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# Skill transfer, affordances and dexterity in different climbing environments



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### ABSTRACT

This study explored how skills in one region of a perceptual-motor landscape of performance, created in part by previous experience in rock climbing, can shape those that emerge in another region (ice climbing). Ten novices in rock climbing and five intermediate rock climbers were observed climbing an icefall. Locations of right and left ice tools and crampons were videotaped from a frontal camera. Inter-individual variability of upper and lower limb couplings and types of action regarding icefall properties were assessed by cluster hierarchical analysis, distinguishing three clusters. Pelvis vertical displacement, duration and number of pelvis pauses were also analyzed. Experienced rock climbers were grouped in the same cluster and showed the highest range and variability of limb angular locations and coordination patterns, the highest vertical displacement and the shortest pelvis plateau durations. Non-fluent climbers (clusters 2 and 3) showed low range and variability of limb angular locations and coordination patterns. In particular, climbers of cluster 3 exhibited the lowest vertical displacement, the longest plateau durations and the greatest ratio between tool swinging and definitive anchorage. Our results exemplified the positive influence of skills in rock climbing on ice climbing performance, facilitated by the detection of affordances from environmental properties.

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## 1. Introduction

According to ideas in ecological dynamics, skilled individuals are seen as capable of exploiting available information about environmental and task-related constraints in order to re-organize the multitude of motor system degrees of freedom during performance of multi-articular actions (Davids, Button, & Bennett, 2008). The acquisition of skilled behavior is influenced by the gap that may exist between a stable pre-existing movement pattern repertoire in a specific performance environment and a 'to-be-used' pattern in another region of the perceptual-motor landscape of performance. An important issue in movement science concerns the ability to adapt one's intrinsic system dynamics (existing coordination tendencies) to the specific constraints of a new task. From this viewpoint, harnessing previous experience is defined by the amount of adaptability between each individual's intrinsic dynamics and the dynamics of a task in a different performance environment with new ecological constraints that need to be satisfied (Warren, 2006). Adaptability refers to a subtle, functional blend between stability (i.e., persistent behaviors) and flexibility (i.e., variable behaviors) in achieving task goals (Davids, Bennett, & Newell, 2006; Li, Haddad, & Hamill, 2005; Warren, 2006). Adaptability was termed 'dexterity' by Bernstein (1967), and is essential to skilled performance of complex multi-articular actions. In skilled individuals, stability is characterized by the consistent achievement of performance outcomes over time, resistant to perturbations and reproducible in the sense that a relatively similar movement pattern may recur under different task and environmental constraints. Stable behaviors do not signify the existence of stereotyped and rigid movement patterns to achieve consistent performance outcomes. Rather, dexterity underpins functional movement patterns, displaying regularities and similarities within their structural components, with an individual not locked into a rigid, repetitive performance solution. It is, thus, important to understand which components of multi-articular actions remain stable and reproducible in dynamic performance environments with different ecological constraints on action, such as team sports (e.g., football and futsal), cycling (e.g., road racing and mountain biking), paddle sports (white water and ocean kayaking) and outdoor pursuits (e.g., indoor wall, rock and ice climbing). Here we sought insight into the capacity of skilled individuals to harness previous experience in rock climbing to satisfy the task constraints of climbing in a distinct performance environment: scaling icefalls.

Regarding the ecological dynamics of skill acquisition, investigation of how individuals acquire new forms of behavior against a background of a pre-existing movement pattern repertoire has historically been an aspiration in motor learning research, typically using rhythmical movement models (e.g., Buchanan, 2004; Kelso & Zanone, 2002; Temprado & Swinnen, 2005; Wang & Sainburg, 2004; Zanone & Kelso, 1997). However, few investigations have attempted to explore how skill acquisition occurs when performing complex multi-articular actions in dynamic performance environments (such as climbing on various surfaces). In our study, this issue was exemplified in an investigation of which aspects of previous experience are reproducible, stable and transferred from rock to ice climbing. Specifically, the issue was examined by observing how rock climbers used their previous experiences in climbing a frozen waterfall surface, known as ice climbing. The issue of skill transfer from rock to ice climbing can provide much-needed theoretical, practical and pedagogical insights.

Three main points emphasized our expectations of a positive transfer of climbing experience between the specific task constraints of rock and ice climbing: (i) the coupling of perception and action in unpredictable environments, (ii) alternation between maintaining body equilibrium and climbing quickly up a vertical surface, and (iii) the use of quadrupedal locomotion in using the extremities of each limb.

- (i) In dynamic and natural performance contexts such as rock and ice climbing, task expertise relates to the coupling of an individual's actions with affordances (i.e., action possibilities offered by properties of the environment; Gibson, 1979) in the performance environment. Considering affordances as opportunities for action in the context of rock and ice climbing suggests that the coordination dynamics of action would emerge from a mutual coupling of a climber's

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