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The effect of heads-up-display (HUD) goggles on skiing and snowboarding speeds

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ABSTRACT

This study empirically explores whether the use of heads-up-display (HUD) goggles increases the risk in ski areas by increasing skiing and snowboarding speeds. Twenty-seven skiers and snowboarders participated in a repeated measures experiment that included a control session without the HUD goggle and three sessions with the HUD goggle under a variety of conditions. The skiing behaviour of each participant was monitored using a Global Positioning System (GPS) tracker. The runs of the ski area were divided into 51 homogeneous run sections and speed quantiles (median to maximum in 5 percentage point intervals) were calculated for each individual pass through these run sections ($n=4,451$). A mixed-effects model was then applied to examine the effect of HUD goggles on skiing speeds for each quantile in combination with various personal (e.g., skiing ability) and external factors (e.g., terrain). Among the variables tested, ability level had the strongest positive effect on skiing speeds, while terrain characteristics including steep gradients, ungroomed runs, and treed areas, were all associated with slower skiing speeds. No long-term effect of HUD goggle use on skiing speeds was found, but advanced/expert skiers did appear to benchmark 'personal best' speeds during first HUD use – particularly on long straight run sections – before returning to slower speeds during subsequent HUD use. Whereas no significant HUD effect was observed among beginners/intermediates, skiing speeds were significantly faster among beginners/intermediates listening to music during the sessions. The potential for distraction as a result of HUD use still requires investigation.

MANAGEMENT IMPLICATIONS

- Considerable growth in the use of smart wearable devices is expected.
- The findings of this study suggest that the use of HUD goggles does not cause a persistent increase in skiing speeds.
- Ski resort managers might want to examine their existing policies and practices (e.g., patrols, speed warning signs) on long-straight ski run sections to mitigate any safety issues associated with advanced/expert users benchmarking 'personal best' speeds during first HUD use.
- Ski resort managers may consider HUD goggle technology as an opportunity for providing visitors with geo-targeted information such as lift wait times and slope congestion data that could improve their skiing experience.

1. Introduction

Resort skiing and snowboarding (herein referred to as skiing) takes place at about 2,000 ski areas around the world attracting approximately 400 million visits annually (Vanat, 2014). Participants choose resorts based on factors such as variety of runs, snow conditions, and value for money (Carmichael, 1996), and take part in skiing for a mixture of reasons including personal achievement, social reasons, enjoyment of nature, escape, and thrills (Hudson, 2000).

Recent technology advances have created a multitude of new devices designed to augment the skiing and snowboarding experience, and considerable growth in the use of smart wearable

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Fig. 1. Recon Instruments MOD Live heads-up-display showing current and maximum skiing speed.

devices is expected (Juniper Research, 2014). Similar to cycling, where the use of trip computers is well established (Fleishman, 2000), many skiers and snowboarders today use smartphone applications or smartwatches to record speed, distance, and vertical (Kirby, 2014), ski helmets that play music through built-in headphones, and wearable video cameras mounted to various ski equipment (Pullen, 2015). At the cutting edge of this trend is a heads-up-display (HUD) goggle (Fig. 1), with a small screen showing current and maximum speed (km/h), distance (km), vertical descent (m), altitude (m), and an interactive resort map. The benefits of HUD goggles include real-time access to dashboard metrics, the location of trails, lifts, and resort facilities, buddy tracking, and synchronization with smartphones to access music, text message, and call functions. In the future, these benefits could in theory be extended to include information such as lift wait times and slope congestion to help users avoid known satisfaction issues such as long lift lines (Perdue, 2002) and overcrowded slopes (Clydesdale, 2007).

Skiing is an inherently risky activity, with an overall injury rate of approximately 2.5 injuries per thousand skier visits (Johnson, Ettlinger, & Shealy, 1997). While higher injury rates have been associated with male gender (Wasden, McIntosh, Keith, & McCowan, 2009), younger age (Kim, Endres, Johnson, Ettlinger, & Shealy, 2012), lower ability (Goulet, Hagel, Hamel, & Légaré, 2010), ill-adjusted equipment (Johnson, Ettlinger, & Shealy, 2009) and unanticipated collisions with trees, rocks, or other skiers (Zuckerman, 2007), excessive speed is the dominant cause of injury (Macnab, Cadman, & Greenlaw, 1998). In extreme cases, excessive speed has also been identified as a contributing factor in fatalities at ski areas (Shealy & Thomas, 1996).

Mobile and wearable technology use while skiing is a potential new source of risk. Media reports associate smartphone application use with excessive speed as a result of access to real-time metrics (Kirby, 2014) and link high tech displays in sports eyewear with distraction (Richtel, 2013). Research by Dickson et al. (2012) also suggests that HUD use should be studied in relation to influencing higher risk-taking behaviours such as excessive speed, while Langran (2013) warns that HUD goggle users should take care to avoid becoming distracted by the screen. To maintain the safety of all resort users, ski area managers need to know if HUD goggles present an increased threat of injury to the wearer – or to other slope users nearby – and if so, how to potentially mitigate such risks.

The purpose of this study is to address this knowledge gap by empirically exploring the effect of HUD use on skiing speed as a function of personal (e.g., age, ability, motivation, use of other technology) and external (e.g., weather, terrain) factors. We hypothesize that HUD use affects maximum skiing speeds the most and that the effect is weaker at lower speed quantiles (e.g., median speed). We specifically examine the following research questions:

(1) Does HUD goggle use effect skiing speeds?
(2) How is the effect of HUD googles on skiing speeds moderated by personal factors (e.g., gender, skiing ability) and external factors (e.g., terrain characteristics, weather conditions)?

2. Background

To our knowledge, there is no existing research that has examined the effect of HUD use in outdoor recreation or skiing in general and with respect to safety in particular. However, substantial research exists on the effect of HUD use on driving behaviour. Tonnis, Lange, & Klinker (2007), for example, show that users drive faster with HUD assistance than without it, and Liu & Wen (2004) indicate that speed control (variations in driving speed) is improved during HUD use. Reaction time to speed limit warnings (Liu, 2003) and emergency information processing is also faster during HUD use (Liu & Wen, 2004), but brake response times increase by up to 30% (Wolffsohn & McBrien, 1998). Liu (2003) also notes a "novelty effect" associated with HUD use, suggesting that the effects change over time as users become familiar with the technology.

A considerable amount of research has been conducted on the skiing speeds and factors affecting risk-taking behavior in skiing. Recreational skiing speeds have increased dramatically in recent decades. Average speeds attained while skiing increased from an estimated 34.7 km/h in the late 1970's to 43.0 km/h by 2005 (Shealy et al., 2005), with the increase attributed to grooming practices, slope design, and boot and ski technology. A recent study by Ruedl et al. (2013) revealed mean speeds have reached 48.2 km/h on slopes of medium difficulty, but Williams et al. (2007) show that skiers navigating non-traditional terrain such as gladed areas and freestyle parks still travel at much lower speeds of below 24.1 km/h. In terms of maximum speeds, research by Dickson et al. (2011) observed a mean maximum skiing speed of 62.0 km/h, and highlights that top maximum speeds now exceed 100 km/h.

Numerous personal factors including gender, age, and ability are known to be associated with higher skiing speeds and risk-taking behaviour in general. Males typically ski faster than females (Shealy, Ettlinger, & Johnson, 2005), and report significantly higher rates of risky skiing behaviour (Ruedl et al., 2010; Ruedl, Abart, Ledochowski, Burtscher, & Kopp, 2012). Younger skiers (Ruedl et al., 2010) – specifically those under 25 years of age (Ruedl, et al., 2012) – are also more likely to take risks, while skiers of higher ability levels including 'advanced' (Ruedl et al., 2010) also report greater risk-taking behaviour. Lastly, higher speed itself is associated with risk taking. For example, self-identified risk-takers are shown to ski at higher speeds compared to more cautious skiers (Ruedl et al., 2010).

Various studies have revealed an association between risky skiing behaviour and 'sensation seeking' (SS), a well established and researched personality trait that is defined as "the need for varied, novel and complex sensations and experiences and the willingness to take physical and social risks for the sake of such experience." (Zuckerman, 1979 p.10). Ruedl et al. (2012) and Haegeli, Gunn & Haider (2012), for example, show that higher scores on Zuckerman's sensation seeking scale are associated with risky skiing behaviour among amateur skiers. Gracz, Elegańczyk-Kot, & Walczak (2008) show that ski racers score between high and very high on Thrill and Adventure Seeking (TAS), the sub-scale