Is it Still Worth Challenging the Status Quo? A Design Process Paper About the Involvement of Co-Dependent Users to Develop Safety Equipment for Horse Riders

Lisa Giusti Gestri
Swinburne University of Technology

Jockeys must wear safety vests as a piece of compulsory personal product equipment (PPE) due to the highly dangerous nature of horse racing. Notwithstanding that 'design thinking' became popular in various fields (e.g. business, education, health, IT), product innovation still not widely attract its application to the design of some PPE products. This article discusses a qualitative case study about the design of Australian safety vests for jockeys along with the application of user-centred design principles. This led to asking for a revision of this framework to accommodate design dependencies in terms of a suggested dependency-based user experience (D-UX) design framework along with further research in this field.

Keywords: innovation, case study, product standards, dependency-based user experience, industrial design

INTRODUCTION

There are various risky activities and race riding is well acknowledged to being one of those. Regardless of a jockeys' training and skill, falls are not preventable due to the interplay between horse and rider, which can result in unpredictable and unsightly events (Cripps, 2000). Despite it being compulsory for jockeys to wear personal protective equipment (PPE) such as gloves, helmets, goggles and safety vests in races, still, jockeys are daily exposed to high risk during races (including at the starting gates, during the flat race, until they cross the finish line) and in conditioning horses during track work, knowing that at some point in their career will likely to fall and be hurt (Polkinghorne, 2016).

Because of the diverse nature of sports and their varied injury risks, PPE is a broad product category with athletes often required to use a combination of pieces of equipment to offer full protection (Daneshvar, Baugh, Nowinski, McKee, Stern, and Cantu, 2011; Graham, Rivara, Ford, and Spicer, 2014). The PPE literature discusses ways in which design innovation and the latest materials have been applied to protect athletes from injury. Despite the thoroughbred horse racing industry sharp rises to popularity, there still is a limited understanding of producing differentiated safety vests to accommodate female and male users, leading to lack of ergonomics. Significantly, to date, no studies are present in the research literature that aimed to comprehend the intimate relationship between jockeys and their track-based medical professionals for insights into how to improve safety vests and their design. A recent publication (Giusti Gestri & Barnes, 2020) reflects on the barriers to innovation in jockey's safety vests due to product standards show limited innovation in the design of these products in Australia despite "*consistent rates of serious and fatal injuries to jockeys and the growing participation of female jockeys in the sport*" (p.838).

This paper discusses intimate insights about safety vests for jockeys gathered through a qualitative research study that involved, at the same time, jockeys and related professional staff. The author considered medical, epidemiological and surgical publications to build the basis of her study, which focused on the product experiences and the design of the safety vests. The importance of wearing PPE during any activities involving horses has been demonstrated in research but still there is a need to bring much more innovation to the design of jockeys' safety vests (Gibson, Thai, Saxon & Pollock, 2008). It is a fact that application of smart wearables in sports health is significantly increased but it is only marginal in this field. A superior classification of jockeys' injuries is required to collect the benefits of technologies because the integration of the cost data of jockeys' injuries claims with the Australian Racing Industry Database may bring benefits in safety measures (Curry, Hitchens, Otahal, Si & Palmer, 2016). Thanks to the knowledge generated by this study along with the insights gathered from the medical staff, my findings can contribute to smart vest blueprints. I focused on the Australian jockey's population that might seem little as the subject for new product design: however, in the future, horse riders and partakers in other sports should also be targeted for innovative safety vests because their injuries are like those reported in other sports (e.g. motorcycling and ski).

The number of participants (overall, 20) may seem limited but the author aimed to gain insights regarding personal experience from locally based jockeys and medical professionals. Therefore, I adopted the case-study methodology that is typically used to focus on a small group or situations and gather information about them on a specific topic, in this case, jockeys' safety vests. However, due to a higher number of jockeys and medical professionals present in Australia and eventually, around the world, the author strongly recommends further research in this field.

Both words *innovation* and *status quo* derived from the Latin language: the first one means renewal or change, while the second indicates the existing state or structure. The author found that in the original situation of jockeys' safety vests, it is hard to change the present products to bring innovation because it is almost impossible to obtain a revision of the standards in use since it is not taking into consideration the users and thus, ergonomics is not applied. Hence, I considered to challenge the *status quo* in this field from a multi-dependent user view of design rather than from that of a single user, or single persona user conventionally used by designers employing the user-experience design (UXD) model. The author asserted that while maintaining the primary user at the center of product innovation, dependencies on other users can become evident and should be accommodated in the design investigation. I discovered that these other users are not necessarily of less importance than the primary user, and incorporation of all users' needs positions the design researcher to detect critical interactions and response patterns that can reveal innovation opportunities in their target product.

Observers and researchers of the design of health products have long mentioned the need for user-centered design to acknowledge secondary and tertiary users (Norman & Draper, 1986; Norman, 1993; Tenhue, 2016). However, they do not have yet utilized a definition of those users that is nuanced to make them the same as primary users in terms of the significance of their input and access role. For instance, the need for a designer of computer interfaces to contemplate a medical 'primary' user and a patient 'secondary' user of a medical screen information display: all the users need equal standing for their important contribution to design success. This is worth even for the safety vests for jockeys: medical professionals and jockeys should have an equal status in the design process because they are directly involved in the use of these products in the specific case of jockeys' falls.

Besides, the growing popularity of activity trackers and wearable health devices has introduced the concept that the data produced by these devices could help health professionals to treat their patients. Hence, the author suggests that technology should be considered and integrated with the safety vest's design process because its application may transform them into a wearable technology, which produces benefits to jockeys and to medical professionals. The current vests are failing in providing sufficient protection and thus a reduction of injury recovery time to jockeys: therefore, the opportunity of upgrading a safety vest into a wearable device deserves more research in this field. Thus far, the development of smart wearable technologies in the sports and health sectors experience rapid success but, in the safety vests field, still need improvement. I considered technology because its role to enhance safety-vest function has not yet been

analyzed in this field: its application can transform a safety vest into a wearable technology, which brings benefits to jockeys and to health professionals. The performance of current safety vests for jockeys as devices to protect against injury during impact is not sufficient to afford demands regarding injury recovery, yet the possibility of upgrading a safety vest into a wearable device may introduce multiple benefits.

The term "wearable technology" refers to garments or accessories that are designed or improved via the use of electronics (King, 2011). Due to wearable technology's proximity to the human body, it can be used to monitor data about a user or its surroundings (Svanberg, 2013). Users are generally considered to be passive adopters of technology, but this study aimed to reconceive the users' role in the active mode because the users are those capable of building new meaning through the wearable interface (Samdanis & Lee, 2013). Hence, challenge the status quo in the horse racing industry could be worth because may generate a new design for safety vests for jockeys. Therefore, the author conducted this study regarding the "design of the solution" which shifts from the outside in.

JOCKEYS' RISKS AND INJURIES

Personal protective equipment (PPE) is core in preserving athletes' safety when participating in sport. Sports are of diverse nature and the PPE literature debates ways in which design innovation and the advanced materials available have been applied to safeguard athlete from injury, although there is no specific literature discussing the design of jockeys' safety vests. Wearing appropriate and properly fitted protective equipment, clothing and footwear help in preventing about 50% of sports injuries (Sports Medicine Australia, 2008).

In Australia, an average of 200 jockeys are injured each year on racetracks, 89% of falls requiring medical assistance with 40% of jockeys not available to ride for an average of five weeks a year (National Jockeys' Trust, 2017). The most common injuries sustained by jockeys are fractures and soft tissue damage, but the most serious are head and spinal damage, which can cause permanent, debilitating injuries and even result in death (Mackey-Laws, 2016; Aitken, 2017; Johnston, 2017, O'Connor, Warrington, McGoldrick, and Cullen, 2017). The catastrophic injuries suffered by jockeys in the torso area because of falls (Filby, Jackson, and Turner, 2012; McCrory, Turner, LeMasson, Bodere, and Allemandou, 2006) highlight the poor level of protection offered by current safety vests. Besides, falls are not preventable due to the interplay between horse and rider, which can result in unpredictable and unsightly events (Cripps, 2000).

Due to the risks that jockeys face, health professionals attend all race meetings to monitor the wellbeing of riders. Indeed, during races, ambulances follow the jockeys from an adjacent track: the staff is composed by a doctor, two ambulance officers and a registered critical care nurse that are ready to immediately rescue to jockeys if a fall occurs (Racing, 2008; Australian Harness Racing, 2015; Wilson Medic One, 2015). As specified by Benbow, who summarized his personal jockey's experience like "*when I go to work two ambulances follow me around, but with a young family at home waiting for me, it puts my mind at ease knowing the National Jockeys' Trust is there to support us in the event of a race fall*." (Moy, 2018).

Notwithstanding the reduction in the number of jockeys' deaths since the introduction of the compulsory use of safety vests, their effectiveness has come under sporadic criticism. Already in 2003, Roe et al. call for the efficacy of safety vests to be evaluated alongside a safety education program being introduced for all horse riders. Even Foote, McIntosh, V'Landys & Bulloch (2011) confirmed the importance of wearing safety vests and helmets during race riding, but criticism about the variety of standards covering PPE for jockeys were discussed. Particularly, Foote et al.'s report noted a paucity of data about the incidence and type of injuries sustained by jockeys in thoroughbred racing. While confirming the importance of wearing safety vests and helmets, Foote et al. (2011) criticized the variety of standards covering PPE for jockeys.

THE CASE STUDY ABOUT JOCKEY'S SAFETY VESTS

The Importance of Good Design for Users

The Australian case study discussed in this paper investigated issues associated with jockeys' safety vests that could prevent product innovation, starting from a User Centered Design (UCD) and User Experience Design (UXD) framework. The design was relevant as considered like an integral part of the evolution and/or implementation of product innovation. Specifically, Harte et al.'s (2017, p.2) definition of UXD as "*the perceptions and responses of users that result from their experience of using a product or service"* was applied to this study to identify primary and secondary users who could affect the development of the safety vests' design.

A complex concept is enclosed into the term '*design*'. This notion has received various nuances over time: however, at the foundations, it is located the purpose to express the work of an artist that, in the case of an artisan piece, happens at the end of the workmanship while in the industrial design piece, it takes place at the beginning (Dorfles, 1972). According to Dorfles (1972), among industrial products, only those possessing an aesthetic intent in the design phase can belong to the design category. As per what happens nowadays for glass, ceramics or carved metal, the artisan products never reach the absolute identity of each copy. However, there always is a differential quid to distinguish one product from another: and it is "precisely in this, albeit small, difference, in this very minute formal imperfection, that the charm and the very essence of this artistic form consists". (Dorfles, 1972, p. 29)

Still, design the shape of a product means much more than designing its external appearance, or rather integrating, coordinating and articulating both functional and technical-constructive factors as well as symbolic and cultural factors (Maldonado, 1976). This is what distinguishes the design from all the other artistic productions: an artistic form that aims to publicize itself in a product and the product in itself. Dorfles (1972) recognizes that in industrial design "there is, in addition to this self-publicizing aspect, also that of a 'presentative symbolism', that is, of a symbolic element which aims to highlight those characteristics proper to making the object in question palatable to the consumer" (p 61).

As previously stated, design research focuses on what ought to be via the disruption of the status quo, thus the author focused on the users. Their understanding, their needs, duties and habitats represent the basis of good design: it is well known that the User Centered Design (UCD) process is at the core of designer-dictated design that considers people as an extension of the designed artefact. Instead, User Experience Design (UXD) process focuses on the experience of what is designed. UXD is a core process of intensifying user satisfaction with a product via its accessibility, usability and the pleasure developed by the interaction of the user with the product.

The application of the UCD process as starting point to due be a dynamic and multi-dimensional cycle incorporating research, defining, creating and testing, led the author started to identify the people who primarily utilize the product (jockeys and related medical staff), then the reasons for using that (it is a safety tool) and under what circumstances it was used (horse racing). Design is still considered a wild or green land in continues evolution but the success of the design of a product is mainly based on the users' needs to be satisfied, as well as on the necessity to consider a third-party dependency situation to achieve what is better known as a design for users (Degani, 2004). Generally, the following kinds of users are identified: primary, secondary and tertiary (Eason, 1987). Specifically, primary users are considered those who utilize a product while the secondary users frequently are occasionally people that use a product via an intermediary. Instead, tertiary users are people that may make decisions or have a say in the product's purchase (Abras, Maloney- Krichmar, & Preece, 2004; Bergvall-Kåreborn & Ståhlbrost, 2008).

This study was the first exploration of the user and co-dependent user, where both depend on the successful design of a product. Its uniqueness is due by the involvement of such an "unusual" group of participants (jockeys and health professionals). In this case study and still based on the UXD and UCD processes, the jockeys were considered the primary users of safety vests in as such directly utilizing the product. Instead, the medical staff were not simply called the secondary users because they directly deal with the safety vests but either not named tertiary users due they are not the decision maker in purchasing the product. Hence, I named the medical professionals as co-dependent- users.

Australian Jockeys' Safety Vests and Design Knowledge

The literature shows a substantial number of studies debating on the frequency and nature of jockeys' injuries, ending in requesting more effective safety vests (e.g. Moss, Wan, and Whitlock, 2002; Yim, Yeung, Mak, Graham, Lai, and Rainer, 2007). Besides, other authors call for specific consideration of the design of safety vests for jockeys (Gibson, Thai, Saxon, and Pollock, 2008; Foote, et al., 2011; Safety Solutions, 2014).

Australian jockeys must wear safety vests, which were introduced in 1998. Since then, the Australian Racing Board (ARB) introduced the Australian standard ARB 1.1998, which was drawn up by Gibson and it is based on the SATRA standard, to which safety vests must to conform (Foote, Gibson, McGauran, 2014). Today, both ARB 1.1998 and EN 13158 standards are still applied. The reason for developing an Australian standard was the perceived climatic differences between Australia and Europe. According to Racing Australia (2021, p. 64) a horse rider "*when mounted on a horse, including but not limited to in a race, official trial, jump-out or track work*'" must wear a properly fastened safety vest. Hence, based on the race meetings or track work sessions they have been booked for, jockeys wear safety vests for many hours every day: they must wear safety vests when mounting horses (races and/or track sessions) but often jockeys even wear them while waiting to go back on the saddle.

The main purpose of a safety vest is to reduce the shock of impact to jockeys' bodies in case a fall occurs and to protect them against penetrating injuries (e.g. being kicked by a horse). At today's date, Australian safety vests for jockeys must comply with the ARB 1.1998 or the EN 13158 standards (Racing Australia, 2021, p.64). Hence, ARB 1.1998 is certified by Standards Australian and it determines that safety vests are made of perforated foam strips of varying thickness, covered with mesh polyester. Some present adjustable strips while others have Velcro® sections on the shoulders or on the waist zones with the aim of maintaining the vests narrow on the jockeys' bodies (Figure 1).

FIGURE 1
JOCKEY'S SAFETY VESTS IN USE AND APPROVED BY THE AUSTRALIAN RACING BOARD (ARB)

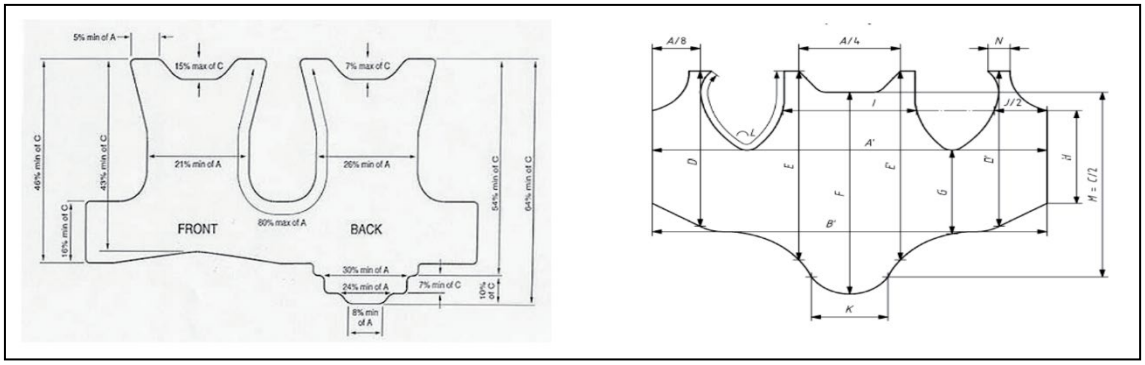
(Giusti Gestri & Barnes, 2020)

The current vests shown in Figure 1 are described as bulky and stiff, and thus restrictive and uncomfortable to wear: specifically, there is a need for jockeys' perspectives to be feed into product

development being recognized. Although wearing PPE is seen to have reduced the number and severity of impact injuries to the jockeys to an extent, still in case of emergency (such as where jockeys require medical attention on the track following a fall) PPE can obstruct access to the chest, face and head, interfering with the ability of medical crews to properly stabilize jockey's spine or head (Giusti Gestri & Barnes, 2020, p.843).

Casa and Stearns (2015) highlight the problem of obstruction where immobilization on a spine board is required. To date, according to the two standards in use in Australia, only two safety vests templates are available and these must accommodate male and female jockeys of varying body shapes and sizes (Figure 2).

FIGURE 2
COVERAGE AREA TEMPLATES APPLIED TO EN (LEFT) AND SATRA/ARB (RIGHT) STANDARDS



(Foote et al., 2014)

SATRA and ARB standards also require a minimum area of padding coverage that is different from that specified by the EN standards, as per Figure 2. The thickness and the kind of material used as padding determine safety vest's impact performance. In Australia, standards play a core role because are those that currently are not allowing innovation (e.g. use of latest materials, technologies and templates) and thus creating a vicious loop for a new design as well.

The vests utilized by Australian jockeys (Racing Australia, 2021, p. 64) are often described as restrictive and uncomfortable to wear with a need for jockeys' perspectives to be fed into product development to be recognized. However, the safety vests may obstruct access to the chest while goggles and helmets may slow down the access to the face and head injuries: medical professionals must quickly overcome these problems to stabilize jockeys and provide medical aid.

Along with the rigidity and hot temperature experienced by the Australian jockeys while wearing the vests, female participants rose another issue. Female jockeys reported to the author to prefer the vests worn during track work to those required for racing because they are heavier but softer: they need extra comfort because those vests tend to mold to their body shape slightly better. Participants clearly explained that the safety vests worn during race days were a source of discomfort and thus, the majority of jockeys reported wearing them differently to how they were meant to be worn, for instance, leaving the vest a bit looser. This may expose them to higher risks rather than offer superior protection.

The Challenge: The Absence of Design Innovation

To understand the complex and the constraints on innovation in the *design* of Australian jockey's safety vests, I organized a program of ethnographic research to understand jockeys' and medical professionals' experiences with and their perceptions of the safety vests. This study employed a flexible, qualitative research design incorporating individual semi-structured interviews, a focus group and observation conducted in 2016/17. The research design utilized the Product Ecology framework as suggested by Forlizzi

(2007) to expand the sense of what a product *is* and what it *could be*: hence, its value was applied to develop insights to contest the representation of a product in a long-established product standard. Forlizzi's concept of product ecology strongly supported this study in expanding how a product evokes social behavior, offering a path for choosing the adequate research method, expanding the design culture in interaction design that allows for design-centered research.

Users are unique, so each one associates different meanings and feelings with the product because of the everyday use of the same product, that lead to a long-established product standard. Hence, a qualitative approach and a holistic, interpretative sense-making approach to the study supported my analysis because qualitative research investigates how people build their realities and what meaning they associate with their experiences (Merriam & Tisdell, 2015).

I identified jockeys as the primary users because wearing the safety vests, while the secondary users recognized as primary users undergoing a secondary-user experience (medical staff) and there are even the tertiary users, which could be those responsible for helping in taking care of the vests and/or those designing/manufacturing them. Therefore, the participants were the primary users of the safety vests, which comprised apprentice jockeys (n=6), fully qualified jockeys (n=9) and former jockeys (n=2). Along with them, there was a secondary user group included: the medical professionals who handle the safety vests when jockeys are injured and often unconsciously lying on the turf. Thus, two doctors and one intensive care paramedic formed this group, which lead to a total of 20 participants (Table 1).

TABLE 1
CODING CODE, RACING AND FALL EXPERIENCES OF PARTICIPANTS IN THIS STUDY

Participant Code	Category	Gender	Years of Experiences	Falls	International Races
AJ 01	Apprentice Jockey	M	5	Yes	No
AJ 02	Apprentice Jockey	F	4	No	No
AJ 03	Apprentice Jockey	M	2	Yes	No
AJ 04	Apprentice Jockey	M	3	Yes	No
AJ 05	Apprentice Jockey	M	3	Yes	No
J 01	Jockey	F	6	Yes	No
J 02	Jockey	M	21	Yes	Yes
J 03	Jockey	M	24	Yes	Yes
J 04	Jockey	F	28	Yes	Yes
J 05	Jockey	M	30	Yes	Yes
J 06	Jockey	M	18	Yes	Yes
J 07	Jockey	F	5	Yes	Yes
J08	Jockey	F	18	Yes	Yes
D 01	Doctor	M	28	n/a	n/a
ICP	Intensive Care Paramedic	M	3	n/a	n/a
D 02	Doctor	M	10	n/a	n/a
AJ 06	Apprentice Jockey	M	3	Yes	No
J 09	Jockey	M	16	Yes	Yes
JR 01	Retired Jockey	M	28	Yes	Yes
JR 02	Retired Jockey	M	12	Yes	Yes

(Giusti Gestri, 2019)

It was crucial to understanding the experiences with and perceptions of current safety vests from all the participants and I created Table 1 to show that I did code them in chronological order, starting from whom firstly met with me. Significantly, the author decided to use different codes for the apprentice and fully

qualified jockeys because due to their natural ages, some of them have started to ride prior than safety vests became mandatory: this offered unique insights for the aim of my study, especially about an important design limitation with the current vests.

Currently, medical professionals must dedicate more time to trying to find the best and less harmful way to remove the vests from injured and often unconscious jockeys laying on the track after falls. This can deeply and negatively impact their job because it stops them from quickly trying to medically aid the injured jockeys.

Highlights From Research Data

Participant jockeys demonstrated consciousness about how risky their profession is and even how they are in welcoming the PPE products on the market, even if they do not totally guarantee their safety, as one stated: "for what we do there is always no guarantee …. And again, the perception is not that we expect the vest to save our lives …. All we want it to do is to help us, not hinder us in a racing incident".

The limitation of movements represents a serious issue for jockeys: they must be able to bend their heads, turn to look around for other horses, talk to each other during races and even roll into a ball in the case of a nosedive fall, which is a common form of tumble where they can be flung into the ground. Jockeys had concerns for not been involved in the development of standards for vest design along with their criticism because their safety vests are tight and restrictive: they mainly attributed this to a "system that had not paid attention to their concerns or involved in the development of standards for vest design" (Giusti Gestri & Barnes, 2020, p.846).

The search for knowledge can be defined via design research, which usually focuses on what ought to be via the disruption of the status quo, while it is concerned with what ought to be rather than what already exists (Milton & Rodgers, 2013) and I found that this is not the case in the jockey's safety vests field. The thoroughbred horse racing industry is affected by luxury, that is predominant in affirming the status quo and it interests jockeys' lifestyles: many people are attracted by the equestrian world because it is a way to show off their success and flaunt their wealth.

The horse racing industry internationally generates a huge volume of money and being part of it as an owner or attendee is another way to show social status. Specifically, the Australian thoroughbred breeding industry is worth more than$1.16 billion per annum to the economy, and employs close to 8000 people, particularly in rural and regional areas (Hardy & Limoli, 2019, p.4).

Female Jockeys' Responses About the Need for Ergonomics

Primary users involved in this case study remarked the rigidity of the safety vests and how these can be hot and even heavy to wear. Significantly, the involved female jockeys commented that vests should be softer to be comfortable to wear and to accommodate their body shapes. This was clearly explained by a participant with these words: "*from a female's point of view or perspective, I think definitely they need to have a male and a female vest. That's my opinion. They do it with all the motorbike gear and all that sort of stuff. The only reason I know is because I used to ride a lot of dirt bikes when I was younger. There's a big difference with the female body suits compared to the male's body suit. Obviously, we've got our breasts and our hips and stuff – our curves [motorbike gear] was all fitted. It was completely different*".

The vests worn during racing activities produce discomfort and thus, several participants declared wearing them differently to how they were meant to be worn, e.g. leaving a bit looser on the sides or even wearing the vest backwards. The author gathered important data from the medical professionals, specifically about the nature and severity of the injuries they have treated and the ways in which the safety vests interacted with their actions.

Factors that suggest the need for significant revisions are the rise of the number of female jockeys (Norton 2015; Parke, 2018), the jockeys' riding style that is in continuous evolution since 1998 along with climate changes that increased the risk of heat stress and uneasiness for Australian jockeys when wearing vests. The current vests indicate a strong need for attentiveness to the ergonomics and the possibility for alternative designs to accommodate male and female bodies.

D-UX: A CATALYST FOR INNOVATION?

How to Accommodate Co-Dependent Users in Design Research

Indeed, every user is unique and may interact with the same product and situation in diverse ways. Therefore, designers became crucial: to guarantee unforgettable users' experience, they must understand the users and their needs, with the scope to create an innovative and winning product design. Particularly, the UXD research relies on positive users' emotions (e.g. delight, enjoyment and pride): for this reason, designers must listen to what users are asking because in this way they are capable of demonstrate empathy. Besides, the use of ergonomics enables the creation of design solutions based on experienced human needs: in this way, a high level of usability may be reached.

There are situations where a product may be asked to meet the need of the user and a co-dependent user whose contribution to the performance and success of the design is crucial, not merely desirable. Such as for the case of jockey's safety vests that show a design that is dependent for its functional purpose on jockeys as the primary users, and upon co-dependent users, which are the medical staff. Hence, this study focused on the role of safety-vest design in product innovation, particularly exanimating the vest functions and standards form the main content. The UCD and the Human Centered Design (HCD) are often utilized interchangeably even though they slightly differ from each other and they are not necessarily suitable for every situation.

I intentionally focused on examining how products intended for one group of users require meeting the needs of a group of co-dependent users: thus, the application of UXD and HCD/UCD models applicable to the jockey's safety vests led me to consider whether the product's success needs the qualitative insights of those that I named *co-dependent users*, whose experience was even critical to the design's success. However, this study confirmed the importance of including the users (jockeys) and co-dependent users (medical staff) in the design process for a product (safety vest) that plays a core role in their lives. Thus, focusing on any kind of user group will lead to creating a design capable of bringing meanings and ergonomics to satisfy users' needs.

A New Design Framework for Future Research?

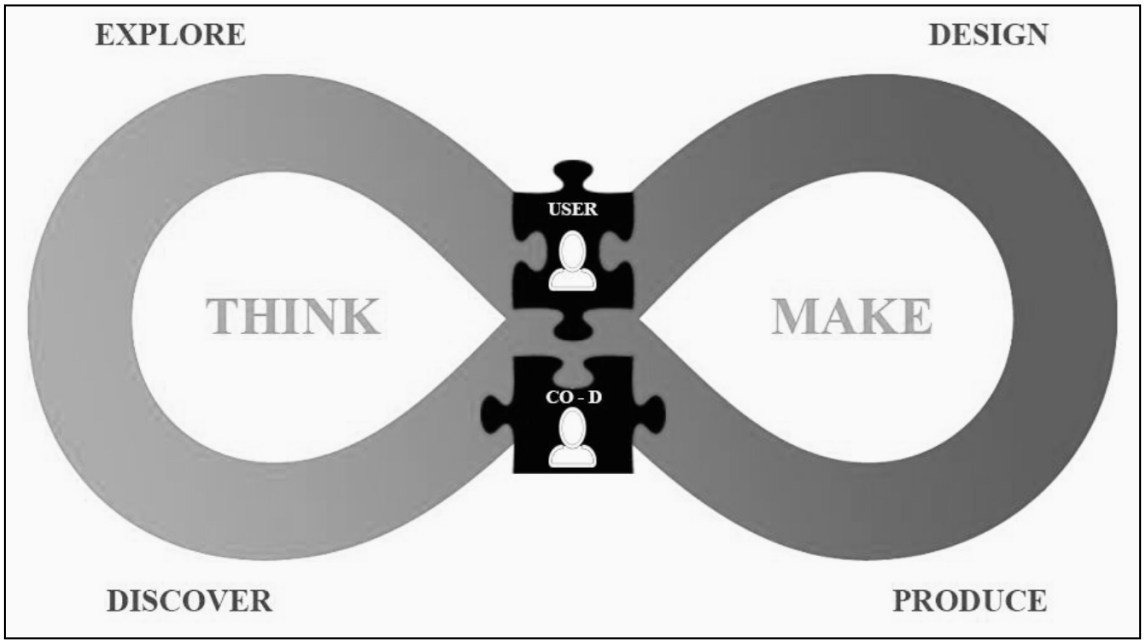
When users' needs are satisfied through a product that can please multiple and diverse users, then it is possible to talk about inclusive design, which is core in a designer's life. Both UXD and UCD focus on providing products that develop and obtain a great experience with the users: there are standards that support and stimulates designers in all fields to consider end-user participation as a characteristic of progressive design practice.

In addition, the only focus on users' everyday life experiences, emotions and desires is the method known as HCD that is capable of interpreting users' moods and is even considered as a tool to solve users' problems (Mattelmaki, Vaajakallio & Koskien, 2013). The HCD process encompass to satisfy questions like *who, what, when, how and why* to provide knowledge of human factors, semiotics, functions, communication and meaning to establish a profound understanding of the context for use (Giacomin, 2014; Harte et al., 2017). Through the employment of human factors/ergonomics and usability knowledge, the design process can be managed. Reflecting on the users' identification, commonly we do not recognize primary and secondary users who may affect the evolution of a product's design. Designers are important because they are those who imagine and create: they interact with the world because they should produce a product that satisfies the users' needs, whose functionality is both physical and emotional due to its design, that means make thing better for people (Seymour, 2012).

This study was based on the features attributed to a product according to the product ecology: via an extension to the conventional UXD and UCD processes in cases such as this one, a class of users might exist that is not classifiable as secondary or tertiary users, nor a stakeholder, but rather a co-dependent user group receives the right attention in design research. Co-dependent users rely on the same product's design that influences also the primary user group: both groups have a core role in product innovation and in as such the author justified their inclusion at the center of this study for the importance of enhancing the safety vest's features of *sustainability*, *ergonomics* and *wearability*.

We live in a fast-changing world rich with strong competition, along with the complexity of product and process needed: thus, to successfully produce good design for products, users' needs must be considered during the process of innovation. Good design is desirable, feasible and viable thus, designers must continuously apply the 4 phases better known as discover, define, develop and deliver which currently are not so well associated with the safety vest's design process. Along with that, the existence of a special class of user experience that can be summarized as a dependent class helped the author in producing the Dependency-based User Experience (D-UX) process (Figure 3), which allows the identification of needs and preferences of co-dependent users, still as a supplement of the conventional UXD and UCD processes.

FIGURE 3
DEPENDENCY-BASED USER EXPERIENCE (D-UX) DESIGN PROCESS



(Giusti Gestri, 2019)

In Figure 3, I incorporated the design thinking concepts that are complementary and lead into each other. The process would therefore be to explore, discover, design, and produce which would generate an infinite loop of iterative thinking and making. The use of the infinity symbol highlights the importance of a designer to always keep repeating the process until a successful product is reached. Besides, design with users rather than design for users led me to highlight the importance of put at the center of a design process not only the user but also the co-dependent user because both rely on the same product's design and thus shown as two pieces of the same puzzle.

Based on the D-UX process, the fact that there are situations in which the success of a product design relies not only on qualitative engagement with a target user or user persona (as the UXD process), or with a special human user at the center (like the UCD process), but is co-dependent on the equal engagement of a critical co-dependent user is confirmed. The D-UX process can assist in developing safety equipment for sports such as horse-racing, horse-riding and others (e.g. cycling, BMX riding, snowboarding and motorcycling) with similar injuries experienced. The D-UX process is suggested to be used when facing a product's design that must accommodate needs from various users' groups.

Synthesis and Proposals

Even though this study intentionally did not introduce specific design attributes, it should be considered as the basis of future research: the aim should be to explore smart materials and latest technologies.

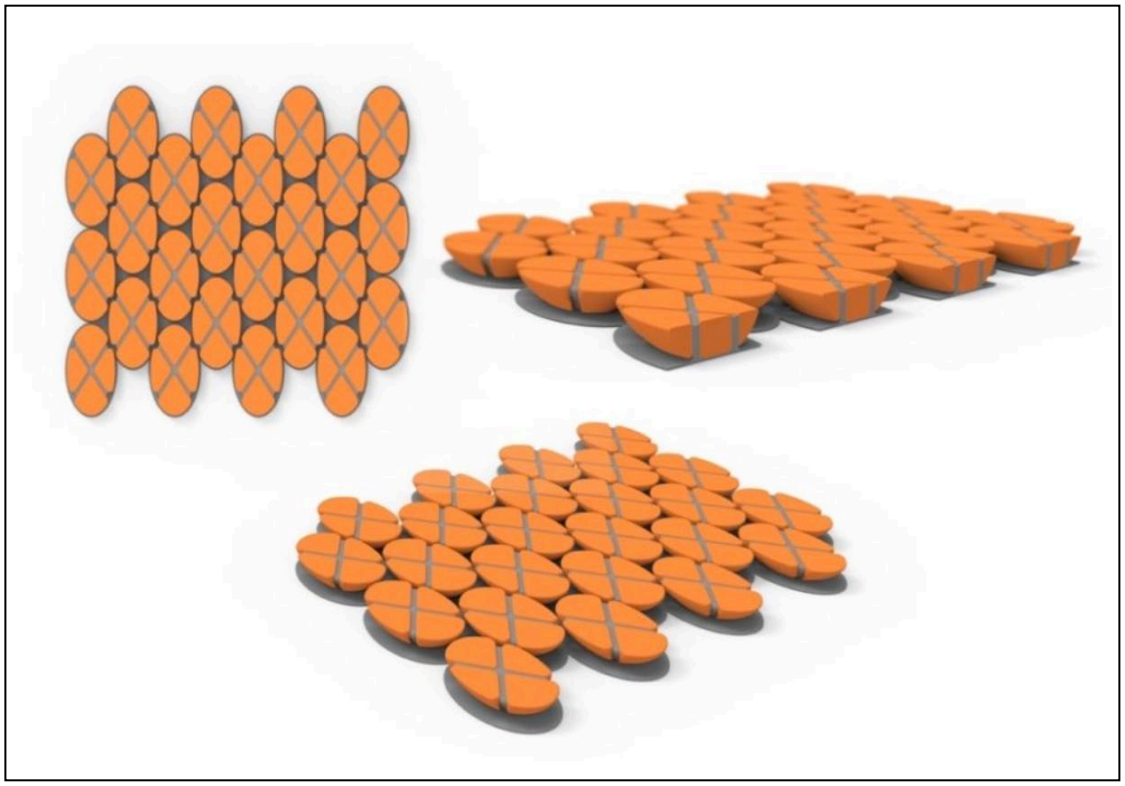
However, I proposed a set of concept designs to show early stages of improvements applicable to safety vests for jockeys with the aim of achieving product innovation and challenge the status quo, which is hindered impacted by the product standards.

The research design was informed by Singh et al. (2012) in as much the use of a design method has core relevance because it needs a very systematic approach. For this specific study, the author applied a problem-driven design: to accommodate the request of a super light in weight but still flexible safety vests, I considered spiders because they can obtain a durable fabric design while the camouflage of chameleons may be helpful in creating fabrics able to communicate the injury's location to the medical professionals.

Particularly, chameleons' skin is covered with several layers of very special cells called chromatophores, that respond to chemicals from the nervous system and bloodstream. The application of a new super-thin fabric composite material, made up of strips that reflect different wavelengths of light may convert these products into wearable tech. For instance, as the fabric bends or moves, different strips are revealed, reflecting various wavelengths and effectively changing color. Each cell could be expanded from an invisible dot into a colorful disk, which grants color to a corresponding portion of the skin, which is layered.

Inspired by this phenomenon, I suggested that safety vests may use different colors to communicate the jockeys' injuries to the medical staff when a fall occurs: this can help them in providing medical help but in a shorter and more accurate time. Specifically, the application of such an advanced material along with a small device (e.g. sensor) may also support the creation of an updated database for jockeys' medical conditions and the possibility to live access to those data by any authorized medical professionals, when needed. Thus, the shape shown in Figure 4 derived from nature design inspirations, specifically from spiders' webs, eggs and flowers.

FIGURE 4
PROPOSED PATTERN FOR JOCKEY'S SAFETY VESTS



(Giusti Gestri, 2019)

The design concept shape in Figure 4 may accommodate jockeys' needs in asking for a product capable of following and adapt their movements, rather than being a restriction to their race posture. Thus, two materials were considered as integration into an innovative shape to reach a product that is able to respect jockeys' movement but still light and breathable in performance. I presents various colors (Figure 5) that may be able to use of stretchable materials that can even fit into a Racelite vest, which at the time of this study was the favored among jockeys during races.

FIGURE 5
PROPOSED PATTERN COLOUR VARIATIONS

(Giusti Gestri, 2019)

The pattern shown in Figure 5 employed smaller shapes than those available on present vests: these new shapes may be made using one of the latest materials accessible on the market but integrated with a stretchy material. Besides, tailor-made variations could be offered that employed various colors or different shape sizes within the pattern: this can be a start to accommodate the different needs that male and female jockeys possess and introduce ergonomics in these products.

I strongly suggest more investigation to understand which option fulfils users' needs and eventually to modify the standards to make such a change possible. Particularly attention should be given to the design of the neck cut at both the front and back of the safety vests: their standards should be reinterpreted and possibly lead to the development of an outfit made of vest and helmet.

CONCLUSIONS

This study proves that there are many unpopular product and users that need to see ergonomics applied in their fields, such as in the case of jockeys' safety vests. The challenge of the status quo and the product standards allows designers to consider multiple users (e.g. primary, secondary, co-dependent), to apply the latest materials and technologies into products along with ergonomics to bring innovation.

The D-UX process that the author proposed may support in addressing the needs of users and co-dependent users, where who all depend on the success of the same product's design (e.g. in the fields of safety vests, coffee machines, medical devices). In my study, the introduction of innovation would support the development of safety vests through the application of the latest materials and the use of technology may create a wearable tech safety vest and lead the input of ergonomics. These findings may be applicable to other high impact sports (e.g. ski, motorcycling, hockey) where users experience similar injuries to those reported by jockeys and horse riders.

The consideration of both users and co-dependent users located in the D-UX process is the core of innovation and the fulfilment of their needs and through a serviceable and functional design, their issues are solved. Due to that reason, designers may offer full customized solutions through a complete application of ergonomics in every design field. Indeed, the utilization of co-dependent user experience design is universal. The application of the D-UX process will be fundamental to guarantee the design's success of a product but even provides foundations for future directions in design research.

REFERENCES

Abras, C., Maloney-Krichmar, D., & Preece, J. (2004). User-centred design. *Bainbridge, W. Encyclopedia of Human-Computer Interaction*, *37*(4), 445-456. Thousand Oaks: Sage Publications.

Aitken, A. (2017). Injured jockey Nash Rawiller may not ride again until June after horror fall. *South China Morning Post*. Retrieved from http://www.scmp.com/sport/racing/article/2088892/nash-rawiller-may-be-sidelined-until-june-after-bad-fall

Australian Harness Racing. (2015). *Change of ambulance services provider at Victorian trots meetings*. Retrieved from http://www.harness.org.au/media-room/news-article/?news_id=27409

Bergvall-Kåreborn, B., & Ståhlbrost, A. (2008). Participatory design: one step back or two steps forward? In *Proceedings of the tenth anniversary conference on participatory design 2008* (pp. 102- 111). Indiana University.

Casa, D.J., & Stearns, R.L. (2015). *Emergency Management for Sport and Physical Activity*. Jones & Bartlett Learning. Massachusetts, Unites States.

Cripps, R. (2000). Horse related injury in Australia. *Australian Injury Prevention Bulletin* (Issue 24). Australian Institute of Health and Welfare. Canberra: AIHW.

Curry, B.A., Hitchens, P.L., Otahal, P., Si, L., & Palmer, A.J. (2016). Australian insurance costs of jockeys injured in a race-day fall. *Occupational Medicine*, *66*(3), 222-229.

Daneshvar, D.H., Baugh, C.M., Nowinski, C.J., McKee, A.C., Stern, R.A., & Cantu, R.C. (2011). Helmets and Mouth Guards: The Role of Personal Equipment in Preventing Sport-Related Concussions. *Clinics in Sports Medicine*, *30*(1), 145-163. doi:10.1016/j.csm.2010.09.006

Degani, A. (2004). *Taiming Hal. Designing interfaces beyond 2001*. United States of America: Palgrave Macmillan. doi: 10.1057/9781403982520

Dey, I. (2003). *Qualitative data analysis: A user friendly guide for social scientists*. Routledge. New York, NY: Routledge.

Dorfles, G. (1972). *Introduzione al disegno industriale. Linguaggio e storia della produzione in serie*. Torino, Italia.

Eason, K. (1987). *Information technology and organizational change*. London: Taylor and Francis.

Filby, M., Jackson, C., & Turner, M. (2012, July 5). Only falls and horses: Accidents and injuries in racehorse training. *Occupational Medicine*, *62*(5), 343-349. https://doi.org/10.1093/occmed/kqs068

Firth, J. (1985). Equestrian injuries. In R.C. Schneider, J.C. Kennedy, & M.L. Plant (Eds.), *Sports injuries* (pp. 431-449). Mechanisms, Prevention and Treatment.

Foote, C.E., Gibson, T.J., & McGauran, P.J. (2014). *Evaluation of Safety Vests. Rural Industries Research and Development Corporation*. RIRDC Publication No 14/037, RIRDC Project No. PRJ- 008125. Retrieved from https://www.agrifutures.com.au/wp-content/uploads/publications/14-037.pdf

Foote, C.E., McIntosh, A., V'Landys, P., & Bulloch, K. (2011). *Health and Safety in Australian horse racing.* Rural Industries Research and Development Corporation. RIRDC Publication No 10/067, RIRDC Project No. PRJ-000765. Retrieved from https://www.agrifutures.com.au/wp-content/uploads/publications/10-067.pdf

Forlizzi, J. (2007). The product ecology: Understanding social product use and supporting design culture. *International Journal of Design*, *2*(1), 11-20.

Giacomin, J. (2014). What Is Human Centred Design? *The Design Journal*, *17*(4), 606-623. doi:10.2752/175630614X14056185480186

Gibson, T., Thai, K., Saxon, J., & Pollock, R. (2008). The effectiveness of safety equipment in horse racing falls. *Proceedings of the 2008 International IRCOBI (International Research Council on the Biomechanics of Injury). Conference on the Biomechanics of Impact* (*36*, 453- 456). Bern, Switzerland.

Giusti Gestri, L. (2019). *Safety vests for jockeys: A case study of primary and dependent-secondary users affecting the evolution of vest design in the Australian horse-racing industry* (PhD Thesis). Swinburne University of Technology. Retrieved from https://researchbank.swinburne.edu.au/searching.do?in=C4cd4b6ad-5852-4c50-9dea-f028f35e8a9e&_ga=2.252401729.931731.1576307414-161509650.1576120172

Giusti Gestri, L., & Barnes, C. (2020). Product standards as a barrier to innovation: The case of jockey's safety vests. In S. Boess, M. Cheung, & R. Cain (Eds.), *Synergy - DRS International Conference 2020*. Retrieved from https://doi.org/10.21606/drs.2020.251

Graham, R., Rivara, F.P., Ford, M.A., & Spicer, C.M. (2014). *Committee on Sports-Related Concussions in Youth and National Research Council, 2014. Sports-related concussions in youth: Improving the science, changing the culture*. National Academies Press (US).

Hardy, G., & Limoli, P. (2019). *Measurement of economic impact of the Australian thoroughbred breeding industry*. Retrieved from https://www.agrifutures.com.au/product/measurement-of-economic-impact-of-the-australian-thoroughbred-breeding-industry/

Harte, R., Glynn, L., Rodríguez-Molinero, A., Baker, P.M., Scharf, T., Quinlan, L.R., & ÓLaighin, G.A. (2017). Human-Centered Design Methodology to Enhance the Usability, Human Factors, and User Experience of Connected Health Systems: A Three- Phase Methodology. *JMIR Hum Factors*, *4*(1), e8.

Hitchens, P.L., Blizzard, L.C., Jones, G., Day, L., & Fell, J. (2011). Are physiological attributes of jockeys predictors of falls? A pilot study. *BMJ Open*, *1*, e000142. doi:10.1136/bmjopen-2011-000142

Johnston, D. (2017). Jockeys Bryan Murphy and Jake Duffy taken to hospital after race fall on Corowa Cup day. *The Border Mail*. Retrieved from https://www.bordermail.com.au/story/4526019/murphy-avoids-serious-injury/

King, M. (2011). *Fashion, the body and technology: Tracing early 20th century techno-utopian ideas, aesthetics and impulses in 21st century wearable technology*. Thesis of Master of Arts (Research). Retrieved from http://eprints.qut.edu.au/50948/1/Madeleine_King_Thesis.pdf

Mackey-Laws, K. (2016). Ecstasy to agony: Nick Olive feared the worst after Single Gaze fall. *The Sydney Morning Herald*. Retrieved from https://www.smh.com.au/sport/racing/ecstasy-to-agony-nick-olive-feared-the-worst-after-single-gaze-fall-20160409-go2kz4.html

Maldonado, T. (1076). *Disegno industriale: Un riesame*. Definizione Storia Biliiografia, Milano, Italia.

Mattelmäki, T., Vaajakallio, K., & Koskinen, I. (2014). What happened to empathic design? *Design Issues*, *30*(1), 67-77.

McCrory, P., Turner, M., LeMasson, B., Bodere, C., & Allemandou, A. (2006). An analysis of injuries resulting from professional horse racing in France during 1991-2001: a comparison with injuries resulting from professional horse racing in Great Britain during 1992-2001. *British Journal of Sports Medicine*, *40*(7), 614–618. doi:10.1136/bjsm.2006.028449

Merriam, S.B., & Tisdell, E.J. (2015). *Qualitative Research. A Guide to Design and Implementation* (4th ed.). Wiley.

Milton, A., & Rodgers, P. (2013). *Research Methods for Product Design*. Portfolio Skills. Laurence King Publishing.
Moss, P.S., Wan, A., & Whitlock, M.R. (2002). A changing pattern of injuries to horse riders. *Emergency Medicine Journal*, *19*(5), 412.
Moy, H. (2018). Jockeys pull whip to retain NJT T20 title in super over thriller. *Herald Sun Racing*. Retrieved from https://www.heraldsun.com.au/sport/superracing/jockeys-pull-whip-to-retain-njt-t20-title-in-super-over-thriller/news-story/8c29ddf38a7f3fb5616eb2b000aba473
National Jockeys Trust. (2017). *Tragic Week for Jockeys Nationally*. Retrieved from https://njt.org.au/index.php?dispatch=news.view&news_id=6
Norman, D. (1993). *Things that make us smart: Defending human attributes in the age of the machine*. Addison-Wesley Longman Publishing Co., Inc. Boston, MA, USA.
Norman, D., & Draper, S. (1986). *User Centred System Design; New perspectives on human-computer interaction*. L. Erlbaum Associates Inc. Hillsdale, NJ, USA 1986.
Norton, S. (2015). Things you didn't know about female jockeys in Australia. *Mamamia Lifestyle*. Retrieved from http://www.mamamia.com.au/lifestyle/australian-female- jockeys/
O'Connor, S., Warrington, G., McGoldrick, A., & Cullen, S. (2017). Epidemiology of injury due to race-day jockey falls in professional flat and jump horse racing in Ireland, 2011–2015. *Journal of Athletic Training*, *52*(12), 1140-1146.
Parke, E. (2018). Female jockeys take over the change room as women start to dominate at regional race meets. *ABC News*. Retrieved from https://www.abc.net.au/news/2018-07-01/female-riders- start-to- dominate-horseracing/9923946
Polkinghorne, D. (2016). Richie Bensley returns to trackwork after fall. *The Sydney Morning Herald*. Retrieved from https://www.smh.com.au/sport/racing/canberra-racing-20160609-gpf4fh.htm
Racing Australia. (2021). *Australian Rules of Racing*. Retrieved from https://racingaustralia.horse/FreeServices/Australian_Rules_Of_Racing.aspx
Racing. (2008). New Raceday Medical Services Launched. *Racing News*. Retrieved from https://www.racing.com/news/2008-07-23/new- raceday-medical-services-launched
Roe, J.P., Taylor, T.K.F., Edmunds, I.A., Ruff, S.J., Plunkett-Cole, M D., Cumming, R.G., … Jones, R.F. (2003). Spinal and spinal cord injuries in horse riding: The New South Wales experience 1976-1996. *ANZ Journal of Surgery*, *73*(5), 331-334. doi:10.1046/j.1445-2197.2003.t01-1-02618.x
Safety Solutions. (2014). *Australia: Research into jockey safety vests lays foundation for change*. Safety Solutions - Health and Safety at work. Retrieved from https://www.safetysolutions.net.au/content/business/news/research-into-jockey-safety-vests- lays-foundation-for-change-35056390
Samdanis, M.K.Y., & Lee, S.H. (2013). *New product development of wearable technologies*. Kent Business School, *27*.
Seymour, R. (2012). *Interview in association with Richard's appearance at the Sleep Event, the leading European Hotel Design Conference and the European Hotel Design Awards*. Sleep Convention 2012. Retrieved from https://www.slideshare.net/Seymourpowell/rich- seymour-sleep2
Singh, A.V., Rahman, A., Kumar, N.S., Aditi, A.S., Galluzzi, M., Bovio, S., . . . Parazzoli, D. (2012). Bio-inspired approaches to design smart fabrics. *Materials & Design (1980-2015)*, *36*, 829-839.
Sports Medicine Australia. (2008). *Safety guidelines for Children and Young People in Sport and Recreation*. Retrieved from https://sma.org.au/sma-site-content/uploads/2017/08/childrensafetyguidelines-fulldoc.pdf
Svanberg, S. (2013). Biophotonics–techniques and applications. *Laser & Photonics Reviews*, *7*(5), A43-A44. doi:10.1002/lpor.201300506
Tenhue, N. (2016). User Experience: Primary and Secondary Users in Healthcare. *Medium*. Retrieved from https://medium.theuxblog.com/user-experience-primary-and-secondary-users-in-healthcare-8dd4c5c61490
Wilson Medic One. (2015). *Event Health Services. Corporate and Government Events*. Retrieved at https://www.wilsonmedicone.com.au/services/Pages/event- health-services.aspx

Yim, V.W.T., Yeung, J.H.H., Mak, P.S.K., Graham, C.A., Lai, P.B.S., & Rainer, T.H. (2007). Five year analysis of Jockey Club horse- related injuries presenting to a trauma centre in Hong Kong. *Injury*, *38*(1), 98-103. doi: http://dx.doi.org/10.1016/j.injury.2006.08.026