Inclusive Design as a Source of Innovation: A Case Study & Prototype on Soccer Spectatorship

by

Andres Felipe Sarmiento Pardo

Submitted to OCAD University
in partial fulfillment of the requirements for the degree of

Master of Design
in
Inclusive Design

Toronto, Ontario, Canada, April 2018

Copyright Notice

Author's Declaration

I hereby declare that I am the sole author of this MRP. This is a true copy of the MRP, including any required final revisions, as accepted by my examiners.

I authorize OCAD University to lend this MRP to other institutions or individuals for the purpose of scholarly research.

I understand that my MRP may be made electronically available to the public.

I further authorize OCAD University to reproduce this MRP by other means, in total or in part, at the request of other institutions or individuals for the purpose of scholarly research.

Andres Felipe Sarmiento Pardo

Abstract

Access to soccer content is achieved mostly through visual cues that convey spatial relations between the ball and players, supplemented by spoken and/or written commentary. Unfortunately, for nonvisual spectators who rely on spoken and written commentary alone, spatial information is lost. Fieldwork in Colombia was selected, designed, and executed in order to observe a unique tactile sign language system that is Co-Designed by actual soccer spectators – a sign language interpreter and a Deaf-Blind spectator. Two portable cameras (GoPro Hero3) were used to capture the live interpretation inside the stadium. Video analysis and field notes revealed how the loss of spatial relations between the ball and players is counteracted by employing a combination of props and gestures. Iterative prototyping through user testing was developed with the aim to design instructions that would teach any visual spectator how to interpret the game from visual to tactile modality. The mixture of ethnographic observations and user testing sessions exposed key properties needed to interpret the game of soccer without using visual or aural cues this work can guide designs towards new spectatorship experiences.

Keywords: Soccer Spectatorship, Sports Accessibility, Tactile Interpretation, Prototype development, Deaf-Blind Spectator, Spatial Representation.

Acknowledgments

A work of this importance and at this level cannot be complete without the support and insights of people that can appreciate the issues. Therefore, I express great gratitude to Dr. Peter Coppin, my principal advisor and mentor, as well as to Sarah Tranum, my committee member and former instructor.

I wish to also express my gratitude to Maya DasGupta for her insights and critique of the draft; her support was always present. I wish to thank my parents, Manuel Sarmiento and Gladys Pardo, for their support and understanding during moments when my attention was focused on this work. My brother, Sergio Sarmiento, whose dedication has been a direct inspiration to complete this project.

Many thanks to Cesar Gaza, David Lancheros, Francisco Henao, and my family from Colombia, who helped me during my field work. And how can I forget the Saturn Cohort? All of you provided the inclusive and creative atmosphere that allowed for the free exchange of ideas.

This research was supported by the Social Sciences and Humanities Research Council (SSHRC), the National Science and Engineering Council (NSERC) Collaborative Research and Training Experience (CREATE) Program on Data Analytics and Visualization (DAV) and Scotiabank.

Dedication

To all the soccer fans who experience the game, in one way or another, your innovation is an inspiration to the sports media paradigm. In addition, I would like to dedicate this to all the people who try to make the game more inclusive. It is through their work that we can recognize the societal role soccer plays as a tool for inclusivity.

Table of Contents

List of Tables

List of Figures

1 Preface

For many people, sports are more than just a recreational activity; they are a part of their upbringing, a source of their belonging in society. Spectatorship can shape lifelong identities, with the idolization of players and memorable moments that are held dear by the spectator. Here is where the author's journey started: he was absorbed by the importance of spectatorship and its lack of innovation within the sport media paradigm. During his first year at OCADU, he enrolled in *DIGF*: *From Data to Perception*, co-taught by Dr. Peter Coppin and Dr. Ana Jofre, a class that helped frame the role broadcasting technology plays in delivering information to fans. During this class, the author partnered with a classmate, Hemanth Pidaparthy to explore prototypes that aim for a fast and intuitive visual summary of the action in soccer game (highlight videos). Their project was in response to the lack of user-friendly content, and of poor accessibility features in online streaming platforms. The project outcome was submitted as a poster to InfoVis'17 (an IEEE conference), where it was accepted and generated valuable discussion within the community. The experience at InfoVis raised numerous research questions that guided the author to be intrigued by the accessibly aspect of sports spectatorship for his major research paper.

2 Introduction

This Major Research Paper sits at the intersection between multimodality, inclusive design, and sports accessibility (to be more specific, the game of soccer). Currently, accessing game content is achieved mostly through visual cues; for people who cannot use visual cues, there are secondary options like audio and text commentary. Commentary is useful and accessible, however, it is inefficient because spatial attributes get lost during translation. This is because spoken or written language poorly conveys the spatial attributes of the gameplay. By recognizing diversity and uniqueness, efforts were focused on finding a case study in which spectatorship falls outside of visual and aural paradigms; the aim was to analyse and showcase these techniques to the public. The role of design is evident in the second part of this paper, where iterative prototyping and user testing was used to develop a set of instructions that would inform the reader how to interpret tactile soccer. This instruction set achieved multiple objectives: it challenged the conventional view that spectatorship is solely visual, it showcased the research to audiences outside academic circles, and it used iterative prototyping as an inductive step to learn additional insights that could improve tactile translation for spectators, on both edges of the sensory ability spectrum.

This paper makes the following contributions to the field: it showcases why tactile interpretations of game content can revolutionize the sport media paradigm, it uses prototyping as an inductive phase, and it creates instructions to promote the use of the tactile sense as a soccer spectatorship method.

3 Chapter One: Recognizing Uniqueness

3.1 Background

Each year, viewership numbers for international sports events rise. With the advent of HD and slow-motion cameras, new technology has significantly improved, enabling spectators to appreciate the nuances of the sport as never before. Despite these advances, spectators that rely on aural sensory input (such as blind or low-vision spectators) have experienced little innovation in the field of sports spectatorship. The situation is even worse for predominantly tactile sensory spectators (Tudor, 2006). While tactile sign language and alphabets can convey game commentary, they are cumbersome and translate only a subset of the game attributes that visually oriented spectators experience. Traditionally, there has been no tactile or sonic translation system or language for soccer spectatorship that does not rely solely on written or spoken commentary. However, a spoken or written language translation does not convey many important properties that are afforded by a visual display. For example, current Web Content Accessibility Guidelines (WCAG) require text descriptions of external graphic representations such as pictures, diagrams, charts, graphs, and information visualizations[1]. However, although an external representation, such as a financial chart, is composed of text-labels

[1] https://www.w3.org/WAI/intro/wcag

with properties that might easily be afforded through text or text-to-speech translation, the "visual" spatial, topological, geometric, or "diagrammatic" (Larkin & Simon, 1987) properties of a graphic are lost during this translation process (Coppin et al., 2015), because of the distinct affordances of sentences (whether they are written or spoken) relative to non-sentential external representations (pictures, diagrams, for example).

Building upon the above, in the case of soccer spectatorship, this paper similarly argues that spatial, topological, or geometric relations among players and the ball are lost during the translation process. Although all acts of translation and representation include subjective interpretation to some degree, spoken or written language poorly conveys the pictorial, spatial properties of gameplay. For example, a spoken or written description such as, "Player 12 kicked the ball diagonally across the field to Player 14, where it was then intercepted by Player 8 from the opposing team," is a conceptual interpretation of visually perceived spatial relations among multiple players and a ball—many spatial events could fall under the same description. This frames the research question: How can we convey the spatial properties of soccer gameplay for audiences who have no access to visual cues?

This chapter reports on an emerging tactile sign language that is designed by actual spectators, through a reiterative and Co-Designing process, to counteract this problem. By employing a combination of props and gestures, they successfully convey the lost spatial, topological, and geometric properties of the gameplay.

3.2 Literature Review

3.2.1 Sports Accessibility

Considerable research focuses on sports inclusion for persons with disabilities in physical environments (Promis, Erevelles & Matthews, 2001), sport adaptation (Kalyvas & Reid, 2003; Darcy, Lock, & Taylor, 2017), and socioeconomic issues (Estabrooks, Lee & Gyurcsik, 2003; Robertson & Emerson, 2010). When we focus on accessibility for spectatorship, most of the work comes from architectural retrofitting and institutional entrepreneurship, as corporations and team franchises aim for inclusivity (Macbeth, 2008). However, the literature regarding accessibility to game content, like spectatorship, lacks depth within each sport.

3.2.1.1 Soccer Spectatorship

Sports participation is essential for inclusivity; one of the important sociocultural attributes of sports is spectatorship and fandom (Mehus, 2005; de Haan, Faull & Kohe, 2014). However, game

content access – in this case soccer spectatorship – has received little interest by the academic world, where innovation happens largely at the institutional level. The Fédération Internationale de Football Association (FIFA) created a program for blind and visually impaired individuals, in anticipation of the World Cup in Brazil 2014[2], however, there seems to be no continuation with the project.

3.2.1.2 Non-Visual Soccer Spectators

Game content is provided mostly through visual cues and, when unavailable, there are secondary options like audio and text commentary. While accessible and useful, commentary carries bias (Cummins, 2009), is inefficient (it cannot keep up with the fast pace of the gameplay), and there data is lost during the translation of modalities (Coppin, 2015). As far as the author is aware, the game-content accessibility issue has been noted as far back as 1937, with the setup of REX Blind Parties, a charity organization that provides live commentary for visually impaired people at soccer matches in Scotland[3]. To this day, REX Blind Parties continues to provide the service, while acknowledging that their patrons demand more information. A staff member explained this in a promotional video:

"They generally expect a bit more information about what's happening

[2] http://www.fifa.com/worldcup/news/y=2014/m=6/news=fifa-doing-its-part-to-make-world-cup-accessible-for-all-2373911.html
[3] http://www.soccersightscotland.org.uk/

on the pitch, that you wouldn't normally get in a normal television commentator or radio commentator and it's important that you give the guys an idea of where the ball is, what's happening, who's got the ball."[4]

Comments like this emphasize the need for a solution to convey spatial properties of the gameplay, solutions that are not based on spoken or written language.

3.2.2 Inclusive Design

'Inclusivity' is a word that has been embraced by many industries and academic fields. 'Inclusive Design' is a relatively new term, and, from principles to dimensions, its meaning takes different forms. There is a distinction to be made between Universal Design and Inclusive Design. The former focuses on a system, object, or service that encompasses the full range of diversity and population; it is one-size-fits-all. Inclusive Design takes a different approach, by developing customizable systems that can be rearranged to fit individual needs; this system is one-size-fits-one. In Canada, the IDRC (Inclusive Design Research Center) is a leading group in the field of inclusive design, using inclusive research methods, processes, and objectives. The IDRC conceptualizes Inclusive Design in three 'dimensions' (rather than principles): *Inclusive Process and Tools*, *Recognize Diversity and*

[4] https://www.youtube.com/watch?v=bqxRg6VjNkM

Uniqueness and *Broader Beneficial Impact*. Within each dimension, there are sub-dimensions that help contextualize and guide a designer[5]. This paper utilizes their concepts when referring to Inclusive Design and inclusivity, specifically the dimension, *Recognize Diversity and Uniqueness*.

3.2.2.1 Recognizing Diversity & Uniqueness

Inclusive Design keeps the uniqueness of each diverse person in mind, recognizing self-determination and self-knowledge. A focus on the abilities of the individual, rather than the disabilities, dictates how researchers expand their research methods. Co-Designing is often an inclusive method deployed to gather data, by recognizing the "participant" as a partner not only during the data gathering phase (Nind, 2017), but also during implementation, delivery, and validation *(*Vargas & Venezia, 2015).

3.3 Emerging Co-Design

One of the contributions of this project is the use of an emerging collaborative design process. Though not created by professional designers, it has key attributes of a Co-Design process. Here, we considered the forces of social and cultural evolution, where the

[5] https://idrc.ocadu.ca/resources/idrc-online/49-articles-and-papers/443-whatisinclusivedesign

selection pressure is driven by the need for access. As it is not set up by professional designers, this emerging Co-Design process is an interesting case study to examine the benefits of Co-Designing, as there are not the same biases or constraints that a researcher brings when creating a Co-Design session.

3.3.1 History of Co-Design

Also known as Participatory Design, Cooperative-Design (Co-Design) is a term that has become mainstream within the field of design. Its history traces back to the 1970s in Scandinavia, and was intended for end users to cooperate with designers, researchers, developers, etc. The benefits of Co-Design became evident with projects like UTOPIA, where the project emphasized the active cooperation between researchers and workers in order to help improve the latter's work situation. This was achieved by reiterative observations, interviews, and the collaborative creation of prototypes (Sundblad, 2010; Bødker, Sjögren & Sundblad, 2000). As Cooperative Design made its way to Western society, it was rebranded as 'Participatory Design,' based on the fear that it could be perceived as communist ideology. Currently, within the North American design landscape, Co-Design is the preferred term, however, branches entitled 'Co-Creation,' 'Distributive Participation Design,' and 'Mass-Participatory Design' can also be found. It could be expected that the

wording of Co-Design may lose its appeal or takes a more rooted meaning to its branches.

3.3.2 Steps in Co-Design Research

Collaborative sessions, or workshops, are the main platform where participants cooperate with researchers. Sessions differ based on both context and needs, however, three basic stages are present in almost all participatory design research (Spinuzzi, 2005).

3.3.2.1 Stage 1: Initial Exploration of Work

This initial stage draws from ethnographic methods such as observations, interviews, site visits, and the examination of artifacts. This phase helps frame a research question or potential area of involvement.

3.3.2.2 Stage 2: Discovery Processes

In this stage, researchers and users interact most heavily, and this usually involves group sessions and activities, using tools to facilitate the discovery process, for example, using probes, toolkits, or prototypes (Sanders & Stappers, 2014).

3.3.2.3 Stage 3: Prototyping

The last stage involves using a variety of techniques for iteratively shaping artifacts. These techniques can include, among

others, mock-ups, paper prototyping, and PICTIVE (Muller, 1991). Here, the artifacts generated differ from Stage 2 as they are the result of the Discovery Phase. The artifacts in the second stage are meant to facilitate the discovery process that would then frame the criteria for Stage 3. However, there are instances in which an artifact can be used in both Stage 2 and Stage 3, for example, generative design tools (Sanders, 2000).

3.3.3 Emerging Co-Design

To answer how we can interpret the spatial properties of the gameplay when we don't have access to visual cues, efforts could have been invested in developing a Co-Design workshop. However, the resources were largely allocated in the search for an environment where the demand for access organically generated a need for a Co-Design intervention. Borrowing the Inclusive Design dimensions by the IDRC, the following framework was created (see table 1): *Recognizing Uniqueness and Diversity* helped detect potential case studies; it was then filtered by selecting the ones that showed *Inclusive Processes and Tools*. The remaining cases were then analysed for *Broader Beneficial Impact* (further discussed in Chapter Two). By researching how spectators with multiple abilities experience the game of soccer, the search focused on finding spectators who did not rely on visual or sonic cues. Two cases were found of Deaf-Blind soccer spectatorship

(one in Colombia and one in Brazil). Existing interviews that were open to the public showed that the interpretation of the example from Colombia was novel in both implementation (the use of a wooden board that was accessible to both the interpreter and the spectator) and development (iterative design with feedback from both the interpreter and spectator, according to the interpreter). This case study met the established criteria and was selected for further study, in order to see how it could be used and developed toward a *Broader Beneficial Impact*.

Table 1: Framework used to outsource Co-Design using the inclusive Design Dimensions of the IDRC.

Framework to search for existing Co-Design interventions	Inclusive Design Dimensions (IDRC)	Colombian Case Study Example
Detect possible case studies	*Recognizing Uniqueness and Diversity*	Recognizing the novel and uniqueness of a soccer interpretation without visual or sonic cues used by a Deaf-Blind spectator
Criteria in the selection	*Inclusive Processes and Tools*	Gestures and artifact served as tools for communication. Co-design was also revealed between interpreter and spectator
Recognize potential for further analysis of case study	*Broader Beneficial Impact*	Lack of multimodality representation in sports media could be improve with a non-visual non-sonic method

3.4 Case Study

3.4.1 Context

Jose Richard Gallego was born with Usher's Syndrome, a rare genetic disorder that, throughout development, results in a combination of hearing loss and visual impairment. From birth, he

started losing his hearing and, closer to puberty, his vision started to deteriorate. As an adult, he can now no longer hear and is legally blind. During the time he had his vision, he became a supporter of his local soccer team. Cesar Daza met Jose Richard three years ago. Cesar, a sign language interpreter, was invited to a meeting with people with visual impairments. In this meeting, he met Jose Richard, and, through their passion for soccer, they became friends. During the meeting, Jose Richard asked Cesar if he could translate a live soccer game inside the stadium. Cesar agreed to try, and a reiterative Co-Design process began between them (see table 2). According to Cesar, the first attempts proved to be challenging, both because of the speed of the game and the numerous attributes that needed to be interpreted. As reiteration continued, a more robust system was developed to improve the interpretation of live soccer games.

Table 2: A comparison between the Co-Design stages and the case study of Cesar and Jose Richard.

Co-Design Stages	Cesar and Jose Richard Case Study
Stage 1: Initial Exploration of Work	Cesar and Jose Richard met, discussion of lack of accessibility to experience soccer games for Deaf-Blind spectators took place.
Stage 2: Discovery Processes	Iterative processes on possible solutions where Cesar could translate live soccer games to Jose Richard took place.
Stage 3: Prototyping	The implementation of an artifact and gesture designs that fit within the needs of the interpreter (Cesar) and the Deaf-Blind spectator (Jose Richard).

3.4.2 Uniqueness

Together, Cesar and Jose Richard developed novel ways of communicating to encode game attributes that could be easily translated and which would fit within a broader context. Pressure to communicate the different properties of the game (such as player-ball position versus a foul) drives the evolution of system components in divergent directions. Building upon prior work on the affordances of external representations and signs (Coppin, 2014, 2015; Coppin, Li, & Carnevale, 2016), and informed by work on artifact (Kirsh, 2010) and language evolution (Imai & Kita, 2014; Senghas, Kita, & Özyürek, 2004), we will discuss how physical constraints interact with affordances of different types of signs. On the one hand, communicating the topological relationship between players and the ball is evolving toward more iconic gestures that resemble the unfolding, concrete situation on the field. On the other, communicating aspects of gameplay, such as player faults or whistle blows, encourages more conceptual specificity, and drives the evolution away from more iconic gestures to more symbolic ones. These correspond to the more abstract categories under which many concrete situations can fall.

3.5 Methods

3.5.1 Process for Ethnography Observation

By the time the author discovered the pair, Cesar and Jose Richard[6] were famous in their hometown in Colombia. Colombian national television (RCN) and news articles from the leading newspaper in Colombia (EL TIEMPO)[7] reported how a Deaf-Blind individual (Jose Richard) could now experience his beloved soccer team. The articles focused on their unlikely friendship, since the teams they each support are the main rivals in Bogota. In a country where soccer fandom can be dangerous, this unlikely friendship caught the attention of the media, and Cesar and Jose Richard saw an opportunity to use their unique situation and popularity to promote and diffuse the message of peace inside soccer stadiums.

[6] In this paper we will be using the proper names of the interpreter and spectator because: a) There is no breach of privacy, all the information and data is available to the public, and our data collected for this study was also recorded by numerous media channels who made their video feed available to the public. All personal information was available to the public from interviews and documentaries in which Cesar and Jose Richard had participated, and both individuals are well-exposed to the media; b) As far as we know, this interpretation is unique; we would like to acknowledge both Cesar and Jose Richard as the original creators of this method.

[7] Montenegro Vergara, A. (2017, August 30). José Richard, el sordociego que siente el fútbol con las manos. *El Tiempo*. Retrieved January 28, 2018, from http://www.eltiempo.com/deportes/futbol-colombiano/cesar-daza-le-narra-partido-de-futbol-a-sordociego-jose-richard-121524

During the summer of 2017, the author contacted Cesar through his charitable organization[8] that provides services to people with visual impairments. Informal conversations helped inform the nature and possibility of conducting fieldwork in Colombia. A field trip in Colombia was organized for December of that same year, to observe and record their method for the duration of a game. With the help of a local assistant, the author and Cesar coordinated a seating plan in the stadium, as well as equipment logistics for the author to be able to record the interpretation. The goal was to (unobtrusively) capture a full game's worth of interpretation, in order to further analyze their method.

3.5.2 Field Work

Field work in Colombia was the primary source of data, gathered from video recordings, observations, and informal conversations. Three small *GoPro Hero3* cameras were taken to the stadium: one was strapped with a harness to the abdominal area of the author, allowing his hands to be free to take notes. This camera was aimed at the interpretation, but was far away enough to capture the surrounding environment. A second camera was held by the assistant from a moderate distance, and it was pointed directly at the interpretation.

[8] https://idrc.ocadu.ca/resources/idrc-online/49-articles-and-papers/443-whatisinclusivedesign

The last camera was unused; it was simply kept as a backup. The author and company were not alone in recording Jose Richard and Cesar, as multiple media channels were present and taking their own footage. However, though they showed curiosity, they were focused on building the narrative of Cesar and Jose Richard as messengers of peace, and were therefore uninterested in the complexity and meaning of the interpretation. (Figure 1)

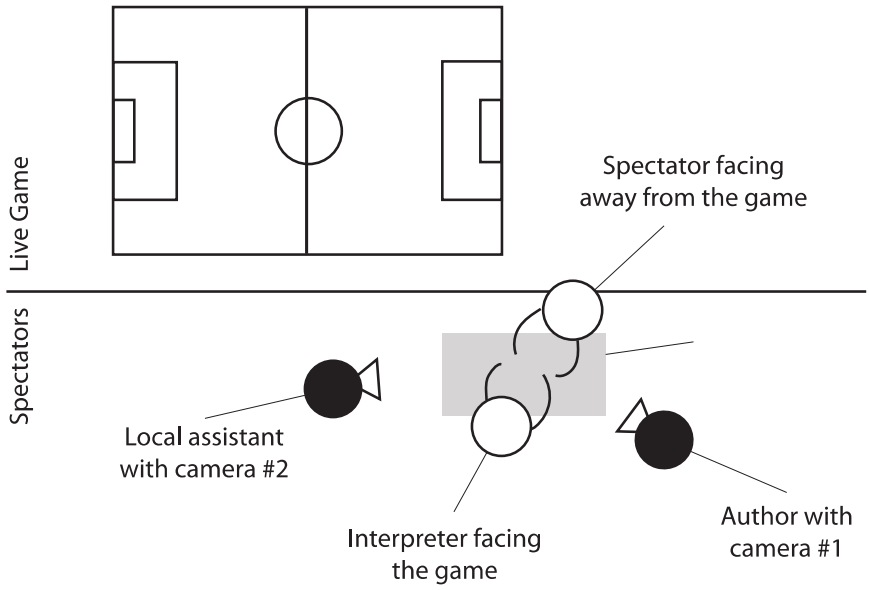


Figure 1: Diagram of the field work set-up. Interpreter sits in front of the spectator while facing the game, local assistant and author hold cameras at opposite sides of the interpretation.

The author took notes during the whole game, without interrupting the interpretation. It was a participant observation study. Based on the *Handbook of Methods in Cultural Anthropology* by DeWalt, DeWalt & Wayland (1998), the observation study is between

Passive Participation and *Moderate Participation*. While both author and assistant acted as bystanders during the interpretation (*Passive*), in order to enter the stadium they had to select a team to "support." Thus, their seats inside the stadium were inside a defined supporting section. In this way, they were merging the "insider" and "outsider" roles, yet they maintained their detachment so as to remain objective (*Moderate*). There is no concern that these insider/outsider roles, nor the awareness of the observation study, had any impact on the interpretation. (Figure 2)

Figure 2: Photo taken during field work by the local assistant. Sitting down on the left, the spectator (blue) and the interpreter (red). On the right, the Author (burgundy) with a camera strapped to his body, while taking notes.

3.5.1 Limitations

Jose Richard's interpreter, Cesar, knows only Spanish, and, while the author is fluent in Spanish, there was some uncertainty regarding the accuracy of the communication from author-to-interpreter-to-spectator. For this reason, feedback from the spectator was not collected for this study. There were also logistical limitations; since the videos were recorded inside the stadium during a live soccer game, due to the dynamic atmosphere, the preparation and recording logistics were uncertain and challenging. In some cases, camera angles had to be adjusted during the recording, due to fan obstruction. Further research needs to be done using improved resources to include the spectator’s direct input, and to improve the consistency of the camera angles during the recording.

3.6 Data Analysis

Video Analysis was done through a triangulation of methods: the use of video synchronization that has proven successful in the analysis of surgical procedure videos (Langerman & Grantcharov, 2017), cross-checked with categories from Manuel Stein’s and Dominik Sacha’s previous works (2014; 2016; 2017) to determine the extent of the interpretation of the soccer game events . Lastly, the comparison

of the video analysis with annotations captured by the author during the field work helped highlight areas of interest.

3.6.1 Video Synchronization

The two captured videos and an additional game feed video, taken from national television, were synchronized. A video recording of the live game from the interpreter's perspective would have been ideal, however, though we sought permission, stadium regulations prohibited us from recording the full game. The three videos were framed independently and rendered as one video, as shown in Figure 3.

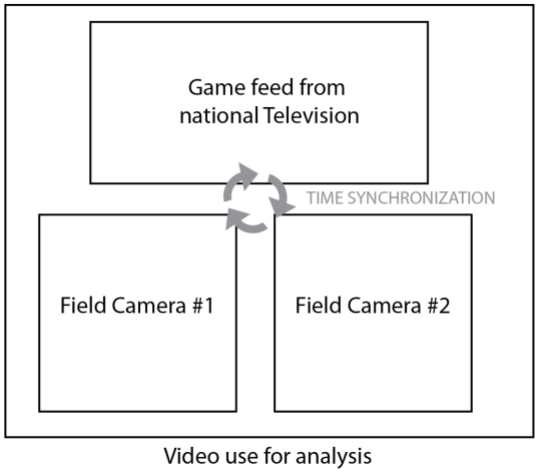


Figure 3: Three videos (2 videos were from the field work and one additional video was captured from a domestic T.V.) were synchronized and then rendered as one video, using the composition shown here.

3.6.2 Cross-Referencing with Previous Work

Cross-referencing the video synchronization with the checklist from Manuel Stein and Dominik Sacha previous works (2014; 2016; 2017) in which their visual analytics methods cover single-player, multiplayer and event-based analytical views of soccer games. However, the checklist had to be expanded to include more relevant information, both for tactile representation and spatial-temporal attributes. For example, on Dr. Stein's list the penalty is one of the categories suggested to be represented, however, for a tactile interpretation, a different technique is created for the penalty foul event, the penalty setup, and the penalty conversion. Therefore, we had to expand the penalty category into three categories for our purposes (Table 3).

Table 3: Small sample of video analysis matrix using the checklist from Manuel Stein's and Dominik Sacha's previous work. Their categories and descriptions are then matched by the time in the game that it was interpreted, or interpretation was missing.

Event Type	Description	Event Specific Interpretation (Time)	Vague Interpretation(Time)	N/A (Time)	Not Interpreted (Time)
Foul Penalty Decision	Referee decision to award the penalty foul	16:08;			
Foul Penalty Kick	Free kick on the goal defended only by the goalkeeper	17:40;			
Clean Challenge	When a player takes the ball away from a player in a tough manner but is not seen as a foul by the referee	8:40; 14:58; 29:38; 37:43; 39:11;	34:17;		45:59; 46:57;

3.6.3 Annotated Information

During the field trip, the author captured notes in a notebook; these notes focused on both general comments (Table 4) and spatial specific comments (Table 5). The synchronized video was used to revisit the notes, to analyze them, and to provide more detail, based on the environment and context. Events that took place more than one time were also recorded in data analysis.

Table 4: Small sample of general comments associated with a specific time during the game interpretation.

Comments	Event Specific (Time)
The bouncing of the ball is often interpreted when players head the ball, by bouncing the fingers (players). Fingers act like a human figure. Heading the ball is interpreted by jumping the finger and heading the "ball" with the knuckles.	2:38; 5:11; 14:52; 36:30;
Again, the descriptive nature of the ball bouncing is highly descriptive, (I notice the way the ball bounces gives a context on the speed of the ball... interesting)	1:10;
Hand balls seem hard for Cesar to interpret this seems to be the case for the far away distance that he is in, that he can't make up if the ball was hand ball or not, in addition the referee decision is not so clear at that distance	7:40; 32:39;

Table 5: Small sample of spatial comments associated with a specific time during the game interpretation.

Comments	Event Specific (Time)
The change of fingers role when the goalkeeper is about to kick the ball. one fingers become the goalkeeper and the ball, while the other finger changes roles to be a waiting non-descriptive player on the middle of the field	1:04; 34:58;
Fingers change roles on Free-kicks in dangerous areas that are aiming at the goal of the opposite team. One finger becomes the ball being kicked while the other finger starts as the location of the goal, and as the ball is being kick it either changes roles as defending player or maintains its role of the goal net	6:30; 41:26;
When the hand represents the ball, it seems that he turns the hand upside down. not sure if this is for resting the hand or it has a deeper meaning	14:15;

3.7 Results & Discussion

Soccer spectatorship traditionally entails the perception of spatial and topological relations among the ball and players through visual cues, often augmented by spoken commentary to convey additional information, such as a player's description and tactical knowledge. While radio and text commentary is accessible, it carries bias and loses information during the translation of modalities (Coppin, 2015). Because our case study is based on a tactile gestural system, it employs non-visual, non-aural techniques. This tactile system empowers Deaf-Blind individuals to participate as spectators at a soccer game. The relationship among players, game circumstance and predictive models can be conveyed using such system.

3.7.1 Background on the Evolution of Language

In his 2001 paper, Angelo Cangelosi suggests that analyses of linguistic and communication systems are based mainly on the semiotic distinction between icons, indices and symbol. (Cangelosi, 2001). The distinctions between these three categories are important to be revisit, as they will serve to lay the groundwork in order to understand the major contribution of this case study. Pierce (2009) originally introduce these distinctions in the following way: "icon" has physical resemblance with the object it refers to, an "index" refers to

time/space with an object, and a "symbol" is based on social conventions or implicit agreement of its meaning. These distinctions will be referred throughout the paper as they will help to visualize the evolution of Cesar and Jose Richard's language to communicate the attributes of the soccer game. It has been noted that the evolution of spoken, written and signed language starts as iconicity (Armstrong, 1987). As language evolves essential features are defined within categories; this ability of humans and animals to create categories constitutes the "groundwork" of cognition (Harnard, 1987). This serves as the platform for language to evolve in complexity; as the categories are named and described, this is called symbolic. Symbolic representation makes it possible to recall the object's categories, its membership, and its invariant features. An example of how language evolves based on this concept, is explained by Cangelose (2001):

> "The word 'horse' is such a type of symbolic representation. Symbolic representations can be combined together to describe new entities and relations. For example, the word 'horse' and 'stripe' can be used together to describe the concept of 'zebra.' Symbols constitute the basis of language, especially in human languages."

Understanding iconic versus symbolic representation is necessary to further explain the features shown in the tactile language developed by Cesar and Jose Richard. Naturalistic observations revealed that

their language started as iconic representation-- for example, the use of finger movement to represente the movement of a player and the representation of a ball trajectory. However, there are also important findings where, as they started repressing categories, the gestures that started as an iconic representation later transition to symbolic. For example, the pulling of a shirt to represented a player being fault by shirt-pulling later started representing all types of faults. The use of fingers to mimic holding a whistle and blowing it to convey the sound of the referee's whistle, later evolved to just blowing the hand to symbolise the sound. Understanding that some features of the language from our case study started as iconic and remained iconic, while others started as iconic and transitioned to symbolic, reveals that key features must remain iconic to successfully convey the necessary information in order to understand the game flow of a soccer game (figure 4).

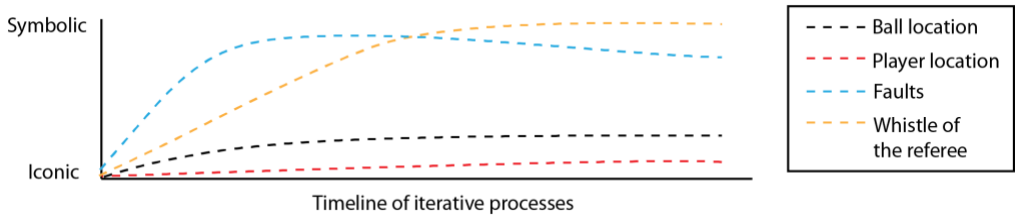


Figure 4: Through the iterative process that Cesar and Jose Richard developed their language to communicate soccer game attributes, we can find references where features started as iconic and then became symbolic -- like faults and referee whistle representations -- while others started as iconic and remained iconic -- like player location and ball trajectory.

3.7.2 The Basics of Cesar & Jose Richard's Method

The centerpiece of the interpretation is a wooden board with dimensions that correspond to the ratio of a standard soccer field. Cesar and Jose Richard sit facing each other and place the wooden board on their laps, as shown in Figure 5. The translator's index fingers mimic the two closest players to the ball (one from each team); the fingers mimic the players' positions on the field onto the wooden board. The spectator wraps his fingers around the translator's index fingers, thus affording the perception of the relationship among the ball and players through the negative space created by the fingers (Figure 6). Through this array of signs, Jose Richard (the spectator) can perceive spatial ties between the ball and players. Accurately, the position of the ball is inferred through the perception of negative space between the players from Team A and Team B that are closest to the ball. Because the interpretation of the game is in real time, any additional information that is needed takes too long to communicate. Additional information requires that Cesar break from his topological interpretation and communicate through sign language. In summary, any information that needs to be delivered besides topological position proves to take too long to inform and, in some cases, too hard to describe through sign language, for example, the severity of a fault or referee decisions.

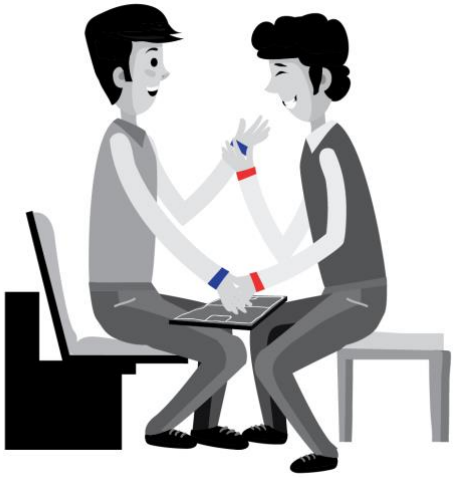


Figure 5: The translator (right) faces the spectator (left), The translator faces the game to interpret the game. A wooden board with raised lines depicts the soccer field and its boundaries.

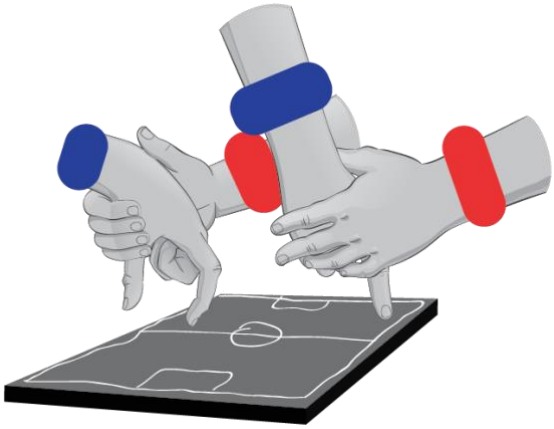


Figure 6: The spectator (red) wraps his hands around the translator's hands (blue) using his index fingers as guidelines. The translator represents the movement of the closest player to the ball (one hand per team).

3.7.3 Spatial Representation

During gameplay, the position of the interpreter's index fingers on the board shows the location of the two players closest to the ball (one from each team); the ball location is inferred from the negative

space between the two closest players. This is referred to as the "default mode" of spatial translation. This is important as it is different from how visual spectators are accustomed to experiencing ball possession - instead of experiencing who has possession of the ball and the ball trajectory, possession is shown through the experience of an imaginary shape between the attacking and defending fingers. This ever-changing shape mimics a type of dance in the field with both fingers (attacking and defending). Form such as this is how the spectator experiences the ball direction and assumed possession. In the game of soccer, this is a novel interpretation of ball possession and game-flow representation (Figure 7).

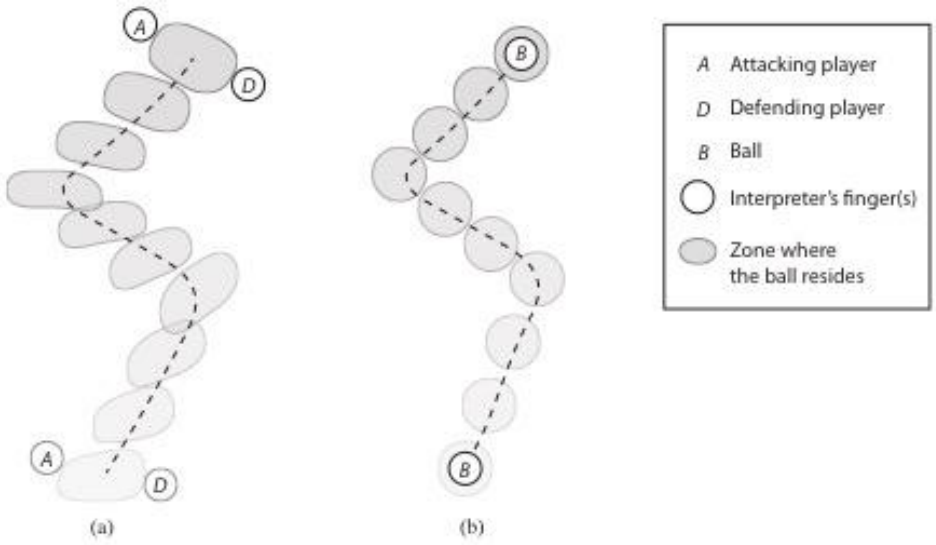


Figure 7: Figure (a) shows the ever-changing shape between the attacking and defending players; the ball trajectory is implied within the center of the shape. On figure (b) we can observe a straight-forward interpretation of the ball trajectory using one finger.

Here, the role of the board as a conceptual space suggests an appropriate framework for non-symbolic models. Like the use of fingers as players, conceptual spaces can represent various kind of information and can also be used to describe concept learning (Gandernfors, 2004). The interpretation also applies a different way to structure space and time. This is important since selecting the appropriate level of interpretation for a given description within the game translation can be interpreted in various ways, and it should according to Freksa (1997). For example, passive game events (where the ball is static) deploy a strategy different than "default mode"; during corner kicks and free kicks the translator's index fingers changes roles; the index finger that corresponds to the attacking team becomes the static ball waiting to be kicked, while the other index finger (defending team) becomes the goal net. (Figure 8) The ruling for passive game events is essential to convey the depth and direction the game event is taking place. After all, the purpose of the game is to score on the opposite team's net; this modification ensures that the spectator has a spatial relation of the goal and ball during passive game events. Here, a local and global reference is shown-- even though similar in task-- they are presented in various ways.

There are some cases in which the ball runs on the pitch without a player in control, yet the location and speed of the ball need to be

known (for example, the ball is kicked on or off target). Using the wooden board as a spatial reference point, the translator changes the role of the attacking index finger to become the ball (like passive game events setup, with the difference that the ball is not static). The ball trajectory is then stylized by bouncing the finger that represents the ball, the angle of the bouncing helps deliver a predictive model of the speed and reach of the ball (Figure 9). Casasanto & Boroditsky argue (2008), that our mental representations of things we can never see or touch (the speed of the ball in the case of the spectator in our case study) may be built, in part, out of "representations of physical experiences in perception and motor action." This explains the use of acceleration and gravity as points of reference for both space and time. Since Jose Richard had sight before this hypothesis holds true, it is uncertain if future spectators using this method with no previous visual recollection of objects and their speed, can also depict space and time with the understanding of gravity, in the same way that Cesar interprets loose balls to Jose Richard.

Figure 8: The attacking team is shown as a static ball in the corner while a player is waiting to take the corner kick; the defending team becomes the goalkeeper or goal net (shown in the illustration). The translator represents the spatial relationship of these events by making his attacking finger the ball and the defending team the net.

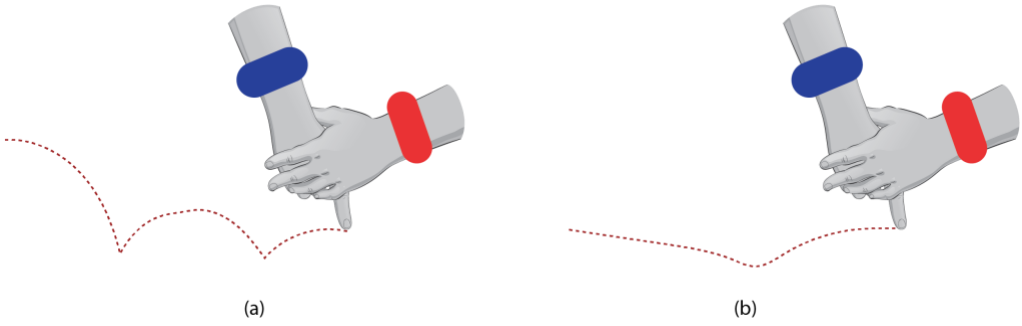


Figure 9: The translator's index finger (blue) changes roles from player to ball, using simple Newtonian laws, he conveys speed and direction when the ball is not controlled by any player. Figure (a) shows the ball bouncing high but moving forward slowly, while the figure (b) shows the ball travelling at high speeds. Thanks to the bounce angle and finger velocity, this proves to be useful when representing speed in the small environment of the wooden board.

3.7.4 Gesture Evolution

3.7.4.1 Interpreting Faults

Gestures play the main part for the case study to be successful; during the study, on multiple occasions, gesture 'feedforward' meaning. For example, the use of the shirt-pulling gesture (discussed later on) fetched the concept of faults and its in-game consequences. This concept draws comparison with work done on lexical retrieval (Morrel-Samuel & Krauss, 1992). In other cases, the gesture itself simultaneously becomes a ball and a player, creating new meaning that aids information transfer. As explained by McNeill "the actual motion of gesture itself, is a dimension of meaning. Such is possible if gesture *is* the very image, not an 'expression' or 'representation'" (2005). While vocalizations and facial expression usually come together with gestures as communicative signals, studies with blind individuals reveal that gesture production in human is automatic (Iverson, & Goldin-Meadow, 1998), and one of the building blocks for the evolution of language (Pollick & De Waal, 2007).

Interpreting faults took considerable time and energy to accurately translate within the context of the game. Faults in a soccer game vary: some are careless, others reckless; some are from

excessive use of force[9]. Cesar was trying to translate his subjective perspective of the severity of the fault committed. One of the challenges in doing so, is that Cesar observes the game, at a considerable distance, from the stadium stands.The distance and lack of video replay made the representation of the severity of the fault subjective because they were based on both memory and small visual cues. In most cases, Jose Richard required an explanation which took resources out of the game interpretation. To resolve this, Jose Richard and Cesar came up with a more straightforward way to convey a fault; once they both noticed that one of the most frequently interpreted faults was shirt-pulling, they started to pull a shirt to express the foul. In this situation, Cesar pulled on Jose Richard's shirt. This pulling gesture rapidly became a symbolic representation of faults in general.

Let us consider how this convention emerged. The meaning of pulling a shirt started as an iconic representation that resembled a concrete situation in the world (the fault of shirt pulling which is a common fault in the world of professional soccer). Over time, it became a symbolic representation, one that encompasses all the faults in the game, as the gesture is easier and faster to deliver. This speaks to the properties we find in the evolution of language and gesture (McNeill, 2012). If Jose Richards wanted a more detailed

[9] *Laws of the game: 2015/2016*. (2015). Zurich: Fédération Internationale de Football Association.

description of the fault, he could request an explanation from Cesar through sign language.

This technique decreased the cognitive load on both the interpreter and the spectator by lexical retrieval of unrepresented information (type of fault and severity). Furthermore, Cesar saw the opportunity to provide additional encoded data with the shirt-pulling gesture. While pulling on Jose Richard's shirt, Cesar increased the strength of the pull based on his perception of the fault. For example, if Cesar saw the fault as a "soft" encounter, he would gently pull Jose Richard's shirt. On the contrary, if he saw the fault as overly aggressive, he would pull the shirt with higher momentum. Here, instead of trying to match the referee's decision with the perceived severity of the fault, Cesar can communicate his inaccurate observation of the fault and how it can compare with the referee's decision. Thanks to this, Jose Richard is aware of the gap between the referee's decision and the perceived fault from a fan point of view.

3.7.4.2 The Whistle of the Referee

The whistle of a referee is an iconic landmark referring to the spatial attributes of the game. Without this visual or sonic marker, actions would be blurry and disorganized, and it would be hard to experience the game by predefined segments, such as before and

after a referee's decision. The blow of the referee's whistle at the start of the game is an essential sonic landmark that signals the beginning of the game, a stop of play, the continuation of play, disciplinary actions, and the end of the game. Concepts like spatial loci are possible with the whistle blow; both the gesture and its sonic properties serve to make "memory rooms" which help us to organize and access information faster (Ozyiirek, 2000). Visuallyoriented audiences might take for granted this visual reference (the referee blowing the whistle) and the sonic reference (the sound of the whistle being blown). However, Jose is unable to access either. Unfortunately, and without taking resources out of the interpretation, the speed of the game makes it hard to transmit this information through standard tactile sign language.

They developed a short-term solution: With Jose Richard's hand wrapped around Cesar's, Cesar shaped his fingers as if he was holding a whistle and blew as if he had a real whistle between them. Jose Richard can experience, through the tactile feedback of the feeling of air blown onto his fingers, the temporal experience of a whistle being blown. (figure 10) This gesture has evolved to the point where the finger positioning to convey the meaning of a whistle being blown is no longer required; it is enough to blow air (with a moderate strength) onto Jose Richard's hand or fingers to transmit the information.

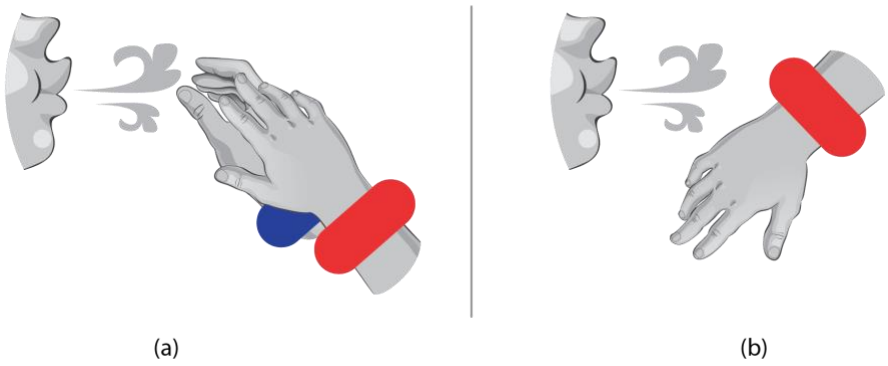


Figure 10: On figure (a) we see the interpreter's (Blue) hand mimicking the use of a whistle and blowing air to represent the referee's whistle being blown. The spectator's fingers are located directly where the air blown can be sensed. Figure (b) shows how the evolution of the whistle gesture was reduced to just a blow action on the spectator's hand.

To summarize, through lexical retrieval, Cesar employs the symbolism of air being blown onto Jose Richard's hands to convey the moments that affect the flow of the game. These include, for example, stop, continue, begin, and end. The gesture of the whistle is no longer used. Unstructured interviews with Cesar revealed that blowing air conveys the information much faster. It frees resources (the use of fingers) that can instead be used to communicate additional information, and the strength of the blow can enhance information transfer by encoding another set of variables. For example, the whistle that marks the end of the game is usually blown passionately by the referees. Here, Cesar transmits the emotion through the strength of his blow onto Jose Richard's hand or fingers, communicating through its strength the passion with which the referee blows the whistle.

3.7.5 Sustainability

The interpretation is successful by the engagement and continuous reiterative process that the interpreter and the spectator have with the live soccer game. This technique does not require fluency in sign language or tactile communication methods; however, it is useful to know sign language, since some inquiries would be too hard to clarify otherwise. For scalability purposes, a set of rules and descriptions could be created (based on Cesar's and Jose Richard's techniques) to enable any soccer fan with a minimal understanding of soccer to become a tactile translator. We can also foresee the use of state of the art technology to provide services to deaf and blind spectators, which would deliver essential attributes that Cesar conveys can be delivered. Using custom-made hardware and software technology, this would improve spectators' independence and autonomy. However, as mentioned above, Jose Richard had a visual and sonic understanding of the game before he lost two of his hearing and visual senses. Further research would have to be done to see how vital this previous sonic and visual knowledge of the game is to understand the physical interpretation of the live game. Future research questions can be framed: can a Deaf-Blind spectator that has never experienced soccer make sense of the tactile interpretation that Cesar delivers?

4 Chapter Two: The Role of Design

4.1 Background

The reporting of a Case Study done in Chapter One, highlighted the need for a new method of spectatorship within the sport media paradigm; it also served to identify what key attributes were conveyed during the tactile soccer translation of the case study. A set of descriptions and conceptual framework was described in light for a future standardization of tactile soccer spectatorship. This chapter examines the role that design plays in the process of developing a prototype. The prototype has multiple objectives: first, it presents the research done in Chapter One to a larger demographic than academic circles. Second, it promotes reflection on current accessibility issues in sport spectatorship, and challenges the common view that soccer spectatorship is solely visual. Third, it uses the reiterative phase of the prototype as an inductive stage. Last, it develops a high-fidelity, interactive prototype where future, empowered participants can follow instructions so they can experience the game of soccer using their tactile sense. Inspired by Speculative Design and user testing, each reiteration phase has a set of properties developed to foster a discussion that is future-oriented, and provides a playground to test the standardization guidelines discussed in the previous chapter.

4.2 Literature Review

To achieve multiple objectives with prototyping concepts from Speculative Design, user testing and Participatory Action Research (PAR) were borrowed. In addition, a review of a success case where the diffusion of sign language was observed is presented. Speculative Design is used to foster a critical discussion of sport media accessibility; user testing and PAR is used to refine a prototype to make it as effective as a product. Lastly, a case study of the diffusion of sign language to a larger population is reviewed, in order to inspire future work, and to look ahead to a similar outcome with our prototype.

4.2.1 Critical design: Speculative Design

Critical Design was made popular by Anthony Dunne and Fiona Raby – the recipients of the first annual MIT Media Lab Award in 2015 for their contribution[10]. They proposed that designers develop a portfolio (objects, services, etc.) that adopts an explicitly critical and experimental stance. Dunne's and Raby's approach to Critical Design is a way of using the "product" to rethink assumptions and the roles that objects play; this process does not attempt to develop marketing products, but rather requires reflection through tools that help form a

[10] https://medium.com/@medialab/introducing-the-media-lab-award-795ac9e7a8d9

critique of the role the objects play in everyday life (Antoinelli, 2008). Critical Design is often directed at designers themselves (Sengers et al. 2005, p. 51). However, the Speculative Design branch has been used when projects have an intended, specific public reach (or at least a limited public), through experienced, hands-on use. One of the aims of this prototype is to be inspired by some of the properties of Speculative Design (Table 6), and to foster a discussion between the participants and the researcher. This lends to a critical discussion of the current and future landscape of sports media accessibility.

Table 6: Example of attributes from Speculative Design that we aim to explore with our prototype.

Speculative Design attributes	Possible example within our prototype
Future oriented	Examines a future of multiple accessibility sources to access game content by persons with different needs
Consequences of technological implementation	How would this new access change what it means to experience the game and the role of spectatorship?
Broad view of implementation	Can we look at this technology outside of its soccer context (multisport) and outside its spectatorship context (to access *any* static content)?
Cross-disciplinary and integrative	Integrates design, sport accessibility and crowd sourcing to maintain sustainability.
How information resources, technological and economic structures interrelate	How can current technologies be reconfigured to disrupt or challenge existing power relationships?
Informed critique favored over usability and marketability	Previous understanding of the game is needed before a tactile interpretation can be achieve.

4.2.2 User Testing

User testing requires participants to test the product in order to debug or refine it, for the purpose of creating a useful, effective

product. This is usually achieved by combining several methods, some of which Jakob Nielsen (1994) categorized and are contained in the following list:

- Heuristic Evaluation
- Cognitive Walkthroughs
- Pluralistic Walkthroughs
- Feature Inspection
- Consistency Inspection

User testing of the prototype is needed as one of our goals is to generate a prototype that can ultimately be used as a product. Our prototype would need to be effective, in order to reach a wider audience.

4.2.3 Diffusion of Sign language to the public

With the advent of the internet, learning sign language is easier than ever, and has been made available to the public through YouTube channels like Bill Vicars[11] and My Smart Hands[12], web resources like ASL Pro[13] and Curious Courses[14], and a growing number of iOS mobile apps like ASL Coach, ASL Fingerspelling, and Marlee Signs. Healthy Hearing promotes sign language literacy by citing studies which claim that people who fluently speak more than one language have better

[11] https://www.youtube.com/user/billvicars
[12] https://www.youtube.com/user/SmartHandsCA/videos
[13] http://www.aslpro.com/
[14] https://curious.com/

memory, and can delay the onset of dementia and Alzheimer's disease[15]. Possibly the most frequently used, yet least considered, example of the diffusion of sign language to the public is the implementation of signing by baseball players during games. Back when the word "dumb" was used to describe someone who could not speak, William Ellsworth Hoy, referred to himself as "Dummy Hoy," instead of William, and often corrected people[16]. In the 1900s, Hoy was the first deaf major league baseball player, and had an impressive set of statistics. In his playing days, when he first started his baseball career, the Umpire shouted all the calls. When Hoy was up to bat, his coach, in third-base, raised his right arm to indicate a strike, his left to indicate a ball. The coach was soon signaling the opposing team's balls and strikes to Hoy when he played outfield. Gradually, using hand signals became common among baseball players, managers, and umpires. Nowadays, hand gestures are engrained in the dynamics and strategy of the game.

While hand signals started evolving outside of sign language conventions, they still carry with them the accessibility principles to both deaf players and spectators. It is a happy coincidence that the most successful public diffusion of sign language happened in the field

[15] https://www.healthyhearing.com/report/52606-Why-you-should-learn-sign-language-in-the-new-year
[16] https://www.startasl.com/dummy-hoy_html

of sports. While the context here (in terms of time period, sport, requirements, and culture) differs from Chapter One's case study, it is notable that Hoy and his peers could have such a lasting effect on a sport, all by making it accessible in a way that would suit Hoy's needs.

4.3 Design Value – Prototype

The development of a high-fidelity prototype has multiple objectives and they each revolve around the journey of the iterations. It is important to note that this prototype is not meant to be used as an empathy tool for participants to 'experience' what a Blind-Deaf person experience during a game, or for them to be used solely for with persons with visual impairments. Rather, this prototype aims to challenge participants' understanding of spectatorship, and deliver entertainment by using their tactile senses.

4.3.1 Objectives

4.3.1.1 Learning by Making

A clear objective in making a prototype was to use the iterative process as an inductive reasoning exercise. This was done by the act of making the instructions and wooden board. New insights were generated as the sessions progressed, by understanding the needs and requirements for both a tactile spectator and tactile interpreter.

4.3.1.2 Challenging the Common View

The process of making and then testing the prototype helped foster a longer conversation that challenges the common view of what spectatorship is, of what it means to be an spectator. Using a tactile sense to translate visual information results in a different and unexpected way to experience the game. For example, during the user iterative sessions participants mentioned that they wanted to know who had possession of the ball. After it was explained to them how, technically, the possession was inferred within the game flow, one participant mentioned that, visually, the first thing you want to know is where the ball is and who has it. This imposes a bias of what they want to experience with the tactile sense.

4.3.1.3 Interactivity

The objective of having a feedback session, where participants could interact both with each other and the prototype was important, as this helped test the prototype's usability and effectiveness. Feedback on the clarity of the instructions, for example, was asked on two occasions during a single session and most participants differ their opinion from before and after they tried the instructions with other participants.

4.3.1.4 Showcase to the public

Diffusing the findings of the data analysis to the public is a future goal for this paper. The use of a prototype as a cultural probe that embodies the research was purposely developed to match GradEx103, the biggest free art, design and digital show in Toronto. The objective of the prototype is to impart to a diverse audience the value of recognizing diversity, and how to display how uniqueness can drive innovation within the sport media paradigm.

4.4 Methods

4.4.1 Participants

Participants were recruited through social media outreach, and snowballing sampling. Participants were asked their knowledge of soccer on a scale of 1 to 10, and responses higher than 3 on the scale were considered for the feedback sessions. Most of the participants were age 25 to 35, and there was a total of 9 participants altogether, made up of 5 women and 4 men. Because the social media outreach was done through the author's personal social media channels, most of the participants were friends and friends-of-friends of the author. The relationship was not an issue, as they were all asked to follow instructions on work they had never seen. Each participant was

recruited for one session only, and the author travelled to the location of their convenience. No incentives were given.

4.4.2 Process

Feedback sessions were developed and organized, with each subsequent session designed to be improved upon from the comments from the one previous. While each session was different from the other, there were commonalities across all sessions, such as semi-structured interviews on the clarity of the instructions and their understanding of the interpreter-spectator role. The duration of each feedback session was approximately 20 to 30 minutes, with a total of 3 sessions within a 2 week period. Each session had a working prototype of the instructions to interpret tactile soccer, and a physical prototype of the wood board that represents the boundaries of the field.

4.5 Feedback Sessions

4.5.1 First Feedback Session

The iteration process started by taking the work explained in Chapter One and designing a set of instructions (see Appendix A – 7.1.1) that could be delivered to participants. An overview of the session process is shown in Table 7, and a small mock-up of a laser-cut, wooden soccer field was made to provide context (see figure 11).

Table 7: Overview of First Iteration.

Process	Description
Objective	Examine the delivery of information and resulting understanding of the tactile interpretation, through the design of instructions based on work described on Chapter One.
Participants	Two participants were recruited for this feedback
Board Design	Explored the use of laser cut on wood to make the soccer field boundaries, feedback on the tactile aspect was collected
Instructions Design	Explored the hierarchy of information, categories and possible layout of imagery

Instructions were divided between the *Gameflow*, *Gestures*, and *Advance Gestures*. Images were provided in some cases, however, some of the images were not the correct description but were placed there for composition purposes. The layout was in the style of a brochure, in order to compile the data in a simple, yet compelling, format.

Two participants, a woman and a man, were recruited for this session. Other than the *Loose-Ball* category, they found the *Gameflow* concept easy to grasp. They understood the *Gesture* category, but found its name confusing. The *Advance Gestures* category didn't garner much interest. The board was useful, but a more realistic size was needed for the participants to test the effectiveness of the instructions, and videos to test their knowledge were also suggested.

Figure 11: Instructions and board design that were used for the first feedback session of the iterative process.

4.5.2 Second Feedback Session

Based on feedback from the first session, the instructions were revised (see Appendix A – 7.1.2), and the layout was changed to include more information, such as a glossary of terms. The *loose-ball* category was merged with the *dead-ball* category, and additional changes were made to the overall writing of the instructions. An overview of the session process is shown in Table 8. Images were only placeholders and the soccer board with appropriate dimensions was provided with textured boundaries, with the aim that participants could

test the instructions (Figure 12). A video with clips of a game event was also developed for participants to observe the different game attributes (Figure 13), and to test what they had learned from the instructions.

Table 8: Overview of Second Iteration.

Process	Description
Objective	Reiterated feedback from first session, tested the board with the full dimensions, tested new instructions and video input
Participants	Two participants were recruited for this feedback
Board Design	Two thin plastics were placed together to add thickness to the board, black texture tape was used for the field lines
Instructions Design	Added a Glossary, rearranged information and layout, and removed the *loose-ball* category.

Two participants, a woman and a man, were recruited for this session. They found the instructions understandable, but only after they read them a few times. The video was useful, but they suggested replacing the video with an interrupted video of the game, because the multiple clips were confusing and were not natural, as in a real game. They suggested using more descriptive text in the instructions, and the use of imagery for explaining gestures (which was left out deliberately). Explaining the role of both the board and interpreter was suggested as an onboarding technique. The size of the field was good, however, participants only used it to test the videos. As they were

short video clips, the participants did not spend much time with the board. Suggestions to include an interpretation for throw-in and celebrations were also noted.

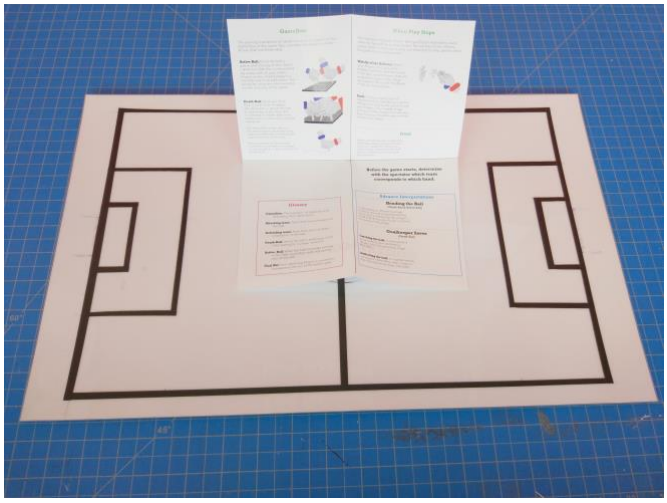


Figure 12: Redesign of the instructions and board design that was used for the second feedback session of the iterative process.

Figure 13: Screenshots of the video that was developed for the second iteration session, (a) and (c) show the title of the clips; (b) and (d) show the corresponding clips.

4.5.3 Third Feedback Session

Based on feedback from the second session, the instructions were revised (see Appendix A – 7.1.3) to include detailed illustrations of each action, and two new gestures that were suggested by

participants on previous sessions and seemed to be needed – throw-ins and celebrations – were added. An overview of the session process is show in Table 9. A second page was added to inform the participants of the role of the board and to set them up better. The board was made from two laser cut sheets of plywood; it was then sanded and painted, and the aesthetics improved with the aim that participants would use the board without any prompting by the researcher (Figure 14). A full video of a game was shown from the web to test the participants' knowledge of the instructions.

Table 9: Overview of Third Iteration.

Process	Description
Objective	Reiterated feedback from second session, improved the aesthetics of the board and materials, tested new instructions and used a continuous video.
Participants	Five participants were recruited for this iteration feedback.
Board Design	Two plywood pieces were laser cut, sanded and painted, also the board could be folded for transportation commodity (Figure 10).
Instructions Design	Addition of 2 new gestures (celebration and throw in), addition of preliminary information and design of all illustrations.

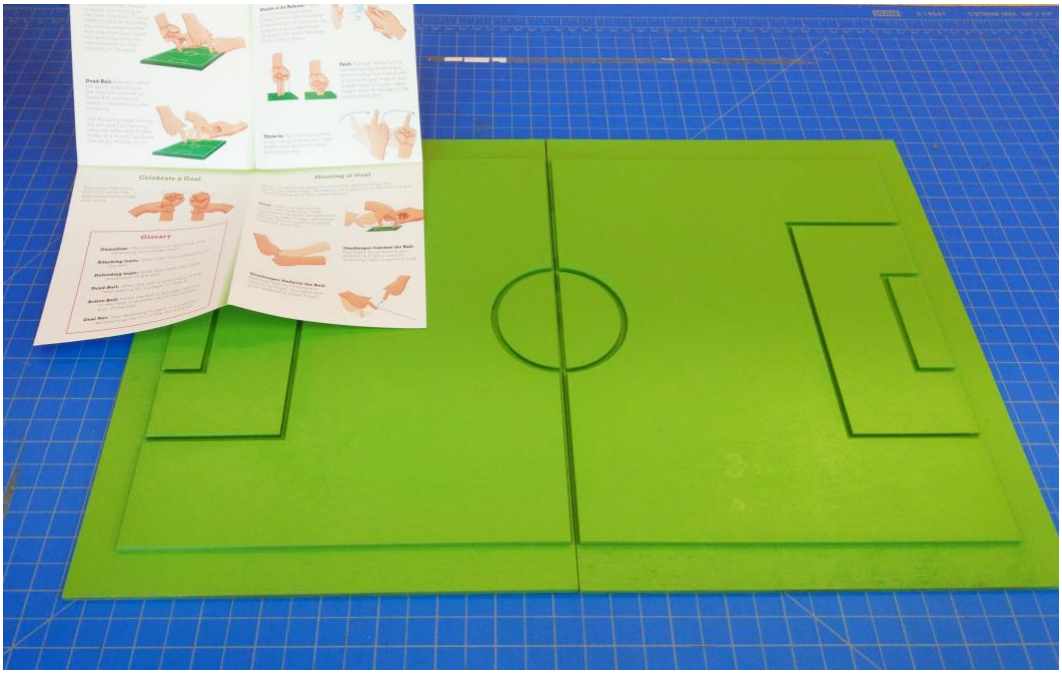


Figure 14: Third iteration for the design of the wooden board as a field and updated instructions.

Five participants, 3 women and 2 men, were recruited for this session. Participants found the illustrations in the instructions clear but commented on the need for differentiation between the interpreter's and spectator's hands; most of the feedback was regarding the design and aesthetic of the instructions, which was a good indication that the content copy was satisfactory. All participants in this session were both interpreters and spectators (they covered their eyes with a sleep mask), and used the wooden board for the whole session (Figure 15). A longer conversation between the participants and author involved the difference between being a spectator using a tactile sense, versus

being a spectator with visual or sonic cues. All participants gave positive feedback about the feeling and size of the board, but most commented that it was still hard to make up the boundaries of the field while they were interpreting – a solution was discussed during the session of having raised boundaries instead. They were asked to suggest a specific game they would like to interpret or spectate, and the author would find a full version of the game on the web and play it on a big screen beside them. This proved to be a good ice-breaker, as most participants used the setup time to get to know each other's team preferences.

Figure 15: Participants using the board and instructions to interpret a soccer game. This was the first time that both the interpreter (left) and spectator (right) they had seen the instructions, and they were able to understand the concept within a few minutes.

4.5.4 High-fidelity Prototype

Using the feedback gathered from the last session, the prototype was refined to include the following changes: the design of the instructions required a redesign to improve space and legibility (see Appendix A – 7.1.4), and, using marketing collateral as inspiration, a four-part set of instructions with both cover and back pages were implemented. The wooden board was redesigned using new materials to showcase the raised boundaries of the field. Lastly, an identity was developed to position the high-fidelity prototype as a potential product during GradEx103. Displaying the prototype at GradEx103 is important, as approximately 40,000 visitors attend over the course of the show. Creating an identity for the prototype is essential in order to market to and engage interested visitors.

4.6 Insights and Discussion

4.6.1 Interpretation and Instructions

Based on the participants' feedback, the design of the high-fidelity prototype reached a comprehensive level that is not entirely intuitive, simply because of the complex nature of the content, rather than because of significant problems with the design of the instructions. On the first try, participants had trouble understanding that both hands of the interpreter would change gestures to represent

different actions of the field – such as switching from field player to goalkeeper, or from ball to goal net. However, as participants practiced, they became familiar with the dynamics of the interpretation.

4.6.1.1 Who is Feeling the Board?

During the feedback sessions, participants kept confusing who (the spectator or the interpreter) would be touching the field. At the beginning, participants found it counterintuitive that, rather than the spectator, the interpreter would be the one touching the field. The interpreter needs to *feel* the board, because while he is observing the game, he has no time to check visually if his fingers are in the right location on the board. Through this method, the spectator also has autonomy to decide when and for how long he will be a spectator. Nevertheless, it is counterintuitive that the tactile properties of the wooden board are used to guide the interpreter, and not the spectator. Participants mentioned that adjusting to the high pace of the game was difficult at the beginning; one participant admitted, "as an interpreter, it was hard for me to know the location of my fingers on the board in relation to the game". Most participants suggested raising the boarders of the field to keep their fingers from falling off the board; this suggestion would be adjusted in future prototypes. In

addition, some participants suggested having different textures for different sections of the field, possibly by engraving a pattern on the wood. This seems like a good solution, but I worry that it would increase the cognitive load while the interpreter is observing and interpreting a high pace activity like a soccer game.

4.6.1.2 Celebration: An Important Experience of Spectatorship

During the analysis of the case study in Colombia there were a lot of gestures that were omitted from the instructions, because they were not directly correlated to the interpretation of the game. Celebrations was one of the gestures omitted in the instructions, however, during the feedback session participants insisted that there be a way to represent celebrations. This proves that the act and the experience of celebrating a goal or a team accomplishment is an important part of game spectatorship – even if is not directly related to the mechanics of the game.

4.6.1.3 Ball Possession

Overall, participants felt the instructions delivered enough information on the interpretations, to understand the basics of what was happening in the game, however a reoccurring comment was that they desired to know which team had possession of the ball, even though it could be inferred by the movement of the fingers within the board. Participants wanted to it to be more evident who had

possession; one was adamant that they represent the possession of the ball. This participant started to wiggle their finger to represent ball possession; at that session, the spectator found the finger-wiggling useful. It was an interesting comment and proposed solution, but it seemed clear that the participant wanted to represent what he is accustomed to seeing, rather than to be open to new concepts and ways to interpret the game. This is an important insight; spectators that use visual cues to experience the game are highly depend on knowing which team has the ball in order to understand game flow. This is very different than Cesar's and Jose Richard's tactile interpretation of possession.

4.6.1.4 The Responsibility as an Interpreter

Participants commented on the inherited responsibility they felt and the pressure to accurately interpret and transmit the game to the spectator; this pressure made it more challenging for them to concentrate on the task. They also felt they had to be consistently looking at the game, because the game is constantly changing so fast. However, they felt rewarded when the spectator understood a specific game event through their interpretation. One participant commented, "It was an awesome interaction with the spectator." Lastly, two participants doubted their soccer knowledge at the time of their interpretation, excusing themselves for a "poor interpretation," this

was an interesting insight as it was assumed prior to the recruitment that a high knowledge of soccer was not required. Further studies on the game of soccer for interpretation purposes would be needed.

4.6.1.5 What the Spectators Felt.

Participants commented positively on their experience as spectators. They enjoyed experiencing the game in a different and unique way and mentioned that they could *feel* the pace of the game. One participant mentioned that the silence was unfordable. This was interesting as the spectators were also deprived from the visual cues (by way of the sleep mask), but not of their hearing. Yet the video that was played was soundless, and the interpreter was quiet throughout the interpretation. However, this tells us that the experience of the spectator could change significantly when there are direct and indirect sonic cues in the background.

4.6.2 Sustainability of the Prototype

A secondary objective of this high-fidelity prototype was to explore the marketability of a potential product that could deliver entertainment value and also foster a larger discussion of what it means to be a spectator. Instructions can be distributed on the web, however, inspired by Rogers Diffusion of Innovation (Rogers, 2010), it is essential to target early adopters in order to diffuse the

entertainment value of the prototype to the public. This could be done by providing a toolkit composed of instructions, wooden board, a sleep mask, and marketing collateral to key supporting fans inside stadiums or communities. The potential of developing a product around the toolkit can recruit diverse people as both fabricators and consumers.

4.6.3 Validation

Many validation studies can be designed to test the various objectives of the prototype. A feedback session can be designed to include professional sports commentators, players and knowledgeable fans, in order to receive input on the innovation of the prototype and its effectiveness. During the feedback sessions, it was observed that the learning curve was steeper than expected for participants to fully understand the concepts needed to implement the instructions. A study to evaluate this learning curve would need to be done to better target audience age and cognitive abilities.

An additional objective would be to develop the instructions as a possible tool for tactile sign language interpreters to interpret soccer games to the Blind and Deaf-Blind community. Feedback sessions with sign language interpreters can gather feedback on the likelihood that both the instructions and the artifact (the wooden board) would have the potential to be circulated within their circles, with the aim to

standardize the tactile interpretation of the soccer game by professional interpreters.

4.6.4 Limitations

During the feedback, session participants wondered how a blind user would read the instructions since the instructions depend on the illustrations to be effective. It was reminded to the participants that the prototype would need two participants and minimum one of them would have to have sight to interpret the game, this participant with sight can explain the instructions and actions to the supposedly blind participant. However, this brings to light a limitation of the prototype, it requires two participants with one required to have sight. There is a lost sense of autonomy from the spectator.

4.7 Future Work

A product resulting from the high-fidelity prototyping can be a stepping stone to diffuse tactile spectatorship to the public and present a potential entertainment value to existing spectators not only from the soccer domain but other sports. While each sport its different in its rules and dynamics, similitudes can be drawn that could make this prototype work on other sports. Basketball, hockey, and rugby are some sports that come to mind because they are ball-centric, multiplayer sports, and fast paces games.

There is also a case to be made for the implementation of the prototype as a cognitive development tool for kids, with the aim to enhance their spatial understanding using multiple senses.

5 Conclusion

This two-part project is a stepping stone to understanding what attributes of the game are needed to convey the understanding of a live soccer game using tactile modalities. By recognizing uniqueness and diversity, we outsourced the Co-Design phase of the project to a case study found in Colombia. We reported on their current stage of reiteration, and our analysis of their methods was explained through previous work done in the field of cognitive semiotics, gesture, and spatial studies. The second part of the paper explores the use of iterative design to develop a prototype. The prototype helped showcase the work done in Chapter One, by fostering a discussion of what it means to be a spectator, developing an interactive and visually appealing prototype, and discussing what would bring the prototype to the public.

As innovative this tactile soccer interpretation is, we are aware that it continues to carry a lot of subjective qualities in its translation, and we hope that our work can encourage designers to develop

different methods to improve both the independence and autonomy of tactile soccer spectators.

6 References

Antonelli, P. (2008). *Design and the elastic mind*. The Museum of Modern Art.

Armstrong, D. F. (1983). Iconicity, Arbitrariness, & Duality of Patterning in Signed & Spoken Language: Perspectives on Language Evolution. *Sign Language Studies*, *38*(1), 51-83.

Bødker, S., Ehn, P., Sjögren, D., & Sundblad, Y. (2000, October). Co-operative Design—perspectives on 20 years with 'the Scandinavian IT Design Model'. In *proceedings of NordiCHI* (Vol. 2000, pp. 22-24).

Casasanto, D., & Boroditsky, L. (2008). Time in the mind: Using space to think about time. *Cognition, 106*(2), 579-593.

Cangelosi, Angelo. "Evolution of communication and language using signals, symbols, and words." *IEEE Transactions on Evolutionary Computation* 5.2 (2001): 93-101.

Coppin, P. W. (2014). *Perceptual-cognitive properties of pictures, diagrams, and sentences: Toward a science of visual information design* (Doctoral dissertation). University of Toronto, Canada.

Coppin, P. W. (2015). What is lost in translation from visual graphics to text for Accessibility. In D. C. Noelle, R. Dale, A. S. Warlaumont, J. Yoshimi, T. Matlock, C. D. Jennings, & P. P. Maglio (Eds.), *Proceedings of the 37th Annual Cognitive Science Society* (pp. 447–452). Austin, TX: Cognitive Science Society.

Coppin, P. W., Li, A., & Carnevale, M. (2016). *Iconic properties*

are lost when translating visual graphics to text for accessibility. In J. Zlatev, P. Konderak, & G. Sonesson (Eds.), *Meaning, mind, and communication: Explorations in cognitive semiotics* (pp. 279–295). Frankfurt am Main, Germany: Peter Lang.

Cummins, R. G. (2009). The effects of subjective camera and fanship on viewers' experience of presence and perception of play in sports telecasts. *Journal of Applied Communication Research*, *37*(4), 374-396.

Darcy, S., Lock, D., & Taylor, T. (2017). Enabling inclusive sport participation: Effects of disability and support needs on constraints to sport participation. *Leisure Sciences*, *39*(1), 20-41.

de Haan, D., Faull, A., & Kohe, G. Z. (2014). Celebrating the social in soccer: spectators' experiences of the forgotten (Blind) Football World Cup. *Soccer & Society*, *15*(4), 578-595.

DeWalt, K. M., DeWalt, B. R., & Wayland, C. B. (1998). "Participant observation." In H. R. Bernard (Ed.), *Handbook of methods in cultural anthropology.* Pp: 259-299. Walnut Creek, CA: AltaMira Press.

Dunne, A., & Raby, F. (2013). Speculative everything: design, fiction, and social dreaming. MIT press.

Estabrooks, P. A., Lee, R. E., & Gyurcsik, N. C. (2003). Resources for physical activity participation: does availability and accessibility differ by neighborhood socioeconomic status?. *Annals of behavioral medicine*, *25*(2), 100-104.

Freksa, C. (1997). Spatial and temporal structures in cognitive

processes. In *Foundations of Computer Science* (pp. 379-387). Springer, Berlin, Heidelberg.

Gardenfors, P. (2004). Conceptual spaces as a framework for knowledge representation. *Mind and Matter, 2*(2), 9-27.

Harnad, S. (1987). Psychophysical and cognitive aspects of categorical perception: A critical overview. In *Categorical perception: The groundwork of cognition* (pp. 1-52). Cambridge University Press.

Imai, M. & Kita, S. (2014). The sound symbolism bootstrapping hypothesis for language acquisition and language evolution. *Phil. Trans. R. Soc. B, 369*(1651). doi:10.1098/rstb.2013.0298

Iverson, J. M., & Goldin-Meadow, S. (1998). Why people gesture when they speak. *Nature*, *396*(6708), 228.

Kalyvas, V., & Reid, G. (2003). Sport adaptation, participation, and enjoyment of students with and without physical disabilities. *Adapted Physical Activity Quarterly*, *20*(2), 182-199.

Kirsh, D. (2010). Explaining artifact evolution. In L. Malafouris & C. Renfrew (Eds.), *The cognitive life of things: recasting the boundaries of the mind* (pp. 121–144). Cambridge, UK: University of Cambridge.

Langerman, A., & Grantcharov, T. (2017). Are We Ready for Our Close-up?: Why and How We Must Embrace Video in the OR. *Annals of Surgery*, 266(6), 934-936. doi:10.1097/SLA.0000000000002232

Larkin, J. H., & Simon, H. A. (1987). Why a diagram is (sometimes) worth ten thousand words. *Cognitive science*, *11*(1), 65-100.

Lukens, J., & DiSalvo, C. (2011). Speculative design and technological fluency. *International Journal of Learning and Media*, *3*(4), 23-40.

Macbeth, J. (2008). Equality issues within partially sighted football in England. *Social and cultural diversity in a sporting world*, 65-80.

McNeill, D. (2005). *Gestures and thought*. University of Chicago press.

McNeill, D. (2012). *How language began: Gesture and speech in human evolution*. Cambridge University Press.

Mehus, I. (2005). Sociability and excitement motives of spectators attending entertainment sport events: Spectators of soccer and ski-jumping. *Journal of Sport Behavior, 28*(4), 333.

Morrel-Samuels, P., & Krauss, R. M. (1992). Word familiarity predicts temporal asynchrony of hand gestures and speech. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *18*(3), 615.

Muller, M. J. (1991, April). PICTIVE—an exploration in participatory design. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 225-231). ACM.

Nielsen, J. (1994, April). Usability inspection methods. In *Conference companion on Human factors in computing systems* (pp. 413-414). ACM.

Nind, M. (2017). The practical wisdom of inclusive research. *Qualitative Research*, *17*(3), 278-288.

Ozyiirek, A. (2000). The influence of addressee location on spatial language and representational gestures of direction. *Language and gesture*, *2*, 64.

Peirce, C. S. (2009). Writings of Charles S. Peirce: A Chronological Edition, Volume 8: 1890–1892 (Vol. 8). Indiana University Press.

Pollick, A. S., & De Waal, F. B. (2007). Ape gestures and language evolution. *Proceedings of the National Academy of Sciences*, *104*(19), 8184-8189.

Promis, D., Erevelles, N., & Matthews, J. (2001). Reconceptualizing inclusion: The politics of university sports and recreation programs for students with mobility impairments. *Sociology of Sport Journal*, *18*(1), 37-50.

Robertson, J., & Emerson, E. (2010). Participation in sports by people with intellectual disabilities in England: A brief report. *Journal of Applied Research in Intellectual Disabilities*, *23*(6), 616-622.

Rogers, Everett M. *Diffusion of innovations*. Simon and Schuster, 2010.

Sacha, D., Stein, M., Schreck, T., Keim, D. A., & Deussen, O. (2014, October). Feature-driven visual analytics of soccer data. In *Visual Analytics Science and Technology (VAST)*, 2014 IEEE Conference on (pp. 13-22). IEEE.

Sanders, E. N. (2000). Generative tools for co-designing. In *Collaborative design* (pp. 3-12). Springer, London.

Sanders, E. B. N., & Stappers, P. J. (2014). Probes, toolkits and prototypes: three approaches to making in codesigning. *CoDesign*, *10*(1), 5-14.

Sengers, P., Boehner, K., David, S., & Kaye, J. J. (2005, August). Reflective design. In *Proceedings of the 4th decennial conference on Critical computing: between sense and sensibility* (pp. 49-58). ACM.

Senghas, A., Kita, S., & Özyürek, A. (2004). Children creating core properties of language: Evidence from an emerging sign language in Nicaragua. *Science, 305*(5691), 1779-1782.

Spinuzzi, C. (2005). The methodology of participatory design. *Technical communication*, *52*(2), 163-174.

Stein, M., Janetzko, H., Breitkreutz, T., Seebacher, D., Schreck, T., Grossniklaus, M., ... & Keim, D. A. (2016). Director's cut: Analysis and annotation of soccer matches. *IEEE computer graphics and applications, 36*(5), 50-60.

Stein, M., Janetzko, H., Seebacher, D., Jäger, A., Nagel, M., Hölsch, J., ... & Grossniklaus, M. (2017). How to make sense of team sport data: From acquisition to data modeling and research aspects. *Data, 2*(1), 2.

Sundblad, Y. (2010, October). UTOPIA: Participatory Design

from Scandinavia to the World. In *IFIP Conference on History of Nordic Computing* (pp. 176-186). Springer, Berlin, Heidelberg.

Tudor, A. (2006). World Cup worlds: Media coverage of the soccer World Cup 1974 to 2002. *Handbook of sports and media*, 232-246.

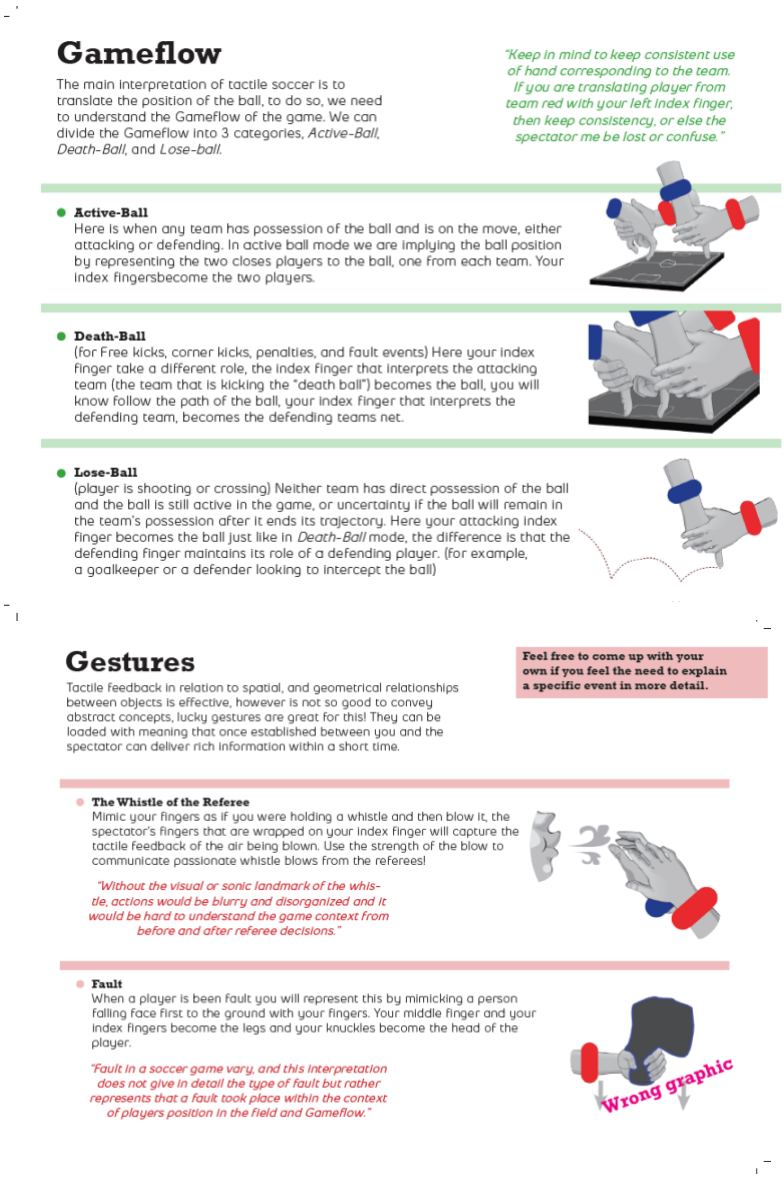
Vargas, J., & Venezia, A. (2015). Co-Design, Co-Delivery, and Co-Validation: Creating High School and College Partnerships to Increase Postsecondary Success. *Jobs for the Future*.

7 Appendices

7.1 Appendix A – Design of Instructions

7.1.1 First feedback session

Instructions shown to participants of the first feedback session.



Gameflow

The main interpretation of tactile soccer is to translate the position of the ball, to do so, we need to understand the Gameflow of the game. We can divide the Gameflow into 3 categories, *Active-Ball*, *Death-Ball*, and *Lose-ball*.

"Keep in mind to keep consistent use of hand corresponding to the team. If you are translating player from team red with your left index finger, then keep consistency, or else the spectator me be lost or confuse."

- **Active-Ball**
  Here is when any team has possession of the ball and is on the move, either attacking or defending. In active ball mode we are implying the ball position by representing the two closes players to the ball, one from each team. Your index fingersbecome the two players.

- **Death-Ball**
  (for Free kicks, corner kicks, penalties, and fault events) Here your index finger take a different role, the index finger that interprets the attacking team (the team that is kicking the "death ball") becomes the ball, you will know follow the path of the ball, your index finger that interprets the defending team, becomes the defending teams net.

- **Lose-Ball**
  (player is shooting or crossing) Neither team has direct possession of the ball and the ball is still active in the game, or uncertainty if the ball will remain in the team's possession after it ends its trajectory. Here your attacking index finger becomes the ball just like in *Death-Ball* mode, the difference is that the defending finger maintains its role of a defending player. (for example, a goalkeeper or a defender looking to intercept the ball)

Gestures

Tactile feedback in relation to spatial, and geometrical relationships between objects is effective, however is not so good to convey abstract concepts, lucky gestures are great for this! They can be loaded with meaning that once established between you and the spectator can deliver rich information within a short time.

Feel free to come up with your own if you feel the need to explain a specific event in more detail.

- **The Whistle of the Referee**
  Mimic your fingers as if you were holding a whistle and then blow it, the spectator's fingers that are wrapped on your index finger will capture the tactile feedback of the air being blown. Use the strength of the blow to communicate passionate whistle blows from the referees!

  "Without the visual or sonic landmark of the whistle, actions would be blurry and disorganized and it would be hard to understand the game context from before and after referee decisions."

- **Fault**
  When a player is been fault you will represent this by mimicking a person falling face first to the ground with your fingers. Your middle finger and your index fingers become the legs and your knuckles become the head of the player.

  "Fault in a soccer game vary, and this interpretation does not give in detail the type of fault but rather represents that a fault took place within the context of players position in the field and Gameflow."

Wrong graphic

7.1.2 Second feedback session

Instructions shown to participants of the second feedback session.

Gameflow

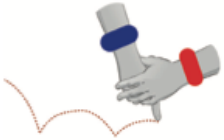
The primary translation of tactile soccer is to experience the GameFlow of the game; Two concepts are needed to know: Active-Ball and Death-Ball.

Active-Ball: Once the ball is active and moving on the field is call Active-Ball, this is interpreted by using each of your index fingers as the closest player to the ball, one from each team. You would be using this interpretation for the majority of the game.

Death-Ball: Goal kick, Free Kick, Corner Kick, Penalties are all events in which the ball is stationary in the field; this is referred to Death-Ball, and tactile soccer interprets it by the following:

The Attacking finger mimics the ball location and trajectory, while the defending index finger represents the team's net.

When a player kicks the ball towards a goal (either on target or off target) it is also considered Death-Ball



When Play Stops

The transition between Active-Ball and Death-Ball takes place when the GameFlow is interrupted. The whistle of the referee, player faults or ball out of play are essential to help define when the game flow is interrupted.

Whistle of the Referee: Place your fingers as if you were holding a whistle and then blow it, the spectator's fingers that are wrapped on your index finger will capture the tactile feedback of the air being blown.

Fault: A player being fault is represented by mimicking a person falling face-first to the ground with your fingers. Your middle finger and your index fingers become the legs and your knuckles become the head of the player.

Goal

When a team scores a goal, the defending hand represents the Goal net, while the attacking index finger represents the ball and its trajectory going inside the Goal net.

Before the game starts, determine with the spectator which team corresponds to which hand.

Glosary

Gameflow: The transition of attacking and defending from either team.

Attacking team: Team that has possession of the ball.

Defending team: Team that does not have possession of the ball.

Death-Ball: When the ball is stationary in the field waiting for a player to kick it.

Active_Ball: When the ball is actively moving in the field, and either team has possession of the ball.

Goal Net: Your defensing fingers in a position representing the arc of the team's goal.

Advance Interpretations

Heading the Ball

(Death-Ball & Active-Ball)

A defending or attacking player heading the ball is represented by using your knuckles as the player's head and lifting your finger to mimic the jump of the player.

Goalkeeper Saves

(Death-Ball)

Catching the ball: is represented by wrapping your defending fingers onto the attacking finger (the ball)

Deflecting the ball: is represented by using your defending index finger to flick the attacking finger (the ball).

7.1.3 Third feedback session

Instructions shown to participants of the Third feedback session.

Gameflow

The primary translation of tactile soccer is to experience the GameFlow of the game; Two concepts are needed to know: Active-Ball and Dead-Ball.

Active-Ball: This is interpreted when the ball is active and moving on the field. Use each of your index fingers to represent the closest player to the ball, one from each team. You would be using this interpretation for the majority of the game.

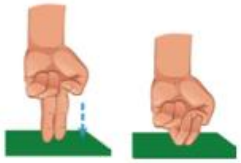
Dead-Ball: Events in which the ball is stationary in the field are referred to Dead-Ball, and tactile soccer interprets it by the following:

The Attacking finger mimics the ball and its trajectory, while the defending fingers (index and thumb) represent the net by making an arc.

When Play Stops

The transition between Active-Ball and Dead-Ball takes place when the play stops, like the whistle of the referee and player fauls.

Whistle of the Referee: Place your fingers as if you were holding a whistle and then blow it, the spectator's fingers that are wrapped on your index finger will capture the tactile feedback of the air being blown.



Fault: A player being fault is represented by mimicking a person falling face-first to the ground with your fingers. Your middle finger and your index fingers become the legs of the person being fault.

Throw In: To inform of a throw in, you swing both of your index fingers back and front, while pointing the sky.

Celebrate a Goal

Rock your fists back and forth while the spectators hand holds your wrist.

Shooting at Goal

When an attacking team shoots at the opponents net, the attacking index finger represents the trajectory of the ball, this are some of the events that could happen.

Goal: When a team scores a goal, the defending hand represents the goal-net, while the attacking index finger represents the ball and its trajectory going inside the goal-net.

Goalkeeper Catches the Ball: Represent by wrapping your defending fingers onto the attacking index finger (the ball)

Goalkeeper Deflects the Ball: Represented by flicking the attacking finger (the ball) with your defending index finger.

Glosary

Gameflow: The transition of attacking and defending from either team.

Attacking team: Team that has possession of the ball.

Defending team: Team that does not have possession of the ball.

Dead-Ball: When the ball is stationary in the field waiting for a player to kick it.

Active-Ball: When the ball is actively moving in the field, and either team has possession of the ball.

Goal Net: Your defensing fingers in a position representing the arc of the team's goal.

7.1.4 Final Instructions

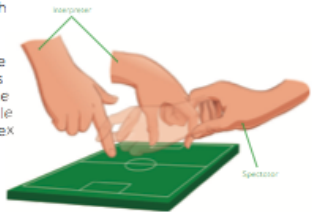
Final instructions developed based on feedback sessions.

Gameflow

The primary translation of VTI is to experience the game-flow; both the interpreter and translator need to know two concepts: Active-Ball and Dead-Ball.

Active-Ball: This is interpreted when the ball is active and moving on the field. The interpreter's index fingers represent the closest player to the ball, one from each team.

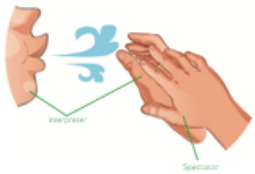
Dead-Ball: Events in which the ball is stationary in the field are Dead-Ball, and VTI interprets it by the following: The interpreter's attacking finger mimics the ball and its trajectory, while the defending fingers (index and thumb) represent the net by making an arc.

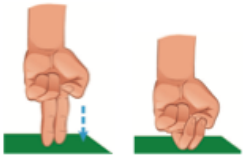


When Play Stops

The transition between Active-Ball and Dead-Ball takes place when the play stops, like the whistle of the referee and in-game faults.

The Whistle: The interpreter blows on an imaginary whistle held in its fingers, the spectator will capture the tactile feedback through the blown air.



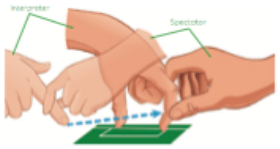


Faults: The interpreter's fingers mimic a person falling face-first to the ground, the middle and index finger become the legs.

Throw In: The interpreter swings both of its index fingers back and forth while pointing to the sky.

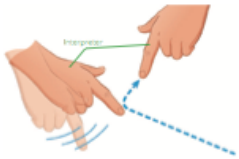
Shooting at Goal

When an attacking team shoots at the opponents net, the attacking index finger represents the trajectory of the ball.



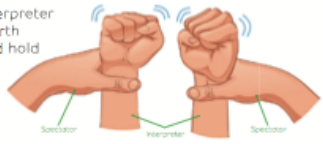
Goal: When a team scores a goal, the defending hand represents the goal-net, while the attacking index finger represents the ball and its trajectory going inside the goal-net.

Goalkeeper Catches the Ball: The interpreter wraps its defending fingers onto the attacking index finger (the ball).



Goalkeeper Deflects the Ball: The interpreter flicks the attacking finger (the ball) with the defending index finger.

Celebrate a Goal: The interpreter rocks its fists back and forth while the spectator's hand hold the interpreter's wrists.



Glossary

Gameflow: The transition of attacking and defending from either team.

Attacking team: The team that has possession of the ball.

Defending team: The team that does not have possession of the ball.

Dead-Ball: When the ball is stationary in the field waiting for a player to kick it.

Active-Ball: When the ball is actively moving in the field, and either team has possession of the ball.

Goal Net: The interpreter's index and thumb representing the arc and location of the team's goal.

VTI Board: Wooden board with soccer boundaries, you can make your own with cardboard and hot glue.

7.2 Appendix B – REB forms

7.2.1 Consent Form

Consent form provided to the participants.

Consent Form
Feedback on Tactile Soccer Instructions

Date: **2018-03-16**
Project Title: **Soccer spectators, Multimodality approach**

Principal Investigator:
Felipe Sarmiento
OCAD University
[redacted]

Faculty Supervisor (if applicable):
Peter Coppin
Faculty of **Design**
OCAD University
[redacted]

INVITATION
You are invited to participate in a study that involves research. The purpose of this study is to address the research question of, what are the game attributes from live soccer games that are needed to interpret or translate to non-visual-non-sonic methods? The session would be recorded and photographed, the videos and photos would only be used for data analysis and would be confidential.

WHAT'S INVOLVED
Participants will be asked for feedback on instructions that explain how to interpret soccer tactile, feedback on clarity and relevance to the game would be encourage. Participants would be asked for to demonstrate the actions to the researcher or fellow-participants (optional). Participation will take 20 minutes (approximately) of your time, the principal Investigator would be present in the session and will record a video, take photos and create observational notes in a notebook. Please see *permission to record* on page 2.

POTENTIAL BENEFITS
Possible benefits of participation include improve the documentation and showcase of methods to interpret soccer action using non-visual non-sonic techniques.

RISKS
The risks and discomfort associated with participation in this study are no greater than those ordinarily encounter in daily life or during the performance of the routine in observation.

CONFIDENTIALITY
Your data and consent form will be kept separate. By participating, you understand and agree that the data an information gathered during this study may be published and/or distributed. This study is not meant to be confidential, please refrain from disclosing confidential data, if for any circumstances any confidential data is disclosed and recorded, it would be promptly destroyed and any associated data collected in the study.

Data collected during this study will be stored securely in an external hard drive in Burlington, Canada. Data will be kept until May 2018 after that it would be destroyed. Access to this data will be restricted to Peter Coppin, Sarah Tranum and Felipe Sarmiento. The analysis of the data would be available to the public.

VOLUNTARY PARTICIPATION
Participation in this study is voluntary. If you wish, you may decline to answer any questions or participate in any component of the study. Further, you may decide to withdraw from this study at any time, or to request withdrawal of your data (prior to data analysis which is 2 weeks after the data is collected), and you may do so without any penalty.

PUBLICATION OF RESULTS
Results of this study may be published in reports, professional and scholarly journals, student's theses, and/or presentations to conferences and colloquia. In any publication, data will be presented in aggregate forms. Quotations from interviews or surveys will not be attributed to you without your permission.

Feedback about this study will be available on an ongoing basis and can be contacted to Felipe Sarmiento at [redacted] or anonymously at OCAD University MDes inclusive Design Students at [redacted]

CONTACT INFORMATION AND ETHICS CLEARANCE
If you have any questions about this study or require further information, please contact the Principal Investigator Felipe Sarmiento or the Faculty Supervisor Peter Coppin using the contact information provided above. This study has been reviewed and received ethics clearance through the Research Ethics Board at OCAD University [101106]. If you have any comments or concerns, please contact the Research Ethics Office through [redacted]

PERMISION TO RECORD

You are aware that video recording and photographs would be use in this study and your visual appearance would be recorded, since it is important for this study that any gestural symbolism would be recorded. This includes hand gestures, facial gestures and any other alike. This video recording and photographs would be confidential and any data analysis visual references would not use any screenshots, video clips, or photographs from the sessions.

CONSENT FORM

With your agreement, we would like to contact you again in 2 week to ask you another set of similar questions. You may decide at that time whether you wish to participate in that part of the study.

I agree to participate in this study described above. I have made this decision based on the information I have read in the Information-Consent Letter. I have had the opportunity to receive any additional details I wanted about the study and understand that I may ask questions in the future. I understand that I may withdraw this consent at any time.

Name: _____

Signature: _____ Date: _____

Thank you for your assistance in this project. Please keep a copy of this form for your records.

7.2.2 Recruitment Script

The following script was posted on the authors social media channels, Facebook, Instagram and twitter.

Are you interested in learning how to interpret soccer using your fingers?

If you have some knowledge of soccer, I would like to invite you to a research study that revolves around the interpretation of soccer games using non-visual, non-sonic techniques.

The study is composed of a session that would show you some instructions on how to interpret soccer with your fingers; your task is to provide feedback on your understanding of the instructions and the relevance of tactile soccer spectatorship. The session would take approximately 20 minutes of your time, I would be providing the instructions and I would also be collecting the feedback.

The session would be recorded and photographed, the videos and photos would only be used for data analysis and would be confidential. This study is confidential; however, the result of the instructions based on everyone's feedback would be available to the public.

If interested, send me an email at [redacted]

7.2.3 REB approval Letter

November 20, 2017

Dr. Peter Coppin
Faculty of Design
OCAD University

File No: 101106
Approval Date: November 20, 2017
Expiry Date: November 19, 2018

Dear Dr. Peter Coppin, Mr. Felipe Sarmiento,

The Research Ethics Board has reviewed your application titled 'Soccer spectators: A Multi-modal approach'. Your application has been approved. You may begin the proposed research. This REB approval, dated November 20, 2017, is valid for one year less a day: November 19, 2018. Your REB number is: 2017-51.

Throughout the duration of this REB approval, all requests for modifications, renewals and serious adverse event reports are submitted via the Research Portal.

Any changes to the research that deviate from the approved application must be reported to the REB using the amendment form available on the Research Portal. REB approval must be issued before the changes can be implemented.

To continue your proposed research beyond November 19, 2018, you must submit a Renewal Form before November 12, 2018. REB approval must be issued before research is continued.

If your research ends on or before November 19, 2018, please submit a Final Report Form to close out REB approval monitoring efforts.

If you have any questions about the REB review & approval process, please contact the Christine Crisol Pineda, Manager, REB secretariat at [redacted] or [redacted]

If you encounter any issues when working in the Research Portal, please contact our system administrator via [redacted]

Sincerely,

Nancy Snow
Acting Chair, Research Ethics Board

7.3 Appendix C –Feedback forms

7.3.1 Feedback form for instructions

Feedback on the clarity of the instructions

What was(were) the most confusing part(s) of the instructions?

Did you have to read the instructions multiple times to understand the content? If yes, do you think this is a problem with the instructions, or the material is complex by nature?

Is there something that you still don't understand even after reading the instructions multiple times?

Did you find the illustrations helpful? If not, what would make them more clear?

Can you comment on the design and aesthetics of the instructions, do you think they add or take away from the content?

Is there any additional comment regarding the instructions that you would like to give?

7.3.2 Feedback form for the interpretation

Feedback on the tactile soccer interpretation

Did you find the tactile feedback of the wooden board relevant or accurate?
If not, do you have any suggestions on how to improve wooden board design?

Using the instructions as a tactile spectator, do you think you understood what was going on in the game?

How was your experience as a tactile spectator?

How was your experience as a tactile soccer interpreter?

Any last comment on the overall session, or the study ?