome screen appeared stating if users won points or not, depending on whether a goal occurred during the 10s countdown.

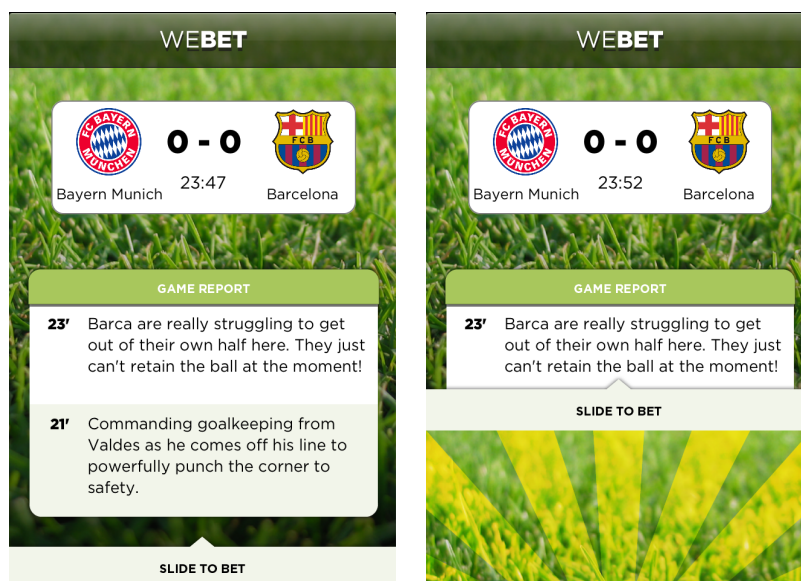


Figure 3.17: Swiping interaction method: upward swiping gesture. The interface with the slide to bet area at the bottom of the screen (a). Performing a swiping gesture (b).

The third interaction mechanism was the one used in the first development stage, and was called “swiping and touching” (Figure 3.18).

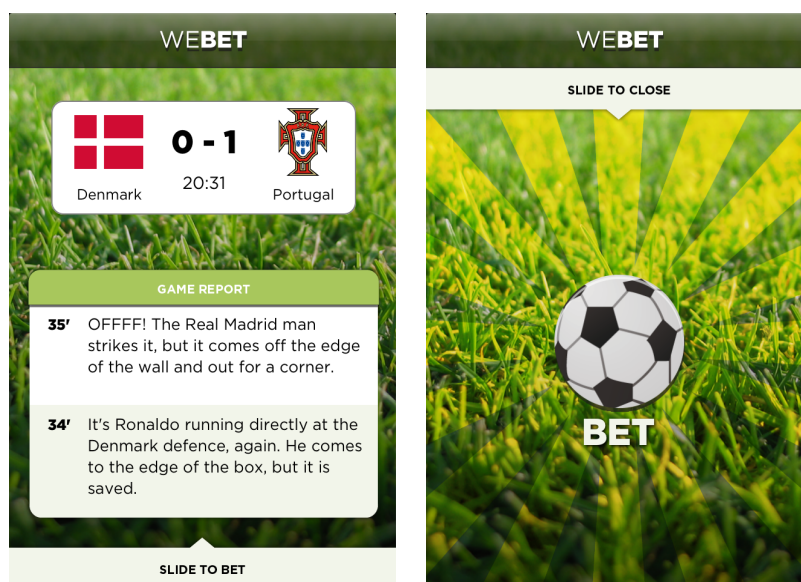


Figure 3.18: “Swiping and touching” interaction method: upward swiping gesture and posterior touch on the screen to place a bet. The interface with the slide to bet area at the bottom of the screen (a). The special bet interface (b).

The goal of the “touching” method was to provide an easy and fast interaction, as users only needed to press a button at the bottom of the screen. We

could not just place a big button in a screen because that would lead to a waste of precious screen estate (besides, that would be error prone). With the “sliding” method, we wanted to present a gesture that would not be triggered inadvertently and would not require constant visual attention. Thus, the use of a sliding gesture that users are familiar with.

### 3.2.5.2. Evaluation

To study the usage patterns and the users’ preferences, we conducted a comparative evaluation study of the three different interaction methods within WeBet. Results allowed us to ascertain which interaction method was the most effective in allowing the users to keep their attention on the broadcast while simultaneously playing WeBet.

#### Participants and Methodology

The user tests were conducted with 18 voluntary participants (13 male and 6 female) aged 13-54 years ( $\bar{x} = 31.78$ ,  $\sigma = 10.03$ ). The tests took place in a room in our department at the University campus. An Apple TV was connected to a television, and users sat in front of the TV screen (Figure 3.19). Users were free to have the iPhone (handed by the researcher) in their hands or on the table, but the majority of them held the iPhone in their hands throughout the test.

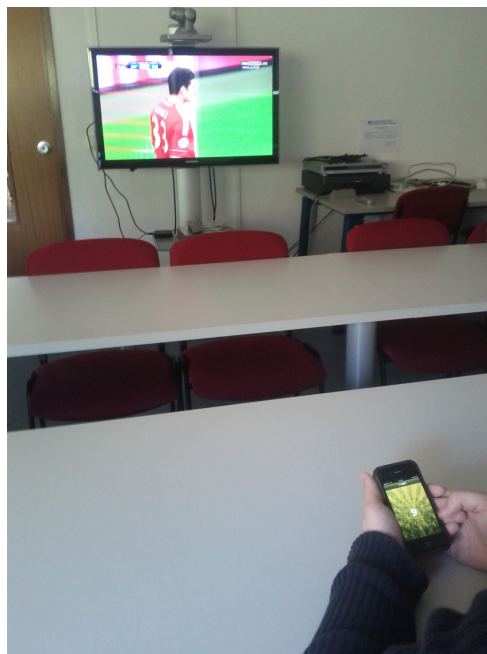


Figure 3.19: Participant interacting with WeBet during the second development stage.

The videos presented were Real Madrid 4 - 2 Osasuna and Bayern Munich 4 - 0 Barcelona (both from 2013), and Denmark 2 - 3 Portugal from 2012. None

of the participants had previously seen the first match, and while some had seen the second and third matches, only two participants remembered some of the footage. Each video was approximately 5 minutes long and had 7 dangerous plays each, or in other words, 7 propitious moments to bet (the start and the end of the match was also shown to contextualize users). Users were not aware of the number of dangerous plays, since the videos were edited to look like typical highlight videos of a match, with the live audio commentary of the match helping to keep the outcome uncertain.

Before watching a video and experiencing the corresponding interaction method, users were explained what they needed to do on the following interaction method. A within-subject experimental design was used to test the three interaction methods and the sequence of interaction techniques was counterbalanced to minimize learning effects. During each test session, the researcher took notes on how users reacted and interacted with the system, and he also counted the moments when users looked at the mobile device with the intention to place a bet. At the end of each test session, users were asked to answer a questionnaire to evaluate the three interaction methods.

### Questionnaire

The questionnaire started by asking users' age and gender. Next, users were asked to rate a set of five statements (Table 3.11) per each one of the three interaction methods, using a five-point Likert-type scale, which ranged from strongly disagree (1) to strongly agree (5). Then, users were asked what interaction method they thought was the most appropriate, taking into account the visual attention given to the broadcasted match and the fact of not betting inadvertently. Users ordered the interaction methods by preference order (1st, 2nd, 3rd), and justify their first option from a set of six possibilities: easier, faster, more reliable, less visual attention required, less tiresome or less frustrating. Users could choose more than one option. Finally, users could express any further suggestions and comments.

**Table 3.11: Statements rated by users regarding each interaction method.**

Statements
S1. I have executed the betting action when I intended to.
S2. I did not lose any detail of the match during a dangerous play.
S3. I would like to use this kind of interaction during a complete match.
S4. I managed to bet without looking at the iPhone.
S5. Betting does not interfere with the visualization of the match.

## Results and Discussion

We performed ANOVA tests in order to compare the results gathered from the three interaction methods used. The analysis of the results (Table 3.12) showed that no significant differences were found between the methods with the exception of statement 4. The p-value in this case was below 0.01. The Tukey test (Table 3.13) showed that there were significant statistical differences between both the “sliding and touching” and sliding interactions, and touching interaction. Figure 3.20 shows the box plots of the scores given to the different interaction methods in statement 4. As we can see, both the swiping and the “swiping and touching” interaction methods had higher scores than the touching method.

**Table 3.12: Summary of the statements results. Higher scores are highlighted.**

Statement	Interaction Method	$\bar{x}$	$\sigma$	$\tilde{x}$
S1	Touching	3.83	1.248	4
	Swiping	3.77	1.30	4
	“Swiping and Touching”	4.22	0.94	4.5
S2	Touching	3.88	1.27	4
	Swiping	3.88	1.02	4
	“Swiping and Touching”	4.05	1.05	4
S3	Touching	2.88	1.37	3
	Swiping	3.88	1.23	4
	“Swiping and Touching”	3.61	1.34	4
S4	Touching	2.88	1.11	3
	Swiping	3.83	1.04	4
	“Swiping and Touching”	4.00	0.84	4
S5	Touching	2.94	1.30	3
	Swiping	3.88	1.15	4
	“Swiping and Touching”	3.77	1.16	4

Table 3.13: Tukey Test Table for statement 4 between the three methods.

Method	diff	lwr	upr	p adj
Swiping / Touching	0.94	0.13	1.76	0.02
“Swiping and Touching” / Touching	1.11	0.30	1.93	0.01
“Swiping and Touching” / Swiping	0.17	-0.65	0.98	0.87

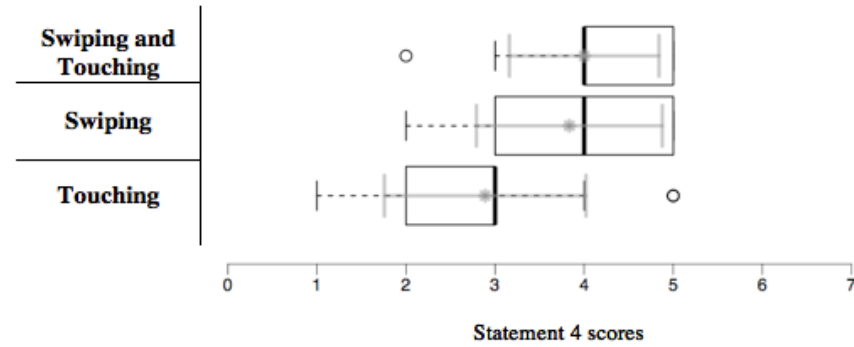


Figure 3.20: Box plots of the three interaction methods for statement 4. Mean and standard deviation added in grey.

We can also observe that despite not finding significant statistical differences in statement 5, the swiping, and “swiping and touching” interactions obtained higher results than touching. The Tukey test for statement 5 in Table 3.14 and the Figure 3.21 confirm this result.

Table 3.14: Tukey Test Table for statement 5 between the three methods.

Method	diff	lwr	upr	p adj
Swiping / Touching	0.89	-0.08	1.86	0.08
“Swiping and Touching” / Touching	0.83	-0.14	1.81	0.11
“Swiping and Touching” / Swiping	-0.06	-1.03	0.92	0.99

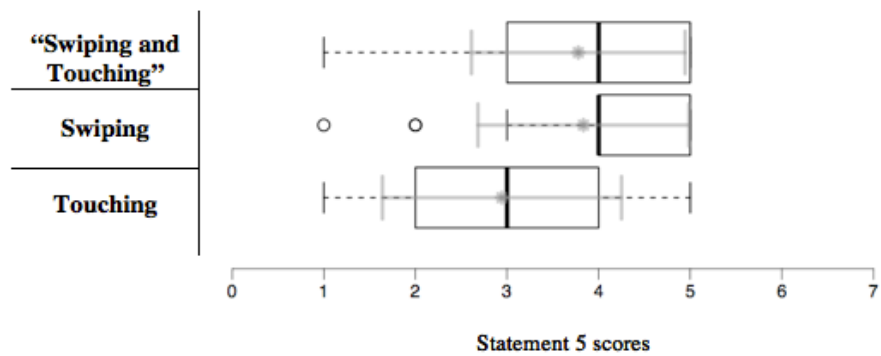


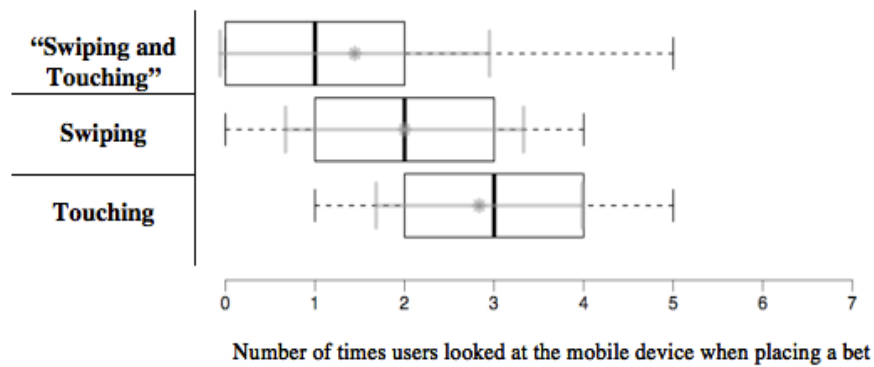
Figure 3.21: Box plots of the three interaction methods for statement 5. Mean and standard deviation added in grey.



Another ANOVA test was performed in order to compare the visual attention pattern given to the mobile device while using each one of the three interaction methods. This test showed significant statistical differences between the methods. The Tukey test indicated that there were differences between the “swiping and touching” method, and the touching method (Table 3.15). Figure 3.23 confirmed these differences between the aforesaid methods in favour of the “swiping and touching” method.

**Table 3.15: Tukey Test Table for comparing the visual attention given to the mobile device between the three methods.**

Method	diff	lwr	upr	p adj
Swiping / Touching	-0.83	-1.91	0.24	0.16
“Swiping and Touching” / Touching	-1.39	-2.46	-0.31	0.01
“Swiping and Touching” / Swiping	-0.56	-1.63	0.52	0.43



**Figure 3.22: Box plots of the three interaction methods for the visual attention pattern. Mean and standard deviation added in grey.**

When asked about the interaction methods’ preferences, 50% of the users preferred the “swiping and touching” method, 28% preferred the swiping method and 23% preferred the touching method. Users who preferred the touching and the swiping methods highlighted that they were easier to perform (50% and 40% respectively), faster (50% and 40% respectively) and required less visual attention (75% and 60% respectively). Users who preferred the “swiping and touching” method did it so because it was more reliable (89%) while also requiring less visual attention (56%). These results were inline with our observations as we noted that users tended to look less to the mobile device to place a bet while using the swiping and “swiping and touching” methods.

Finally, participants made suggestions and recommendations to improve the application, such as increasing the bet countdown timer to give more time to analyse a dangerous play and to bet safely, i.e. so users do not feel rushed to



interact (which we did, by increasing it from 10s to 20s). On the other hand, other users said that the vibration during the “swiping and touching” method distracted them, and thus they preferred the swiping gesture. Other users said that they preferred the “swiping and touching” method, because they could bring the special bet interface before a play becomes really dangerous and then when they felt that a goal could happen, they just needed to touch anywhere on the screen to bet. This was consistent with our observations.

As a final remark, we concluded from both the questionnaire results and our observations, that the “swiping and touching” and the “swiping methods were better than the touching interaction method. The analysis of the questionnaire showed no significant differences between “swiping and touching” and swiping methods, so that the major factor of the difference in interaction method is swiping. The analysis of the users’ preferences verified these results, but also showed that participants preferred “swiping and touching” method over both the swiping or the touching methods. Thus, we felt that the “swiping and touching” method was the one that best satisfied our goals of creating a method that would not divert users from a TV broadcast.

### **3.2.6. Real Setting Stage**

After ascertaining which was the preferred interaction method to conduct future studies, we decided that it was time to deploy the WeBet concept in a real life environment. Within the scope of our close cooperation with Viva Ronaldo [78], we were able to introduce a new feature known as the Goal In The Next Seconds feature (or GITNS) based on the WeBet concept, allowing Viva Ronaldo users to guess if a goal is about to happen in the next seconds during a live match. The study that we conducted allowed us to collect invaluable information regarding the challenges involved in deploying real-time second screen interactions during live broadcasted events.

#### **3.2.6.1. Design and Development**

In the third development stage, we wanted to move away from the lab into the real world to collect real users’ feedback regarding their experience while using such an application, as well as to analyse their levels of entertainment and the real impact of using second screen applications on their experience of watching a broadcasted sports event. So, we needed to test the WeBet concept during real live events, and the Viva Ronaldo application was a perfect way to do it. This application allows users to perform several activities, such as sending virtual gifts to Ronaldo, or answering quizzes about his career, to move up

in the rankings and win prizes, and even get feedback from Ronaldo himself. Some of these activities can be performed whenever the users wish to, but some others can only take place during live match broadcasts. The Viva Ronaldo application uses Real Time Application Servers for live matches. It provides a WebSocket API for the client applications so that users can receive real time events (e.g. goals or corner kicks). From a user experience perspective, this means that all events happen without the need of user interaction. For instance, when a penalty kick happens during a match, a screen appears on the mobile application asking what users think is going to happen (Figure 3.23a), regardless of which application screen the user is in. Users have some time to answer before the bets are closed, and the outcome is presented shortly after (Figure 3.23b). Users get points if their predictions are right, as well as when they correctly answer trivia questions and polls about what is going to happen along the broadcasted matches (e.g. “Will Cristiano score before the end of the game?”). All these events are triggered by an application, operated by a Viva Ronaldo staff member watching the match live, and synchronised with the client applications. Due to iOS limitations users can only receive all match events when the application is running on the foreground. Thus, Viva Ronaldo application is forced to stay active for the duration of the live matches to prevent users from having to unlock the mobile device after a period of user inactivity.

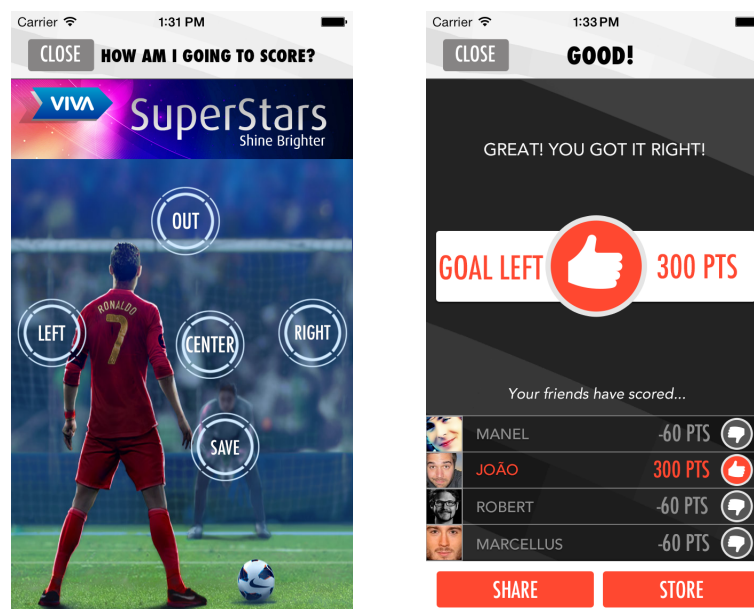


Figure 3.23: A match event prompting users to answer what they think will happen during the coming penalty kick (a) and the corresponding outcome (b).

When a match starts, users hear a whistle signalling the kick-off. From that moment on, users can check the match time and follow a game report while waiting for match events to happen. Users can navigate throughout the applica-

tion, either chatting with their friends, checking the global rankings of the match or how they stand with their friends on the Friends Ranking. From our analysis, this seeks to explore extrinsic and intrinsic motivators. Users that want to win prizes, are motivated by the Global Ranking, where they compete with all the online fans (hence the extrinsic motivators). Users that want to compete just with their own friends, only for the simple satisfaction of beating them, end up interested in the Friend Ranking (thus the intrinsic motivators).

Finally, at both half time and full time a whistle is heard and the match timer stops. When the match ends, the final rankings are calculated.

### **Interaction Method**

The interaction method used in the GITNS feature is very similar to the “sliding and touching” method from the previous development stage, although some changes were made to fit Viva Ronaldo’s design. Users can only bet on goals from Ronaldo’s team, be it Real Madrid or Portugal, since that is the team they support. Once a match starts, the special bet interface appears at the bottom of the screen on any of the main application screens (Figure 3.20a). While the special bet interface is at the bottom of the screen, the overlaid text switches between “Slide to guess a Team CR (Cristiano Ronaldo) goal...” and “will happen in the next seconds” (3 seconds) to get the user’s attention. The special bet interface automatically disappears at the end of each half.

Next, we present an interaction walkthrough with the special bet interface during a live match.

- 1) While holding the device, users can perform a bottom-up gesture from outside to inside the screen. This allows users to start pulling the special bet interface up as their fingers enter the bottom of the screen, with no need to look at the device (Figure 3.24a). A quick upwards swipe gesture makes the special bet interface go full screen immediately (Figure 3.24b).
- 2) As soon as the special interface is at full screen, an upward sound is played (lasting 500 milliseconds) and the mobile device starts vibrating repeatedly every 400 milliseconds. This informs users that they can now bet that a goal is about to happen, by touching on the middle area of the mobile phone screen (as shown on Figure 3.24b), with no need to look at it.
- 3) To close the special interface (without betting), and return to the application screen (Figure 3.24a), users just need to do a down-

ward swipe gesture anywhere on the screen, and a downward swipe sound is played accordingly (lasting 400 milliseconds). At this point, the mobile device stops vibrating and no bet is made.

- 4) When a bet is placed, the mobile device stops vibrating, the selection sound is played, a 20-second countdown appears, and a heartbeat sound is played to help creating a tension moment. Once in this state, the special interface completely covers the whole screen (navigation bar on the top of the screen included) and users cannot close it while the countdown is running down.
- 5) In order to further increase the users' emotional levels during a dangerous play, there is a bonus stage. This means that if users already bet that a goal is about to happen (and the 20-second countdown is running down), they can touch anywhere on the screen to get a percentage bonus (usually 25%). This action requires users to spend a CR (the Viva Ronaldo in-game currency).
- 6) Finally, an outcome screen appears stating whether the user won points or not, depending on whether there was a goal during the 20-second countdown. Moreover, a cheerful or disappointment sound is played accordingly to the outcome (if there was a goal during the 20-seconds or not) and the mobile device vibrates once to get the users' attention.

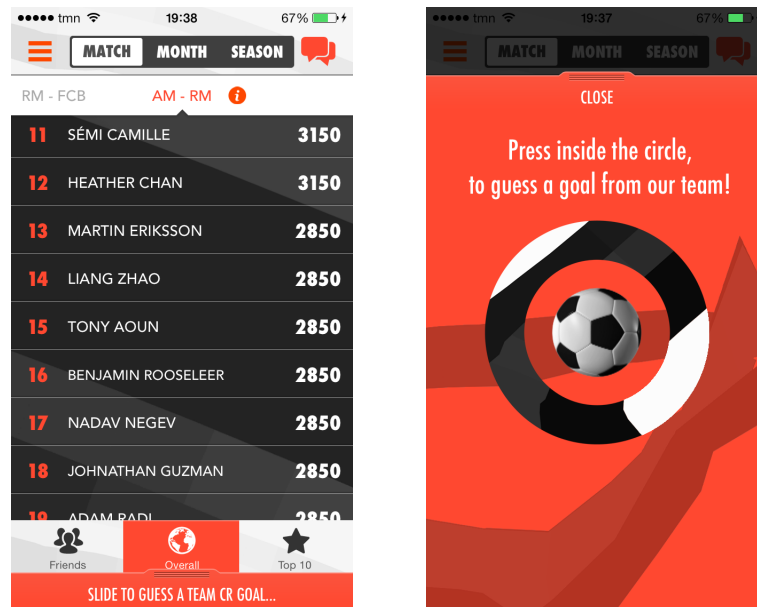
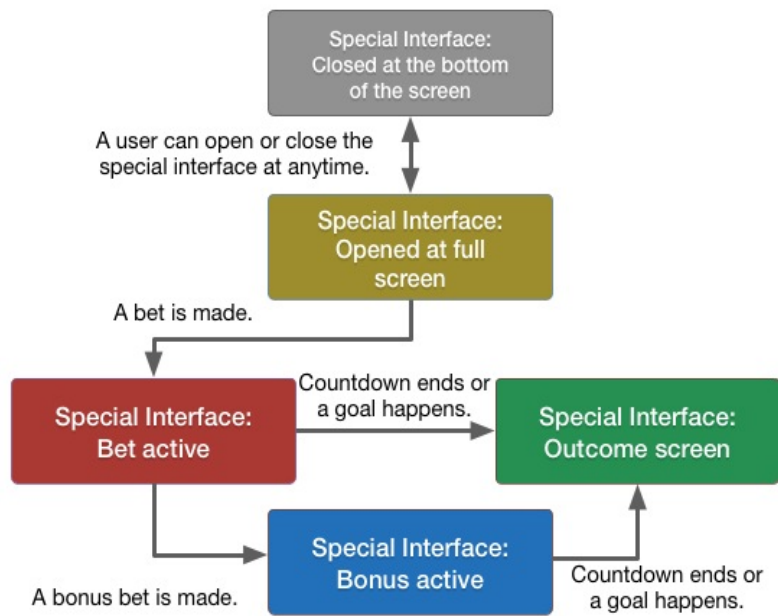


Figure 3.24: The eyes-free interaction mechanism on Viva Ronaldo: doing a swiping upward gesture (a) displays the special bet interface (b).

Figure 3.25 gives an overview of the interaction walkthrough.

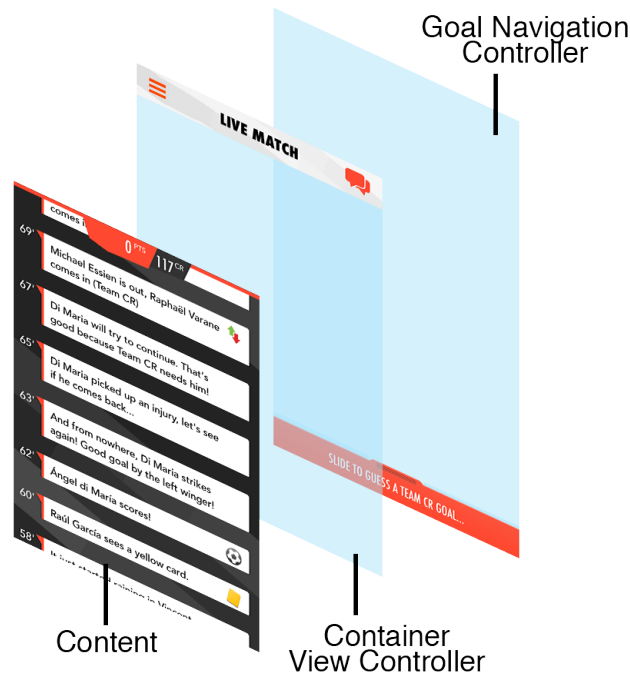


**Figure 3.25: Interaction states overview.**

Developing the GITNS feature on Viva Ronaldo was not a straightforward task. Mainly due to the challenges that we needed to overcome, and considerations we needed to take, when deploying this feature on a real life environment. These issues cover three different areas: interface design, communication and TV broadcast delays, and gameplay discussion.

### Interface Design

From early on in the design phase, we knew that it was crucial to have access to the special bet interface on all the Viva Ronaldo application main screens. This meant that users should not have to worry about being “stuck” at the only one screen that allowed them to use the GITNS feature. Otherwise they would not freely navigate through the Viva Ronaldo application during a match, since they would be afraid of losing the chance to bet if a dangerous play suddenly happens. To accomplish this in a seamlessly and effortless way, we encapsulated each main application screen on a controller, known as “Goal Navigation Controller” (GNC). Each application screen is a container view controller that manages the navigation of hierarchical content. The GNC is also a container view controller, making it easy to be extensible in the future with other controllers on the stack, if necessary. Figure 3.26 depicts this process.



**Figure 3.26: Process to encapsulate the GITNS feature on any given screen.**

Another important issue that we took into account was one of the new features on iOS 7: the Control Center. The Control Center allows users to toggle on and off settings on the mobile device, by swiping up from the bottom of the screen, which is exactly the same action that users perform when using the GITNS feature. This fact presented a problem: users would frequently access the Control Center instead of the GITNS feature. Therefore, we present a pop-up the first time the user enters the Viva Ronaldo application during a live match, asking users to turn off the access to the Control Center, and informing them how to do it. This may not be the ideal solution for this problem, but as the iOS stands, we think it is the best solution at the moment.

Finally, as mentioned before, instead of allowing users to click anywhere on the special interface to place a bet, we only allow users to click on the middle area of the screen (which is still a significant area). This was changed after some reports of users who stated that they bet inadvertently, while trying to close the special bet interface by swiping down on the handle (top of the full bet interface screen). This happened because the device could mistakenly identify the first touch on the screen to perform a swipe down gesture, as a touch to bet. After some informal tests, users stated they felt comfortable by just using the middle area of the screen to place a bet, and therefore we decided to restrict the clickable area (Figure 3.27). This was consistent with the analysis of the area reached by the thumb when holding the phone with one hand, presented by Hooper

[135]. In the end and accordingly to the previously informal tests, this change did not have a negative impact when placing a bet without having to look at the phone, and eased the detection of the cancel action. However, we did not make this change to the bonus stage since users cannot close the special interface during it. That is why users can touch anywhere on the screen to get bonus points.

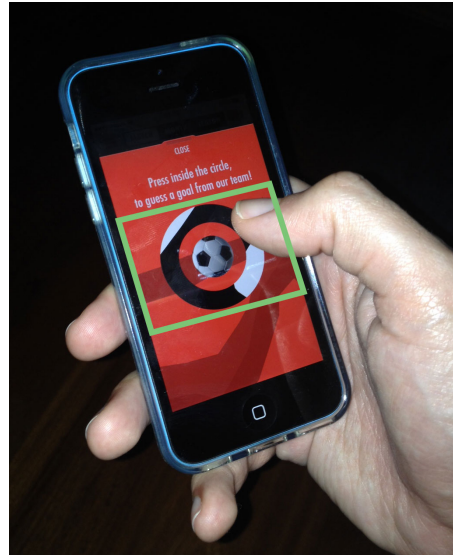


Figure 3.27: Clickable area to place a bet. Users can easily touch it using their thumb, while holding the phone with one hand and without looking at the screen.

### Communication and TV Broadcast Delays

As in any network-based application, the communication between the Viva Ronaldo application and server can sometimes suffer delays. Moreover, different TV service providers can have different broadcast delays during a live match, making it difficult to have the broadcasted match perfectly synchronized in the whole world (this is further discussed at the end of the next section). Therefore, we decided to introduce two tweaks to improve the user experience. First, users who bet shortly after the goal (within a 2-second interval) will still get a few points (50), so that they can be pleased for apparently getting the goal right (while in reality they did not, due to the broadcast delays). The second tweak consists on a message that appears to users when a bet was made some seconds after a goal (within a 2 to 5-second interval). The message states “You almost made it! You were just a bit behind the actual moment of the goal...”, while a disappointment sound is played and the mobile device vibrates once to get the user’s attention. Users do not win any points, but understand the reason and do not feel frustrated. Figure 3.28 depicts the different bets’ outcomes according to the moment they are made in relation with the timestamp of the goal (the real time of the goal), along the match timeline.  $T_{SG}$  stands for the



timestamp of the goal. If there is a bet within the 20 seconds that precede it, the bet is correct (green area), otherwise if it is done 2 seconds after the goal, just a few points are given (blue area). If a bet is made on the following 3 seconds, a message appears stating that the user almost got the goal right (yellow area). Finally, if users make a bet on any other situation, a message states that there was no goal during that interval (red area).

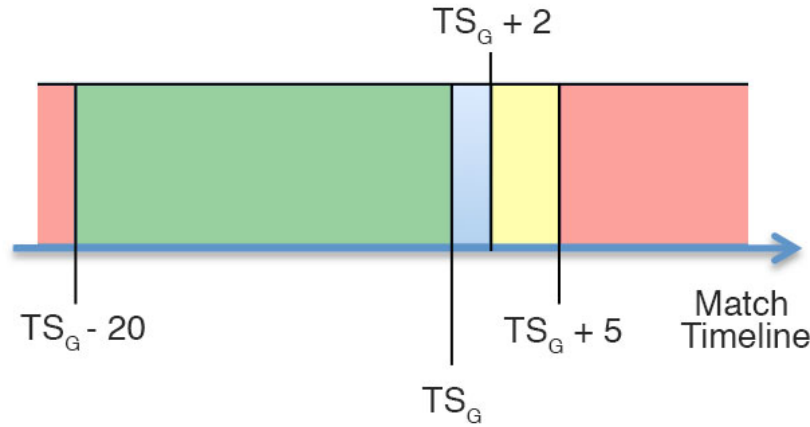


Figure 3.28: Match timeline showing the different outcomes according to the moment of the bet in relation with the timestamp of the goal.

### Gameplay Discussion

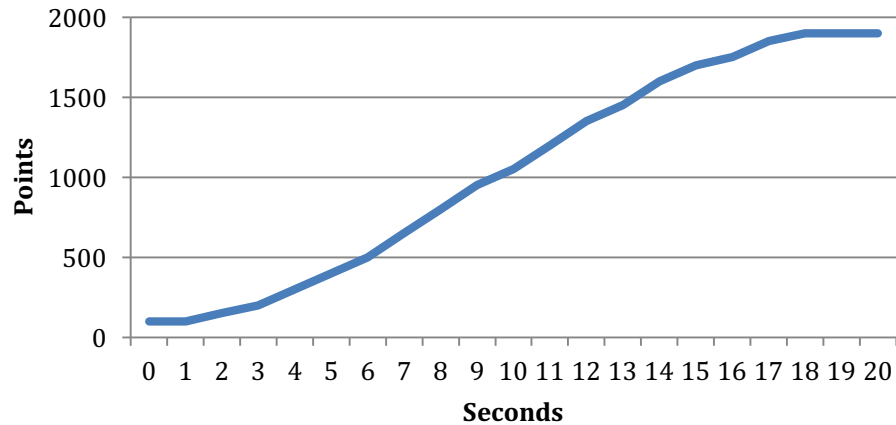
The GITNS feature rewards users for knowing their team. When knowledgeable users watch certain collective plays or individual players' movements, they know that a goal may be imminent, so it is a good time to use the GITNS. If users bet that a goal will happen and it effectively does within the 20-second countdown, the corresponding points will be determined by the following formula, where  $x$  represents the number of seconds between the bet and the goal:

$$\left\lceil \frac{-0.017 * x^3 + 0.48 * x^2 + 0.2 * x + 1}{1.67} \right\rceil * 50 + 100$$

The goal of this formula is to produce values between 100 and 2000 points (Figure 3.29), making the GITNS feature a good bonus point factor on Viva Ronaldo. The idea behind the formula was to award points in-line with the rest of the score system of Viva Ronaldo, where 100 points is usually the minimum number of points that users can get on the other available features (e.g. betting the outcome of a match correctly), while 2000 points are sufficient to turn the tide of a match's ranking at anytime. With this formula we wanted to award few points when users guess a goal right before it was about to happen (points increase slowly when  $x < 4$ ) and benefit users who know their favourite team well enough to risk guessing a goal within a significant anticipation (points in-



crease quickly when  $4 < x < 14$ ). Moreover, we wanted to avoid benefiting pure luck bets made on some cases (points increase slowly when  $x > 14$ ). This is why we did not opt for a linear formula. If the player used a CR to get bonus points, this score is further multiplied by a variable bonus factor (1.25 on most matches).



**Figure 3.29: Points rewarded when using the GITNS feature according to the number of seconds between a bet and the goal.**

While the 20-second countdown is running out, users can see the number of points that they might win if the goal happens on the current moment (points are increased each 100 milliseconds). The idea is to get users excited by watching the points increasing as the countdown runs out. This is seen as an extra feature since it takes users' attention away from the match, so using it is at users' discretion. However, as we saw before, communication and TV broadcast delays can play a role on the user's perception of the match. Users might think that they will get a bet right 7-seconds before the goal, but in reality it may be just 4 or 5 seconds before it. Thus, we present to the users only 40% of the points that they might win (this value corresponds to the goal validation time by the operator plus the average real time communication delay that we observed while we were implementing GITNS in Viva Ronaldo). Once the outcome of the bet is presented, users will receive the number of points they expected, or even slightly higher, which will be positive for the user experience.

Finally, if a goal does not happen during the 20-second countdown, users will lose 50 points, in order to discourage indiscriminate use, like in WeBet. As in every game, balancing the scoring system is an on-going process that often depends on how the players are performing in the game. The GITNS feature is no exception, as we carefully monitored several matches to adjust the formula to prevent cheating and to provide a good user experience.

### 3.2.6.2. Evaluation

To gather the users' feedback regarding the use of the GITNS feature and the corresponding interaction method, a user evaluation study was conducted. This study also allowed collecting important information regarding the challenges involved in deploying a real-time interaction during a live broadcast event.

#### Participants and Methodology

The 51 participants (22 male and 29 were female) of the user tests were aged 14-44 years ( $\bar{x} = 22.23$ ,  $\sigma = 6.67$ ). We were already expecting a high number of female participants, since there are many female fans of Cristiano Ronaldo who use Viva Ronaldo. The participants resided in sixteen different countries, such as United States, Colombia, Iraq, France, and Norway, with the majority residing in Europe (66%).

At the time of the evaluation tests, only the iOS version of Viva Ronaldo was available. Today, Viva Ronaldo can be downloaded both for iOS and Android from the corresponding App Stores. To participate on a live match, users just needed to open their application when a real match was taking place. Users were never instructed regarding the GITNS eyes-free interaction mechanism. We wanted users to notice by themselves that they did not need to shift their attention from the TV broadcast to the mobile device to make their bets. Also, our goal was to test the GITNS feature and interaction method with real fans using the application on a real life environment, without any artificial constraints (such as using mobile eye trackers or within a controlled environment), which could result on a non-real, disrupted experience.

Participants were Viva Ronaldo application users who were free to use the GITNS feature for several months before the user study was conducted. The 150 users with the top match scores during the month prior to the study were selected to answer a questionnaire, since they should be expert fans used to interact with the GITNS feature. The goal of this questionnaire was to evaluate the GITNS feature and the corresponding interaction method. During the month prior to testing, there were 10 matches, where Cristiano's team scored 22 goals. Our data shows that during these 10 matches there were 9875 bets that a goal was about to happen.

Users did not know that they would be asked to answer a questionnaire, in order not to influence their use of the GITNS feature during the matches preceding the questionnaire. The questionnaires were sent by e-mail. From the 150

e-mails sent, 18 could not be delivered. From the remaining 132 e-mails, 51 users answered the questionnaire over the period of one week, after which the questionnaire was disabled. There was not any relation between the users that answered the questionnaire and their performance when using the GITNS feature. We asked users to answer the questionnaire only if they had used the GITNS feature at least once.

### Questionnaire

The first part of the questionnaire gathered users' personal data, such as age, gender, and how often do they watch sports on television. Next, users were asked how many live matches they had already participated on Viva Ronaldo. They could choose "a lot" (20 or more matches), "some" (10 or more matches), "a few" (5 or more matches) or "just started using it" (less than 5 matches). Then, the questionnaire focused on usability and user experience issues, including general feedback about the GITNS feature, its usability and ease of use, users' entertainment and emotional involvement, and suggestions and comments. The questions related with the general feedback, and usability issues were based on the USE questionnaire. Users were asked to rate statements, using a five-point Likert-type scale, which ranged from strongly disagree to strongly agree. These statements (presented in Table 3.16) focused on the GITNS interaction method and the overall experience that users have while using the GITNS feature.

Users were also asked to select the words that best describe their experience while using the GITNS feature, through a question based on the Microsoft "Product Reaction Cards" [116]. Finally, users could express any further suggestions and comments.

**Table 3.16: Statements, regarding general feedback, usability and entertainment issues, rated by the users.**

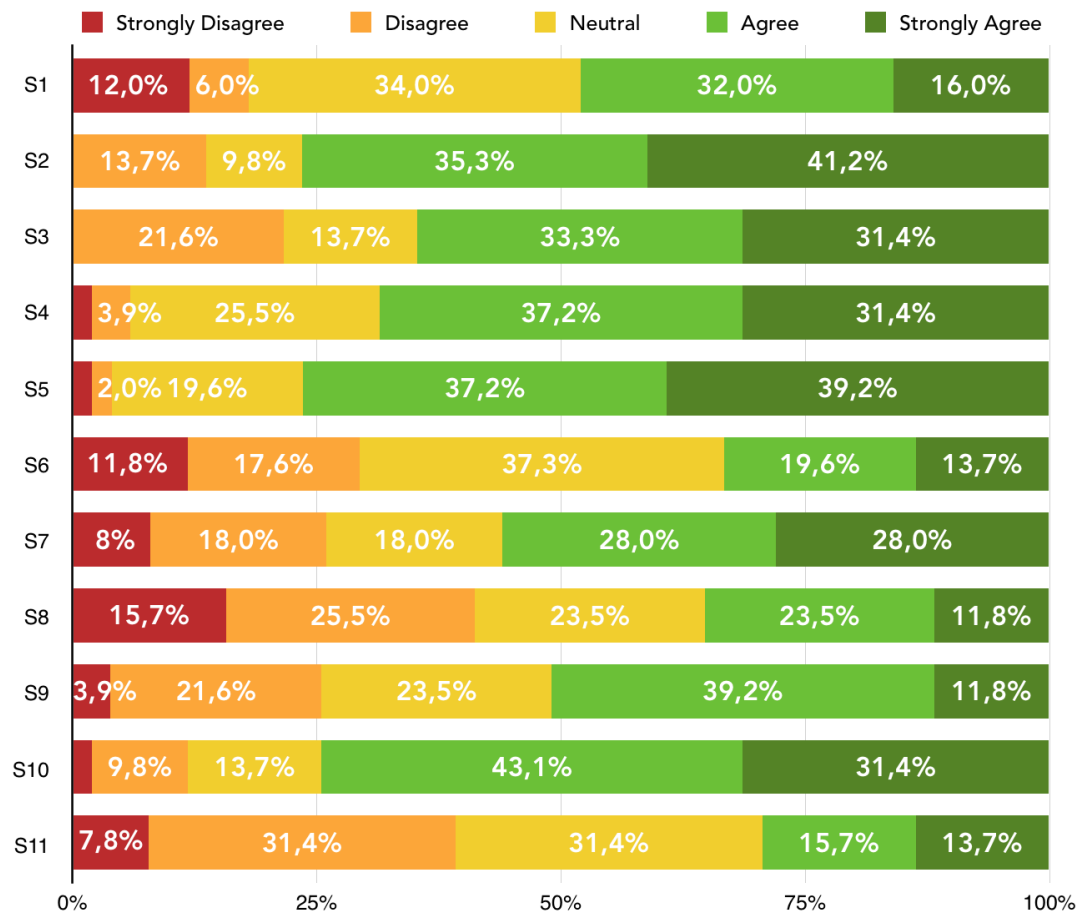
Statements
<b>General Feedback</b>
S1. I like to use this feature.
S2. It is easy to learn how to use this feature.
S3. It is easy to use this feature.
<b>Usability and Entertainment</b>
S4. Vibration helps me to interact without looking at the phone.
S5. Sound helps me to interact without looking at the phone.
S6. I can execute the betting action (guess a goal) without looking at the phone.
S7. The match gets more exciting when using this feature.

<b>S8.</b> This feature distracts me from the action on the match.
<b>S9.</b> I usually pull the special bet interface before a play becomes really dangerous.
<b>S10.</b> It is very exciting to guess a goal on the application.
<b>S11.</b> I only use the feature when the ball is entering the net or even after that.

## Results and Discussion

Regarding the users' habits while watching sports on television, results showed that almost every participant watches a sport event on TV at least once a week (98%). Only one participant answered that he watched live sports on a monthly basis. When asked how many live matches users had participated on Viva Ronaldo, 7.8% answered less than 5 matches, 3.9% between 5 and 10 matches (3.9%), 15.7% between 10 and 20 matches (15.7%), and 72.6% answered more than 20 matches. As the results show, most of the users regularly watch sport events on TV and use Viva Ronaldo application during live matches TV broadcasts. Hence, the majority of the feedback gathered from the questionnaire comes from people who like sports and are experienced using Viva Ronaldo.

As shown in Figure 3.30, most participants were either neutral or agreed with the statement 1. While there were a lot more participants liking to use the GITNS feature (32% agreed with the statement, while 16% strongly agreed) than disliking it (6% disagree, while 12% strongly disagree), we were surprised to see that 34% had neutral feelings about using this feature. As some users reported at the end of the questionnaire, while they do enjoy using the GITNS feature and guessing that a goal is about to happen, they sometimes had disrupted experiences due to the TV broadcasts delays, as we explain ahead. Regarding the following two statements (2 and 3), participants agreed that it is easy to learn how to use the GITNS feature (35.3% agreed and 41.2% strongly agreed) and that it is easy to use (33.3% agreed, while 31.4% strongly agreed). Based on these results, and on the fact that we did not give any instructions on how to guess a goal in the next seconds, we are keen to conclude that a feature based on this interaction mechanism is simple and intuitive to use.



**Figure 3.30: Summary of results from general feedback, usability and entertainment issues.**

Participants stated that both vibration and sound helped them to interact without looking at the phone (37.2% agreed and 31.4% strongly agreed with statement 4, while 37.2% agreed and 39.2% strongly agreed with statement 5). As a conclusion, we think that similar interaction methods that rely on the use of a touch-based device while looking at the TV screen during key moments, should take vibration and sound into account. In particular, well-identified sounds should be used in order to help users to differentiate sounds coming from the mobile device from the ones coming from the broadcasted event. For example, in our case, we used sounds that resembled user's actions (i.e. a selection sound is played when the user enters a bet, a swipe upwards and downwards are played when the user accesses and dismisses the special betting interface), which are very easy to distinguish from the sounds usually coming from a TV broadcast. This provides users with an extra level of perception that helps them to interact without looking at the screen, balancing the lack of tactile feedback on these devices. Statement 6 aimed at understanding whether users could execute the betting action without looking at the phone. Strangely, the

results were not in line with the positive feedback from the two previous statements. Results show a mixed feedback regarding this statement, with 37.3% of users being neutral about it, and a similar percentage of users having negative and positive feelings about it. We believe that some of the reasons that might explain these results are:

- 1) The lack of instructions explaining users that the tactile feedback of the Home button can give them the perception of where their thumbs are when holding the mobile phone. That way users would learn that they could easily perform a swiping upward gesture when they feel the Home button.
- 2) Despite the complementary audio and vibration feedback, users like to have a quick visual confirmation of their actions.
- 3) Users simply never thought of using the interaction mechanism without looking at the mobile phone. Hence the neutral results.

Whatever the reason may be, we think that these results can be improved by adding a small demonstration both for novice and expert users, showing that it is possible to execute the betting action without looking at the phone, by relying on the tactile feedback of the Home button.

The following statements focused on the concept and the user experience while using the GITNS feature. Regarding statement 7, the majority of the users stated that the matches become more exciting when using the GITNS feature (both 28% agreed and strongly agreed). We feel that this is a clear sign that factors like eustress/drama explored by the WeBet concept, are increased through the GITNS feature usage. Also, it contributes to increase users' engagement and entertainment. Next, users had mixed feelings about statement 8: "this feature distracts me from the action on the match". While the majority disagreed with this statement, 23.5% were neutral and 23.5% agreed with it. We think that this outcome may be related with the results of statement 6, as discussed before. Those users that look at the mobile device to place their bets will feel more distracted from the live match. Results from statement 8 may also happen because users are so focused on obtaining a high score while using the GITNS feature, that they tend to pay more attention to this game feature. Statement 9 shows that many users usually pull up the special bet interface before a play becomes really dangerous (39.2% agreed, while 23.5% were neutral) so as to allow for a quicker bet in case that the play becomes effectively dangerous. However, there were still some users who did not have this habit, but we believe that the addition of a small gameplay tip may improve these results. Next, users stated that

they become very excited when they correctly guess a goal (43.1% agreed and 31.4% strongly agreed). Besides the thrill of their team scoring a goal, users become smug since they “saw” it happening beforehand. The points obtained also play a role, since users get motivated to climb up the rankings, beating other players and their friends, as it happens on any competition. Finally, the majority of users stated that they do not tend to use the GITNS feature when the ball is about to enter the net or even after that (31.4% disagree with statement 11, while 31.4% were neutral about it). This is exactly what we aimed at with our scoring system, since there is no challenge in guessing a goal on these cases.

The analysis of the question based on the “Product Reaction Cards” [116] showed mix results. The most selected word was fun (52.9%), followed by frustrating (43.1%), stressful (37.3%), simple (29.4%), pleasant (27.5%), and enthusiastic (25.5%). We were very surprised to see both positive and negative emotions as top selections. Furthermore, when we analysed some of the questionnaires in detail, we noticed that there were users who simultaneously selected words like “fun” and “stressful” or “frustrating”. After reading their comments and suggestions we discovered that although users enjoyed using the GITNS feature, they sometimes got frustrated or stressed because the match on TV was delayed relative to the real match and consequently to the match on the Viva Ronaldo application. That delay makes users think that their bets were correct when they see the goal happening on TV. But then they get no points, because the goal had already happened before they made their goal bets, and also before they saw it on TV.

Lastly, we analysed the comments and suggestions given by the participants. Twenty-four of the fifty-one participants expressed their opinion mainly regarding two areas: the scoring system and the TV broadcast delay. Regarding the scoring system, some users felt there were too many points being given when guessing a goal, which could be unfair for a wild guess. Others thought the contrary: they liked to get many points, because it gave them a chance to get to top ranks when a goal happened. We particularly like the idea of giving a boost to users when guessing a goal some time before it really happens. It makes users eager to see a goal happening, and that is the pinnacle of a football match. Also related with the score system is the TV broadcast delay. As mentioned before there were some users saying it was hard to guess a goal due to the difference of the match times between their TV broadcasts and the match on the Viva Ronaldo application. The Viva Ronaldo platform considers the real timestamp of the goals (the time when the goal really happened at the stadium) in order to prevent cheating (users predicting a goal that has already hap-

pened). However, this approach also has its disadvantages, as users who have a TV service provider with a high broadcast delay cannot guess a goal efficiently. As we will see in Subchapter 3.4, we developed a synchronisation mechanism that helps users to synchronise their second screen applications while preventing cheating during a gaming competition.

### **3.2.7. Conclusions**

Results from the evaluation tests have shown us that the WeBet concept works, even during a real life environment, with fans stating that football matches got more exciting when trying to guess a goal in the next seconds. To accomplish such feat, it was necessary to overcome many challenges and take different considerations into account, to provide a good user experience to remote fans. The major difference between the use of a simulated broadcast and a real one lies in the multiple communications and TV broadcast delays that exist worldwide, as they can make or break a good user experience. Due to these factors, it was necessary to add new UI elements and tweak the gameplay design of Viva Ronaldo. However, as we described before, remote fans still felt frustrated or stressed either because a) they received a goal notification before watching it on the television, keeping them from guessing a goal, or b) they placed a bet before watching a goal and the goal notification received a few seconds after, stated that they did not win any points. WeBet was designed to increase the drama and eustress of remote fans during dangerous plays, but not like this. It is completely valid that fans feel frustrated or stressed when a player misses a goal that they had bet on, but it is undesirable not being able to predict a goal due to telecommunication technologies. Moreover, since fans have different TV broadcast delays, if we allow them to set their own delays to provide a good user experience, this becomes a two-side problem, as they can set a higher delay in order to predict goals that have already happened. However, we were able to study and solve this problem, by designing a synchronisation mechanism to provide a good user experience, and by developing a personalisation algorithm to prevent fans from exploiting the game system. More details can be found in Subchapter 3.4.

Regarding the interaction method, results showed us that users rated it as being easy to use and to learn how to use, and that the use of vibration and sound cues helped them to interact without looking at the phone. However, we also concluded that it could be further improved by adding UI elements, either to novice and expert users. As mentioned before, one improvement could be to add a small demonstration showing how it is possible to execute the betting ac-



tion without looking at the phone, by relying on tactile and sound feedback. Other improvement could be to add a small gameplay tip, stating that users can bring the special bet interface before a play becomes really dangerous, and then, place a bet when they wish, as results showed that not all users had this behaviour. We think that these changes can help to improve the user experience not only in Viva Ronaldo, but also in future adaptations of the interaction method to other sports such as basketball, American football, or tennis.

### **3.3. WeFeel**

As noted in Subchapter 2.1, one of the top factors motivating fans to watch sports events is group affiliation, i.e. the desire of being with others supporting the same team. Moreover, fans have strong emotional connections with their teams as they envisioned being part of it when the team succeeds (BIRG), or they distance themselves from it in order to not be a part of the team failures (CORF). These behaviours sparked our interest to approach the social engagement that fans seek during sports events. This involvement exists not only when fans share the same physical space, but also, when fans engage online through social networks. Take for instance Twitter. Twitter is a great example of how social involvement motivates human beings to express themselves. It is no wonder that it became so popular during sports events, as fans can post their thoughts in just a matter of seconds, not only to their followers, but also to the whole world. Throughout the years, Twitter has carried out several initiatives regarding sports, either from analysing the peaks of conversation of all the Super Bowl editions [136] and other major sports events (e.g. US Open [137]), to creating an account focused only on sports promotion (TwitterSports [138]), and even featuring a guide of best practices for athletes, teams, leagues and organisations, and network channels [139]. This high crescendo of social involvement during broadcasted events, led to the creation of the Social TV concept, a merge between social media and television. It is frequent for TV hosts to promote the sharing of opinions on a second screen application, or on the TV show's Facebook and Twitter pages. Network channels also add hashtags to the TV broadcast, so viewers can acknowledge which hashtag is being used to connect the discussions about the TV content being watched. Furthermore, it is expected that the Social TV market will be worth \$256.4 billion by 2017 [36], which shows how much this concept is gaining traction. To capitalize on it, we developed our third proof-of-concept prototype, WeFeel. WeFeel is a system that enhances the experience of remote spectators of broadcasted sports events, by allowing them to share their opinions and emotions with friends through the

TV screen using a mobile device. Furthermore, WeFeel aims to deliver a seamless user experience and a sense of community, by displaying the remote fans' global emotions during key moments of a football match.

Next, we describe the social involvement that exists while watching broadcasted live sports, even when viewers are separated apart by distance (Subchapter 3.3.1). In Subchapter 3.3.2, we present a set of computational approaches to emotion assessment. The WeFeel prototype is briefly described in Subchapter 3.3.3, while the first development stage aimed to evaluate the WeFeel concept is presented in Subchapter 3.3.4, and the second development stage where we evaluated the potential and users' preferences of emotion sharing, is detailed in Subchapter 3.3.5. Finally, the conclusions regarding the WeFeel concept are presented in Subchapter 3.3.6.

### **3.3.1. Social Engagement during Broadcasted Live Sports**

It is undeniable that television has the power to bring people together. Ever since being made commercially available, in the late 1920s, the familiar screen has become a dependable source of news and various sorts of entertainment. Television also contributes to the creation of social experiences, as friends and family often exchange opinions and comments about what they are watching. As a reflection of progress – namely the advent of new portable devices that are now a habitué in our lives, such as smartphones, tablets and laptops – the socialization that could once only take place among people in the same physical space, can nowadays be extended, reaching viewers regardless of the distance that separates them. Indeed, people frequently exchange opinions about what they are watching using chat-based services, such as SMS and WhatsApp, or social networks like Facebook and Twitter. In the first case, viewers interact on single or group chats, with participants usually being friends, colleagues or relatives. The private nature of the interaction facilitates conversations similar to the ones that participants would have if they were watching the TV show together, in the same physical space. In the latter case, social networks seek to empower users to share their thoughts, not only amongst their personal circle but also with the world. To this end, Twitter provides a public forum for real-time commentary, thereby allowing spectators to have a more active role.

Both chat services and social networks make possible to draw inferences about the popularity of particular TV show moments – indeed, we can find a good indicator in the number of exchanged messages. Take, for instance, the 2014 Winter Olympic Games, where Twitter registered a peak of 72630 tweets

per minute, when USA beat Russia in the Olympic Game's men's ice hockey competition [140]. Furthermore, we also know that South Korea, Russia and Japan were the countries that sent the most tweets – the quantities are impressive and provide a glimpse of what the world is watching on TV. Other initiatives in this area are TwitInfo [141], #EpicPlay [142], and World Cupinion [143]. Twitinfo is a system for visualizing and summarizing events on Twitter, allowing users to browse a large collection of tweets using a timeline-based display that highlights peaks of high tweet activity. #EpicPlay is a tool that automatically selects highlight videos in live broadcasted sports events by analyzing sudden bursts in Twitter activity. World Cupinion is a mobile application developed to ascertain whether real-time opinion sharing is reasonable. Results from watching a football match, indicated that viewers using the application had more fun and felt more connected to other viewers while sharing their opinions. These data support the classic ideal that sports have the power to unite the whole world. It is easy to picture people all around the world, in front of television sets, rooting for their favourite teams or athletes, all the while chatting enthusiastically with one another about what they are seeing – either directly or through some communication service. A possible explanation for this enthusiasm is the sports' natural unpredictability and the strong affective connections between fans and the athletes or the clubs they root for, as mentioned in Subchapter 2.1 – “How are fans connected with their favourite sports team?”. Since each sports event is a different challenge and the fact that fans' satisfaction is directly affected by their team's performance, it is not surprising that sports events generate a lot of positive and negative emotions. Based on this fact and also on the notable willingness that people have to add emotional indicators to their communications – think, for instance, about the ubiquity of emoticons or the recent addition of emotional states to Facebook – we argue that emotions should be considered an essential aspect of any system designed to support communications between remote spectators of sports events.

Therefore, bearing in mind the number of people that watch sports events remotely [144], the emotional involvement they have with their favourite teams or athletes and their interest in exchanging opinions and emotion (as also mentioned in Subchapter 2.1), we developed a system, WeFeel, targeted to the expression of ideas and emotions during TV broadcasted sports events, in a simple and fun way. In a nutshell, WeFeel lets users select one of six different emotion words with the help of an application running on their mobile phones, complement it with a comment, if they so desire, and then share the composed message. In order to enable users to share their emotions in a simple and

straightforward way, we evaluated different emotion assessment tools, which are described in the next subchapter.

### 3.3.2. Accessing Emotions through Computational Devices

Over the years the fields of Psychology and Human-Computer Interaction have proposed a number of methods for emotional assessment that have become quite popular. These methods assess people's affective states through paper-based questionnaires, which can be presented before, during, or after an experiment. Some examples are:

- **PANAS (Positive and Negative Affect Schedule) [145]:** a 20-item self-report paper-based questionnaire to measure the positive and negative users' affective states. Users are presented with a set of words identifying different emotions, that need to be ranked according to the following scale: (1) very slightly or not at all, (2) a little, (3) moderately, (4) quite a bit, (5) extremely.
- **SAM (Self-Assessment Manikin) [146]:** images are used as a way to assess the emotional state of each user. There are three rows of images, one to evaluate valence, other to evaluate arousal, and the last one to evaluate dominance. Users are requested to choose an image from each row, which will result in the users' emotions.
- **Russell's Affect Grid [147]:** a scale designed to assess users' disposition along pleasure-displeasure ( $x$  axis) and arousal-sleepiness dimensions ( $y$  axis) on a 1-9 scale. Users select the cell in the grid that best represents how they feel, which is then used to assess the users' affective states.
- **Microsoft Product Reaction Cards [116]:** as already mentioned before, a method to check the emotional response and desirability of a user experience or a product, where users can select as many words as they want from a list of about 60% of words considered positive and 40% considered negative.

These methods, however, are usually based in lengthy, pen-and-paper administered questionnaires, something that ends up imparting some unwieldiness to the whole assessment procedure. Acknowledging this difficulty and requiring more direct and quick procedures, the HCI research community has proposed some interesting approaches to emotion assessment:

- **PAM (Photographic Affect Meter) [148]:** users are requested to select from a wide range of random photos from Flickr, the one that

best suits their current mood. The photos are arranged in a 4x4 grid, along the axes of Russell's Affect Grid [147]. This way, PAM uses the emotional power of photos to ask users for their current valence and arousal values (the same dimensions measured by the Russell's Affect Grid).

- **CAAT (Circumplex Affect Assessment Tool) [149]:** built upon the Robert Plutchik's Circumplex Model of Emotions [150], this tool allows researchers to perform multi-dimensional, quick and simple assessments of emotional experiences. CAAT switches between two states: open, where users can select the emotion that best suits their mood from a set of 25 emotional states, and closed, which shows the user selected emotion by occupying minimal space on screen.

There are also examples of other solutions for emotion assessment applied in specific systems. One of them detects changes in the user's electrodermal activity (the skin's ability to conduct electricity) and asks what emotion is the user experiencing from a list of emotions [151]. Buttons' backgrounds are coloured in accordance with the relations between emotions and colours, in order to convey a better user experience. Another study is the one conducted by Bailie et al. [152], where it is presented a location-based game using a mobile phone attempting to trigger emotional responses as the users play it. The authors use a new methodology based on an adaptation of Whissell's Emotion Wheel [153], that aims at capturing the players' emotional reactions when performing different activities at different locations (e.g. when near a health building users are asked to perform a repetitive exercise with the intent to produce boredom). Finally, iFelt [154] is a system that categorizes movies based on the emotions felt by the viewers, or the emotions the director expects to elicit in the viewer. The system classifies scenes from two perspectives: objective emotion, which is the emotion that the scene conveys, and subjective emotion, which is the emotion that is induced in the viewer. iFelt, like CAAT, is based in Plutchik's basic emotions, and features six different emotions: anger, distrusts, fear, sadness, surprise, and happiness.

### 3.3.3. The Prototype

WeFeel is a mobile application that enables users to share their opinions and emotions, during a football match TV broadcast. The idea behind WeFeel is simple indeed: since people naturally share their opinions and emotions with their personal circle while attending live events, remote spectators should be empowered to do the same, regardless of the distance that sits between them

and the venue. Moreover, they should be able to do so in a fun and minimally disruptive way. Thereby, in order to keep the interactions as little intrusive as possible, and since we dispose of two screens to build them, instead of displaying data (emotions and comments) on the mobile devices, WeFeel displays them on the TV screen. This helps to reduce intrusiveness and creates a different experience, since users are not forced to shift their visual attention from the TV to the mobile screen in order to see their friends' status. Indeed, as the results of the user tests have shown, participants were surprised and enthusiastic about being able to talk with their friends in real time through the TV screen. To further complement the experience, a chart appears periodically on the television screen, summarizing the fans' expressed emotions during event-specific key moments, like goals or referee decisions. The WeFeel concept works on any kind of live broadcast sport event, and can be easily adapted to any TV broadcast genre.

WeFeel was developed in two phases. Like in WeBet, in the first development stage (concept stage), we aimed to evaluate the prototype concept [155]. We designed a first version of WeFeel and we conducted a set of user tests with high school students. In the second stage (users' preferences and potential stage), we evaluated whether participants prefer to visualise emotions and opinions on the mobile device or on the television, and we assessed the potential of sharing emotions to automatically create appealing content [156].

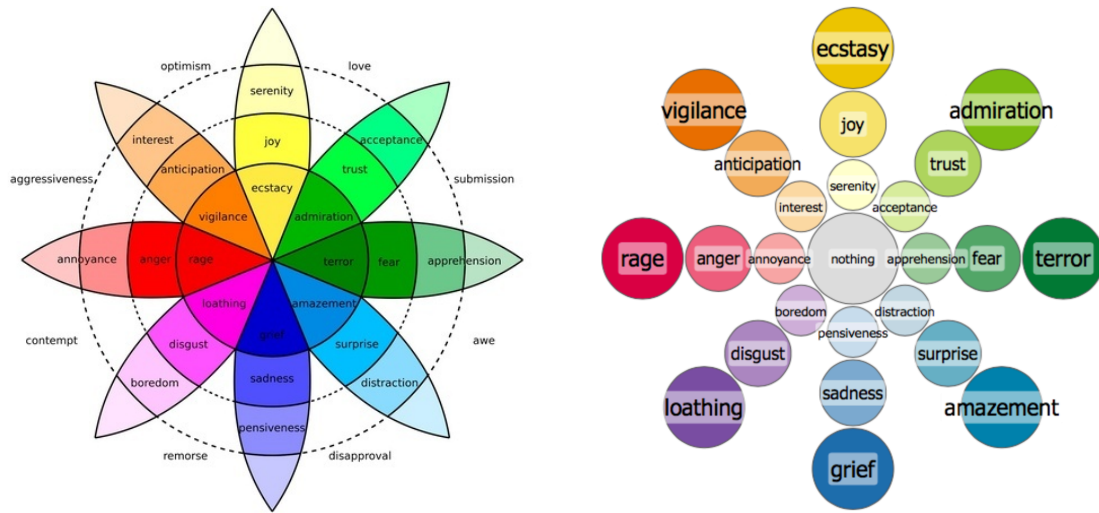
### **3.3.4. Concept Stage**

We started designing WeFeel by deciding which emotion assessment tool we should use and how it could be accessed. Next, we designed the interface on the mobile device, and we defined the areas of the television screen where the shared emotions should appear, in order to avoid obstructing the match events. The mobile application featured a screen with the assessment tool, and match elements like the report, time, and result, while the television presented the emotions and opinions, and the emotions' charts at key moments of the match. Like in WeBet, in order to allow for a faster development, a highlight video of a football match was presented on a television through AirPlay, using Apple TV.

#### **3.3.4.1. Design and Development**

The WeFeel emotion assessment method was based on CAAT [149]. While we also acknowledged the value of other interactive assessment tools, like PAM [148], we felt that it did not provide a direct answer to our needs. Indeed, PAM's evaluations produce four separate, numeric scores while the focus of

WeFeel is the sharing of emotions, a task that may be made easier if accomplished by sharing emotion words. CAAT on the other hand, meets this requirement, and it proved to be easy to integrate into the concept of WeFeel. As it was built upon Plutchik's Circumplex Model of Emotions (Figure 3.31), CAAT features the same emotion-colour associations and the same 24 emotion words, arranged radially around the centre, in intensity ordered axes (although the emotion word's intensity ordering is reversed in the CAAT axes).



**Figure 3.31: Robert Plutchik's Circumplex Model of Emotions (a) and the CAAT tool featuring reversed intensity ordering on the axes (b).**

In spite of the tool's easiness of use – it simply asks users to select one or two emotions that best describe how they feel – the 24-featured emotion words add to the CAAT's visual complexity. This, of course, is not desirable in a system that aims to be simple and straightforward to use, even if at cost of some loss of detail in the assessments. Truly, WeFeel required a simpler, yet still firmly rooted, assessment method. We devised a way to answer this requirement in Lee et al.'s work [157], in which six dimensions of emotions frequently associated with professional sport team brands were identified: connectedness, elation, surprise, anger, unhappiness and worry. Due to the analogy between these six emotion words and six of the eight Plutchik's basic emotions (see Table 3.17), it was easy to adapt the CAAT to use the new emotion words in a way that users could visualize and quickly access them. First, we removed the intensity variants present on the CAAT axes; next, we replaced six of the remaining eight basic emotions with their sport-related counterparts and, finally, we deleted the two basic emotions without pair (disgust and anticipation). This, of course, is a simplification of the underlying model of emotions and, as consequence, it may imply some loss of information in the assessments; however, true to the principles of the CAAT, emotions are chosen by similarity. Thus, if users do not find

the emotion word they are looking for on the tool, they are instructed to choose the one they consider to be more similar.

**Table 3.17: Relation between Plutchick and WeFeel's model emotions.**

Plutchik's Model Emotions	WeFeel's Model Emotions
Anger	Anger
Trust	Connectedness
Sadness	Unhappiness
Joy	Elation
Surprise	Surprise
Fear	Worry

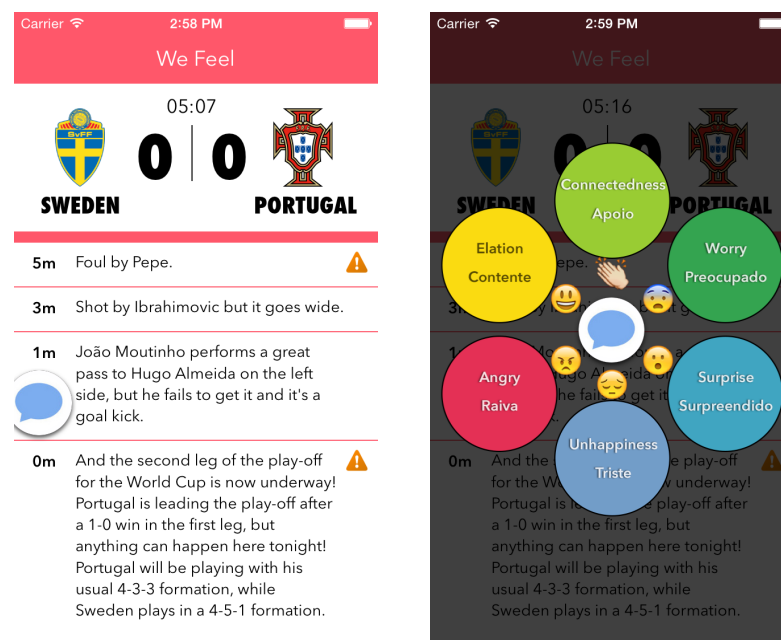
As a side note, we mention that, other than self-assessment, we could have explored alternative methodologies for emotional assessment. For instance, the evaluation of sympathetic activity, like the galvanic skin resistance (often combined with different physiological recordings, such as heart rate or respiratory rate), is becoming common in research studies. However, this approach – besides being intrusive – assumes the existence of a relationship between the measured phenomenon and emotional arousal, something that cannot always be taken for granted. Indeed, we would have to deal with the risk of interference from many external factors, like muscular activity or variances in ambient temperature. Moreover, emotional arousal is just one of the dimensions used to characterize an emotional experience and, incidentally, is not the one accounting for the most variation. In practical terms, this means that different emotions may register similar arousal readings, thereby making it difficult to pinpoint which specific emotion underlies a given arousal reading. Ultimately, we consider that implementing a self-assessment procedure was mainly a design decision, and one that proved to be adequate. Indeed, it turned out to be simple, easy to understand and, as far as our user tests have revealed, well integrated into the WeFeel user interface and overall user experience.

We set the six emotions' buttons in a radial layout (menu). As an additional visual cue, next to each of the emotions' button we added an emoticon to help users to figure out the emotions and provide them with a preview of the content their friends would see. Users could select any emotion by simply clicking on it, and then they could enter a comment if they wish to. At the end of



this process, the radial menu went back to the initial state, waiting for another emotion to be selected.

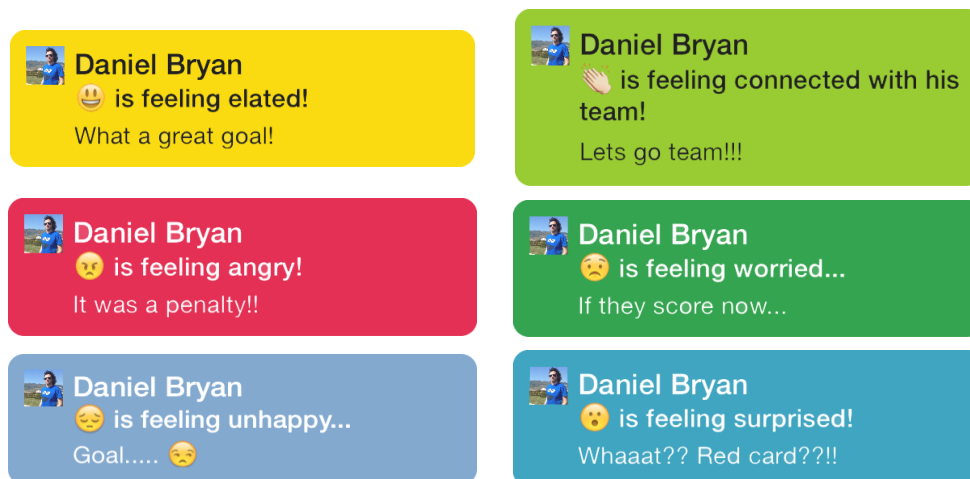
Due to the total space required to present the radial menu with all the emotions simultaneously visible, this interface was designed to fit a mobile device full screen. However, we added an option to expand and minimize the radial menu, so users can hide or access it whenever they want. This way, the minimized radial menu can be placed anywhere on the left and right borders of the mobile device's screen. When users want to access the menu, they just need to click on it and the menu will expand and show all the available emotions. While in the expanded state, clicking anywhere on the screen (besides the buttons), will minimize the menu. Figures 3.32a and 3.32b show the final interface with the minimized and expanded radial menu respectively.



**Figure 3.32: The minimized radial menu on the left centre of the screen (a) and the expanded radial menu presenting all the emotions also in Portuguese for user testing (b).**

The TV interface was also carefully designed to ensure both a pleasant user experience and a minimal interference with the broadcast. We devised two areas: on the right side of the screen, we displayed the individual emotions and comments shared by friends and, on the left side, we presented the emotions experienced by all users watching the match. We chose those areas to avoid obstructing the broadcast with interface elements. On the right side of the screen, each emotion shared by a friend is presented on a pop-up with the friend's name and photo, the comment (if any), the selected emotion word and the corresponding emoticon, and a background featuring the same colour as the selected emotion (Figure 3.33). Once shared, the emotions are shown for 15 se-

conds and, afterwards, they fade away, disappearing from the screen. When there was a pop-up on the screen and a new emotion is shared, the pop-up on the screen would move down so that the new one may take its place. This process would continue until a pop-up reached the bottom of the screen and, once there, it would simply disappear. This way we managed to maintain a simple interface without too much crowded space.



**Figure 3.33: The six different pop-ups when sharing emotions that can appear on the broadcast screen.**

On the left side of the screen we occasionally presented a chart depicting the remote users' global emotions during key moments of the match (e.g. after a goal or a red card). Once there was a replay of a key moment of the match (the detection of such key moments follows a Wizard of Oz), the system analysed the emotions shared in the previous 10 seconds and shows this data on a chart for 10 seconds. The idea was to give enough time for users to share their emotions after an important moment. With this feature, we sought to complement the remote users' experience by showing them that there were many other fans watching the match with them and sharing emotions. This helps to create a social experience, even if a user is not sharing their emotions with their friends. In other words, the remote users' experience can be enhanced even without requiring any kind of interaction. Of course, our goal is for users to share their emotions and to chat with their friends; however, if they do not have any friends watching the match, or simply do not want to share their emotions, they can always be entertained by checking the fans' emotions around the world. Figure 3.34 shows an example of a chart displaying different fans' emotions, while Figure 3.35 presents both a chart and two emotions shared by friends.

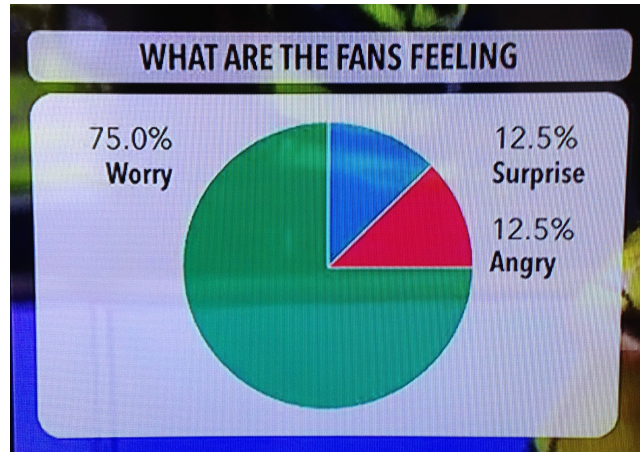


Figure 3.34: A chart showing what the fans are feeling during a particular key moment.



Figure 3.35: Emotions being shared by friends on the right side of the screen, while a chart appears, on the left side of the screen, depicting the overall users' emotions.

### Influential Sports Factors

WeFeel was designed to address five influential sports factors: group affiliation, connectedness with supporters, self-esteem, team satisfaction, and team dissatisfaction (Table 3.1 – “Factors that influence fans’ behaviours”). WeFeel is, of course, a clear example of how a second screen application can convey sociability. Traditionally, sports fans engage in discussions through text-based chats during live events, thus, we introduced a concept that allows them to share their emotions and opinions with friends in an innovative way. This way, fans can see which emotions their friends are feeling, resulting in more personal experiences. The use of emotion charts seeks to convey a sense of community, where fans are not alone watching the match. This connectedness between sup-

porters further motivates users to experience WeFeel, even if they do not have any friends watching the match, or if they simply do not want to share their emotions. By using WeFeel we can have a timeline of emotions, which allow us to ascertain the users' self-esteem during an event. Thus, by relying on the users' selected emotions and the match events, it is possible to infer if fans are satisfied with their team or not. In this sense, we added a feature that took into account the emotions shared during the match, in order to automatically generate short highlight videos that users can watch at the end of the match (see Subchapter 3.3.5). Table 3.18 presents a summary of this discussion.

**Table 3.18: Influential sports factors addressed in WeFeel.**

Factor	Description
Group Affiliation	WeFeel is a system that enables users to share their opinions and emotions with friends, resulting in more personal experiences.
Connectedness with Supporters	By visualizing emotion charts during key moments of a match, users may feel that they are watching the match with others.
Self-esteem	WeFeel explores the strong emotional connection that fans have with their teams, in order to ascertain their self-esteem.
Team Satisfaction	The analysis of the emotions shared by users, allows the automatic creation of short highlight videos to acknowledge in which moments fans were satisfied/ dissatisfied with their team.
Team Dissatisfaction	

### Remote Fan Experience Elements

WeFeel explores two elements of the remote fan experience: the TV broadcast and the social factors. By using the television screen to display the emotions and opinions shared, and the emotion charts, we aimed to create a seamless experience where users can quickly check their friends' messages and the emotion charts after specific key moments, without having to shift their attention from the TV. However, we did not want to design an interface like the one in WeApplaud since we think that it took too much screen estate, ending up in giving more focus to WeApplaud's game than to the actual broadcast. Thus, we conducted a careful evaluation of how the UI elements should be presented, in order to overlay the broadcast, but without obstructing it. Regarding the social factors, we designed WeFeel to create social experiences in an online environment, but it can also work in a local environment, since the visualization of

emotions and opinions in a shared physical space can incite fans to participate in a discussion. So, for instance, if there is a group of friends using WeFeel while watching a sport event together, and an emotion chart appears after a certain key moment stating that the majority of the fans are feeling angry, it can lead to a discussion between the group of friends. Another scenario is the one where the group of friends wants to follow the same conversation, and by visualizing the messages on the television, they can do it so, without having to constantly check their mobile phones. In Table 3.19 we present a summary of the previous elements.

**Table 3.19: Remote fans experience elements explored in WeFeel.**

Element	Description
TV Broadcast	<p>A custom interface was added to the television, with friends' emotions pop-ups and emotion charts.</p> <p>The use of UI elements on the television allows for a seamless experience, where users do not need to shift their visual attention from the TV to the mobile phone so frequently.</p> <p>UI elements appear as an overlay to the TV broadcast, and therefore it was important to select well-defined areas to position them in order to not occlude the broadcast.</p>
Social Factors	Fans engage in an online environment, but the use of WeFeel also incites social interaction in a local environment.

### 3.3.4.2. Evaluation

A first evaluation phase of user tests was conducted, in order to evaluate the system and the user's reactions. One of our main goals was the evaluation of the overall concept, in order to ascertain if participants would use it on a real life environment. We were also interested in finding out whether the interaction method was appropriate for the proposed activity, if it was easy to use, as well as whether the range of available emotions fulfilled the users' needs.

#### Participants and Methodology

The tests were conducted with 53 voluntary participants (35 male and 18 female), with ages 13-44 years ( $\bar{x} = 28.50$ ,  $\sigma = 7.01$ ). WeFeel was deployed during a large event for high-school students. We set up WeFeel in a room with two TVs, placed back to back, each connected to an AppleTV, allowing it to be simultaneously used by two participants, each with an iPhone handed out by

the research team. Participants were free to enter the room and were invited to try WeFeel (Figure 3.36).



**Figure 3.36: User choosing an emotion on a smartphone, while two different emotions from friends appear on the TV screen.**

The test sessions were conducted by two researchers, who played the roles of facilitator and observer. Together, they were responsible for briefing the users and providing assistance with any issues, as well as taking notes about users' reactions and the way they interacted with the system. To make the test sessions more engaging and given that they were performed in Portugal, we used the record of a particularly important football match, in which the Portuguese national team needed to win or draw in order to qualify for the World Cup 2014. The video was 15 minutes long and it was edited to emphasize different kinds of events (like fouls, dangerous plays and goals). All of the emotions shared during the test sessions were saved, in order to create the data clusters used to build the charts that were displayed on the TV screens during the key moments of the match. This way we could simulate that there were a lot of people sharing their emotions when, in reality, the data was gathered from previous test sessions.

Lastly, at the end of each test session, users were asked to answer a questionnaire with which we have evaluated WeFeel's usability and entertainment value. This questionnaire is detailed next.

### **Questionnaire**

The first part of the questionnaire addressed users' personal data such as age, gender, and habits while watching broadcasted sports events. Then, the



questionnaire focused on usability and user experience issues, including general feedback, application's usability, users' entertainment and emotional involvement, and suggestions and comments.

To evaluate WeFeel's usability and the entertainment experienced by users, we asked them to rate ten statements (Table 3.20) using a five-point Likert-type scale, which ranged from strongly disagree (1) to strongly agree (5). The statements were based on the USE questionnaire and were aimed at assessing whether the users had a good time using WeFeel, appreciated its concept and felt like they would use it in their homes, in a real sports event scenario. Like in the previous prototypes, a question based on the Microsoft "Product Reaction Cards" [116] was also included to rate the WeFeel's experience. Finally, users could write down any further suggestions and comments.

**Table 3.20: Statements, regarding general feedback, usability and entertainment issues, rated by the users.**

Statements
<b>General Feedback</b>
<b>S1.</b> I liked to use WeFeel.
<b>S2.</b> It is easy to learn how to use WeFeel.
<b>S3.</b> It is easy to use WeFeel.
<b>Usability and Entertainment</b>
<b>S4.</b> The interaction (selecting an emotion and entering a comment) is appropriated.
<b>S5.</b> The visualization of the emotions and the chat on the TV screen does not obstruct the match display.
<b>S6.</b> I like to express my emotions during the match.
<b>S7.</b> The visualization of the emotions and comments on the TV screen creates an enjoyable experience.
<b>S8.</b> I like to see the chart (overall emotions) on the TV.
<b>S9.</b> I would use WeFeel system during a real match.
<b>S10.</b> I could express all the emotions that I felt.
<b>S10.1.</b> If you answered no, which emotions you were not able to express?

## Results and Discussions

During the user tests, 248 emotions were shared through WeFeel, averaging 4.67 shares per person and 17.7 shares per minute, with a peak of 22 shares after the first Portuguese team's goal. Figure 3.37 presents the relation between the key moments on the video and the users' shares.

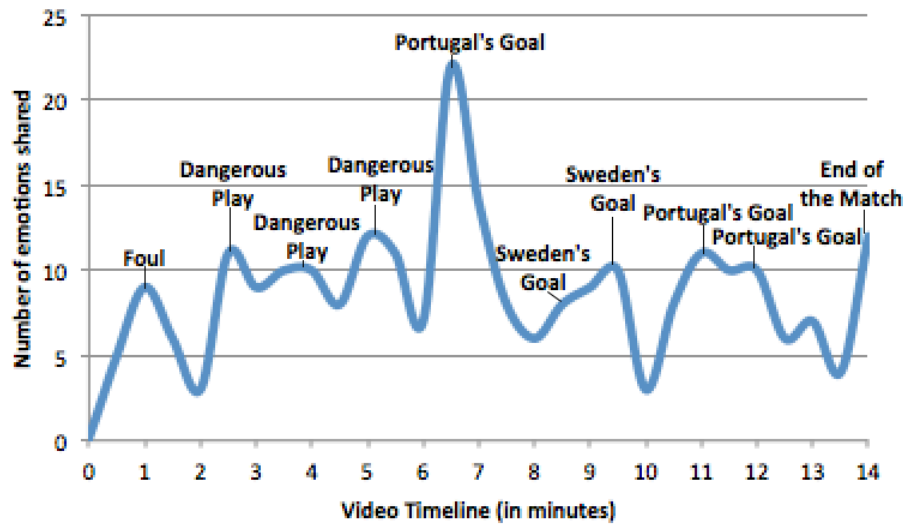


Figure 3.37: Timeline depicting the emotions shared.

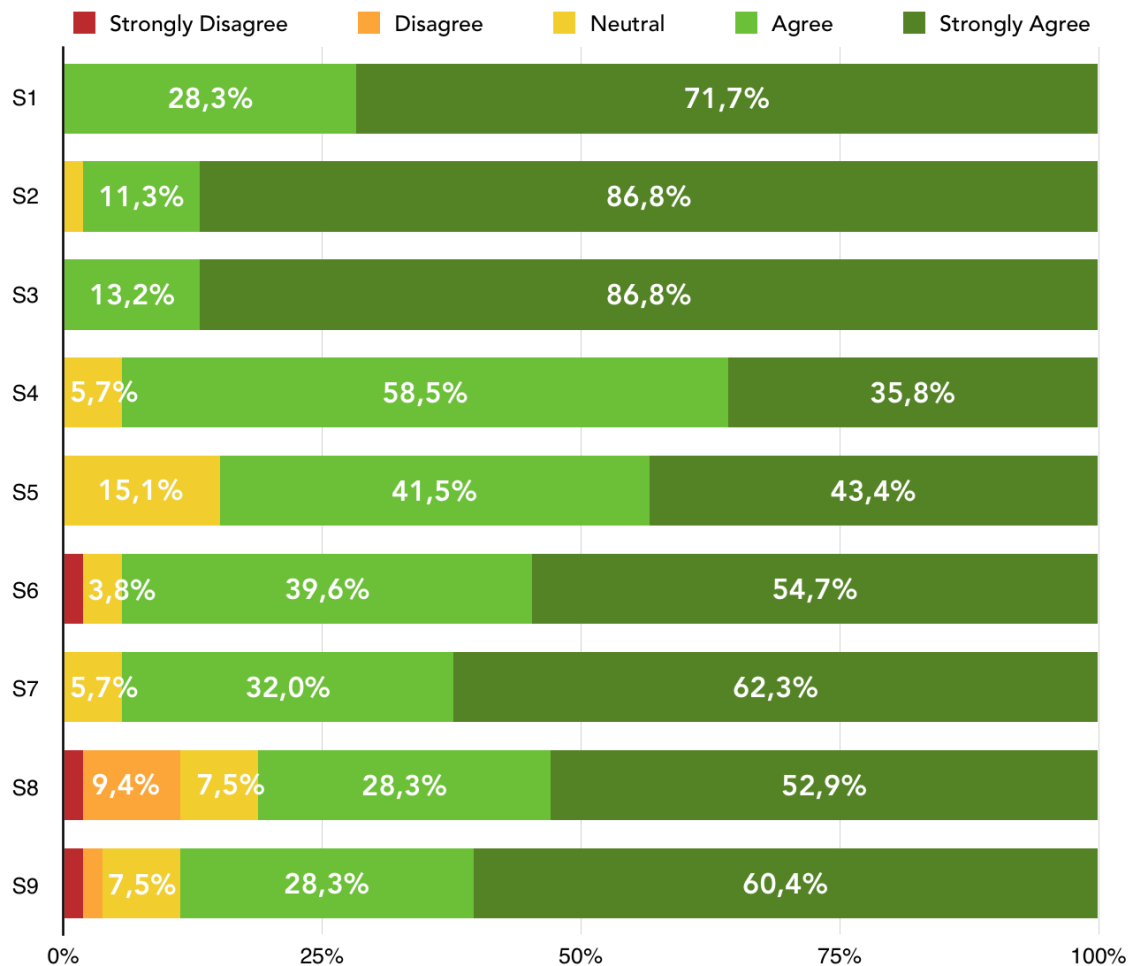
Regarding the questionnaire, results showed that the majority of the participants (62%) watched sports events on TV on a weekly basis, 11% did it fortnightly, 6% on a monthly basis, and 21% rarely watched sports on TV. In a more detailed analysis, 73% of the participants who watched sport events on TV on a weekly basis were male and 27% were female, while the rest of the participants who watched it less frequently were 50% male and 50% female.

The most popular device used while watching a broadcasted sports event was the cellphone (64%), then the computer (49%) and lastly the tablet (26%). From those who used additional devices while watching broadcasted sports events, 67% used social networks, 61% exchanged SMSs, 52% browsed the web, 39% participated in chat conversations and 20% made voice calls. These results indicate that the majority of participants were already used to interact with technological devices while watching sports on TV, and have a high interest in interacting with friends in real-time during a broadcasted sports event.

As shown in Figure 3.38, most participants strongly agreed with the statements concerning the general feedback (statements 1, 2 and 3). Participants generally liked to use WeFeel and found it easy to learn and use. The feedback regarding the following statements was also positive. Statement 4 focused on the evaluation of the developed interaction method, and the majority of the participants agreed (58.5%) or strongly agreed (35.8%) that it was appropriate. By talking with the participants and by analysing the suggestions provided by them on the last part of the questionnaire, we found out that although the majority of users liked the radial menu and the way it could be expanded and minimized, some of them did not perceive that they could share an emotion without a comment. This happened because the commentary box did not reflect that



a user could simply click on “Send” without having to write anything on it to send the emotion with no comment. Therefore, we changed this aspect in order to allow users to quickly share an emotion (without entering a comment), by double tapping the emotion’s button.



**Figure 3.38: Summary of results from general feedback, usability and entertainment issues.**

Statement 5 focused on the interface elements that appeared on the television screen. Most of the participants agreed (41.5%) or strongly agreed (43.4%) that the emotions and comments did not obstruct the match display. Statement 6 showed that the majority of users liked to share their emotions during the match (54.7% strongly agreed and 39.6% agreed with this statement), giving us a lot of confidence to continue our research on WeFeel. The visualization of the emotions and comments made by friends on the television screen (S7) was received with great enthusiasm. 62.3% of the participants strongly agreed and 32.1% agreed that it makes an enjoyable experience. In fact, as we were presenting the prototype to users at the beginning of the test sessions, they got really

surprised to see the emotions and comments appearing on the television, and were interested in trying for themselves. We believe that this happened because: (1) it is a different conversation concept that they are not used to; (2) there is not yet a lot of commercial applications that proportionate this kind of experience between mobile phones and TVs; and (3) users liked to read their friends' status on the TV screen, while they are watching the match. While statement 8 was the one with most scattered results, they were still very positive. The majority of users liked to see the users' overall emotions chart on the TV screen (52.8% of the participants strongly agreed and 28.3% agreed with this statement). Finally, the results of statement 9, assessing if users would use a similar system during a live broadcast of a real match, were also very positive, with 88.7% of the participants agreeing with S9 (60.4% strongly agreed and 28.3% agreed).

As previously explained, WeFeel allows users to select one of six emotion words, extracted from Lee et al.'s work [157]. Evidently, we acknowledge that six emotions do not make a remotely comprehensive list of human affects. However, since those words are specific to sports spectatorship, we needed to understand if such a limited selection is more of a hindrance to expression or an improvement to usability. Therefore, the questionnaire also featured an item that asked participants whether they felt they were able to express all of the emotions they have experienced (and did want to share). 77% of users answered positively, while 23% answered negatively. From those 23%, about a quarter said they wanted to express "anxiety", 17% wanted to express "enthusiasm", while others wanted to express different emotions like "boring", "despise", "confusion", "disappointment" and "despair" (11,6% each). The first remark that should be made about these observations is that it is virtually impossible to present users with an exhaustive list of all existing emotion words without impairing usability. That being said, and while we acknowledge that WeFeel would probably benefit if more emotion words were featured, the selections should be made by similarity, like to what happens in the original CAAT.

From the analysis of the question based on the Microsoft "Product Reaction Cards" [116], we concluded that most participants did appreciate the concept of WeFeel. The most selected words were fun, pleasant and simple (71.7% each), followed by attractive (64.2%), innovative (58.5%), exciting (45.3%), and finally stimulating (39.6%), motivating (37.7%) and useful (35.8%). Users had a great time with WeFeel and hence they rated it as a fun experience. Furthermore, the words pleasant, simple, innovative and exciting were among the top chosen words, showing that WeFeel provides a simple, yet thrilling experience.

Lastly, we analysed the comments and suggestions provided by the participants. As mentioned before, some users stated that they had not understood they could share an emotion without writing a comment, while three users have asked about the possibility of different chat modalities. Two users, for instance, wanted to interact simultaneously with different persons or groups. Although we did not approach this topic, we believe that this is an important issue when bringing the WeFeel concept to the real world, as users should be able to manage to whom they are chatting with.

### **3.3.5. Potential and Users' Preferences Stage**

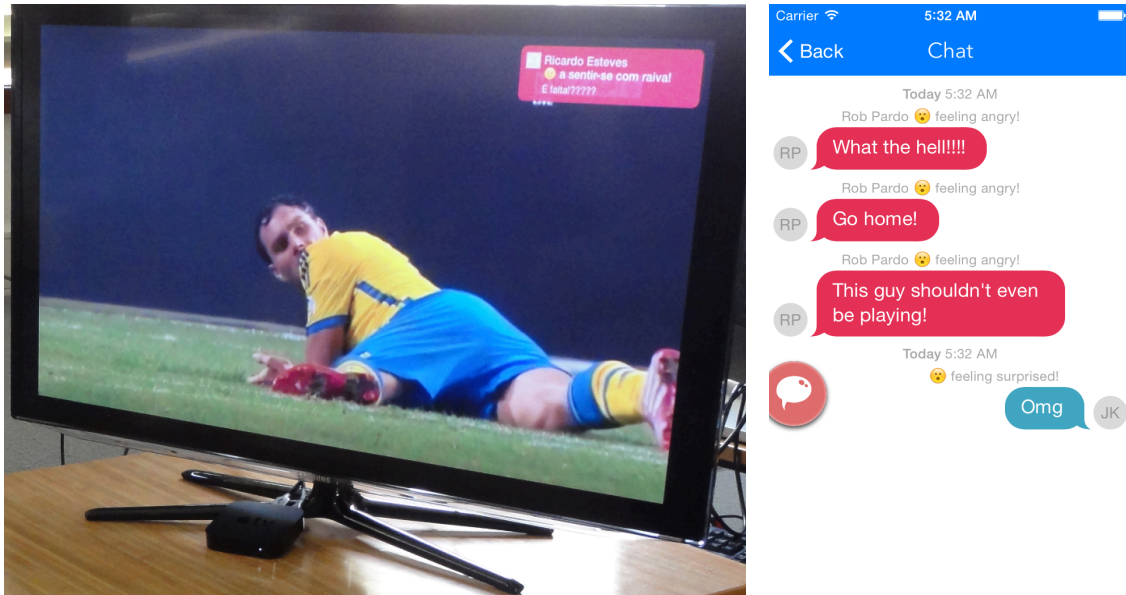
In the first study we evaluated if users liked the WeFeel concept, if the interaction method was appropriate for the proposed activity, and if the range of available emotions fulfilled the users' needs. In this second study, we aimed to ascertain whether users preferred to check their friends' messages on the television or on the mobile device, as we acknowledge that in some situations users may want to keep their messages private (e.g. when there are other individuals in the same physical space). This led to our first research question (1): do users clearly prefer one way of visualising information to the other? And if so, which one do they prefer? Our second research question was related with the potential that the emotions data can have for the detection and analysis of special events during a TV broadcast. As presented in Subchapter 3.3.1, there have been different initiatives that seek to automatically generate highlight videos of a given TV content. Within this context, a second research question (2) was raised: what are the users' reactions towards the automatic creation of videos based on the emotions felt during a sport event? Are these videos useful or appealing for those that watched the sport event and for those that did not?

To answer the two research questions (1 and 2), we expanded WeFeel so users could chat and share their emotions, either through the television or the mobile device. Furthermore, all the emotions shared were used to generate automatic videos at the end of the simulated football match, which could then be watched by the users.

#### **3.3.5.1. Design and Development**

We started by tweaking WeFeel to support two different visualization methods: a public and a private one. In the first situation, the information appears on the television screen, visible to all viewers in the same physical space, like in the previous stage. In the second situation, the information is only visible to the user who is interacting with the application, as users engage in a more

traditional and private conversation. The process to select an emotion and add a comment remains the same, but this time, users can quickly enter an emotion by double tapping on it. Figure 3.39 depicts the two visualization methods.



**Figure 3.39. The two visualization methods: public (a) and private (b).**

Another new feature that we added was the possibility to automatically generate short highlight videos at the end of the football match, based on the emotions shared during it. Six videos are created, each one related with one of the possible emotions. Each video contains the top moment of the football match in which the users shared the highest number of occurrences of a particular emotion. We preliminarily aimed at evaluating the users' feedback regarding the use of emotions to automatically generate highlight videos. Thus, to create the videos, we developed a simple algorithm that can be optimized in the future according to the user studies. Taking into account the frequency and the timestamp of each emotion, the current algorithm creates each one of the six videos as follows:

- 1) Based on the timestamp of the occurrences of a given emotion, different clusters are created. A threshold of 10 seconds is used to help group the same emotions from different users that are close (in time) to each other. At the end of this stage, we will have different clusters with different number of occurrences.
- 2) Upon identifying the cluster with the highest number of occurrences for a given emotion, an average timestamp is calculated for this cluster.

- 3) The algorithm then subtracts 10 seconds from the average timestamp (defined as the minimum value, never negative), and adds 5 seconds to it (defined as the maximum value, never higher than the match duration). This is due to the fact that emotions are frequently registered after an event, and thus it is more important to show the moments before an event than the ones after it.
- 4) Finally, the algorithm creates a video segment between the minimum and the maximum value, and saves it for later access.

Once the algorithm creates and saves all the six videos (one for each emotion), the application presents a menu where users can select which video they would like to watch.

### **3.3.5.2. Evaluation**

A user study was conducted to evaluate the users' preferences regarding the two methods for the visualization of their friends' status and comments, and to scrutinize their interest regarding the automatic generated videos.

#### **Participants and Methodology**

The user tests were conducted with 18 voluntary participants (16 male and 2 female) aged 20-40 years ( $\bar{x} = 25.4$ ,  $\sigma = 6.12$ ). For this evaluation study, we used the same video from the previous evaluation stage, since WeFeel was deployed in a different context. Therefore, all the participants never interacted with WeFeel before.

During each test session, two participants interacted with each other. Each participant was watching the football video on a different TV connected to an Apple TV and used an iPhone. Thus, the set up included two TV sets, two AppleTVs and two iPhones paired together through a wireless connection. Two researchers were in charge of briefing the users, as well as taking notes about their reactions and interactions. Users started each test session by choosing the visualization method instructed by the researchers. At the middle of the video, the researchers told users to switch to the other visualization method (that was then used until the end of the video). The sequence of visualization methods between test sessions was counterbalanced to minimize learning effects. At the end of the football video match, six different highlight videos were created based not only on the different emotions shared during the current test session, but also on the ones shared during the previous sessions. Next, a screen appeared on the mobile device, allowing the users to select and watch the different videos. Once users selected an emotion, the corresponding video was

played on the TV. After users visualised all the videos that they wished, the researchers asked them to answer a questionnaire.

### Questionnaire

The first part of the questionnaire addressed users' personal data, such as age, gender, and habits while watching broadcasted sports events. Next, we asked users to rate a set of four statements regarding each of the two visualization methods, using a five-point Likert-type scale, which ranged from strongly disagree (1) to strongly agree (5). These statements focused on comparing the different characteristics of the two visualization methods. Therefore, the users rated these statements twice, once regarding the public visualization method and the other regarding the private visualization method.

Finally, to evaluate the interest and appeal of the mobile prototype and the automatic video generation functionality, we asked users to rate four additional statements. These statements are presented in Table 3.21.

**Table 3.21: Statements, regarding visualization methods, and the interest and appeal of WeFeel and the automatic generated videos.**

Statements
<b>Visualization Methods</b>
S1. I liked to use the WeFeel through this method.
S2. The visualization method is appropriated.
S3. I did not lose any important moment of the match in order to visualise the messages and emotions.
S4. In a real context, I would like to use this visualization method.
<b>Interest and Appeal of WeFeel and the Automatic Generated Videos</b>
S5. The use of WeFeel makes the experience of watching a TV broadcast more appealing.
S6. The visualization of the most emotional moments of the match at the end of the video is interesting.
S7. In a real context, I would like to watch a highlight video containing the most emotional moments, in case I have watched the match.
S8. In a real context, I would like to watch a highlight video containing the most emotional moments, in case I haven't watched the match.

### Results and Discussion

The majority of the participants (67%) watch sport events on TV on a weekly basis, 17% rarely does it, 11% watch fortnightly, and 5% does it on a monthly basis. The most popular device used while watching a broadcasted sports event was the mobile phone (72%), then the computer (66%) and lastly

the tablet (33%). Only one participant (5%) reported he did not use technological devices while watching sport events on TV. Regarding the participants' habits while using technological devices, 35% of users frequently talk with their friends while watching sports events on TV, 29% does it sometimes, 24% always does it, and 12% rarely talk.

Table 3.22 presents a summary of the questionnaire's results regarding the visualization methods. In order to compare the users' preferences regarding the two visualizations methods used, we conducted Wilcoxon Matched-Pairs Signed-Ranks tests for statements 1, 2, 3 and 4. These tests were based on the null hypothesis (H0), i.e., there was not a significant statistical difference between answers. In all tests the alpha level was 0.05, in order to achieve an interval of confidence of 95%.

**Table 3.22: Summary of results regarding the visualization methods. Higher scores are highlighted.**

Statement	Visualization Method	$\bar{x}$	$\sigma$	$\tilde{x}$
S1	Private	4.50	0.51	4.5
	Public	4.72	0.57	5
S2	Private	4.44	0.78	5
	Public	4.55	0.51	5
S3	Private	3.66	1.02	4
	Public	4.27	0.82	4.5
S4	Private	4.33	0.68	4
	Public	4.50	0.85	5

Results from statement 1 revealed that participants really liked to use the mobile prototype in both situations (private visualization:  $\bar{x} = 4.50$ ,  $\sigma = 0.51$ ,  $\tilde{x} = 4.5$ ; public visualization:  $\bar{x} = 4.72$ ,  $\sigma = 0.57$ ,  $\tilde{x} = 5.0$ ). Regarding statement 2, participants stated that both the private and public visualization methods were appropriate ( $\bar{x} = 4.44$ ,  $\sigma = 0.78$ ,  $\tilde{x} = 5.0$ , and  $\bar{x} = 4.55$ ,  $\sigma = 0.51$ ,  $\tilde{x} = 5.0$  respectively). However, in both cases, the Wilcoxon Matched-Pairs Signed-Ranks did not show significant statistical difference to conclude that users preferred (S1:  $W = 3.5$ ,  $Z = -1.63$ ,  $p > 0.05$ ) or find one method more appropriate (S2:  $W = 7$ ,  $Z = -0.82$ ,  $p > 0.05$ ) than to the other.

With statement 3 we aimed to study if participants felt they lost any important moment of the match when visualising their friends' messages on the mobile device ( $\bar{x} = 3.66$ ,  $\sigma = 1.02$ ,  $\tilde{x} = 4.0$ ) and on the television screen ( $\bar{x} = 4.27$ ,  $\sigma = 0.82$ ,  $\tilde{x} = 4.5$ ), i.e. whether the shift of visual attention from the TV screen to the mobile device caused participants to miss a key moment on the football match. The Wilcoxon Matched-Pairs Signed-Ranks ( $W = 0$ ,  $Z = -3.05$ ,  $p < 0.05$ ,  $r = -0.51$ ) showed a significant statistical difference between the two methods, with participants losing fewer important moments while visualising the chat messages on the television screen. Finally, on statement 4 we sought to evaluate whether users in a real context would like to use the different visualization methods. The feedback was positive when visualising the chat messages on the mobile device ( $\bar{x} = 4.33$ ,  $\sigma = 0.68$ ,  $\tilde{x} = 4.0$ ) and on the television ( $\bar{x} = 4.5$ ,  $\sigma = 0.82$ ,  $\tilde{x} = 5.0$ ), but the Wilcoxon Matched-Pairs Signed-Ranks ( $W = 15$ ,  $Z = -1.00$ ,  $p < 0.05$ ) did not show statistical difference to conclude that participants preferred to use one method to the other in a real context.

Regarding the second part of the questionnaire, users rated statement 5 positively ( $\bar{x} = 4.44$ ,  $\sigma = 0.61$ , 50% strongly agreed, 44% agreed), showing that the concept of sharing emotions either through the private or the public visualization method, can improve the user's experience while watching a TV broadcast. Statement 6 showed that the concept of visualising the most emotional moments at the end of the match was interesting ( $\bar{x} = 4.72$ ,  $\sigma = 0.46$ , 72% strongly agreed, 28% agreed). As a side note, the videos were created taking to account the 151 emotions shared during the tests, which averaged 16.7 shares per test session. Finally, we wanted to evaluate whether users, in a real context, would like to watch highlight videos based on the emotions expressed during the match, after they have watched it ( $\bar{x} = 4.44$ ,  $\sigma = 0.46$ , 50% strongly agreed, 44% agreed) and in case they have not seen the match ( $\bar{x} = 4.89$ ,  $\sigma = 0.32$ , 89% strongly agreed, 11% agreed). As the results show, the feedback was highly positive, especially when the users could not manage to watch the football match.

### 3.3.6. Conclusions

With WeFeel, we introduced a concept that can be easily applied to any sport, and even to other TV broadcasts genres. In fact, the emotion assessment method that we used features six sport-related emotion words that "inherited" both the position and colour of six of the eight CAAT's basic emotions. Thus, it is fair to say that the emotion assessment method implemented on the final pro-



prototype of WeFeel is an adaptation of the CAAT for the scope of sport events. Furthermore, the work that we started by using the emotions shared during a match to automatically generate short video highlights, has already been expanded to be the subject of study of a master thesis. This thesis, entitled “Automatic Generation of Sport Video Highlights Based on Fan’s Emotions” aims to develop an algorithm that will allow for the automatic creation of appealing short video highlights for any kind of live sports broadcast. The algorithm uses the emotions data and low-level features existent in the video and audio stream, such as color, shape, object motion, sound or on-screen text. In the future we hope that this work can also be applied to other kinds of broadcasts, like talk shows, reality shows, or variety shows.

We think that the users’ feedback that we had from the evaluation tests was really positive. We really felt that participants liked this concept and were very interested in using a similar application in their homes. In fact, the top comment made by users seconds after experiencing WeFeel was “where can I download it?”. This clearly shows a great interest and enthusiasm about the perspective of using WeFeel on a real life environment. In fact, just recently, we updated WeFeel to support client-server architecture, a live television feed and Facebook Messenger as a proof-of-concept. This means that friends who are not using WeFeel, can chat through Facebook Messenger with others who have WeFeel (which is integrated with a real live television feed). The only difference is that only the WeFeel users can share and visualize emotions through the two visualization methods. Nevertheless, if we think about it, the WeFeel concept can easily be adapted by Facebook to integrate its Messenger application. Facebook already uses emotional states to assess users’ emotions, so in the near future, if a device or a Smart TV allows to integrate applications with the television feed, chat-based applications like Facebook Messenger will quickly become one of the most sought applications by viewers to interact with others while watching TV. Moreover, through other applications like Twitter, CNN, and ESPN, it will also be possible to receive notifications of important tweets, breaking news, and the latest sport scores updates, while watching a TV broadcast. We think that this will bring a new meaning to the Social TV concept, as mobile devices and television sets become fully integrated to engulf viewers in a seamless experience.

### **3.4. WeSync**

As mentioned in Subchapter 3.2, the results that we obtained from deploying the WeBet concept on a real life setting showed that the TV broadcast delays

affect the user experience and must be strongly considered when developing second screen interactions during live events. These delays are a consequence of the different types of connection and hardware that TV providers have, which causes viewers to watch events on television before others who use different TV providers. Thus, viewers with a higher TV delay have a disruptive experience, since they receive key information regarding an event, on a second screen application before watching it on the television. With this problem in mind, we implemented an interaction mechanism to mitigate the aforementioned issue. This interaction mechanism, named SMUF (Synchronisation Mechanism through User Feedback), is based on the feedback given by users on how the application events are synchronised with the corresponding TV broadcasts. We developed a prototype called WeSync to evaluate how users interact with SMUF and to analyse if they are able to synchronise a second screen application with a TV broadcast using SMUF. Furthermore, we also addressed a problem that exists during second screen gaming competitions, where users can gain advantage by setting a delay that is higher than the real delay of the TV broadcast. Therefore, we also implemented a solution that seeks to ensure a cheat-free gaming experience.

The next subchapter gives an overview about the TV broadcast delays on live sports (Subchapter 3.4.1). Subchapter 3.4.2 presents some examples of techniques to synchronise second screen applications with TV broadcasts. In Subchapter 3.4.3, the WeSync prototype is described. Two evaluation studies were conducted in order to assess the synchronisation mechanism existent in WeSync. The first one is presented in Subchapter 3.4.4 and focuses on the SMUF concept and how users interact, and the second one, described in Subchapter 3.4.5, focuses on development of cheating detection modules. Finally, the conclusions are addressed in Subchapter 3.3.6.

### **3.4.1. TV Broadcast Delays on Live Sports**

For better or for worse, live television events are accompanied by a delay. This can be a result of two factors: either the TV broadcast intentionally delays the event so that any inappropriate material can be removed or bleeped out, or the use of technology to broadcast the event from the venue to the viewers' homes unintentionally introduces a delay.

In the first case, the TV broadcast uses a software module to introduce a profanity delay, which usually delays the broadcast of live content by 5-30 seconds. This gives time to the broadcaster to censor the audio and video feed when necessary, either by cutting directly to a non-delayed feed (skipping past

the undesired moment) or by using dedicated hardware units to edit content on the fly. Other option is to use bleep sounds so the profanity can be unheard. For instance, in the 2008 Summer Olympic Games held in Beijing, the TV broadcast was delayed 10 seconds, due to risk of political protests [158]. Moreover, since 2004, there is a five-second delay imposed by the Federal Communications Commission in the United States to all broadcast television networks. This was a result of the famous “wardrobe malfunction” between Justin Timberlake and Janet Jackson during the Super Bowl XXXVIII half time show [159].

In the second case, there are different technological processes that introduce a delay: encoding and capturing, image conversion, modulation, propagation, and buffering, rendering and decoding [88]. Encoding and capturing can introduce a relative delay between different TV stations when broadcasting the same live content; a conversion of the digital image format can also add extra delays; modulation and propagation used between the satellites and the TV access network can introduce slight telecommunication delays, and finally, buffering, rendering and decoding stages also add a delay based on the digital TV and set-top box hardware. Whole this process often leads to a common scenario that the reader might have already experienced. Imagine that you are at home watching your national football team playing. The match is tied 1-1 and it is on the final stages. Your national team has ball possession and is building up an attacking play, when suddenly you hear your neighbor screaming “Goal!”. Although you might be satisfied that your team has scored, the truth is, the drama and excitement that rises from watching a dangerous play unfolding into a goal is gone. Your experience as a viewer, as a fan, is disrupted. All due to the play-out difference between two different TV providers. Perhaps, the next time your national football team plays, you will think twice where you will watch it, in order to not be spoiled about the outcomes. Or else, you will evaluate how much it costs to change to other TV provider, which sometimes is not possible due to contract limitations.

Now, imagine this happening in a second screen application context. If you are spoiled by live events in a second screen application, before watching them on television, you have a simple alternative: you stop using the application. If you think about it, this creates a paradox, as second screen applications are designed to deliver better user experiences, but in reality, they have the power to disrupt them. Thus, in order to allow viewers to synchronize their second screen applications with the corresponding TV broadcasts, we devised SMUF to rely on user feedback to synchronize any second screen application to work as intended. To evaluate how users interacted with it, we developed

WeSync, a mobile game that prompts users to guess the outcome of corner kicks, penalty kicks and freekicks during a football match. Although there have been several initiatives to automatically synchronize second screen applications with TV broadcasts, we could not rely on them due to different reasons as described next.

### **3.4.2. Synchronising Second Screen Applications with TV Broadcasts**

Although it is possible to diminish the telecommunication delays by adding or replacing hardware, this topic is out of the scope of our work. Our focus is on how to solve this problem from a software point of view, whether by developing a solution that can be implemented by the TV service provider or by the second screen application developer. To this end, one can solve this issue in either two ways: by approaching multicast communications to introduce an algorithm that synchronises all the viewer's televisions, or by using automatic content recognition (ACR) on the TV broadcast audio to synchronise each viewer's mobile application. To achieve the first solution, it is necessary to approach a popular research topic in multicast communications for live media: the inter-destination media synchronisation (IDMS). In a nutshell, the goal of IDMS is to deliver the same stream for all the individuals of a group at the same time. There have been several approaches to achieve this goal, either based on reporting the media stream arrival time and buffering at the end-points (clients) [90], or doing it so at the network itself (for example, by using edge nodes) [91]. However, viewers are dependent on the TV service providers to implement these solutions, and if they do not do it, the synchronisation problem will remain. In fact, the TV service providers who have a lower broadcast delay have nothing to gain by synchronising with TV service providers with a higher broadcast delay, as they can use their technological advantage as a selling point of their service. Regarding the second solution, there are two main methods in ACR to identify a given TV show: audio watermarking and audio fingerprinting. Audio watermarking works by adding a well-defined sound - but difficult to perceive for the human ear - to an audio stream, in order for it to be detected by an audio algorithm. On the other hand, audio fingerprinting - which has become widely popular with Shazam [160] - works by comparing a short audio fragment with a database of unique audio fingerprints of millions of audio files. An example of an ACR algorithm, is the one developed by Wywy [161], which uses a satellite dish to receive the TV shows directly from the satellite, sends the signal to its own server and monitors it. The mobile application detects a user's

signal on a three-second audio playback of the show, makes a digital fingerprint and sends it for the server to search for a given match. When a match is found, the delay is calculated and the mobile application uses it from then on to present events synchronised with the TV broadcast. However, when using third-party APIs for ACR, such as Entourage [92], developers may not be able to identify the show that they desire. Entourage, while being very robust, only works on 6 countries and 173 TV channels, which is obviously insufficient. Finally, if developers decide to implement their own ACR system – which may result in a complex and lengthy process – it will not work during live events (such as sportscasts) in all countries where the feed is being broadcasted, because the audio from the original feed is distinct for each country due to each sportscasters’ differing feeds.

As we mentioned before, it is easy to think of a scenario where solutions like the IDMS algorithms and ACR are not able to deliver a synchronised experience between the TV and the second screen applications. Since different viewers might have different TV broadcast and network delays, we argue that the solution needs to go through them. In other words, users should be involved in the solution process, in order to provide feedback about their experience. To accomplish this, it is necessary to design an intuitive and simple interaction mechanism. Therefore, we approached this issue from a human computer interaction perspective, so users could easily understand what they are supposed to do, in order to have an enhanced user experience. With this in mind, we designed SMUF, a mechanism that can be quickly added by developers to their second screen applications and through which users can easily perform the synchronisation and adjust their experience.

Although we acknowledge that different users will end up having different delay values – due to different Internet and TV service providers – we do not perceive this as an issue. It is the client application that delays the events from appearing on the second screen device in order to synchronise user interaction with the TV broadcast. This way, even someone with a high TV broadcast or network delay can have a great user experience.

### **3.4.3. The Prototype**

WeSync is a mobile application that prompts users to guess the outcome of corner kicks, penalty kicks and freekicks during a football match. Users can also check their predictions’ outcomes, as well as their friends’ scores. Furthermore, WeSync also notifies users when a goal is scored (allowing them to quickly share their thoughts on social networks), or when a half starts or ends. How-

ever, these events are not synchronised with the TV broadcast, and thus, users need to synchronise it by using SMUF, which can be done by adjusting a slider after each event occurrence. Through SMUF, users can rate their experience, providing feedback on how the application is presenting the events: before, at the right time or after they appear on TV. Each subsequent event is presented taking into account the previously provided feedback, in order to achieve the synchronisation between the application and the TV broadcast. With WeSync we focused on evaluating the SMUF concept and usability, and not the WeSync concept itself (although some users also liked the idea of betting at key moments during the match, as presented in the evaluation studies).

We developed WeSync in two phases. In the first phase, we aimed to evaluate the SMUF concept and interaction method, so we could acknowledge if SMUF was easy to use and helped users to synchronise WeSync [162]. In the second phase, we sought to prevent a flaw that can be exploited by allowing users to set their own delay on a second screen application (as it happens in SMUF and ACR concepts) [163]. Therefore, we developed an algorithm that dealt with cheating to provide a fair gaming experience.

#### **3.4.4. Concept Stage**

Since the focus of this prototype was to evaluate SMUF, we began by designing how users could easily and quickly interact. After that, and as we wanted to test SMUF in a competitive scenario like the one found in WeBet, we decided to implement a new game where users needed to guess the outcome of different key moments. Like in WeBet, users won points for predicting outcomes correctly (corner kicks, freekicks and penalty kicks like in Figure 3.40), but we did not remove any points when they got it wrong since there was no need to further penalize the players. As a side note, the reason why we did not test SMUF in WeBet, was because SMUF relies on the feedback given by users at key moments of a match, and since WeBet only features one type of key moments (goals), it would take more time for users to have their applications synchronised. Due to the resemblances that WeBet have with WeSync (they are both betting games), WeSync approaches the same influential sports factors and remote fan experience elements as in WeBet. Finally, and as in the previous prototypes, WeSync simulates a football match broadcast displayed on a TV through Apple TV, where a video with several highlights is presented. Running on an iPhone, the mobile application presents a screen with the match status, while waiting for key moments to occur.

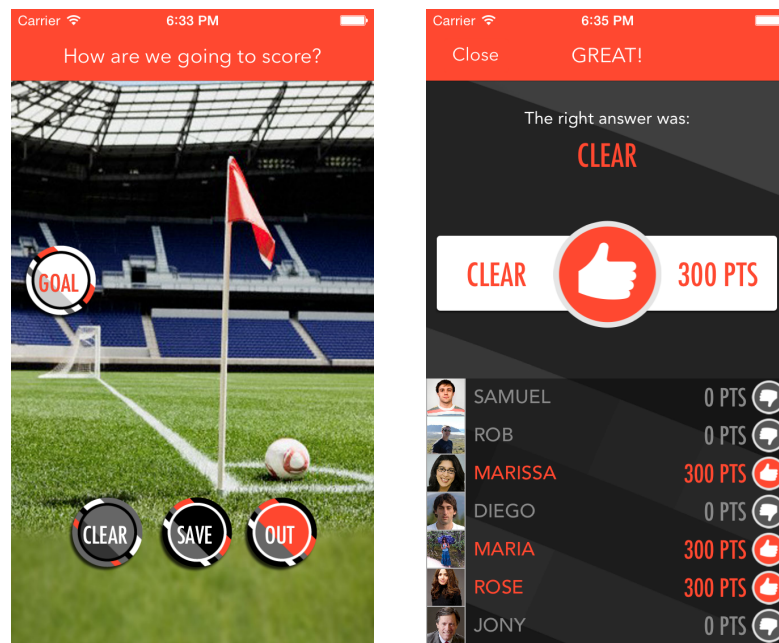


Figure 3.40: A key moment that prompts users to predict a corner kick (a) and the corresponding result (b).

#### 3.4.4.1. Design and Development

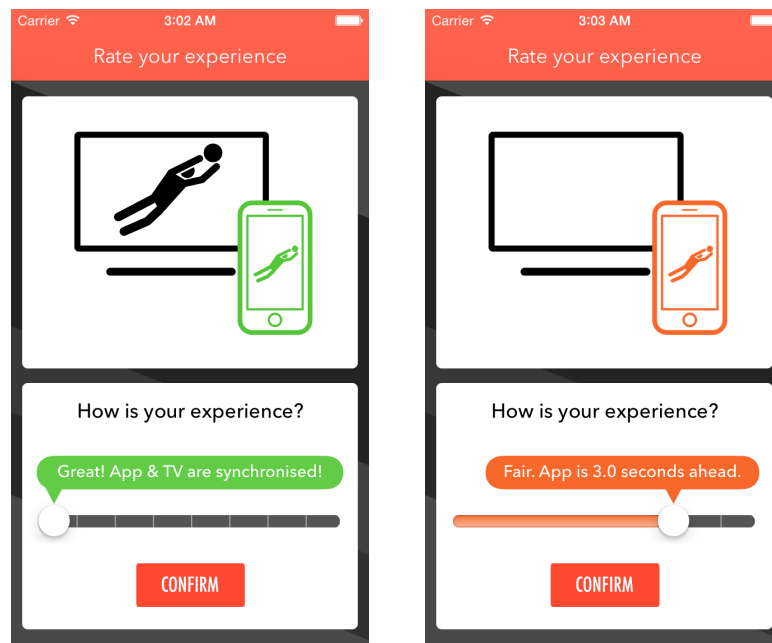
An interaction walkthrough is presented below in order to give a better perception on how SMUF was designed to work on WeSync or any kind of application and TV broadcast:

- 1) After users complete a given interaction, like predicting the outcome of a corner kick and getting the corresponding result (Figure 3.40), a screen appears asking users to rate their experience (Figure 3.41a).
- 2) Users may specify that the application is synchronized by simply clicking on the “Confirm” button, or they can adjust the slider in order to select how the application behaves in relation to the TV broadcast. The initial delay is 0s.
- 3) If the user starts to adjust the slider, a text appears describing the experience rating currently selected (e.g. “Great! App & TV are synchronised!”), and showing the delay being set by the user. Moreover, the slider changes its colour (e.g. red indicates a high delay) and an animation starts on the upper half of the screen indicating how that given delay corresponds to the user’s experience. So, for instance, if users select that the application is 3s ahead, an animation will start on the upper half of the mobile

screen (Figure 3.41b) showing a scene occurring on the mobile device and 3s later, on the TV. Users with a high broadcast delay can move the slider all the way to the right (maximum is 4s) and once there, if they keep their finger on the slider, its scale will increase to allow for a higher maximum value (4s are added to the maximum value every 0.5s a finger is kept on the slider). Once users are pleased, they can touch on the “Confirm” button.

- 4) If a delay was set, the next time a key moment happens, the application will delay the request by the number of seconds chosen by the user, so it can be closer to the TV broadcast timeline. After the user finishes interacting with the key moment, a screen will appear once again asking for his/her feedback (Figure 3.42a). At this time, users can move the slide to the left, decreasing the delay that was previously set (they can also keep their finger on the slider to increase the minimum value, where the minimum is the delay value previously selected). Users can also move it further into the right, increasing even more the delay, again up to a maximum of 4s. This process will repeat until the user selects that the application is synchronised or very close to be synchronised (1s at maximum, which according to the observations by Mekuria et al. [88], viewers do not notice major delay differences below this value) with the TV broadcast, hence having an optimal experience.
- 5) Once the users state that the application is synchronised, the application stops asking them about their experience. Then, a pop-up appears stating that from now on they can synchronize their experience when they wish, by clicking on the top-right button that has just appeared on the main screen of the application (Figure 3.42d).





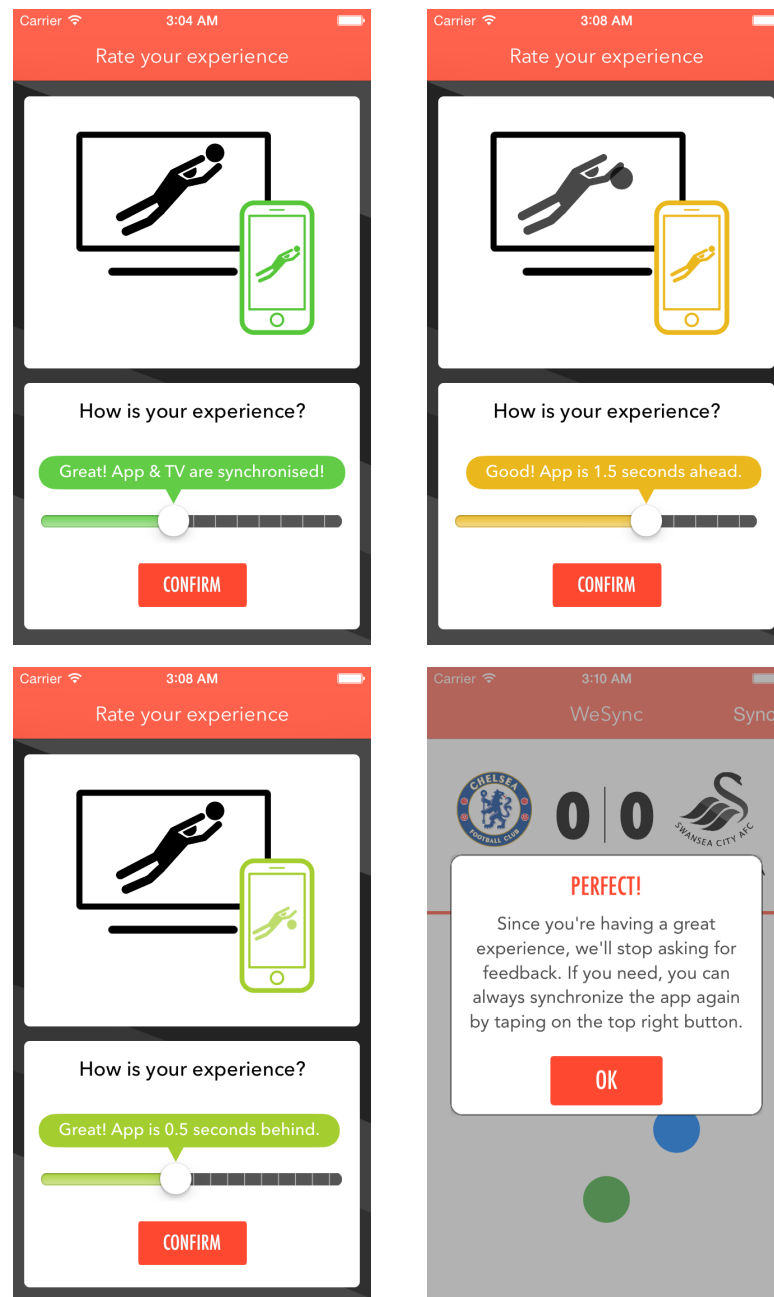
**Figure 3.41: Initial screen of SMUF (a). User setting a delay (b).**

We designed SMUF by taking several facts into account. First of all, we only allow users to adjust the application, because there is no way for users to calibrate the television. Users are watching a live feed – which is always delayed, compared to the live action on the venue – and have no control over it. The mobile application is their reference model that they can adjust. Bearing this in mind, we assume that the events triggered on the second screen application are always synchronised with their real counterparts occurring on the venue where the event is taking place. This is not just for the sake of simplicity, but it is a guideline for similar works: live second screen interactions that rely on tight synchronisation will not work correctly if they are not synchronised with the real time of the live action, or at least, the fastest TV broadcast available. If this is not the case (e.g. the human operator triggering the events on the application is watching a TV broadcast delayed a few seconds), users with a TV broadcast delay lower than the operator’s will get the events on the second screen application after they have occurred on the TV broadcast, without the possibility of synchronising them with the TV broadcast.

Second, we designed SMUF to allow users to easily synchronise the TV broadcast with a second screen application, without the need to understand how it really works in the background. Therefore, we introduced four interaction cues to facilitate the user interaction: the temporal indication, the illustrative animation, the overall colour, and the experience rating. The temporal indication aims at giving precise information on how the TV delay compares with

the mobile application events (e.g. “App is 3.0 seconds ahead”). Some users may not be able to initially identify their exact delay, but they will gradually get closer. The remaining cues are defined according to the temporal indication value. With  $sv$  being the slider’s value and  $ds$  the delay set, the temporal indication is calculated by  $|ds - sv|$ . This is because each time SMUF appears, users should adjust the delay taking into account their experience at that precise moment. Thus, if a user sets a 3s delay at the first interaction (Figure 3.37b), and when SMUF appears for the second time (Figure 3.42a) s/he sets a 1.5s delay (Figure 3.42b), s/he will set a 4.5s delay overall, but only a 1.5s delay comparing with the previous experience (SMUF interaction). However, if the user set a delay a little higher than the desired, s/he can further adjust the application by decreasing the delay by 0.5s (Figure 3.42c), which triggers the pop-up on Figure 3.42d. Therefore, to accomplish this whole behaviour, it was necessary to calculate  $|ds - sv|$ , as  $sv$  is a value between 0 and  $ds + 4$  (possibly expanded by 0.5 amounts by keeping the finger on the slider). This way, and since the initial  $sv$  is always equal to  $ds$ , each time the SMUF appears, users can decrease the delay by moving the slider to the left (when  $ds > 0$ ), or further increase the delay by moving the slider to the right. On a side note, we initially let users to move the slider’s value by 0.1s amounts, but preliminary tests showed us that users tend to make small adjustments each time they changed the slider’s value, being afraid of increasing too much the delay. This was not intended, since it takes more time for users to synchronise the mobile application, when they make many small adjustments before they finally get the application synchronised. Besides, value differences of less than 0.5s are almost imperceptible for viewers. Hence, we decided to let users increase or decrease the slider’s value by 0.5s each time they wanted to change it.

The illustrative animation simulates the situation corresponding to the delay specified by the user, aiming at providing the user with a better perception of his/her choice: the key moments on the mobile device are appearing synchronised with the television (Figure 3.42a), ahead of the television (Figure 3.42b), or behind the television (Figure 3.42c). The animation reproduces the exact delay selected by the user (temporal indication value) up to a maximum of 4s.



**Figure 3.42: Iterative process of setting a delay. After setting a 3s delay ( $ds = 3$ ,  $sv = 3$ ) (a). Second try to set the right delay ( $ds = 3$ ,  $sv = 4.5$ ) (b). Third try to set the right delay ( $ds = 4.5$ ,  $sv = 4$ ) (c). Notification after the application is synchronised (d).**

The use of colours allows the user to immediately recognize the current situation: green for synchronised (positive experience), red for not synchronised at all (negative experience) and yellow for in between situations. In order to create smooth transitions between states, the colours grade from green to red. Since people in most countries are used to associate green with something positive, red with negative, and yellow with in between situations (see the traffic lights for example), we used these colours to tint the mobile application's illus-

trative animation, slider bar and its text popup (Figure 3.36b). To complement this cue, we also added a popup text describing the experience rate currently selected by the user, which intends to further specify how is the user's experience. The way that the values change on both of these interaction cues were based on the work done by Mekuria et al. [88]. It shows that viewers with a TV delay less than 1s were barely annoyed with it, viewers with a delay between 1 and less than 4s were somewhat annoyed, and a delay equal or higher than 4s clearly annoyed the viewers. Thus, we mapped out these values to match the colors previously described. Similarly, we also analyzed how viewers noticed the TV delays in [88] to identify the different experience ratings. When there was a TV delay less than 1s, users barely noticed it, but once the TV delay increased up to 2s, more than half of the users could notice it. Finally, once the TV delay reached the 4s, almost all users noticed it. We used these values to identify the four experience ratings: "Great!", "Good!", "Fair.", and "Poor...", respectively. Table 3.23 summarizes the behaviour of each interaction cue.

**Table 3.23: Interaction cues used to help users understand how to use SMUF.**

Interaction Cue	Behaviour
<b>Temporal Indication</b>	The slider's value is increased or decreased by intervals of 0.5s, up to a maximum of 4s (possibly expanded by 0.5s amounts by keeping the finger on the slider) and a minimum equal to the previously delay set. Each time there is a change in the slider's value, the temporal indication text changes according to $ ds - sv $ .
<b>Illustrative Animation</b>	When the SMUF screen appears, or after a user changes the slider's value, an animation starts on the upper section of the display, depicting a keeper's save. The animation starts at the same time both on the mobile device and the television images (if $ds = sv = 0$ ), first on the mobile device (if $ds < sv$ ) and after $sv$ seconds (4s at maximum) on the television, or first on the television (if $ds > sv$ ) and after $sv$ seconds (4s at maximum) on the mobile device. Once an animation stops, it resets again after 5s.
<b>Overall Colour</b>	The overall color grades from <b>green</b> ( $ ds - sv  < 1$ ), to <b>yellow</b> ( $ ds - sv  \geq 1$ and $ ds - sv  < 4$ ), and <b>red</b> ( $ ds - sv  \geq 4$ ).
<b>Experience Rating</b>	The experience rating text changes from " <b>Great!</b> " ( $ ds - sv  < 1$ ), to " <b>Good!</b> " ( $ ds - sv  \geq 1$ and $ ds - sv  < 2$ ), to " <b>Fair.</b> " ( $ ds - sv  \geq 2$ and $ ds - sv  < 4$ ), and to " <b>Poor...</b> " ( $ ds - sv  \geq 4$ ).

Finally, we did not include any information regarding the live sports event, such as the match time (which could easily be used to compare the TV broadcast match time with the application match time to synchronise both feeds), because we wanted to have a universal synchronisation mechanism that could be deployed during any sport broadcast, TV show, or even e-Sport. Thus, considering that it is not certain that any well-defined cue is present on the TV broadcast to help the users synchronising their applications, we designed SMUF without relying on any extra information besides the users' feedback regarding their experience.

#### **3.4.4.2. Evaluation**

To evaluate the SMUF's usability and usefulness, in order to know if it is easy to use and helps users to synchronise their second screen applications with the TV broadcasts, we carried out a user study using the WeSync prototype.

##### **Participants and Methodology**

The user tests were conducted with 30 voluntary participants (28 male and 2 female) aged 20-36 ( $\bar{x} = 23.3$ ,  $\sigma = 4.33$ ). The tests took place in a room at our University campus. Before each test session, participants were briefed about the test. In each session, participants watched three 7-minute highlight videos from Chelsea 4 - 2 Swansea match that took place on September 13, 2014. None of the participants had seen the match before. We edited each video to contain the same number of events: 3 predictions of the outcome of corner kicks or freekicks, and 3 notifications to alert for goals and the start or end of each half.

Since several TV providers can have different delay values, for each highlight video it was set a low, medium and high delay, based on the work by Kooij et al. [89], which presents several playout differences for regular TV. Thus, we defined the low, medium and high delays as random values between 0 and 2 seconds, 2 and 4 seconds, and 4 and 6 seconds respectively, since these were the most common delay values registered by Kooij et al. [89]. A within-subject experimental design was used to evaluate the three delay scenarios and the sequence of videos and delay scenarios was counterbalanced to minimize learning effects.

After watching each of the three videos presented during each test session, we asked participants to rate two statements, from a questionnaire, regarding their user experience at the beginning and at the end of the video (Table 3.23 – first six statements). We intended to evaluate whether the users perceived an

improvement in their experience as they used SMUF to get the application synchronised with the TV.

Lastly, at the end of each test session, users were asked to fill in the remainder of the questionnaire.

### Questionnaire

The questionnaire comprised six initial statements that users rated after interacting with WeSync during each of the three videos with different initial delays (two statements after each video), and nine additional statements (based on the USE questionnaire [115]) regarding general feedback about the activity, and the SMUF's interaction cues, rated by the users at the end of the test session (Table 3.24). Users rated these statements by using a five-point Likert-type scale, which ranged from strongly disagree (1) to strongly agree (5). Finally, users could write down any further suggestions and comments.

We also registered all the users' interactions during each test, such as the users' predictions, number of times SMUF was accessed, response times, delays set by users, scenario delays, and if users stated the application as synchronised. With these data logs, we were able to perform different measurements, and together with the questionnaire responses we were able to achieve several conclusions.

**Table 3.24: Statements, regarding general feedback about the activity and the SMUF's interaction cues.**

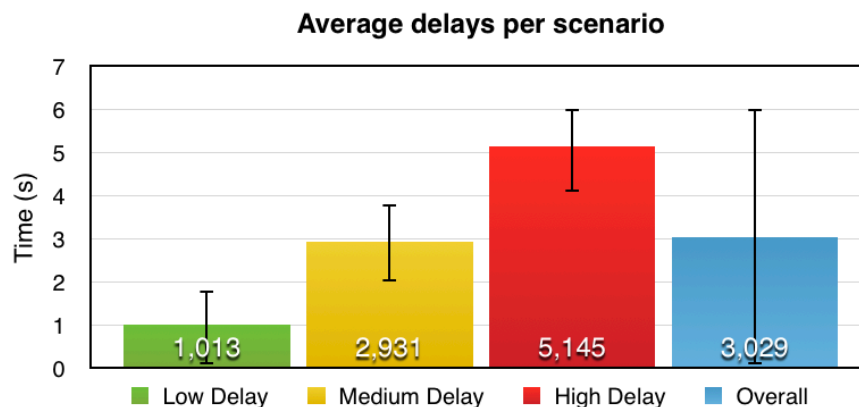
Statements
<b>User Experience – Low Delay Scenario</b>
<b>S1a.</b> In the beginning, I had a good experience.
<b>S1b.</b> In the end, I had a good experience.
<b>User Experience – Medium Delay Scenario</b>
<b>S2a.</b> In the beginning, I had a good experience.
<b>S2b.</b> In the end, I had a good experience.
<b>User Experience – High Delay Scenario</b>
<b>S3a.</b> In the beginning, I had a good experience.
<b>S3b.</b> In the end, I had a good experience.
<b>General Feedback</b>
<b>S4.</b> I liked to use the interaction mechanism.
<b>S5.</b> It is easy to learn how to use the interaction mechanism.
<b>S6.</b> It is easy to use the interaction mechanism.
<b>S7.</b> I had difficulties to understand how the key moments (of the application and the TV)

should be synchronised.
<b>S8.</b> This mechanism is useful to synchronise the application with the TV broadcast.
<b>Interface and Feedback</b>
<b>S9.</b> The temporal indication (e.g. “App is 0.5 seconds ahead.”) helped to synchronise the application.
<b>S10.</b> The experience rating (e.g. “Great!”) helped to synchronise the application.
<b>S11.</b> The overall colour helped to synchronise the application.
<b>S12.</b> The illustrative animation helped to synchronise the application.

## Results and Discussion

As stated before, in all three scenarios delays were randomized between 0 and 2 seconds (low delay scenario, average of 1.013,  $\sigma = 0.58$ ), 2 and 4 seconds (medium delay scenario, average of 2.931,  $\sigma = 0.75$ ), and 4 and 6 seconds (high delay scenario, average of 5.145,  $\sigma = 1.07$ ). Figure 3.43 presents the average delays for each scenario (including the overall scenario, average of 3.029,  $\sigma = 1.77$ ).

Users accessed SMUF 240 times during the whole evaluation process, averaging 2.677 times per user and per scenario ( $\sigma = 1.43$ ), with 1.566 times during the low delay scenario ( $\sigma = 0.78$ ), 2.633 times during the medium delay scenario ( $\sigma = 1.16$ ), and 3.833 times during the high delay scenario ( $\sigma = 1.31$ ) (Figure 3.44). These data show that when the delay is lower users needed to perform fewer interactions with SMUF to get the application synchronised with the TV than when the delay is higher. Since each scenario had 6 key moments where users could compare the mobile application with the TV broadcast, these results are very positive. Only in high delay scenarios users needed to set a delay more than 3 times on average.



**Figure 3.43:** Average delays for each scenario including the overall scenario. The error bars indicate the maximum and minimum registered delays.

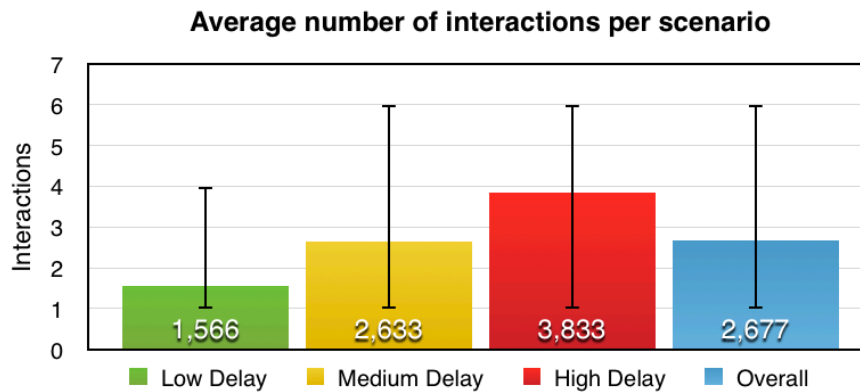


Figure 3.44: Average number of interactions per user for each scenario including the overall scenario. The error bars indicate the maximum and minimum measurements.

We also analysed the time duration of each user interaction with SMUF. We were interested in finding out if the users' interactions with SMUF get shorter as the number of interactions performed by them increase and they become more familiar with SMUF. The data that we gathered show that on average during the first interaction users took around 7 seconds to set a delay. In the second interaction, the average response time decreased to around 5 seconds, but on the third interaction results were different for each one of the scenarios. In the low delay scenario, the response times increased to 6.78s, while in the high delay scenario it increased to 7.91s. Only in the medium delay scenario the interaction's time did not increase. This data caused the average overall response time to increase to 6.63s. This was curious to note, as the third interaction was the only interaction where the overall response time increased. So far, we did not find any data that could explain these results in an objective matter. Although, we presume that, at the third interaction, users were wondering why the application was still not synchronised with the TV broadcast, hence the time they took to set a new delay. On the fourth interaction, the average response time decreased again to around 3 seconds on the low and medium delay scenarios, and 5 seconds on the high delay scenario, with the overall time decreasing to 4.01s. For the fifth and sixth interaction, we could only have analysed the medium and high delay scenarios, as users did not access SMUF more than 4 times during the low delay scenario. The average response time for the medium delay scenario decreased to around 2s, while on the high delay scenario it increased slightly (from 5.28s to 5.59s) and then it decreased to 4.68s. This led the overall response times to remain at around 4s and then decreasing to 3.5s. We think that these data are very promising, as it validated our idea of developing a simple and quick to use interaction mechanism, upon learning how to use it. Figure 3.45 presents the response time data previously mentioned.



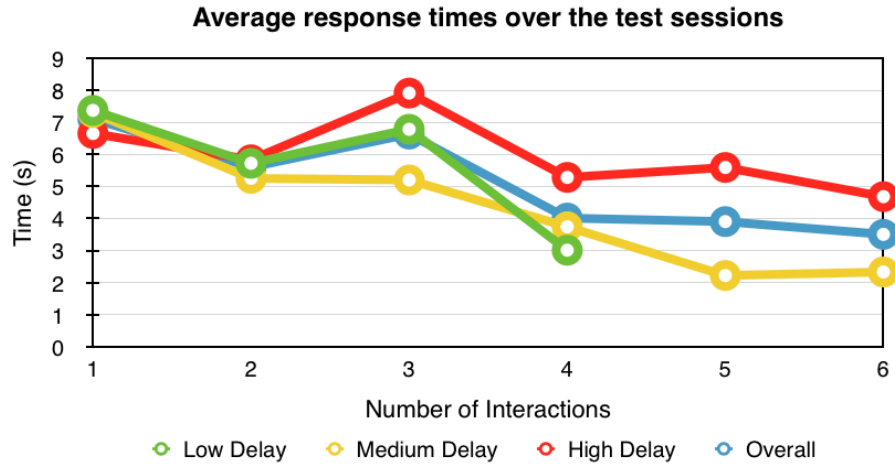


Figure 3.45: Average response time for all scenarios including the overall scenario.

An important topic that we also investigated was the difference between the initial delays of the scenarios and the final delays achieved by the users at the end of the videos. We wanted to analyse which delay values the users were satisfied with, and whether they managed to set the application as synchronised at the end of a video. We verified that on average users ended the low delay scenario, the medium delay scenario, and the high delay scenario with a 0.6s ( $\sigma = 0.63$ ), 1.38s ( $\sigma = 0.70$ ), and 1.61s ( $\sigma = 0.98$ ), scenario delays, respectively. Overall, the average final delay was 1.20s ( $\sigma = 0.89$ ). It is important to note that the negative values of Figure 3.46 mean that the application was delayed relatively to the TV broadcast (i.e. the final delay was higher than the initial delay). Thus, a -1.2s delay on the high delay scenario (as presented on Figure 3.46), means that the delay set by the user on the mobile application was 1.2s higher than the delay initially set. As a side note, we presume that the values presented in Figure 3.46 could change slightly if the videos were longer – the delay difference was converging to values near or below 1s over time as presented on Figure 3.47 –, as users may still try to do fine adjustments in order to reach a perfect synchronisation (ending up decreasing the average difference). Our data also show that all the participants, on the low and medium delay scenarios, stated that the application was synchronised at the end of the video, and 95.6% did it so on the high delay scenario. Thus, the majority of the users perceived the application as being synchronised with the TV, so they were satisfied with the delay values presented above. This also means they were able to perform the synchronisation in order to achieve an adequate experience. In addition, we verified how many users on average changed the delays after setting the application as synchronised during the videos. Only 19.57% did it on the low delay scenario, 29.49% did it on the medium delay scenario and 22.22% did it on the

high delay scenario. Overall, 23.76% of users changed the delay after setting the application as synchronised, trying to achieve a perfect synchronisation.

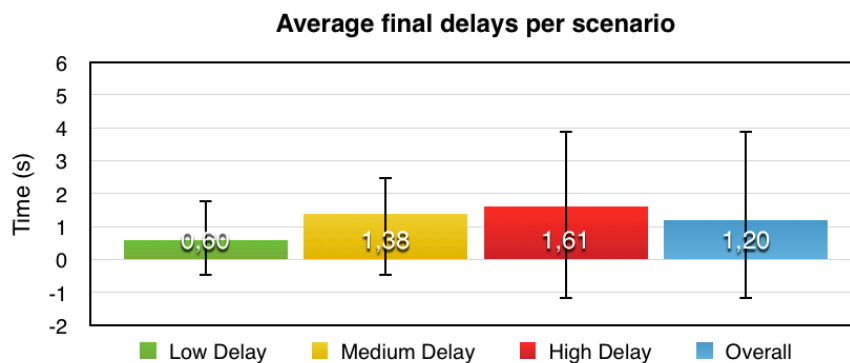


Figure 3.46: Average final delays for each scenario including the overall scenario. The error bars indicate the maximum and minimum measurements.

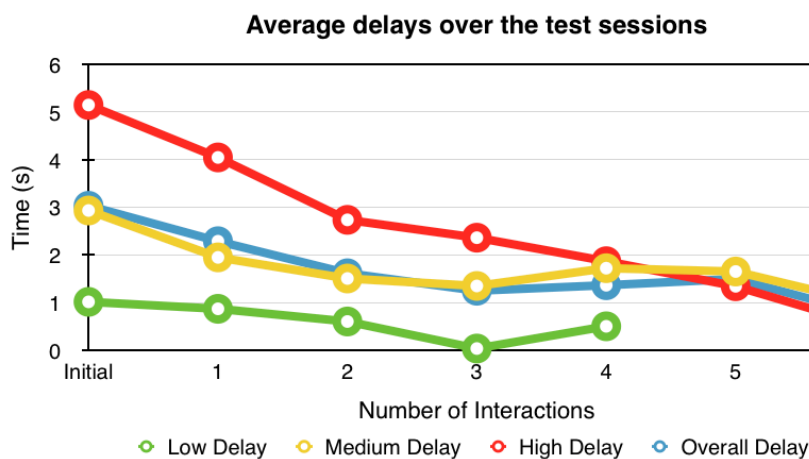


Figure 3.47: Average delays for all scenarios including the overall scenario.

Regarding the questionnaire, results were extremely positive when we analysed the reported user experience at the beginning and at the end of each video. Users stated that concerning the low delay scenario, they had a good experience at the beginning of the corresponding video (43.3% agreed and 36.7% strongly agreed with statement 1a), but at the end of it they had an even better experience (16.7% agreed and 83.3% strongly agreed with statement 1b). On the medium delay scenario, the users reported a decent to good experience at the beginning of the video (33.3% were neutral and 40% agreed with statement 2a), but it clearly improved at the end of it (20% agreed and 76.7% strongly agreed with statement 2b). Finally, on the high delay scenario, the user experience was slightly negative (36.7% disagreed and 40% were neutral about statement 3a), but the results shifted to a good user experience at the end of the video (both 46.7% agreed and strongly agreed with statement 3b). This is an important

milestone in our work, as one of our main goals was to deliver a good user experience to viewers regardless of the TV broadcast delays. Figure 3.48 summarizes these results.

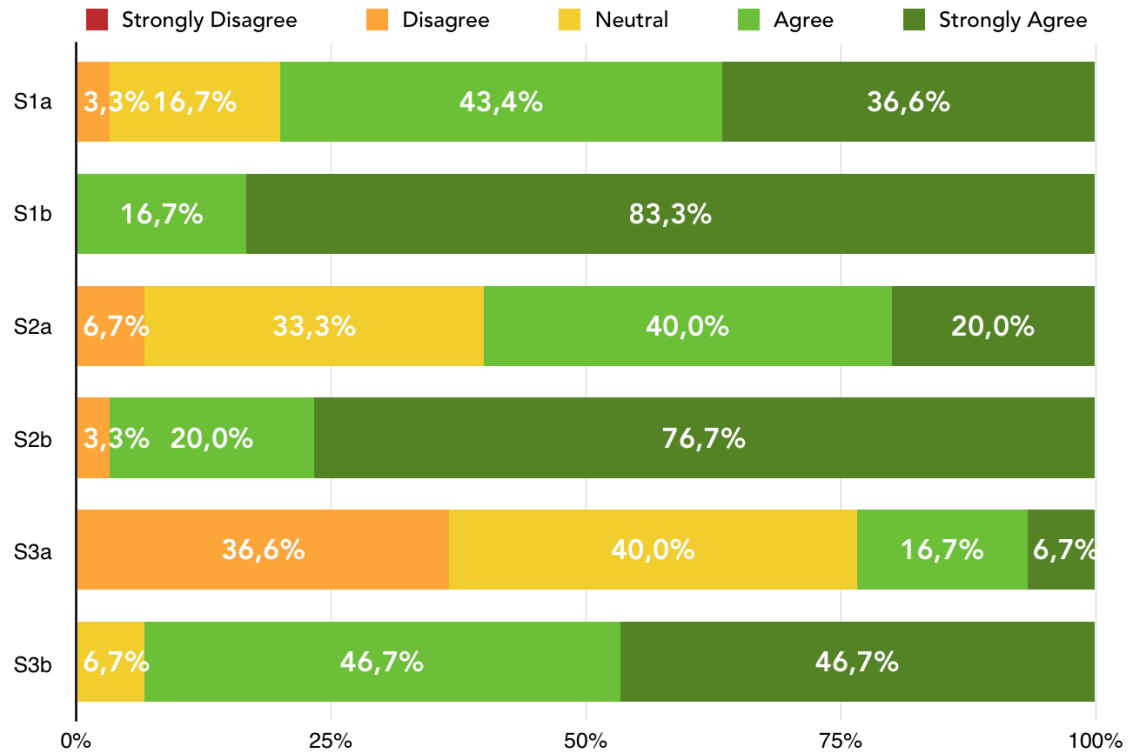
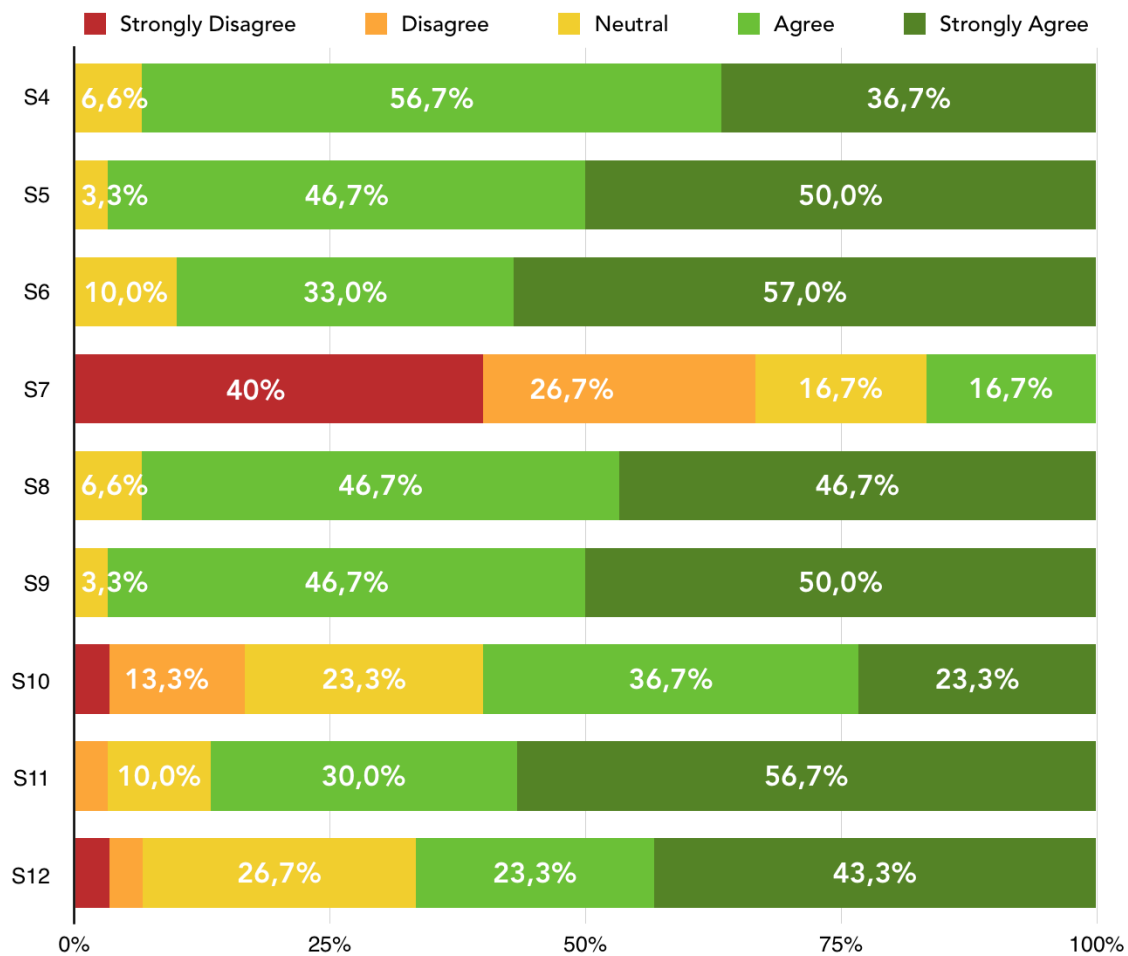


Figure 3.48: Summary of the questionnaire results regarding the user experience at the beginning ("a" statements) and end ("b" statements) of the different scenarios. Low delay in green, medium delay in yellow and high delay in red.

The remainder of the questionnaire also showed positive results. Most participants agreed or strongly agreed with the statements concerning the general feedback (statements 4, 5 and 6) as presented in Figure 3.49. In general, participants liked to use SMUF and found it easy to learn and to use. The feedback regarding the following statements was also positive. First, the majority of the participants stated that they had no difficulties in understanding how the key moments (on the application and on the TV) should be synchronised (40% strongly disagreed and 26.7% disagreed with statement 7). Finally, almost all participants stated that SMUF was useful to synchronise the application with the TV broadcast (both 46.7% agreed and strongly agreed with statement 8).



**Figure 3.49: Summary of questionnaire results regarding the questions presented at the end of each test session.**

Next, we evaluated the different interaction cues to ascertain whether they helped the users to synchronise the application with the TV broadcast. The temporal indication (e.g. “App is 0.5 seconds ahead.”) proved to be very helpful for users to interact with SMUF (46.7% agreed and 50% strongly agreed with statement 9). Regarding the experience rating (e.g. “Great!”), the results were also positive, although they decreased slightly compared with the previous statement (36.7% agreed, and both 23.3% strongly agreed and were neutral with statement 10). Results increased again when users stated that the overall colour helped them to synchronise the application (30% agreed and 56.7% strongly agreed with statement 11). Finally, users stated that the illustrative animation helped to synchronise the application (43.3% strongly agreed 23,3% agreed and 26.7% were neutral about statement 12). To further establish which were the most useful interaction cues, we analysed the average rates for each of the corresponding statements. As expected, results were undeniable regarding the two most preferred interaction cues: the temporal indication ( $\bar{x} = 4.467$ ,  $\sigma = 0.57$ ) and

the overall colour ( $\bar{x} = 4.4$ ,  $\sigma = 0.81$ ). The illustrative animation came in third place ( $\bar{x} = 4.0$ ,  $\sigma = 1.08$ ) while the experience rating came in last place ( $\bar{x} = 3.633$ ,  $\sigma = 1.09$ ).

Finally, one third of the participants entered their comments and suggestions. Participants mainly approached 3 topics: tactile feedback, secondary events and the predictions' interaction flow. In the first case, users wanted the device to vibrate on whistles that signalled the start and end of each half of the matches, as they were confused if the whistle was on TV or on the mobile application. We agree with this concern – vibration is already used when the other key moments occur – and we followed the users' suggestion. In the second case, users asked for more secondary events such as free throws, to help synchronising the application. We think this might not be ideal during a full match (too many events can annoy users), but an alternative can be to add a rule to automatically turn off secondary events after the user has set the application as synchronised with the TV broadcast. Finally, regarding the last case, users were somewhat annoyed by the fact that they could not change the delay after making a prediction, and while waiting for its outcome. As it stood in this version, users had to wait for the outcome of a prediction before being able to come back to the main screen of the application or the SMUF screen automatically appears. However, we noticed that it makes sense to let users change the delay during this time, and shortly after the tests we made the necessary adjustments to let users access SMUF after a prediction, while still being able to access the outcome afterwards.

### **3.4.5. Cheating-Free Competition Stage**

In the second development phase we sought to prevent a flaw that can happen when allowing users to synchronize their second screen applications through synchronization methods like SMUF or ACR. In this case, in a competitive game context, if players synchronize with a delay higher than the real delay of the TV broadcast, they will have an unfair advantage over the others. Therefore, to deliver a cheat-free gaming experience we developed two modules: a Cheater-Detection Module (CDM) and a Cheating-Penalization Module (CPM), with the first one allowing the system to detect users with a "abnormal gaming pattern" (e.g., several correct answers in a row in a very short time period), who may be classified as "cheaters", while the latter penalizes those users who try to exploit SMUF. This solution can be easily integrated as a layer in a second screen game project, keeping the game mechanics intact while providing a synchronized and cheat-free experience.

### 3.4.5.1. Design and Development

Since each user has its own TV broadcast delay, gaming skill, and syncing behaviour, we argue that to detect cheaters in the system, users should be classified according to their unique profiles. Thus, to develop the CDM we used P<sup>2</sup>MUCA [164] and followed its generalized model for personalization in order to build a profile for each user according to her gaming and syncing behaviours, based on interaction data (resources), such as the current application delay, and the total number of key moments responded. CDM allows the system to detect users with an “abnormal gaming pattern”, which may be classified as cheaters. On the other hand, the CPM deals with the users who are detected as cheaters by the CDM, returning the users’ cheater status, according to their previous behaviours. The module can also be used directly by the game mechanics of the second screen application since its output is a cheater status (counter) that will be used to set the users penalization. In the context of this work, this status is used to automatically restrict the delay set by cheating users while interacting with SMUF.

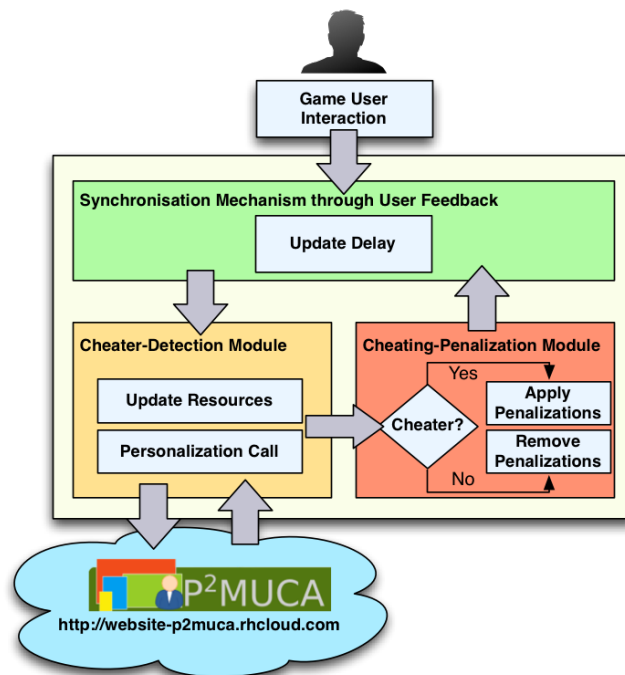


Figure 3.50: Architecture with the algorithm’s main actions.

Figure 3.50 summarizes how our solution works. A user interacts with the gaming interface, either to play or to synchronize the application through SMUF. Next, CDM updates the interactions resources involved in the current interaction (e.g., the application delay or an answer to a quiz question), and calls P<sup>2</sup>MUCA, which returns the user’s profile. This profile is used to deter-

mine whether the user is a cheater. This information is then sent to CPM, which acts accordingly, removing penalizations (if the user had any) in case of a negative result or updating the user's cheater status, when the user is detected as a cheater. Afterwards, the cheater status is used to define the user's penalizations.

### **Cheater-Detection Module**

We needed to implement a CDM in order to cope with potential dishonest users as they can freely control the application delay with SMUF. In the implementation of CDM, we followed the generalized model for personalization provided by P<sup>2</sup>MUCA [165], which can help us expressing what can be a cheater's profile according to the users' gaming and syncing behaviours. Therefore, application delays placed by the users should be personalized (automatically adapted) to benefit the users' experiences and prevent them from cheating.

P<sup>2</sup>MUCA is a personalization platform for multimodal ubiquitous computing applications that provides tools and services to help developers in the implementation of personalization solutions. The core of this platform is the generalized personalization model called X-Users, which can be applied to different applications from different domains. In order to use P<sup>2</sup>MUCA and apply X-Users, we should decide a priori, at design time, what should be personalized.

Thus, in WeSync, since we wanted to automatically adapt the application delay set by users according to their behaviours in the second screen gaming experience, we had to select a set of resources, in the context of WeSync, and combine and weigh them to obtain two parameters: GamerProfile and SyncerProfile. The used resources were:

- **keyMoments (R1):** total of key moments answered.
- **totalResponseTime (R2):** sum of the response time used for all answers.
- **totalCorrectResults (R3):** total of correct answers.
- **currentUserDelay (R4):** current value of the application delay after last key moment, placed by user.
- **totalDeltaUserDelay (R5):** sum differences between successive application delays at each key moment.
- **totalUserDelay (R6):** sum of the application delays at each key moment.

Each parameter is given by a mathematical expression that results in a numeric value representing a specific user behaviour in terms of the specified resources. At each key moment, the user will therefore have two values: the

GamerProfile represented by equation (1), and the SyncerProfile represented by equation (2).

$$0.3 / (R2/R1) + 0.7 * (R3/R1) \quad (1)$$

$$0.5 * R4 + 0.25 * (R5/R1) + 0.25 * (R6/R1) \quad (2)$$

These equations were determined after several simulations and the results obtained in the first phase of the user tests (described in the Evaluation section) confirmed them as being appropriate for this work. We were mainly interested in discovering if at each key moment a user should be marked as a cheater (meaning s/he set a delay higher than the real one), or not. So, initially we decided to represent only two profiles (for cheater and non-cheater) and, for that, we only needed a parameter (e.g., called TVViewerProfile). However, we found out that two parameters would make much more sense with the separation of resources into Gamer and Syncer profiles, giving us a greater granularity to work on. This way, we defined two options for each parameter: High and Low (they revealed themselves as being appropriate as demonstrated by the results in the section 3.4.5.2 – “Evaluation”). This way, P<sup>2</sup>MUCA’s clustering algorithm divides the users in two clusters for each parameter, representing the profiles, and receives as input a parameter vector composed of the parameters’ values representing each user [165]. The permutations of these two options (clusters) per parameter correspond to four personalization options: Non-Cheater Tier-1, Non-Cheater Tier-2; Non-Cheater Tier-3, and Cheater (Table 3.25).

**Table 3.25: Combinations of the two parameters options.**

	High Gamer value	Low Gamer value
High Syncer value	<b>Cheater</b>	<b>Non-Cheater Tier-3</b>
Low Syncer value	<b>Non-Cheater Tier-2</b>	<b>Non-Cheater Tier-1</b>

In our study, we considered that a user should only be marked as a cheater (final profile) when both parameters (sub-profiles) result in high values. The three tiers of non-cheater should be treated equally by the application if it is not necessary to distinguish non-cheater users that have different sub-profiles.

### **Cheating-Penalization Module**

It is necessary to take action after detecting a user as a potential cheater. While we could simply prevent a user from playing the game, it is necessary to take into account that due to factors like luck, network latency, lack of infor-



mation regarding the real TV delay, and possible imprecisions of the CDM, we need to give users the benefit of doubt. Therefore, we setup three penalization stages that are applied after the users are identified as potential cheaters:

- **Penalization Warning:** the first time a user is identified as a potential cheater a message appears on the second screen application stating that the delay set by the user does not correspond to the real delay of the TV broadcast s/he is watching, and therefore, the system reset it back to 0 seconds. The message also states that the user can change the delay again as s/he wishes, but if the same behaviour is repeated, s/he will be penalized. However, if the user thinks that this message is an error (i.e. a false positive), s/he can ignore it. To dismiss this message, the user can click on a button labelled: "OK, I understand" which will take him to the SMUF screen
- **Temporary Penalization:** if the system identifies a user as a potential cheater and verifies that the user was detected as a cheater on the previous evaluation, a temporary penalization message will be displayed. In this case, it is stated that the user's delay still do not correspond to the TV broadcast s/he is watching, so the delay resets to 0 seconds, and the user cannot change it until the personalization profiles changes back to non-cheater. Each time the user is detected as a cheater in the next three evaluations – which can be the result of continuous cheating (e.g. user is listening to the radio), or having a high clustering value –, the user's delay will still be equal to 0 seconds, and his/her cheater status will be incremented.
- **Permanent Penalization:** finally, if the system verifies that a user was detected as a cheater on the four previous evaluations (cheater status = 4), a message appears stating that from now on the user's delay is 0 seconds and s/he cannot change it anymore until the end of the competition.

The reason we started by adding a penalization warning was to acknowledge users that they could be doing something unexpected. We wanted to give them the possibility of choosing a new delay - or the same delay if they were being honest and a false positive was detected -, and at the same time notify them to rethink their behaviour, since they could be penalized. With the temporary penalization, we sought to punish users on the next key moment by resetting their delay to 0 seconds, so they could not watch what would happen on the TV broadcast before receiving the key moment on the application. The idea was to evaluate how users behave (do they still keep giving correct an-

swers?) when a delay was not set, like if they were on the venue where the event was taking place. Once again, to account for false positives, which can just be due to luck on a couple of key moments, the system does not apply a harsh penalization until a user receives 4 consecutive temporary penalizations. After this, a permanent penalization is applied that sets the user's delay to 0 seconds and prevents him from changing it until the end of the broadcast. Figure 3.51 presents a summary flow of the CPM that helps to understand the previous descriptions. It is important to note the existence of the Cheater Status counter, which serves as an auxiliary flag in order to determine when to apply a temporary or a permanent penalization. For game developers, the Cheater Status can be useful if there is the need for applying penalizations that change the game mechanisms, like the removal of game points, the impossibility of participating in the next events, or even the prohibition of playing the game.

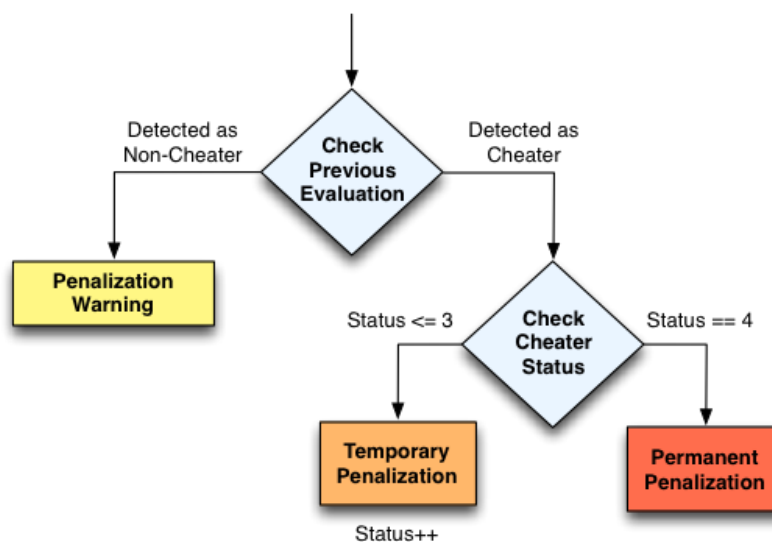


Figure 3.51: Summary flow of the cheating penalization module when a user is detected as a cheater.

Although we considered other alternative processes to penalize a cheater, none of them led to conclusive results during our preliminary informal evaluations.

### 3.4.5.2. Evaluation

We carried out two phases of user tests with the WeSync prototype in order to evaluate the users' feedback regarding the different parts of the proposed system. In the first phase we aimed to collect data to create and adjust the different personalization profiles. CDM and CPM were not used in this first phase. In the second phase, we wanted to evaluate the system as a whole, studying how users interact with it and collecting data to analyse how well CDM and

CPM worked to ensure a cheat-free gaming experience when SMUF is used. In both phases, the tests were conducted individually for each participant. Finally, at the end of each phase, participants filled in a questionnaire.

### Phase 1

The user tests were conducted with 15 voluntary participants (11 male and 4 female) aged 23-45 ( $\bar{x} = 31.5$ ,  $\sigma = 7.4$ ). The tests took place in a lab at our University campus. Each participant's test session was divided in two consecutive parts. In each part, the participant watched a different 8-minute highlight football match, containing six key moments to predict what the outcome would be. Each participant had two initial moments to become familiar with SMUF, before the key moments start appearing, allowing them to better understand how to set a delay. After the first part of a test session, we asked the participant to rate six statements in a questionnaire (using a five-point Likert-type scale, which ranged from strongly disagree (1) to strongly agree (5)) regarding their experience (Table 3.26).

Table 3.26: Statements of the Phase 1's questionnaire.

Statements
<b>Synchronisation Mechanism</b>
S1. I had a good experience.
S2. It is easy to use the interaction mechanism.
S3. This mechanism is useful to synchronise the application with the TV broadcast.
<b>Competition and Cheating Perception</b>
S4. This mechanism allows for an unfair competition.
S5. It is easy to cheat while using the synchronisation mechanism.
S6. The synchronisation mechanism motivates me to be honest while using it.

Like in the previous tests, the questionnaire revealed very positive results regarding the user experience with SMUF. Figure 3.52 shows that, in general, participants had a good synchronization experience ( $\bar{x} = 4.1$ ;  $\sigma = 1.13$ ) and found it easy to use ( $\bar{x} = 4.0$ ;  $\sigma = 1.07$ ) and useful to synchronize the application with the TV ( $\bar{x} = 4.6$ ;  $\sigma = 0.83$ ). The remainder of the questionnaire also showed very interesting results. Although the majority of participants have agreed that SMUF allows us to have an unfair competition ( $\bar{x} = 3.8$ ;  $\sigma = 1.32$ ), there are a considerable number of neutral opinions and two participants even stated that "the competition would not be unfair since everyone has the same conditions to cheat". Participants really found it easy to cheat using SMUF ( $\bar{x} = 4.4$ ;  $\sigma = 0.83$ ),

generally after a few key moments. Nonetheless, results showed participants felt motivated by SMUF to be honest ( $\bar{x} = 3.6$ ;  $\sigma = 1.18$ ). We believe this happens because of social and peer-pressure. It is interesting to refer that one participant told us he would be dishonest if he would perceive that others were cheating.

Furthermore, we also asked participants to indicate (using a five-point Likert-type scale which ranged from dishonest (1) to honest (5)) how they behaved in terms of honesty when setting the application delay for each of the six key moments (e.g. I was honest on the first key moment, I was dishonest on the second event...). This was important to link the gathered interactions data with the users' perception on cheating, in order to ascertain different profiles (i.e. this way we were able to analyze how different types of users behaved).

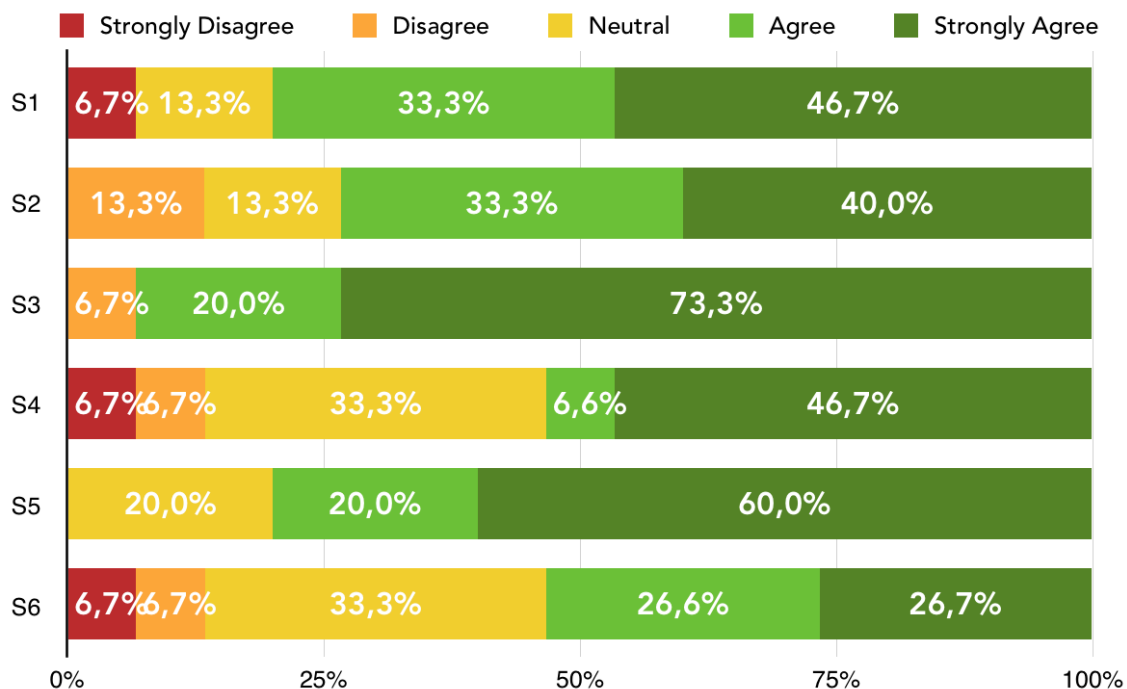


Figure 3.52: Summary of the questionnaire results of Phase 1.

In the second part of the test, we asked each participant to set an application delay for each key moment according to a “behaviour guide” with soft indications on how we would like each participant to behave (e.g. be dishonest on the first key moment, be honest on the second event...). This way, we could gather interactions data (delays set by the users) that corresponded to different profiles, having participants behaving according to our four options (non-cheater tier 1, non-cheater tier 2, non-cheater tier 3, and cheater). Results obtained helped to further determine the different profiles, and to tune the GamerProfile and SyncerProfile equations, as presented in the Cheater-Detection Module sub-section.

## Phase 2

The second phase of user tests was conducted with 30 voluntary participants (21 male and 9 female) aged 18-36 ( $\bar{x} = 20.67$ ,  $\sigma = 3.6$ ). The tests took place in the lobby area of the library in our University campus. Before each test session, participants were briefed about the test, noting that this was a game competition with a digital prize to be awarded by the end of the tests, in order to encourage users to compete using all possible means.

Each participant watched a 6-minute highlight video from a football match that took place in 2012. While some participants may have remembered the final result of the match, none of them could recall the plays featured on the highlight video. During the video the users were prompted to predict the outcome of 12 corner kicks or free kicks, and they received 1 notification of the start of the match. This notification, and the first two predictions were used as learning checkpoints so users could understand how to interact with SMUF and how the predictions unfolded. After presenting the outcome of a prediction, WeSync updates the different resources on P<sup>2</sup>MUCA (as described in the Cheater-Detection Module sub-section), and requests a new personalization profile, in order to know how to react to the current user's behaviour (i.e. should the user be penalized or not).

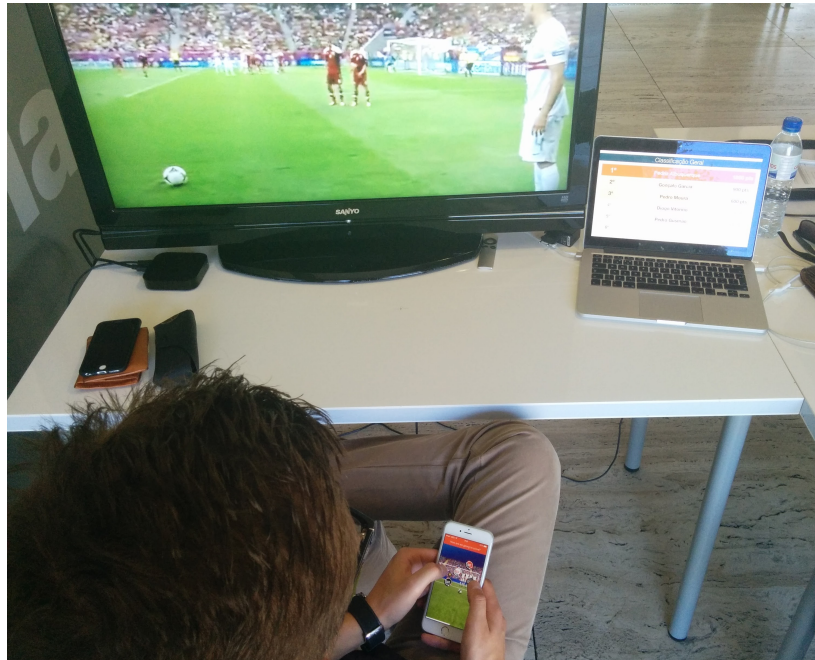


Figure 3.53: Participant playing WeSync during tests.

Users had 7 seconds to answer to each prediction request (a decreasing bar indicated the remaining time users had to answer), which was enough time to

visualize what was happening on the field and make a prediction. Each correct guess was awarded 300 points (0 points for wrong guesses), which means that the highest possible score was 3000 points (the first 2 predictions did not count towards the score). A scoreboard was added next to the television, so users could quickly check how they were standing comparing to the previous players (Figure 3.53).

### Questionnaire

The first part of the questionnaire gathered users' personal data, such as, age, gender, and their familiarity with second screen applications. Then, we asked users to rate (using a five-point Likert-type scale, which ranged from strongly disagree (1) to strongly agree (5)) 10 statements. The first six were exactly the ones used in the Phase 1's questionnaire. The remaining four statements addressed mainly the detection and penalization modules (Table 3.27).

**Table 3.27: Additional statements of the Phase 2's questionnaire.**

Statements
S7. I had a good experience.
<b>In case you were detected as a cheater...</b>
S8.1. I think the detection mechanism acted properly.
S8.2. I think the penalization mechanism was adequate.
S8.3. I think I would not cheat, if I knew that there was a cheating detection mechanism beforehand.

### Results and Discussion

Users made 360 predictions, and accessed SMUF 140 times ( $\bar{x} = 4.66$  per test session) during the whole evaluation process. As stated before, after each prediction's outcome, a personalization profile was requested from P<sup>2</sup>MUCA and, during these tests, the system classified the users as following: 22% as "non-cheater tier-1", 44% as "non-cheater tier-2", 17% as "non-cheater tier-3", and 17% as "cheater". From the users classified as cheaters, 72% were really cheating at the time (users' delays were higher than the TV delay and the answers were always correct), but 28% were not (false positives). However, not even all false positives had consequences beyond the penalization warning (only 23% had a temporary penalization with cheater status = 1), and all of them rolled back to a non-cheater profile after it. Finally, it is also important to note that all users who tried to cheat (9 participants, 30%) were detected and, in

three of these cases, if the video was longer, they would have been permanently penalized and therefore unable to further change the delay.

We also analysed the behaviour of different users during the user tests and we point out some of them. For instance, two users with different profiles (one of them being a cheater) ended up obtaining the same top score (1800 points). This of course was not desired, as a cheater should not have achieved such a high amount of points. However, his cheater status was equal to 3, which means that he was very close to have a permanent penalization if the test had continued (one more key moment would be enough). As an advice, if game developers want to prevent this kind of scenario, they can penalize users by resorting to the game mechanics (in the case of WeSync, by deducting points). We also analysed two other cases, where a user with 600 points was penalized early on for being a cheater - and then tried to increase his delay to see how far he could go, until he was penalized again -, and another one with 900 points who after being detected as a cheater changed his behaviour by decreasing the delay initially set.

Regarding the questionnaire, results revealed that participants did not use second screen applications to interact with the TV broadcasts on a regular basis. The majority of participants (46.67%) stated that they never use second screen applications, while 26.67% rarely use it. A fifth of the participants (20%) frequently interact with second screen applications related with the TV broadcasts, and 6.67% use it very frequently. Nevertheless, during the briefing, the researchers conducting the tests explained what were second screen applications, as well as the problem of having applications not synchronized with the TV broadcast, and the participants seemed to have understood the concept.

Regarding the synchronization mechanism, 53.3% of the participants agreed with statement 1 and 23.3% strongly agreed with it (Figure 3.54). When we asked if SMUF was easy to use, the response was very positive. The majority of participants strongly agreed with statement 2 (46.67%), while an equal number of participants (26.67%) agreed or were neutral towards it. Participants understood the issue that SMUF tried to solve, as they rated statement 3 very positively: 53.3% agreed and 40% strongly agreed with it. These results corroborate the ones from Phase 1, where different participants also stated that SMUF was easy to use and useful to synchronize a second screen application with the TV broadcast.

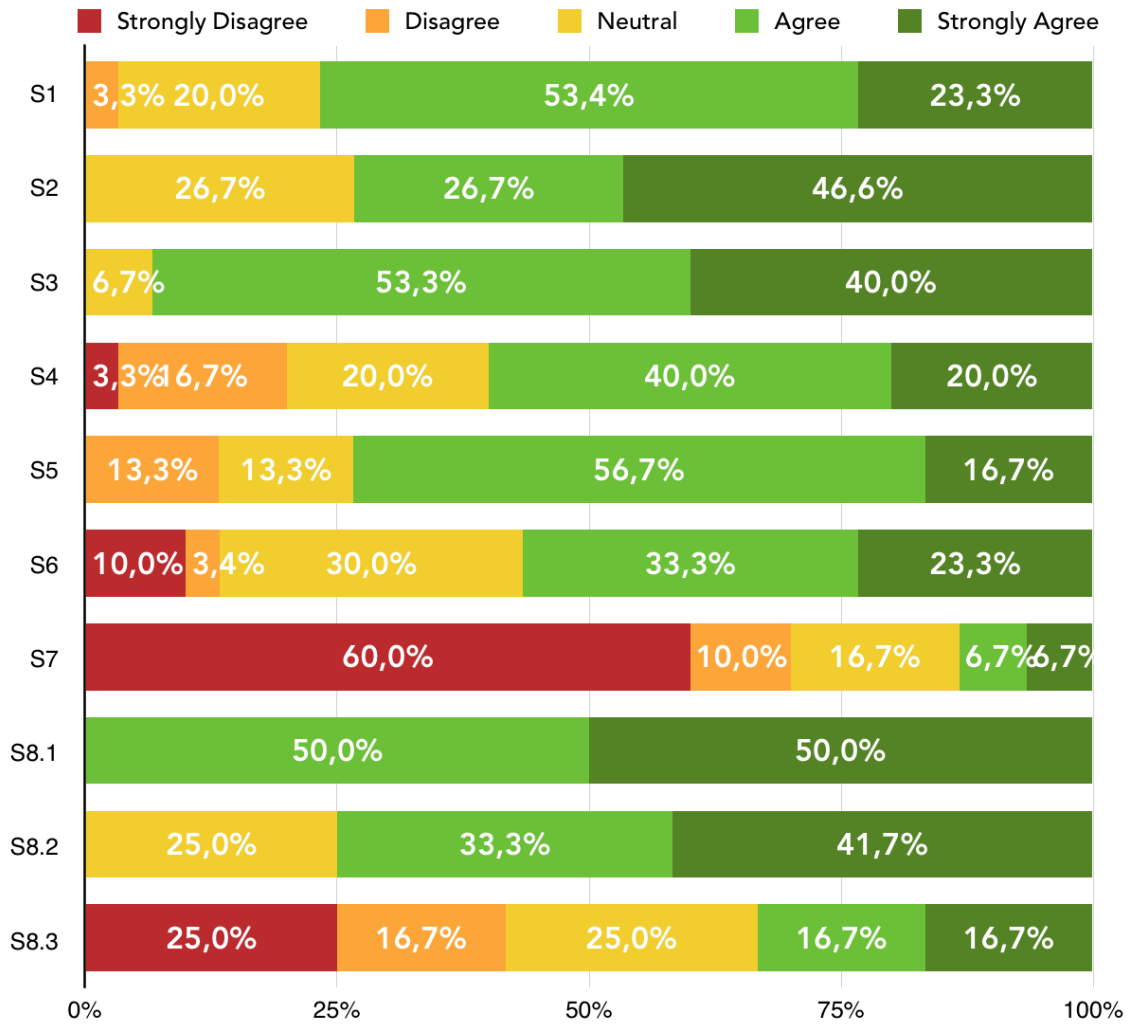


Figure 3.54: Summary of the questionnaire results of Phase 2.

Regarding the statements related with the gaming competition, most of the participants stated that SMUF allows for an unfair competition (40% agreed and 20% strongly agreed), meaning that participants understood how to exploit this synchronization mechanism. Even so, there were 20% of participants who were undecided about this statement, some of them stating at the end of the questionnaire that they only realized that SMUF allowed for an unfair competition after playing WeSync. Similarly, 56.7% of participants agreed and 16.7% strongly agreed with statement 5 (it is easy to cheat while using the synchronization mechanism). However, the results from both statements 4 and 5 ( $\bar{x} = 3.6$ ,  $\sigma = 1.10$  and  $\bar{x} = 3.8$ ,  $\sigma = 0.89$ , respectively) showed lower values than the ones from Phase 1 ( $\bar{x} = 3.8$ ,  $\sigma = 0.57$  and  $\bar{x} = 4.4$ ,  $\sigma = 0.82$ , respectively), showing that in the presence of the detection and penalization modules, participants do not find it so easy to exploit the synchronization mechanism. When we asked participants if the synchronization mechanism motivated them to be honest while



using it (statement 6), results were very similar to the ones found in Phase 1 ( $\bar{x} = 3.6$ ,  $\sigma = 1.18$  at Phase 1 and  $\bar{x} = 3.6$ ,  $\sigma = 1.19$  at Phase 2). Once again, we believe that these results may be a result of external factors like social peer-pressure, being observed, or being seen as a dishonest person playing WeSync, although we aim to further investigate this topic in the future. Finally, results from statement 7 were not surprising, as we knew beforehand from the analysis of the data logs that only 30% of participants tried to cheat. Therefore, results from the questionnaire match the ones from the data logs, which show that 60% of participants disagreed with statement 7 (i.e. the majority of them did not cheat), while 16.7% were undecided about it.

Lastly, participants who were detected as cheaters (false positives included), were asked to rate three additional statements: 8.1, 8.2, and 8.3 (40% of the total participants answered these questions). Regarding 8.1, results were clearly positive as all participants who rated this statement agreed or strongly agreed with it (50% each). This means that the participants believed that the CDM was working properly, even if sometimes a false positive occurred. Next, we evaluated if the penalization mechanism (CPM) was adequate and the results were equally positive (41.7% strongly agreed and 33.3% agreed). Finally, participants had mixed feelings regarding statement 8.3, and thus, conclusive results cannot be drawn from it.

As for the suggestions and comments made by participants, some of them stated that they noticed they could exploit the system only after playing WeSync, or after synchronizing it with the football match. One participant said that he liked the experience and he thought that second screen applications like WeSync will improve the way we watch TV broadcasts. Lastly, one participant alerted to the possibility of using other devices (e.g., radio) to know in real time what will happen next on some TV broadcasts. In this case, the CDM may not detect that the user is classified as a cheater (since s/he may not have a High Syncer value), and a possible solution may be to monitor the user's answers (manually or automatically) in order to ascertain if there is an excessive number of correct answers in a short interval. Nevertheless, as in any competitive gaming scenario, we advise developers to always monitor all top players' scores, as there are not fail proof anti-cheating methods.

### **3.4.6. Conclusions**

WeSync development allowed us to validate the SMUF concept and interaction, as well as the design philosophy of CDM and CPM. One of the most important results was that participants stated that they had a better user experi-

ence by using SMUF to synchronise WeSync with the different videos. This marks an important milestone in our study, since it has been presented that an out-of-sync application can be improved by having it synchronised with the TV broadcast. Thus, within our context, it makes sense to apply SMUF to the others prototype concepts as well: to synchronise the moment that users need to applaud with the match's action (WeApplaud); to being able to predict goals effectively without being spoiled about the outcome of dangerous plays (WeBet), and to discuss the same events in-sync with friends (WeFeel). Therefore, we argue that any kind of second screen application should be synchronised with the TV broadcast in order to provide an optimal user experience. Like IDMS and ACR, SMUF is another method that helps users to achieve this goal. We hope that in the future, new second screen applications can adopt SMUF's design, or even improve it, in order to deliver a synchronised experience to all the remote fans worldwide.

Regarding the use of CDM and CPM, our approach presented to be valid as we were able to detect the users trying to cheat, based on diverse resources like the current users' delays and the number of key moments answered. Those identified as cheaters were penalized by setting their delay back to 0, which prevented them from answering what would happen in the next key moment after watching it on the TV broadcast. Although some users won points before they were penalized, we did not perceive it as an issue as it is up to game designers to decide which consequences should be applied according to the game mechanics. In WeSync we decided to be more benevolent and give the benefit of the doubt to users, but in a real life context where users may be playing for real prizes (e.g. money or expensive items), harsh penalties should be applied.

Even though some false positives were detected, we consider it being a normal consequence of the early version of the algorithm. Further improvements can be done, by adjusting the parameters of the cheater-detection module in order to obtain even less false positives. Nevertheless, we promote the usage of both modules in similar second screen gaming applications that have competitions taking place. We hope that these solutions can be used as motivational factors to deploy new kinds of second screen games, not only based on mobile devices (e.g. WeSync and WeBet), but also on the television to provide richer experiences (e.g. WeApplaud). Perhaps in the future, we can even see a new breed of competitive games that become a new genre in eSports, relying on mechanisms similar to the ones that we presented.

# 4

## Enhancing Fan Experience in Sports, TV Shows and eSports

*A mind that is stretched by a new experience can never go back to its old dimensions.*

- Oliver Wendell Holmes, Jr., Judge

In the previous chapter we presented four proof-of-concept prototypes we developed to enhance the user experience during live football matches TV broadcasts. These prototypes were based on four different interaction concepts: to applaud on key moments, to make live predictions, to share emotions and opinions with others, and to synchronise second screen applications with TV broadcasts. In this chapter, we show how these concepts can be applied beyond football, in different sports, live TV shows, and eSports.

Since we initially applied the four concepts to football, we started by analysing how they could be generalized to any kind of live event. Table 4.1 presents the interaction concepts in two scenarios: in the football scenario as studied in Chapter 3 and in a general scenario, in order to fit a wide range of live events.

**Table 4.1: How the different interaction concepts are applied in the football scenario, and how they can be generalized to different kinds of live events.**

Interaction Concepts	Scenarios	
	Football	General
<b>Applaud on Key Moments</b>	Applaud along the chants, when a great play occurs, when a goal is scored, or at the end of the match.	Applaud to support a performance or to show appreciation.
<b>Make Live Predictions</b>	Guess a play's outcome.	Guess if a certain outcome will happen next.
<b>Share Emotions and Opinions</b>	Assess emotions in a reliable and quick way and present the overall fans' emotions after a great play, a goal, a red card, or at the end of a half.	Assess emotions in a reliable and quick way and present the overall fans' emotions following predefined moments (manually triggered) or after detecting emotion sharing peaks (automatically triggered).
<b>Synchronise Second Screen Applications</b>	Ask how is the user experience at the beginning and end of halves, goals, corner kicks, free kicks and penalty kicks.	Ask how is the user experience after key moments that do not distract the users from important action on the TV.

Taking into account the general scenario, we analysed the most popular sports, live TV genres and eSports videogames genres, in order to determine how the four concepts could be applied in different contexts. Given the nature of this work, we started by analysing the most popular sports.

## 4.1. Sports

Due to the media impact that Summer Olympic Games have all over the world, we decided to analyse how the interaction concepts could be applied on the sports scheduled for 2016 Summer Olympic Games [166]. We also chose to analyse four other sports (American Football, Baseball, Motor Racing, and Cricket), due to their popularity in countries like United States, Japan, France, Spain, Italy, India, and Australia. Thus, we comprised a list of 31 sports, which we classified into five categories: Team Sports, Combat Sports, Target Sports, Racing Sports, and Performance Sports. This classification was based on the resemblances that exist between sports and the similarities on how the interaction concepts can be applied (i.e. fans can perform the same actions in similar moments in different sports, like applauding after a goal in Handball and Field

Hockey). As a side note, we did not classify the modern pentathlon (a sport that is comprised of 5 events: fencing, freestyle swimming, show jumping, shooting, and cross-country run) since it contains a set of sports from different categories, although, all the interaction concepts can be applied to this sport, like they are applied to the corresponding set of sports. Moreover, we did not approach some sports disciplines (such as Synchronising Swimming or BMX) due to the high similarity that they share with other sports (like Gymnastics and Cycling), which we already analyse.

Team Sports refers to the head-to-head competitions that athletes participate to score more points than the opponents. Besides football, this category contains 11 sports: American Football, Rugby Sevens, Basketball, Field Hockey, Handball, Badminton, Table Tennis, Tennis, Volleyball, and Baseball. As a side note, while we acknowledge that tennis, badminton and table tennis can be played in singles, these can also be played in doubles. Like in the football scenario presented before, the most appropriate moments for remote fans to applaud are after a great play, along the in-venue fans' chants, when points are scored, when there is a break (e.g. end of an half or quarter), or at the end of a match. These are usually the most emotional moments of the sport event, and therefore, the most suitable for fans to cheer their team or favourite athlete. Once again, due to the resemblances that these sports have with football, remote fans have different opportunities to guess if a point (or multiple points, depending on the sport) will happen. For instance, in basketball, fans can guess if an athlete will score a free throw, or if a dunk will happen in the next play. The most suitable moments to present the overall fans' emotions are after a great play, when a team scores an important point, or when there is a break (e.g. end of an half or quarter), as presented in Chapter 3. Finally, the application can ask users to rate their synchronising experience at the beginning or end of a break, or after a play's outcome.

Combat Sports are competitive contact sports where athletes engage in one-on-one combats. This category is comprised of 5 sports: Boxing, Taekwondo, Judo, Wrestling, and Fencing. The most suitable moments for remote fans to applaud their favourite athletes are when there is a great movement (e.g. an athlete goes down), a knockout, a point, or when an athlete is on focus (e.g. as they enter the ring). Remote fans can guess count outs, points, pins or knockouts, beforehand (as each round can be seen as a key moment for fans to make their predictions) or anytime they wish due to the unpredictability of the sport (similar to guessing a goal in football). The overall fans' emotions should be presented after a round, point, when an athlete goes down, or after a

knockout, as emotions are expected to have reached peak levels. Lastly, a good opportunity to ask users if the application is synchronised with the TV broadcast is before or after a round (e.g. boxing) or when points are scored (e.g. taekwondo or judo).

In Target Sports, the main objective is for athletes to hit a certain target. We identified 3 sports that fit this category: Archery, Golf, and Shooting. Unlike the sports of the previous categories, athletes do not compete in real time, instead they take turns to achieve the best possible scores. Thus, the most suitable moments to applaud are after the outcome of a shot or a golf swing, since these are the most exciting moments to cheer athletes. Due to the turn-based nature of these sports, remote fans can guess beforehand, if a shot will have a specific score or if a golfer will be a certain amount of yards from the hole in a given swing. As stated before, the most exciting moments to cheer athletes are after the outcome of a shot or a golf swing, and consequently, these are also the right moments to present the overall fans' emotions. To synchronise the second screen application, users can rely on the plays' outcomes to compare the difference between the TV feed and the application's feed.

As the name implies, Racing Sports are speed competitions where a team or individual athletes compete to reach the finish line first. There are 7 sports in this category: Swimming, Canoeing, Cycling, Motor Racing, Rowing, Sailing, and Triathlon. This scenario is quite different from the previous sports categories, because these sports do not rely so heavily on predefined key moments or point systems. As such, it is necessary to determine the different key moments for remote fans to interact beforehand, and sometimes, even introduce different checkpoints during the race (in particular, during long races, like in sailing or cycling). Thus, in this case, remote fans can applaud during the course of a race, either after a breakaway, overtake, to cheer athletes on the final stretch (or lap), or at the end of the race. Similarly, remote fans can also guess if a breakaway or overtake will happen in the next seconds, kilometer or lap, since these are the most exciting actions in this kind of sports. Remote fans should be able to visualize the overall fans' emotions on predefined checkpoints (e.g. after a lap or on the last 200 meters), after a breakaway or overtake, or at the end of the race. Finally, the application can ask how is the user experience at the beginning of the race or after a lap, or on predefined checkpoints when a race is not based on laps (e.g. before an important part of the course, like in cycling or triathlon).

Performance Sports are often individual sports where athletes participate in exhibitions. This category is comprised of 4 sports: Athletics (Track & Field), Equestrian, Weigh Lifting, and Gymnastics. The focus is on the athletes' per-

performances, and therefore remote fans should interact when an athlete is on focus or after the performance's outcome. Thus, remote fans can applaud along the in-venue fans' chants (e.g. slow clap before a triple jump), to cheer an athlete that is being presented, or after a performance. These sports can be performed in turns or in real time, with remote fans guessing specific outcomes such as an evaluation score, if an athlete jumps above or below a distance, or if an athlete is able to lift a weight. The overall fans' emotions can be presented on predefined checkpoints (e.g. after a difficult obstacle in a equestrian course), after a great movement (e.g. gymnastics), or after a performance. Lastly, the most suitable moments to ask how is the user synchronising experience are at the beginning or end of an athlete's performance, or at predefined checkpoints (e.g. when there is 5 km left to end a marathon).

To summarize the previous discussion, Table 4.2 presents a brief description of the sports categories and how they can be explored to apply the four interaction concepts.

**Table 4.2: Summary of the sports categories and their characteristics.**

Categories	Description	Sports
<b>Team Sports</b>	Real time head-to-head competitions characterized by having multiple key moments that can be used to enhance the fan experience.	American Football, Rugby Sevens, Basketball, Football, Field Hockey, Handball, Badminton, Table Tennis, Tennis, Volleyball, Baseball, and Cricket.
<b>Combat Sports</b>	One-on-one combats where point systems and breaks can be explored to provide propitious moments to interact.	Boxing, Taekwondo, Judo, Wrestling, and Fencing.
<b>Target Sports</b>	Turn-based sports events where the most appropriate moments to prompt fans to interact are before or after each athlete's action.	Archery, Golf and Shooting.
<b>Racing Sports</b>	Short or long speed competitions, which may require the use of predefined checkpoints in order to apply the four interaction concepts.	Swimming, Canoeing, Cycling, Motor Racing, Rowing, Sailing, and Triathlon.
<b>Performance Sports</b>	Sports that are often based on individual exhibitions, and thus, fan interaction can be explored mainly before or after the different performances.	Athletics, Equestrian, Weight Lifting, and Gymnastics.

## 4.2. TV Shows

Over the years, the television industry has spawned multiple TV genres to appeal different demographics. Today, besides the variety of TV shows that integrate a network television schedule, there is also a wide range of thematic network channels purely focused on broadcasting a specific type of content to certain ages and genders. Thus, in order to identify the TV genres that could be most suitable to apply the interaction concepts, we took into account the resemblances that sports can have with the different TV genres. As such, we sought to apply the interaction concepts in TV genres that featured the following conditions: were broadcasted live and were able to convey strong emotions due to the existence of unpredictable events. From a study conducted by Film Victoria (an Australian State Government agency that provides strategic leadership and assistance to the film, television and digital media sectors) to analyse free to air programming by genre and network [167], we were able to identify four TV genres that checked previous conditions: Reality Shows, Game Shows, News Shows, and Talk Shows. Additionally, we also analysed Award Ceremonies broadcasts (such as The Oscars [168] or The Golden Globes [169]) due to their high popularity and worldwide media coverage.

Reality Shows are a TV genre that often uses unknown cast to document daily non-script situations. This genre has become highly popular since the debut of series like Big Brother [170], Survivor [171], and Idols [172]. Today, there is a wide range of shows broadcasted in different countries such as The Amazing Race [173], The Biggest Loser [174], Master Chef [175], Got Talent [176], and Secret Story [177]. Although there is not a clear definition for a reality show, we considered the shows that featured contests over a long period of time (months) and incorporated audience involvement (usually through voting). In these cases, the most appropriate moments to applaud are those during or after contestants' performances, or to support a contestant (e.g. after s/he is voted out of the competition). Remote viewers can also guess if a certain contestant will advance or not to the next round, or achieve a specific outcome (think of the minor game events in shows like Big Brother or Secret Story). Regarding the overall fans' emotions, these can be presented after the voting results, when juries give their opinion, after an emotional event between participants (like a kiss), or after an outstanding or terrible performance. Finally, the change of content segments and commercials are good opportunities to ask users to rate their synchronising experience, as they can be used to compare the broadcast feed and the second screen application feed. These situations can be explored in the same way in Game Shows, News Shows, Talk Shows, and Award Ceremonies.



Game Shows usually rely on answering questions or solving puzzles for prizes. Examples of shows are: Jeopardy! [178], The Price is Right [179], Money Drop [180], Who Wants to be a Millionaire? [181], Weakest Link [182], and Wheel of Fortune [183]. Although the majority of these shows may not be broadcasted live (so producers can have absolute control over the show), once in a while there are special live broadcasts, which do not have an impact in the show format. In this case, viewers can applaud when contestants are presented, after a puzzle is solved, or a correct answer. Viewers can also predict if a contestant will overcome a puzzle or correctly answer a question. Similarly, the most appropriate moments to present the overall fans' emotions are after the outcome of puzzles or questions.

News Shows go back as the television inception. They were, and still are, hugely popular shows that report daily news and late breaking stories. Well-known examples of this genre are the classic newscasts (think of Today [184] and SportsCenter [185] shows), interviews, and debates like the ones before electoral campaigns. In these situations, the most appropriate moments to applaud are after an answer from a guest, as there are not many other situations that remote fans can engage with the in-venue audience. However, the possibility to make live predictions does not seem to fit this scenario, as there are not any relevant outcomes to guess. Finally, the overall fans' emotions are suitable to be presented after a news highlight or an answer from a guest, as these are moments that can trigger affective responses in the viewers.

Today's Talk Shows feature a host discussing different topics with guests, comedy sketches, and musical performances. This genre is very popular in United States, Europe, and Japan, with iconic shows running for several years. Some examples are: The View [186], The Talk [187], Larry King Live [188], Live! with Kelly and Michael [189], Você na TV [190], and Waratte ii tomo! [191]. In this kind of show, remote viewers can applaud like if they were in the audience after specific events (e.g. interview introduction or musical performance) or a guest's answer. Due to the high interactivity that these shows can have with guests and both the in-venue and remote audiences, it is easy to picture different segments where remote viewers can predict what will happen in certain events (e.g. "will a guest be able to do 50 two-foot jumps?", "how many quiz questions will a guest be able to answer in 30 seconds?"). Lastly, remote viewers can visualize the overall fans' emotions after a segment (e.g. comedy sketch), a guest's answer, or a musical performance.

Finally, the Award Ceremonies are remarkable events that honour industries' achievements. Like sports, it is undeniable that they have the power to

unite the whole world in front of the television. Examples of popular Award Ceremonies are The Oscars [168], The Golden Globes [169], The Emmys [192], The Grammys [193], FIFA Ballon d’Or [194], and Laureus World Sports [195]. Appropriated moments to applaud are after a nominee wins an award, to introduce a nominee or host, after a content segment or a musical performance. Naturally, remote viewers can predict which nominee will win an award, and therefore, different competitions can be designed around this concept. Lastly, remote viewers can visualize others’ emotions after a nominee wins an award, a content segment, or a musical performance.

To summarize this analysis, we present in Table 4.3 a description of the previous TV genres and how their features can be explored to apply the interaction concepts.

**Table 4.3: Summary of the TV genres and their characteristics.**

Genres	Description	Examples of Popular Shows
<b>Reality Shows</b>	Non-script TV shows featuring different performance segments and daily situations that can be used to enhance the viewer experience.	Big Brother, Survivor, Idols, The Amazing Race, The Biggest Loser, Master Chef, Got Talent, and the Secret Story.
<b>Game Shows</b>	TV shows that present several challenges to participants, which can be explored to apply the different interaction concepts.	Jeopardy!, The Price is Right, Money Drop, Who Wants to be a Millionaire?, Weakest Link, and the Wheel of Fortune.
<b>News Shows</b>	Informative shows structured around news segments and guests’ answers, which are suitable to prompt remote viewer interaction.	Classic newscasts, interviews, and debates.
<b>Talk Shows</b>	Chat shows that have the possibility to involve the remote audience in different activities, due to the openness of the show script.	The View, The Talk, Larry King Live, Live! with Kelly and Michael, Você na TV, and Waratte ii tomo!.
<b>Award Ceremonies</b>	Noteworthy live events broadcasted worldwide, where remote viewers can interact particularly during the award inductions.	The Oscars, The Golden Globes, The Emmys, The Grammys, FIFA Ballon d’Or, and Laureus World Sports.

### 4.3. eSports

Electronic sports or eSports is a term used to describe professional competitions in video games. This is an entertainment area that should not be ignored.

Their resemblances with sports are undeniable, as both activities are based on a competition between two or more individuals. Furthermore, both have the capacity to fill stadiums and arenas, and unite fans from all over the world to watch high profile matches. In fact, in recent years the eSports scene had a huge growth in popularity [196], in part thanks to the focus that game designers put on creating competitive games, but also thanks to Twitch [38], the leading video-streaming platform for videogames. According to eSports Earnings [197] and Battlefy [198] the most popular and profitable video game titles are based on the following genres: Fighting, First Person Shooter, Multiplayer Online Battle Arena, Massive Multiplayer Online Role Playing Game, Real Time Strategy, and Trading Card Game. We did not analyse the Sports genre since these games are simulations of real sports, which were already analysed before.

Fighting games like *Combat Sports*, are competitions where individuals engage in close combat with an opponent. Game series like *Street Fighter* [199], *Super Smash Bros.* [200], *Marvel vs Capcom* [201], *Dead or Alive* [202], *Mortal Kombat* [203], *Tekken* [204], and *Soul Calibur* [205] have been a continuous presence in fighting-based eSports events like *EVO* [206] and *Capcom Pro Tour* [207]. These games are designed around time-limit rounds, and therefore, the most appropriate moments to applaud are after a great movement or at the end of a round. Remote viewers can also predict who will win a round (or a game) and how it will be won, and when a player's knockout will occur. The fans' emotions can be presented either after a great movement or at the end of a round when a winner is determined. Finally, and as in *Combat Sports* like boxing, the most suitable moments to synchronise a second screen application are before and at the end of a round.

First Person Shooters (FPS for short) are games where players look through the eyes of an avatar, and use different weapons to eliminate opponents and achieve specific goals. This genre became widely popular after the release of *Doom* [208] in 1993, and today, there are several game series that feature in eSports tournaments: *Counter-strike* [209], *Call of Duty* [210], *Halo* [211], *Quake* [212], *Battlefield* [213], *Painkiller* [214], and *Destiny* [215]. Although the FPS gameplay mechanics may differ from the Multiplayer Online Battle Arena (MOBA) and Massive Multiplayer Online Role Playing Game (MMORPG) genres, all of them share common goals and design rules. In MOBAs (e.g. *League of Legends* [216], *DOTA* [217], *Heroes of the Storm* [218], *Heroes of Newerth* [219], and *Smite* [220]), a player controls an avatar in one of two teams and the objective is to destroy the opposing team's main structure, while in MMORPGs (like *World of Warcraft* [221], *World of Tanks* [222], and

Guild Wars [223]), the objective (in eSports Events) is to kill all players of the opposing team. Therefore, all the interaction concepts can be applied in the same way in these videogame genres. Typically, to advance in these games, players need to win several rounds against several opponents. As such, remote viewers can applaud after the end of a round, when a great play occurs, or after a kill. Like in fighting games, remote fans can guess who will win a round, a game, and if a kill will happen next. The most appropriate moments to present the overall fans' emotions are after a great play, a kill, or at the end of a round. Finally, remote viewers should synchronise their second screen applications at the beginning or end of a round, and on predefined checkpoints (e.g. an objective is destroyed).

Real Time Strategy (RTS) is a classic videogame genre where players have a wide range of warfare units to control in order to defeat the opposing player's army. In the early 2000s, this genre became widely popular due to titles like Starcraft [224], Warcraft [225], Command and Conquer [226], and Age of Empires [227] selling millions of copies. Like in Racing Sports, this genre also features long competitions (matches usually take 20 minutes or more to finish), requiring the addition of checkpoints to prompt user interaction during matches. Therefore, remote fans can applaud their favourite players when a great play occurs or at the end of a game. Viewers can also predict at predefined checkpoints which player will win a game or if there will be a winner in the next seconds. The most appropriate moments to present the fans' emotions are after a great play or at the end of a game, since these moments usually convey strong emotions due to unexpected events. Finally, viewers should be able to synchronise their applications at the beginning or end of a game, and on predefined checkpoints (e.g. building constructed).

Recently, the Trading Card Game (TCG) genre has seen a growth in popularity with the release of Hearthstone: Heroes of Warcraft [228], Hex [229], and Pokémon TCG Online [230]. In this genre, two players take turns to draw cards from their decks, in order to defeat the opponent by playing creatures, spells and other kind of cards. Since it is a turn-based type of game, we can make a similar analysis like the one we did with Target Sports (Subchapter 4.1 – "Sports"). Therefore, viewers can applaud after a great play or at the end of a turn/game. It is also possible to predict if a player will be defeat in the next turn or the outcome of a turn (e.g. "what card will a player use in the next turn?"). Besides visualizing the overall fans' emotions after a great play or at the end of a game, it would be appropriated to also see what the remote audi-

ence feels when a special card is drawn. Lastly, good opportunities to adjust a second screen application delay are at the beginning or end of a turn/game.

Table 4.4 presents a summary of the previous analysis and describes how it is possible to enhance the fan experience in different gaming scenarios.

**Table 4.4: Summary of the eSports genres and their characteristics.**

Genres	Description	Examples of Popular Videogames
<b>Fighting</b>	A genre based on highly frenetic and thrilling action, as users should only shift their attention from the fight when nothing exciting is happening.	Street Fighter, Super Smash Bros., Marvel vs Capcom, Dead or Alive, Mortal Kombat, Tekken, and Soul Calibur.
<b>FPS</b>	Three different, yet similar genres, which feature several players' kills and rounds that can be used to prompt remote audience interaction.	Counter-strike, Call of Duty, Halo, Quake, Battlefield, Painkiller, and Destiny.
<b>MOBA</b>		League of Legends, DOTA, Heroes of the Storm, Heroes of Newerth, and Smite.
<b>MMORPG</b>		World of Warcraft, World of Tanks, and Guild Wars.
<b>RTS</b>	Like Racing Sports, this is a genre characterized by long matches, being necessary to add predefined checkpoints throughout the match to promote fan interaction.	Starcraft, Warcraft, Command and Conquer, and Age of Empires.
<b>TCG</b>	A turn-based type of game that can be easily explored due to the slow-paced gameplay.	Hearthstone, Hex, and Pokémon TCG Online.

As a final remark, our analysis shows that there is a wide range of possibilities for remote fans to interact with broadcasts, regardless the type of the event. Viewers can interact with others, get more engaged in the broadcast, and see others' emotions at the right time without worrying about TV delays, and without diverting their attention from the TV screen during important moments. Moreover, other features can be explored after a live event has ended, such as the possibility to access automatically generate short highlight videos in different sports, TV shows and eSports, as presented in WeFeel.



# 5

## Designing Second Screen Applications during Live Broadcasts

*Design is so simple, that is why it is so complicated.*

- Paul Rand, art director and graphic designer

In the previous chapter we demonstrated how it is possible to apply the different interaction concepts to different sports, TV shows, and eSports, to create a whole new range of applications. The knowledge that we gathered during the prototypes' studies allowed us to go one step further and identify from a human computer interaction perspective, a set of challenges and guidelines for the design of second screen applications during live broadcasts. These guidelines approach different topics in user interaction design and user interface design.

### 5.1. User Interaction Design

The user interaction design of second screen applications should take into account a varied number of factors. In our studies we were able to identify four main topics: General, Environment, Eyes-Free, and Synchronisation.

The main challenge that we faced in our work was how to design non-intrusive second screen interactions that did not disrupt the TV watching experience. Since remote viewers watch a TV broadcast for its content, when they

are prompted to use a second screen application, their focus should remain on the TV broadcast, as the second screen application should be a complement to the TV watching experience and not the primary experience. To achieve this goal, we carefully evaluated how users should interact and how the mobile application should give feedback to users. As the development of the prototypes unfolded, it became clear that there were two ways to prompt users to interact: on application-triggered events and user-triggered events. Examples of application-triggered events (or key moments) are the ones that we introduced in WeApplaud and WeSync, where the application prompts users to interact after a specific action occurs during the broadcast (e.g. dangerous play, goal or freekick) when they can safely shift their visual attention to the mobile device. In this scenario, it is not expected that users will be looking at the mobile device during the whole broadcast, and therefore it is necessary to get the users' attention by using audio or tactile cues, to alert when it is time to interact. Moreover, if possible, developers should design a well-balanced experience, that does not constantly prompt users to interact (e.g. too many moments to applaud may be annoying). On the other hand, users might want to perform actions at anytime, by their own initiative, which means that they can issue user-triggered events. Examples of these events are the ones presented in WeBet and WeFeel, where users can bet that a goal will happen or share an emotion at any given time. In this scenario, it is recommended to design interaction mechanisms that should be one tap way, otherwise users might lose the opportunity to interact.

As we saw at the beginning of Chapter 2, remote viewers can watch a TV broadcast in two kind of environments: alone or with others. Even when viewers are alone, it is usual for them to chat and engage in discussions with their friends, family members, and unknown viewers through messaging applications. Therefore, we think that it is utterly important to design second screen interactions that can be complemented by presenting other fans' actions (as explored in WeBet, WeFeel, and WeSync). While sharing a physical space with others, second screen applications can also promote social interactions by relying on cooperative or competitive local multiplayer interactions to achieve a specific goal. Think for instance in deploying prototypes like WeApplaud on third places like sports bars and coffee shops in order to foment sociability, as described in Chapter 3. Or an experience where remote fans on a sports bar need to perform la ola (Mexican wave) in the correct order like if they were in the stadium. Ultimately, as presented by Wann et al. [30], remote viewers would feel more satisfied by watching an event with others, helping to reduce the loneliness felt when watching it alone.



Sometimes, it may be necessary to interact when something exciting is happening on the TV broadcast. In this case, viewers do not want to (nor do they should) shift their visual attention from TV broadcast to a mobile device, since they are eager to know what will happen next (we are talking about exciting live events after all). Thus, it is necessary to rely on eyes-free interaction techniques that use tactile, audio, and haptic feedback to allow for user interaction without diverting the visual attention from the TV screen. As presented in WeBet, we explored the bezel area surrounding the touchscreen display and the presence of physical buttons to create an interaction mechanism that users could easily initiate as soon as they had their fingers on the device. Furthermore, we used well-identified vibration patterns and sounds to distinguish the different states of the interaction method. These cues allowed users to become aware of the application state without the need to have a visual confirmation of their actions, keeping their focus on the TV broadcast. While we are not expecting that novice users will immediately use second screen eyes-free interactions as designed, our observations during WeBet evaluation tests, presented insights that users over time tended to look less to the mobile application in order to confirm their actions.

As we observed with WeBet, TV broadcast delays issues might arise during live events, as both the television and the mobile device feeds are not synchronised. When this happens, the users' interactions are not synchronised with the TV broadcast. Furthermore, and although we did not deploy WeFeel on a real environment like we did with WeBet, we know that it can suffer from the same problem, as users who have a high TV broadcast cannot predict goals efficiently. Thus, to solve the aforementioned issue, we suggest using an automatic method like ACR (when possible) or a manual method like SMUF (an universal synchronisation mechanism) to have both feeds (TV and mobile device) synchronised. As we demonstrated at Chapter 3, this will have a huge impact in the user experience, as users stated that they had a better user experience by using SMUF to synchronise WeSync. Moreover, it is also important to evaluate user interaction patterns in competitive gaming scenarios in order to prevent cheating (setting delays higher than the real ones). As demonstrated in WeSync, we developed an anti-cheating system that detected and penalized users who lied about their TV broadcast delay (so they could predict events after watching them on the television), which can be personalized by developers in different gaming scenarios.

## 5.2. User Interface Design

The existence of an extra screen makes it necessary to design a well-organized interface both on the mobile device and on the television. Therefore, we assembled a set of guidelines that approach the user interface design in three topics: General, Mobile Device, and Television.

As mentioned before, in order to reduce the loneliness that fans may feel when watching a live event, it is necessary to deliver a sense of community, to remind viewers that they are watching an event together. We delved into this subject in WeApplaud and WeFeel, as users could hear the sound of the applause from the in-venue fans in order to follow along, and see other remote viewers' emotions during key moments of a football match. However, we acknowledge that this subject can be further expanded in different ways: by presenting how many remote viewers are watching a live event, by prompting remote viewers to cooperate to achieve specific goals, or even by creating experiences that require both in-venue and remote viewers to be in-sync during specific moments (e.g. an expansion of the WeApplaud concept with a bi-directional impact). Likewise, and although we did not approach the stadium screen in our work, we should not forget that it can also be used as an extra device to present relevant information about the remote audience status. Therefore, we advise future research to present to both remote and in-venue viewers each other's actions in order to create the feeling of a worldwide connected audience.

Regarding the mobile device, if users wish to predict that an event is going to happen in the next seconds – think about the WeBet concept – or if they want to share an emotion – the WeFeel concept – they need to have immediate access, from any screen of the application, to the appropriate interaction mechanisms no matter which application screen is currently on display. Similarly, if an application-screen event is issued (like in WeApplaud and WeSync), the interaction screen should appear right away, regardless of which application section the users are at, and what they are doing. If the interface is not designed in this way, the users will be forced to navigate to a specific screen before being able to interact, and since there may be just a short window of time to do it, they may lose the opportunity. On the other hand, if users stay on a specific application screen for the entire broadcast – so they can always access a given interaction –, they might lose access to other screens equally rich in content (e.g. providing real-time information about the broadcasts), which also is not desired.

The initial approach that we took when designing WeApplaud interface on television proved not to be optimal, leaving room for improvements (too many UI elements permanently on the screen resulted in a loss of impact of the TV broadcast). Thus, we changed our approach when developing WeFeel by expanding the TV broadcast to full screen. With WeFeel we used the television screen to create a more seamless experience where users could quickly check their friends' emotions and messages, without having to shift their attention from the TV. In this scenario, the UI elements appeared as an overlay to the TV broadcast, and therefore it was important to select well-defined areas to position them in order not to occlude the main scene displayed on the TV. Moreover, it was necessary to fade the UI elements after a few seconds to avoid a cluttered interface and, when possible, choose less relevant moments of the TV broadcast to overlay the UI elements (emotions' charts) on the TV display. Results showed that the UI elements of WeFeel (chat messages and charts) did not have a negative impact when watching the TV broadcast, quite the contrary: users were pleasantly surprised when the chat messages appeared overlaying the TV broadcast. In fact, users clearly stated that the visualization of the charts and chat messages on the TV screen did not obstruct the match display, which helped to validate our design philosophy.

Table 5.1 summarizes the previously mentioned challenges that arose during the development of our work, along with the set of guidelines that we collected to overcome them.

**Table 5.1: List detailing how several challenges can be overcome with simple guidelines.**

Guidelines for Designing Second Screen Applications during Live Broadcasts			
Areas		Challenges	Guidelines
User Interaction	General	<ul style="list-style-type: none"> <li>- Engage in second screen interactions that do not disrupt the TV watching experience.</li> </ul>	<ul style="list-style-type: none"> <li>- Second screen interactions should rely on application-triggered events and user-triggered events.</li> <li>- Second screen experiences that rely on application-triggered events should contain (if possible) a well-balanced number of events, otherwise users might be annoyed with too many interactions.</li> <li>- Application-triggered events should get the users' attention by using audio or tactile cues, to alert them when it is time to interact.</li> <li>- User-triggered events should be one tap away, otherwise users might lose the opportunity to interact.</li> </ul>

User Interface	Environment	<ul style="list-style-type: none"> <li>- Promote social interactions both for remote viewers watching the TV broadcast alone and for remote viewers watching it with others.</li> </ul>	<ul style="list-style-type: none"> <li>- Design second screen interactions that are complemented by presenting other remote viewer's actions.</li> <li>- Design cooperative or competitive local multi-player interactions that require several users to achieve a goal.</li> </ul>
	Eyes-Free	<ul style="list-style-type: none"> <li>- Interact when something exciting is happening on the TV broadcast.</li> </ul>	<ul style="list-style-type: none"> <li>- Use tactile, audio, and haptic feedback so users can perform an action without the need to divert their attention from the TV screen.</li> <li>- Use well-identified vibration patterns and sounds to distinguish the possible states of the system.</li> </ul>
	Synchronisation	<ul style="list-style-type: none"> <li>- Synchronise users' interactions with the TV broadcast.</li> </ul>	<ul style="list-style-type: none"> <li>- Use ACR to synchronise the application when possible.</li> <li>- Use a manual interaction method like SMUF whenever ACR is not available.</li> <li>- Evaluate user interaction patterns in competitive gaming scenarios in order to prevent cheating (setting delays higher than the real ones).</li> </ul>
	General	<ul style="list-style-type: none"> <li>- Allow viewers to feel a sense of community.</li> </ul>	<ul style="list-style-type: none"> <li>- Present other fans' actions to remote viewers, so viewers can acknowledge that they are watching an event together.</li> </ul>
	Mobile Device	<ul style="list-style-type: none"> <li>- Access second screen interactions in a quick and easy way.</li> </ul>	<ul style="list-style-type: none"> <li>- Design the UI so that users do not need to navigate between application screens to perform time-sensitive actions.</li> <li>- If an application-screen event is issued, the application should present it immediately, so users can interact with it.</li> </ul>
	Television	<ul style="list-style-type: none"> <li>- Add UI elements to the TV screen without causing a negative impact in the TV broadcast.</li> </ul>	<ul style="list-style-type: none"> <li>- Present UI elements on the television screen so users can visualize important data without shifting their attention to the mobile device.</li> <li>- Select well-defined areas where the important action will rarely occur (like the top-left or the top-right areas).</li> <li>- Make the UI elements fade out after some seconds, i.e. when they are not relevant anymore.</li> <li>- If there are too many UI elements at the screen at a given time, set a priority for them to disappear, or allow users to set the elements location.</li> </ul>

To conclude, we hope that these guidelines can help to deliver optimal user experiences while using second screen applications. Nevertheless, we encourage the development of new prototypes and research studies that can help to expand and refine the different aspects of Table 5.1, which should lead to even better second screen experiences. For instance, an extensive study can be conducted to assess how to gather and present the remote viewers' actions on a stadium screen, so in-venue fans and performers can feel the remote fans' support. This way, a loop can emerge as remote fans are motivated to support their team or favourite athletes by acknowledging in-venue fans' actions through a

second screen application, and in-venue fans are encouraged to keep their support by visualizing the remote audience involvement through the stadium screen.



## Conclusions and Future Work

*Stay hungry, stay foolish.*

- Steve Jobs, co-founder and former  
CEO of Apple Inc.

In this dissertation we aimed to detail how second screen applications could help enhancing fan experience during live sports broadcasts. This led to a simple question that proved to be rather complex to answer: how is it possible to accomplish such feat? Reaching the end of this work, we are now able to answer that question.

### **6.1. How to improve the remote user experience while watching a broadcasted live sports event?**

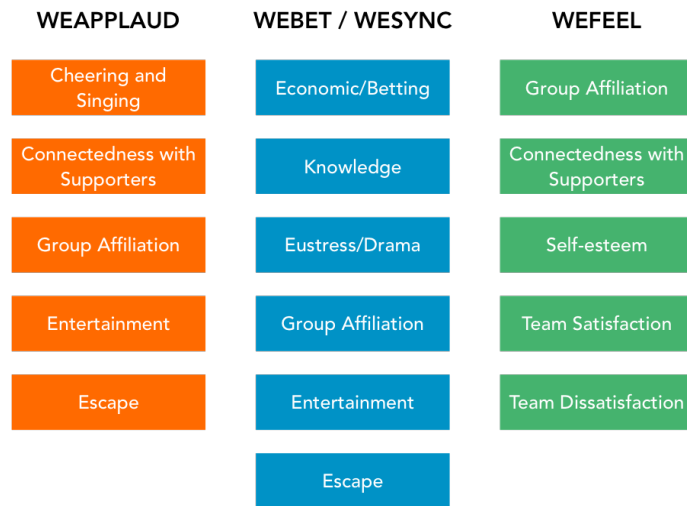
Improving a user experience is always a challenging issue. In our context, remote fans do not feel so emotionally connected with the athletes and the in-venue fans, as if they were watching it live where the event takes place. Thus, we sought to encourage remote fans to participate in entertainment and social activities in order to enhance their experiences. The work that we developed showed us that this could be accomplished using second screen applications. However, to achieve our goal it was necessary to answer different questions: what factors of the event contribute more for the fan experience, how to create satisfying social experiences, and how should user experience be designed, so it does not interfere in a negative way with the TV watching experience?

### 6.1.1. What factors of the event contribute more to the fan experience?

There is a wide range of factors that make live sports events appealing. Whether fans watch a live sports event at home, at a sports bar, or at the venue, they watch it because they are motivated by different factors. Some fans might be interested in the outcome of a sport event because of gambling, others might want to spend some time with friends, while others might watch it simply for its entertaining value. The research that we conducted to identify the factors that most influence fan behaviour, resulted in the classification of three categories: connection, motivation, and attendance (Chapter 3, Table 3.1). Connection refers to how fans are connected with their favourite team. In this case, fans tend to “Bask in Reflecting Glory” when their team matches their expectations, referring to it as “we”, or they “Cut Off Reflected Failure”, distancing themselves from the team failures, referring to the team as “they”. By motivation we mean the reasons for fans to watch sports events. Usually, fans are motivated by a combination of factors, not just a single one. Factors such as group affiliation, eustress, self-esteem, entertainment, betting, and knowledge are some that influence fans to watch a live event at home or at the venue. Finally, attendance refers to the stimuli that motivate fans to attend sports events. These can be of four types: organiser, spectators, game action, and stadium architecture. Factors like cheering and singing, crowd size, history with an opponent, and connectedness to other fans most contribute for the sport stadium atmosphere, as described by the participants of the studies presented in Chapter 2.

Some of these factors were taken into account to develop appealing second screen prototypes (Figure 6.1). Results showed that factors like group affiliation and connectedness with supporters were very well received by users, as participants from the evaluation tests really enjoyed to watch and hear other fans’ emotions and applauses. Factors like eustress and knowledge were also explored, by prompting users to bet what would happen next. Participants became frustrated when they bet that a goal was about happen and it did not, and became excited when they previewed it right.





**Figure 6.1: Influential factors addressed in the different prototypes.**

To conclude, and to answer the question addressed in this sub-chapter, while we did not explore all the factors of a sports event that contribute to the fan experience, we presented a list that encompasses them, open to be explored by future research. Our prototypes mostly focused on the connection that fans have with their team and favourite athletes, and the sense of community that fans seek when watching a live sports event with others, since, as presented in Chapter 2, these are the factors that most contribute for the fan experience.

### 6.1.2. How to create satisfying social experiences?

It is usual for fans to cheer, support, exchange opinions, and even brag about their teams with others during a sports event. Thus, it is crucial to make remote fans feel connected with others and provide them with an enhanced experience by creating the feeling that they are not alone watching the sport event. The concepts that we introduced were designed to deliver social experiences to fans in different contexts: those watching sports events with others, and those watching sports events alone. In WeApplaud we designed a local multiplayer game that motivates fans to gather at each other's homes or at third places, in order to watch a football match and play WeApplaud. WeBet (and WeSync for that matter) was designed to provide online social experiences as remote fans can acknowledge others' bets and engage in conversations with friends and even unknown fans about WeBet. WeFeel was designed to create social experiences in online environments, but it can also encourage fans in a local environment to participate in discussions, due to the visualization of emotions and opinions on the television screen. The evaluation tests that we conducted with simultaneous participants allowed us to validate our concepts. In

WeApplaud, participants engaged in conversations about the match and WeApplaud, chatting about the match events and thrash-talking about each one's performance. In WeFeel, users enjoyed sharing their emotions and opinions with their friends, sometimes even laughing about what each one wrote. Moreover, the top comment made by users seconds after experiencing WeFeel was "where can I download it?", which clearly shows a great interest and enthusiasm to use WeFeel on a real life environment.

As we can see, people enjoy engaging in social experiences. Second screen applications have the power to form communities around live sports events, helping to create a sense of community. Thus, to create satisfying social experiences, we argue that second screen applications should explore the local and online environments where fans engage, and present information about other fans' actions, so remote fans can feel that they are watching a live event with thousands of other fans.

### **6.1.3. How should the user experience be designed?**

As described in Chapter 5, the main challenge when developing second screen applications is to design non-intrusive interactions that do not disrupt the TV watching experience. Second screen applications should be approached as a complement to the TV watching experience, and not as the primary experience. To meet this criterion, we presented a set of guidelines to help designing second screen user interactions and user interfaces during live broadcasts.

From the set of user interaction design guidelines proposed in Chapter 5, it is important to note that second screen interactions should happen when it is safe to shift the visual attention from the TV broadcast (for application-triggered events) or when the viewers desire (for user-triggered events). Application-triggered events (like the ones used in WeApplaud and WeSync) should call the users' attention by using audio or tactile cues to alert them when it is time to interact, while user-triggered events (WeBet and WeFeel) should be accessible one tap away, otherwise users might lose the opportunity to interact. Furthermore, when using eyes-free interactions, these should rely on tactile, audio, and haptic feedback so users can perform an action without the need to divert their attention from the TV screen. As we found out during WeBet evaluation studies, users might be frustrated if they are not synchronised with a live sports event, due to the TV broadcast delays. We acknowledged this issue, and we suggest that future works use ACR (if possible) or a manual synchronisation method like SMUF to synchronise a second screen application with a live TV broadcast. In fact, the results we obtained from evaluating SMUF with WeSync

showed that the user experience significantly improved after using SMUF, a clear sign that the mechanism works as intended. Finally, in competitive gaming scenarios it may be necessary to detect cheating users, who set higher delays than the ones they have in order to win points for predicting events that they already know the outcome. To solve this problem, we introduced an anti-cheating system that detects and penalizes users who lie about their TV broadcast delay, which can be personalized by developers for different gaming scenarios.

Regarding the set of user interface guidelines, the existence of an extra screen requires the design of a well-organized interface both on the mobile device and on the television. The mobile application should allow users to perform time-sensitive actions from any of the application screens (like in WeBet and WeFeel). Moreover, if an application-screen event is issued, the application should present it immediately, so users can interact with it. On the other hand, UI elements can also be presented on the television screen so users can visualize important data without shifting their attention to the mobile device. In this case, it is necessary to select well-defined areas where the important action will rarely occur, fade the UI elements when they are not relevant anymore, and set a priority for them to disappear, when there are too many UI elements at the screen at a given time.

So, how should user experience be designed? By providing additional activities that complement the TV watching experience without becoming the focus of attention. In other words, additional activities should not require users to shift their visual attention to mobile devices during exciting moments of the event, nor should they overload users with a high number of events to interact. If second screen applications are developed with these mantras in mind, we do not have any doubts it will be easier to improve the remote fan experience.

## **6.2. Future Work**

In this work we studied how state of the art mobile technology can be explored to enhance the fan experience while watching live sports broadcasts. We presented a set of concepts based on four sports themes (fans' actions, live betting, social engagement, and broadcast delays, as presented at the beginning of Chapter 3), which were materialized into different second screen prototypes. However, it is easy to imagine new kinds of second screen applications that exploit the set of themes in novel ways (1), single applications that combine different concepts (2), and new concepts that explore other sports themes besides the ones we presented (3).

The prototypes that we developed were a reflection of just one of our personal interpretations on how the sports themes could be explored. However, further works can be carried out within these themes (1). For instance, with WeApplaud we devised a cooperative competitive rhythm game to motivate viewers to applaud on key moments, but one can also think about different takes to explore the fans' actions theme, like singing along support chants. In this case, a social application can be developed to present in the stadium screen the lyrics of a support chant to in-venue fans, and both in-venue and remote fans need to sing along (think of a unique real-time worldwide karaoke experience). Another example is the WeFeel prototype. As described in Chapter 3, we approached the social engagement theme due to the strong emotional connection that fans have with their teams. Since people naturally share their opinions and emotions with their personal circle while attending live events, we argue that remote spectators should be empowered to do the same. However, a chat-based application like WeFeel, can also promote social engagement by asking specific questions to remote viewers. As an example, when a player is sent off in a football match, the application can issue a poll for viewers to vote if the decision was a good call or not, and why. This way, social interactions can spark during a match, and not only after it, as it is usually the case when fans visit sports websites and applications to discuss what they have just witnessed.

The prototypes that we developed were based on four concepts: WeApplaud takes fans to applaud during key moments; WeBet prompts fans to make live predictions; WeFeel lets fans to share emotions and opinions with others, and WeSync allows fans to synchronise second screen applications with TV broadcasts. Although, it is possible to integrate different concepts in a single application (2), as we did in WeSync (although at the time we mainly aimed to evaluate the SMUF concept and usability). WeSync, like WeBet, allows users to predict what will happen next. Both betting features were applied in Viva Ronaldo [78], as users could interact in different situations (key moments and dangerous plays) seamlessly. Similarly, it is also possible to integrate both the WeBet and the WeFeel concepts into an application, as remote fans can guess goals and share emotions when they wish. It is expected that during dangerous plays, remote fans will not share emotions (we already observed this behaviour in our evaluation tests), so they will be focused on predicting goals. After it, users are free to share their emotions and opinions, which sometimes may very well be related with the outcome of a bet. However, allowing users to both applaud and bet during key moments may not be a wise choice, as these will end up overlapping user interaction, confusing users on what they need to do.

Thus, we argue that when different concepts are explored in a single application – in particular those based on application-triggered events (e.g. WeApplaud and WeSync) – it is necessary to have a well-balanced designed experience (since too many moments to interact might annoy users, as described in Chapter 5), or at least have the possibility to turn off specific features (e.g. the user may not be interested in applauding).

Finally, based on the factors that influence fans' behaviours and the elements that play a part in a sport broadcast as presented in Chapter 3 (Figure 3.1), it is possible to delve into new sports themes besides the ones we presented, and introduce new concepts that enhance the fan experience during live sports broadcasts (3). For example, future research can focus on factors like knowledge, history with opponent, or fan attendance. In the first two cases, trivia-based competitions can be designed to keep remote fans engaged in a live event. In the later case, one can install a video camera among the in-venue crowd in order to stream what in-venue fans are watching. This way, remote fans can really hear and see what is like to be in the venue watching the live event.

All previous concepts were presented with mobile devices in mind. As we described in Chapter 1, we chose to address mobile computing because people became so attached to their phones that they always have them by their side. Nevertheless, we do not deny the possibility of using other technological devices to enhance the remote fan experience. In fact, today we can already adapt our mobile prototypes to wearable devices, such as smartwatches. In some cases, these devices can even lead to more engaging, intuitive, and non-intrusive experiences. For instance, imagine using a WeApplaud version where users just need to clap their hands naturally, as smartwatches rely on accelerometer and sound data to identify claps. Or a WeFeel version that asks users what they are feeling after detecting a change in their heart rate. Furthermore, new prototypes can be created to deliver personal experiences, like “feeling” the same heartbeat of a referee, a player, or a coach. The possibilities are endless. We think that wearable technology can become the next chapter in the second screen concept's history, and we are eager to see what future research can create.

Unfortunately, other systems like the ones mentioned in Subchapter 2.2 - “Remote Live Experiences”, namely MirrorSys [52] (a 220-inch display with 8K resolution and a 22.2-channel sound system) and Kirari [53] (a system that features sensing technology, video and sound transmission technology at 4K and 8K resolutions, to reconstruct remotely the in-venue action), are still a few years away and it will take a while before we can experience that kind of telepresence

systems at our homes. However, we believe that we will get there. The possibility of participating in entertainment and social activities with other fans through second screen applications combined with telepresence systems, allow us to dream of a future where remote fans can feel like if they were supporting their team at the venue. A future where remote fans experience live sports events in first hand. A future where we watch live sports events with thousands of other fans around the world. This may sound like out of a sci-fi movie, but did not today's technology seem far off only a couple of years ago? Dreams have always pushed the human race forward. They inspired us to imagine, to explore, to create, to invent, to make a stand for our beliefs. So, what is life without dreaming?



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