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Implementation of usability analysis to detect problems in the management of kitesurfing equipment

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Abstract

Equipment used for high-risk sports, such as kitesurfing, needs to be efficient for the intended use and the user, and thus meet the mechanical demands and provide sufficient safety. Accidents related to kitesurfing occur, and the consequences are sometimes catastrophic. One important factor is the equipment design, which can influence the type and number of injuries due to insufficient safety systems. The aim of this study was to investigate how the design of kitesurfing equipment can affect safety issues from a usability perspective in relation to the task of preparation. A focus group of 6 subjects analyzed the task of preparing kitesurfing equipment for riding, using the evaluation methods Enhanced Cognitive Walkthrough (ECW) and Predictive Use Error Analysis (PUEA). From the evaluation, a list of plausible usability problems was identified together with proposed design guidelines. The results showed that usability problems occur during preparation. In total 35 usability problems were found, of which 11 (4 from ECW and 7 from PUEA) have a great impact on safety. These 11 problems were hard to detect for the user and could result in serious consequences for the kitesurfers during riding. The analysis resulted in some general guidelines that are possible to implement on different types of kites. To conclude, education and improved design of the equipment are essential to increase the safety of the sport.

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1. Introduction

Equipment used for high risk sports needs to be efficient for the intended use and the user, and thus meet the mechanical demands and provide sufficient safety and comfort. Products from the surfing industry have a wide market. The summer board sport equipment in 2008 accounted for more than 3% of the total global sport market [1]. The equipment design can influence type and number of injuries due to insufficient safety systems. Kitesurfing is one of the more recently popular sports and is often described as a high risk sport in terms of risk for injury or accident [2-7]. The equipment has been shown to contribute to the extent of the injury in several cases [4, 7]. Kitesurfing is an on-water board sport, and the participant uses a kite to capture the wind in order to ride or perform jumps and tricks on the water surface. The kite is attached to a hook on a harness around the lumbar part of the trunk via a steering bar and chicken loop and four lines of 15-30 meters.

Earlier studies have shown that accidents related to kitesurfing occur, and that the consequences are sometimes catastrophic. One of the causes of injury has been the kitesurfer not being able to release him/herself from the kite in a hazardous situation [6]. Other causes of injuries have been environmental aspects (changes in wind speed or direction, shallow water or stones in the water), equipment aspects (damage, being hit by board, heavy fall or landing from height) or human causes (fatigue, poor technique, overconfidence or inattention) [2-7].

No studies have been published that reveal the usability aspects of kitesurfing equipment. Here, usability is defined as “the ease with which the user of the product can understand how it works and how to get it to perform” [8]. However, for other tasks where the equipment plays a central role in safety (e.g. medical devices), analytical usability studies have been used to identify deficiencies that can cause problems in usage [9]. There are heuristic methods, that focus on the usability of interfaces [9-12], and there are methods that deal with risk analyses based on use errors [9, 12]. Use errors are defined here as “act or omission of an act that has a different result than intended by the manufacturer or expected by the operator” [13]. These methods have been used mainly for medical devices, in health care and in information technology [9, 14-17]. Bligård & Osvalder [12] developed two methods with the purpose of predicting, identifying and presenting usability problems and use errors: Enhanced Cognitive Walkthrough (ECW) and Predictive Use Error Analysis (PUEA). These methods have been useful to detect usability problems and risk for use error while managing medical devices and are also suitable for equipment that make great demands on safety [9].

Kitesurfing equipment belongs to the category of products where safety aspects are central to preventing accidents and that thus must meet a high level of usability during both preparation and execution. So far, usability issues regarding kitesurfing equipment have not been evaluated for a scientific purpose. The aims of this study are to identify possible usability problems and use errors that can occur while managing kitesurfing equipment for preparation. The preparation phase has been chosen because accurate set up of the equipment is crucial for safety later in the process (during launch of the kite and riding). The goal is to propose design guidelines for this type of sport equipment, in order to enhance the usability of the equipment, which might lead to decreased risk for incidents.

2. Methods

The elements of kitesurfing were identified by observations and prepared in a hierarchical task analysis (HTA) [18]. The functions in the HTA were graded according to their problem seriousness, and the most crucial functions were chosen for further analysis. Subsequently, a focus group consisting of a moderator, two experienced kitesurfers (5 and 10 years) and instructors, one kitesurfing beginner, and two novices. The HTA description of the task “preparation of the equipment for kitesurfing” were analyzed using the

ECW and PUEA methods [12]. All focus group participants had previously been shown and practiced the task and had knowledge about the correct management of the equipment. A kitesurfing bar (2009 Cabrinha Switchblade) was used during the analysis.

The results from the focus group discussion were analyzed to elicit the most prominent usability problems and use errors, especially those that had a great impact on safety [14]. Based on the findings, design guidelines related to usability aspects were created.

3. Results

The ECW- and PUEA- analyses resulted in a total of 35 detected usability problems or potential errors, 11 of which had a significant impact on safety, because these problems were hard for an intended user to detect and could result in serious consequences for the kitesurfer when riding.

3.1. ECW results

ECW detected a total of 11 usability problems, 4 of which were both scored as a serious problem and considered important for safety during launch of the kite and riding. The usability problems are described in detail in Table 1.

Table 1. The four serious usability problems and problem type detected by ECW for the task "preparation of the kite"

Task	Usability problem	Problem type
Put bar down on ground	It is not possible to know which way to put the bar if a known colour code is not present.	Insufficient markings
Attach chicken loop to harness	There is insufficient feedback if the "chicken pin" is properly attached in the hook.	Insufficient feedback
Attach leash	It is not clear where the leash should be attached. Differs between bars.	Hidden function
Attach leash	It is not obvious if the leash is correctly attached. The effect of releasing the kite is uncertain for the novice user.	Insufficient feedback

3.2. PUEA results

Twenty-four potential use errors were detected in the PUEA-analysis. Of these, 7 actions were considered both hard to detect for the intended user and having the potential to lead to serious consequences for the user during launch of the kite or riding. The use errors are described in Table 2.

Table 2. The seven use errors and their consequences detected by PUEA for the task "preparation of the kite"

Task	Error	Primary consequence	Secondary consequence	Detection
Unfold lines	Attach the lines before they are unfolded from the bar.	Lines are tangled and can be attached at the wrong site. The kite cannot be controlled.	Accident can occur while launching the kite.	Should be detected before the kite is launched.
Put bar down on ground	Sand in the pulley system.	Movable parts such as pulleys can become immovable, be torn or lose their function.	Accident can occur while launching the kite if the pulley is immovable.	The user does not appreciate sand in the pulleys as a hazard.
Attach bar to kite	Attaching the knot directly through the 'pig tail', without making a loop, or not tightening the loop enough.	The loop is too loose and comes off.	The kite can pull quickly and with a lot of force while launching or riding.	Hard to detect before the consequence occurs.
Attach kite to user	The chicken loop is attached to the harness before the harness is fastened on the user.	Increased risk for tangle. Hard to attach the harness properly and tight enough.	Hard to control kite if the bar or lines are tangled. Can increase risk of damage of the equipment.	It is an active action by the user and will be hard to detect.
Secure kite with leash	Leash missing, or comes off.	Nothing connects the kite to the user if the chicken loop unhooks from harness, or the quick release (QR) is pulled.	The user might not release the kite if it unhooks and tries to hold on to it. When released, the kite will fly in the direction of the wind.	If the leash is missing it is an active action by the user and will not be detected. If the leash hooks off the attachment, this will be detected by the user.
Secure kite with leash	The leash is wrapped around the harness.	The QR does not function properly in an emergency situation.	The user will still be attached and follows the kite if an emergency situation occurs.	The user can see that the leash is wrapped around the harness, but might choose to neglect it or does not understand the consequences.
Secure kite with leash	The leash is attached to the wrong location.	The leash will not keep the kite if the chicken loop unhooks by mistake, or the leash will keep holding the kite even if the QR is pulled.	The user can be pulled by the kite in an emergency situation. If the user unhooks and lets go of the kite, it will fly with the wind.	It is an active action of the user and will not be detected by the user before a consequence occurs.

3.3. Results analysis and proposed guidelines

The results from ECW and PUEA indicate that usability problems exist when kitesurfing equipment is prepared and use errors can occur while preparing kitesurfing equipment. To avoid this, training and design guidelines for the equipment are important in increasing the safety level of the sport. The reasons why use errors occur while preparing kitesurfing equipment are often user slips or the user being a novice

and not having enough experience or training. However, this implies that the equipment does not provide sufficient information for the novice user to completely understand the process, or to notice if there is an anomaly in the setup. Errors that occur are not always immediately obvious for the novice user, and are consequently not detected. The experienced user presumably detects errors before launching the kite, but may be subjected to hazards anyway, for example in the case of a sudden wind change, self-launching or an inexperienced launcher.

The analysis revealed three main problem areas of the equipment. These areas are listed below together with proposed design guidelines.

1. Problems with the bar and lines, e.g. putting them upside down, tangled lines or insufficient connection.
   - To make these problems less likely to occur standards for color coding should be used, for left and right, all the way from bar to kite, for the connection of mid- and steering lines, and markings for up and down on the bar.
2. The safety system was clearly identified out on the bar system, but the leash attachment point was not considered obvious.
   - The leash attachment point should be identified with a sign and indicate that a leach should be present. The leash should allow the safety system to release only if it is released manually and should not disconnect by accident.
3. Many kites have pulley systems for smooth handling of the kite, in which sand can stick and hinder the function.
   - If pulleys are used, they should be resistant to corrosion and dirt/sand, and not consist of loose parts that can fail or become immovable.

4. Discussion

The results show that use errors that affect safety can occur while preparing kitesurfing equipment. The use errors can be traced to usability problems. If the use errors can be avoided by better design with a high degree of usability, the safety of the sport can be increased, leading to fewer injuries due to traumatic accidents. The three guidelines proposed to reduce the probability for usability problems are general and thereby possible to implement on different types of kites.

Finding product solutions to minimize use errors ought to be prioritized within the industry. One procedure could be the implementation of standards in the kitesurfing manufacturing industry, such as for color coding, line connections, safety systems and informative markings. Other sports, such as snow sports, bicycling, climbing, gymnastics, hang gliding etc. have developed standards for product design and construction within the industry (ISO-TC83). Standard development and certification can be useful in gaining a consistency in safety-related design factors equalized between the brands [19, 20]. Knowledge-based mistakes can to some extent be met by training requirements and standards, as is practiced by the organizations the International Kiteboarding Organization (IKO) and the Kitesurf and Snowkite Association (KSA).

This study focused on revealing usability problems and presumptive use errors in the management of kitesurfing equipment while preparing for practicing, which can have an impact on safety later in the process. The main procedure with a focus group performing ECW and PUEA was appropriate for this study and resulted in useful guidelines to improve usability aspects in the design. In further studies, it could be of interest to explore how usability aspects affect the performance of kitesurfing in combination with other factors, i.e. biomechanics, task complexity, skill level, physical fitness etc.

In conclusion, there are usability issues related to the design of kitesurfing equipment that can affect the safety of performing the sport. The major problems are related to display of information on the

equipment and the procedure of performing tasks, which are not always obvious to the novice user. Novice users in particular also have problems in detecting use errors when they have occurred, with the result that severe consequences can occur. This study recommends the development and implementation of standards for color coding and safety information within the kitesurfing equipment manufacturing industry.

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