THE VISUAL SEARCH STRATEGIES UNDERPINNING EFFECTIVE OBSERVATIONAL ANALYSIS IN THE COACHING OF CLIMBING MOVEMENT

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ABSTRACT - ENGLISH

Despite the importance of effective observational analysis in the coaching of climbing movement, there is currently no existing research to inform the education of climbing coaches. Through the use of eye tracking technology and semi-structured interviews, the perceptual mechanisms underpinning the visual search strategies of expert and novice climbing coaches were investigated. Visual gaze data identified that expert climbing coaches have fewer fixations, fixate for longer durations and fixate on different areas of the visual display than their novice counterparts. Semi-structured interviews further explained differences in the contextual knowledge underpinning visual search strategies, enabling experts to actively focus on the most relevant aspects of climber's performance. The present study concludes that expert observational analysis can be summarised as a 'top down' processing model of observation, underpinned by a hierarchy of skills and their related movement principles. Eye tracking technology provides a valuable methodology to capture the contextual knowledge underpinning effective observational analysis and the critical factors that underpin successful movement.

KEYWORDS - ENGLISH

Eye Tracking; Coach Education; Bouldering.

ABSTRACT – FRENCH

Malgré l'importance des analyses d'observation efficace dans le mouvement de l'entrainement de la grimpe, actuellement il n'existe aucune recherche pour informer l'éducation des moniteurs de la grimpe. A travers l'usage des technologies qui suivent le mouvement des yeux et des interviews semi-structurés, on a examiné les mécanismes perceptives qui soutiennent des stratégies de recherche visuelle des moniteurs de la grimpe experts et débutants. Le data des regards visuels a identifié que les moniteurs experts ont moins de regards fixes, fixent pour plus longtemps et fixent leur regard sur les régions différentes du champ visuel que leurs collègues débutants. En plus, des interviews semi-structurés ont expliqués les différences dans le savoir-faire contextuel qui soutient des stratégies de recherches visuelles, qui permet aux experts de faire le point sur les aspects les plus pertinents de la performance d'un grimpeur. L'étude actuelle a comme conclusion que les analyses d'observation d'un expert peut être décrit en somme comme un modèle d'observation où l'expert sait ce qu'il recherche « top down », soutenu par une hiérarchie d'expertise, et les principes de mouvement y associés. La technologie qui suit le mouvement des yeux fournit une méthode utile pour capturer le savoir-faire contextuel qui soutient les analyses d'observation efficaces, et les facteurs essentiels qui soutiennent un mouvement réussi.

INTRODUCTION

Climbing coaches use observation as a fundamental tool to inform much of their coaching practice. The vision and qualities of a coach's observation (analysis, diagnosis and feedback) may inform every aspect of training and competition. Through a directed visual search of the environment, and the ability to extract useful information from the visual display, a coach can identify key aspects of the athlete's performance that can subsequently be targeted for improvement (Hodges & Franks, 2004). Experts have been shown to possess more specific knowledge of the task and a greater ability to select, process, codify, organise, and recover information in a more efficient way, rapidly encoding information in long-term memory and efficiently accessing it for later tasks (Nougier, Ripoll, & Stein, 1989; Spitz, et al., 2016). Experts focus their gaze on more informative areas of the visual display and have an enhanced ability to utilise a greater proportion of their parafoveal vision to extract relevant cues (Kundel, et al., 2007; Hancock & Ste-Marie, 2013). Despite the importance of effective observation, there is currently no existing research to inform the education of climbing coaches. A systematic understanding of the mechanisms that underpin the development of effective observational analysis has yet to be explored.

The present study addresses two specific aims: (1) to investigate whether there are identifiable differences between the visual search strategies of novice, and expert climbing coaches in the observational analysis of climbing movement; (2) to investigate whether common visual search patterns can be established amongst expert climbing coaches, that would serve as the basis to inform an observational framework for the purpose of future coach education.

METHODS

Through convenience sampling, 6 participants were recruited, consisting of 3 expert climbing coaches (aged 35 ± 2.65 [mean ± SD]; 3 male), and 3 novice climbing coaches (aged 23 ± 5.1; 1 female, 2 male). Coaches were categorised by: (1) Level of their coaching experience (Experts national level, GB junior team; novices club level, employed min part-time); (2) experts, a minimum 5 years of coaching experience (years 8.3 ± 1.5) and novices a minimum of 1 year experience (years 3.6 ± 2.1). The study was approved by the University of Derby Research Ethics Committee.

Each coach observed the same intermediate (V4/F6B+; Draper et al., 2016) climber (male; 21 years) climb 4 different boulder problems (2 x vertical, 1 x slab, 1 x roof) at a grade of V4 (F6B+) repeating each problem 3 times. The coaches were instructed to observe the climber, to assess the quality of movement and identify movement errors. Coaches were fitted with mobile eye tracking glasses (Sensory Motoric Instruments 2.0 mobile eye tracker 60 Hz) to record their visual gaze data whilst observing the climber (fixation count, fixation duration and fixation location).

Visual gaze data was analysed using SMI BeGaze 'Semantic Gaze Mapping' (SGM), mapping fixations against predefined areas of interest (AOI). The mapped visual gaze data of individual coaches was aggregated and compared between expert and novice groups, to identify differences in visual search behaviour. All values are reported as mean ± SD. No statistical comparisons were made of novices and experts due to the small sample size. However, the magnitude of differences were determined using Cohen's *d*. All data were analysed using Microsoft Excel (Version 15.37, Santa Rosa, CA).

Following the observation of the climber, each coach was interviewed by the lead researcher. The semi-structured interviews, ranging from 39 to 52 min in duration, aimed to ascertain the cognitive-perceptual process underpinning the coach's observational strategy. To encourage discussion of the observational behaviour, the coach's own visual gaze data was downloaded using SMI BeGaze and replayed to the coach at normal and half replay speeds (1 x 100%; 1 x 50%). During the interview, coaches were required to verbalise how their visual gaze data (fixation being defined as ≥ 100 ms) relates to the rationale underpinning their visual search strategy and coaching process. The transcribed retrospective think-aloud (RTA) interview data was analysed utilising thematic analysis (Braun & Clarke, 2006).

FINDINGS & DISCUSSION

Visual fixations are of great interest to researchers, as the duration of the visual fixation seem to denote the relative importance of an area of the scene for the observer (Just & Carpenter, 1976), as eye movements and attention are linked (Rayner, 1998). Eye tracking research within a sporting context has previously demonstrated that experts are often more perceptually skilled, requiring fewer fixations of longer duration in order to extract task-relevant information, indicating an underlying efficiency to their gaze behaviour. Experts in sport extract more task-relevant information from each fixation than lesser skilled performers (Mann, et al., 2007). The visual gaze data gained through the present study supports this proposition, showing that expert coaches had a slower fixation-rate (Experts $223s^{-1} \pm 0.20s^{-1}$; Novices $244s^{-1} \pm 0.37s^{-1}$; d = 0.71) and greater average fixation durations than novice coaches (Experts 315ms ± 30ms; Novices 261ms ± 59ms; d = 1.07). Williams (1999) argues that a greater number of fixations, of smaller duration, represents a less efficient and less effective search strategy. The 'information-reduction hypothesis' (Haider and Frensch, 1999) proposes that experts optimise the amount of processed information by neglecting task-irrelevant information and actively focusing on task-relevant information. This is accomplished through strategic considerations to selectively allocate attentional resources. The increased number of fixations of shorter duration amongst novice coaches suggests an inability to disregard non-relevant information, subsequently increasing cognitive load and reducing the effectiveness of their observation (Gegenfurtner, et al., 2011). Without sufficient time to process task-relevant cues, oversights and incorrect decisions are inevitable (Mann, et al., 2007).

Themes emerging from RTA data gave further insight into the cognitive-perceptual processes underpinning differences in the search behaviours of the coaches interviewed. Expert coaches were far more explicit in their ability to relate their visual search strategies to principles of climbing movement. Experts were able to provide rich description of the critical factors that underpin successful movement and relate such principles to their visual gaze data. Novice coaches by comparison, were commonly unable to communicate any form of rationale to underpin their visual search strategies and were consistent in describing a lack of knowledge in the principles of climbing movement as the limiting factor in knowing where to focus their attention.

Experts coaches described a ‘top down’ processing model of observation (Malcolm & Henderson, 2010), detailing ‘rules of thumb’, that guide their visual search strategies, based on a set of movement principles. Eye tracking and RTA data demonstrated that experts were more proactive in their observations (they know where they want to look and why), whereas novices were more reactive (they follow whatever is moving, looking for an error to jump out), reflecting a more ‘bottom-up’ processing model. A ‘top-down’ model is consistent with the expert groups visual gaze and RTA data, enabling experts to focus on key areas of interest in the visual display for longer, as they have reduced the number of fixation locations, through a refined observational strategy. Furthermore, experts described what could be termed a hierarchy of skills underpinning this top-down process, whereby experts alluded to a process of assessing components of technique in a logical hierarchical order to build up a picture of the athlete’s ability: Assessing the athlete’s ability to perform the most fundamental skills and progressing through to skills of increasing complexity until faults begin to be identified.

Certain inferences can be drawn from the location and duration of the observer's visual fixations and are regarded as an index of the relative importance of a given cue within a stimulus display (Moreno et al, 2006). Knudson (2013) suggests that in order to effectively analyse and evaluate the quality of an athletes performance, the coach must have an extensive knowledge of the ‘critical factors’ that underpin successful movement. The aggregated fixation locations of expert coaches provide useful information as to the most relevant areas of the display for a given movement. When combined with RTA data, the relative aspects of performance at those locations can be established. In the present study, experts allocated a greater proportion of their attentional resources to proximal features (core) of the climber’s body, demonstrating a greater number of fixations (Experts 58.7 ± 24.5; Novices 17.4 ± 1.4; d = 2.4) and longer total fixation durations (Experts 23.6 ± 14.5 s; Novices 4.5 ± 1.2 s; d = 1.9). Experts placed less attention on the climber’s hand placements than novices, with fewer total fixations (Experts 41.0 ± 25.9; Novices 69.5 ± 27.6; d = 1.1) and shorter total fixation durations (Experts 16.6 ± 11.6 s; Novices 25.8 ± 0.4 s; d = 1.1). Experts spent far more time fixating their attention on the climber’s foot placements than novices, with greater numbers of total fixations (Experts 44.7 ± 14.6; Novices 38.5 ± 14.9; d = 0.4) and longer total fixation durations (Experts 20.2 ± 4.7 s; Novices 11.1 ± 1.4 s; d = 2.6). The AOI data identifies distinct differences in where expert and novice coaches consider to be the most informative areas of the visual display to extract relevant visual cues to inform their analysis of the climber’s movement. Whilst the present study was too limited in scope to establish a comprehensive framework detailing the critical factors underpinning climbing movement, common principles of movement were evident amongst the expert coaches. For example, the relationship between positioning the centre of mass (core) within the points of contact, was a consistent theme and supports the attention experts dedicated to the climber’s core. The present study identified consistencies within the search strategies of expert coaches, suggesting the possibility for future research to identify common visual search patterns. Such insights potentially provide coach educators with evidence highlighting the most salient areas of the visual display, in order to extract the most task relevant information, increasing the efficiency and quality of developing coaches’ observational analysis.

CONCLUSION

The present study identified distinct differences in the visual search strategies between novice and expert climbing coaches. The greater contextual knowledge of expert coaches allows them to actively focus on the most relevant aspects of climber's performance. Expert coaches demonstrated a 'top down' processing model of observation, underpinned by a hierarchy of skills and their related movement principles. The efficacy of eye tracking technology to capture expert coaches' knowledge of critical factors that underpin successful movement has been confirmed, though further research is required to develop comprehensive observational frameworks which more accurately reflect the complexity of climbing movement. Future research might further explore the effectiveness of specific forms of perceptual training, increasing the salience of task-relevant regions, to provide a more effective method of accelerating the training of novice climbing coaches.

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