EXPLORING THE RIGHT SPOT: HOW MUCH INFORMATION REALLY TO EXPLORE FOR EFFICIENT CLIMBING?

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The purpose of this study was to investigate the optimal amount of information to explore by a climber to effectively anticipate the next actions and therefore ensure efficiency during the climb. Climbers (N=6), with mean age 15.6 years (+/-1.6) were assigned based on their maximal performance to an "expert" group (N=3 who can climb a route with difficulty level 7 or more) and a "beginner" group (N=3 who can climb a route with difficulty level 5c maximum). All those 6 climbers practiced 6 times not identical but similar routes (same difficulty level and technical requirements), but the number of visible holds was decreased trial after trial. In other words, during the first trial the next 6 holds were visible (the holds lights on as far as the climber actually climbs up), the second trial showed only the 5 next holds, the third trial showed only the next 4 holds, etc… Both the performance, efficiency and exploratory activity were measured during the ascent. Results showed that a major drop in performance arose for experts when they went through the condition with 3 visible holds to the condition with only 2 visible holds, showing that expert climbers can ensure fluidity of their climb by anticipating in the next 3 holds. Concerning the beginners, no drop in performance were observed, advocating for a lack of anticipation for the beginners, as they mainly use the next hold to anticipate (or rather "not anticipate").

KEYWORDS: information, climbing, exploration, efficiency.

INTRODUCTION: In learning efficient climbing, Seifert, Boulanger, Orth, and Davids (2015) showed that manipulation of hold orientation during a learning protocol invited individuals to both exploit their pre-existing behaviours (i.e., horizontal hold grasping pattern and trunk face to the wall) and to explore new behaviours (i.e., vertical hold grasping and trunk side to the wall), leading to a safe exploration during learning. Those studies have shown how route design can induce more or less exploratory behaviours during learning leading to final functional performance (Orth, Davids, & Seifert, 2017). However, in those preliminary studies, the learning environment was kept constant during the learning phase. In other words, although the constraints applied were supposed to enhance the exploration of the environment by the learner, those constraints did not change all along the learning phase, mainly to allow for comparison of learning conditions. As a result, if exploration was promoted at the beginning of the practice, it decreased after few sessions when the learners were adapted to the constraining situation. Only few studies, promoting differential learning and training approach, added stochastic perturbations in the learning task through 'no repetition' and 'constantly changing movement tasks' (Schöllhorn et al., 2012). In those studies on differential learning, although there was constant induced variability, this variability was "random" and did not prioritise the use of constraints to design learning environment. In other words, the theoretical assumption is that variability itself is beneficial for learning, whatever is variable. Conversely, the constraints-led approach advocates for an actual exploration of relevant information of the perceptual-motor workspace, in order to develop relevant information-movement coupling. In conclusion, the actual nature of the exploration has to be questioned to inform about the actual effectiveness of infused variability during learning. In other words, what is explored by participants? And how much has to be explored? The aim of this study is to investigate the optimal amount of information to explore by a climber to effectively anticipate the next actions and therefore ensure efficiency during the climb. In other words, what level of information really has to be explored for better performance and learning.

METHODS: Ethical approval was received from the Nanyang Technological University Institutional Review Board (IRB-2019-02-017). Participants gave written consent to participate in this study. Climbers (N=6), with mean age 15.6 years (+/-1.6) were assigned based on their maximal performance to an “expert” group (N=3 who can climb a route with difficulty level 7 or more) and a “beginner” group (N=3 who can climb a route with difficulty level 5c maximum). All those 6 climbers practiced 6 times not identical but similar routes (same difficulty level and technical requirements), but the number of visible holds was decreased trial after trial. More precisely, during the first trial the next 6 holds were visible (the holds lights on as far as the climber actually climbs up), the second trial showed only the 5 next holds, the third trial showed only the next 4 holds, etc… Therefore the six practice conditions were be as follow: Condition 1: 6 holds visible / Condition 2: 5 holds visible / Condition 3: 4 holds visible / Condition 4: 3 holds visible / Condition 5: 2 holds visible / Condition 6: 1 hold visible. The condition of interest is the condition that shows a major drop in performance (e.g. decrease in performance when going from the condition with 3 visible holds to the condition with 2 visible holds). For the purpose of implementing those climbing conditions, a specific instrumented climbing wall has been used (ClimbLing.com), where the holds can be light on and off as requested and in the meantime, each hold records when the climber grasp it and release it. The performance indicator were based on existing works (Orth, Kerr, Davids, Seifert, 2017; Orth, Davids, Seifert, 2018) and covered three main points, i) performance, ii) efficiency and iii) exploration. The first indicator was the raw speed of climbing, i.e. the time of the ascent. The second indicators were related to efficiency (following Newell, 2001 in defining efficiency as the main feature of expertise). The efficiency in climbing has been defining as “fluidity”, or “fluency”, which is defined by a regular movement without saccades. Fluidity was previously measured by tracking the hip of the climber on a video, and a lower geometrical index of entropy were associated with greater fluidity (i.e. less useless movements within the global shape of the hip trajectory during the ascent, see Orth, Kerr, Davids, Seifert, 2017). In the present case, the fluidity was additionally assessed by the instant timing between the touch of two successive holds normalized by the distance between those two holds. More precisely, if every hold is a “step” in the ascent, a regular timing between each hold is a sign of high fluidity, whereas a longer time between two holds means that the climber paused his ascent at this portion of the route. Therefore, different timings between successive holds will be a sign of bad fluidity. Also, an indicator of exploration was calculated as the number of touches of a hold before the last grasping of this hold. In other words, if the climber actually grasps the hold without any a priori touch there is no exploration and the higher the number of touches before grasping the higher the exploration. In summary, our independent variables are the group (i.e. expert or beginner) and the conditions (condition 1 to condition 6), whereas the dependant variables are the time of the ascent, the index of fluidity (i.e. hip geometric index of entropy, variability of timing between holds) and the level of exploration.

RESULTS: As expected, the expert group showed better fluidity based on traditional index of fluidity. The geometric index of entropy was 0.76 ((+/-0.04) for experts and 1.52 ((+/-0.12) for beginners. However, the timing between the successive holds did not show a significant difference between the groups (mean = 2.7 sec +/-2.1), probably due to a high variability within groups and within participants for this indicator. In the same vein, the level of exploration was very low for both groups without any significant difference between the groups (mean = 0.7 touch before grasping +/-0.4). Most interestingly, a significant drop in fluidity (i.e. an increase in the geometric index of entropy) appeared for the experts between the condition with 3 visible holds and the condition with 2 visible holds (figure 1).

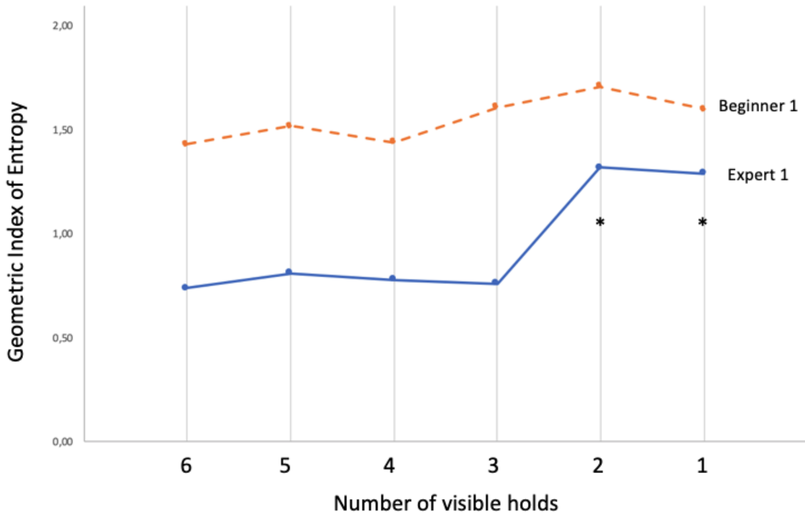

Figure 1: Dynamics of geometric index of entropy between the conditions for one expert (continuous line) and on beginner (dashed line), * represent a significant increase in the value of geometric index of entropy for the expert (i.e. higher values than the conditions 6,5,4 and 3).

DISCUSSION: In the present study, experts were more fast and more fluent in climbing the same route as beginners. On another side, it appears that the timing between successive holds is not a relevant indicator to assess the fluency of the climber, either beginner of expert, and the geometric index of entropy remains the best solution (although it requires the use of additional material, the video camera). Most interestingly, the present study, although with limited participants, advocates about a very limited information gathering from the beginners in terms of the following holds. Indeed, whatever the amount of visible holds, beginners did not exhibited any change in efficiency, showing that this information (i.e. following holds) is not effectively used by those climbers). This lack of information about next holds could explain the lower fluidity in the ascent, as the capacity to chain movements in climbing (i.e. to anticipate what will be the next movement) is a key features of expertise. Concerning the experts, the results showed that a major drop in performance arose for experts when they went through the condition with 3 visible holds to the condition with only 2 visible holds. This drop in fluency advocates that expert climbers can ensure the fluidity of their climb by anticipating on the next 3 holds, and if those next 3 holds are not available it impacts the performance and fluidity of the climbers. In other words, those next 3 holds represent the functional level of information for those climbers.

CONCLUSION: This study focused on the information that is effectively necessary for a climber to ensure an efficient climb (i.e. with high fluidity) and showed that expert climbers can anticipate their movement based on the next 3 holds. In the future, it will be useful to firstly increase the sample from this experiment, but also increase the range of expertise levels of the climbers. Indeed, it seems now interesting to check weather higher skilled participants (e.g. who can climb up to 8a routes) can use “further” information” (or holds).

REFERENCES

Newell, K. M., Liu, Y. T., & Mayer-Kress, G. (2001). Time scales in motor learning and development. *Psychological review*, 108(1), 57–82.
Orth, D., Kerr, G., Davids, K., & Seifert, L. (2017). Analysis of Relations between Spatiotemporal Movement Regulation and Performance of Discrete Actions Reveals Functionality in Skilled Climbing. *Frontiers in Psychol*ogy. 8:1744.
Orth, D., Davids, D., Seifert, L. (2018). Constraints representing a meta-stable regime facilitate exploration during practice and transfer of learning in a complex multi-articular task. *Human Movement Science*, 57, 291-302.
Schöllhorn, W. I. (2012). The Nonlinear Nature of Learning - A Differential Learning Approach. *The Open*

Sports Sciences Journal, 5, 100–112.
Seifert, L., Boulanger, J., Orth, D., & Davids, K. (2015). Environmental Design Shapes Perceptual-motor Exploration, Learning, and Transfer in Climbing. *Frontiers in Psychology*, 6.

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