Cognitive Training Strategies for Orienteering: An Online Material

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Abstract
Orienteering integrates physical activity with high-level cognitive challenges, requiring athletes to efficiently interpret maps and make navigation decisions in changing environments. While many resources teach technical skills, guidance for systematically training cognitive abilities in orienteering is limited.

This thesis reviews existing research on the cognitive demands of orienteering, such as spatial memory, map reading, attention management, reflection, relocation, and decision-making, and adapts key concepts into practical exercises for athletes and coaches. The training activities are organized into an accessible online platform (https://ej.uz/cognitivetraininginorienteering) to support learning and performance.

By linking cognitive science with training methods, the thesis aims to help athletes progress from intermediate to advanced levels and offers coaches tools for designing effective practice sessions. Although the effectiveness of the proposed materials is not experimentally evaluated, they provide a foundation for future research and coaching development in orienteering.

Key words
Orienteering, Cognitive training, Athlete development, Online material

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1 Introduction

Orienteering is a sport that uniquely combines physical endurance with cognitive navigation skills. The objective is to navigate to a series of checkpoints (controls) as fast as possible using a topographical map and a compass. Athletes choose their own routes for each leg (the segment between two controls), but as the map is retrieved only at the start, route planning and decision-making occur during the race, requiring high cognitive demands

Many athletes and coaches recognise the cognitive challenges of orienteering but lack the know-how to train these skills purposefully. Martland (1986, 120) concluded, that certain actions and technical skills, such as simplifying the leg, are expected from the athlete, but no information is provided on how to train it, leading to aimless practice. Deliberate and goal-specific practice that targets specific skills is more effective than unstructured repetition, especially in overcoming current weaknesses (Baker & Young 2014, 135-136). Although previous studies have outlined the cognitive demands and processes in orienteering, there is limited guidance on training these skills. This thesis aims to bridge this gap by connecting scientific understanding with practical training design.

The objective of the thesis is to create a practical cognitive training material for orienteering coaches and athletes. By translating cognitive science and orienteering research into practical exercises, we aim to help junior and youth athletes overcome performance plateaus and close the gap between intermediate and expert orienteering, and support coaches in training athletes' cognitive skills. We aim to gather and categorise a variety of exercises into a single online platform that is freely accessible to everyone.

The thesis focuses specifically on cognitive components of orienteering, which include map reading and mental model construction, spatial-perceptual processing, attention control, decision-making, relocation, and reflection. The thesis assumes, that the target group – youth and junior orienteers – already possess the basic technical skills required to complete a course. The effects of physical conditioning and psychological factors are excluded from the scope.

The thesis is divided into two parts: a review of existing literature regarding cognitive components in orienteering, and a product development section describing the process and development of the training material. The effectiveness of the material is not tested within this thesis.

The expected outcome of the thesis is a practical online platform that compiles cognitive training exercises for orienteering. The material is intended to help intermediate level athletes develop advanced navigation skills, as well as support coaches in designing purposeful training sessions and contribute to the broader development of cognitive training practices within orienteering.

2 Cognitive skills in orienteering

The cognitive skills presented in this section are derived from existing research on orienteering and related cognitive sciences. The categorisation is based on themes identified across multiple studies that examined the mental processes and cognitive demands orienteers face during competition. The following sub-chapters describe the key cognitive processes involved in orienteering – map reading, perception and spatial navigation, attention, relocation, and reflection and analysis. For each skill, suggested training methods are presented that translate the theory into practical examples. While the skills are discussed individually as separate categories to provide structure, they are highly connected and interrelated in orienteering practice. It is important to note that many of the suggested training methods may target and develop multiple cognitive skills at a time.

2.1 Map reading and interpretation

Map reading is the central cognitive skill in orienteering that serves as a bridge between the abstract representation of the terrain and the navigation experience. It can be understood as the ability to interpret and translate the information of the map into real terrain and vice versa. It is not just pure recognition and interpretation of the symbols, but rather active navigation and adaptation. Ottosson (1986, 76) describes the map as a tool for anticipation, in which the mapmaker has decided which elements of the terrain to present. The map can be defined as a tool for the anticipation of the environment. Ceugniet (1991, 45) compares map reading to text reading, highlighting how individual symbols resemble words, while the integration of several features in a coherent model draws parallels to the comprehension of sentences.

2.1.1 Mental models

Ottosson (1986, 76) describes three representations that are constructed in the process of orienteering. Two models are representations of the terrain – the map and the orienteer's mental representation, the third is one’s own mental model of the map. Seiler (1996, 60) argues that map reading is a process of building a simplified mental model of the terrain, which allows the orienteer to plan actions before reaching a control. He acknowledged that the mental model is approximate and does not accurately represent the detailed reality. Mismatches between mental representation and the terrain lead to errors and the need for relocation.

Mental models of the map are constructed using the information presented on the map and the orienteer's own knowledge about the terrain (Seiler 1996, 60). Experts subconsciously build an image of the terrain and, in addition to the knowledge of symbols, use their previously acquired knowledge about the terrain. They can identify the unique characteristics of the environment, such as the width of a stream, based on their previous experiences. (Murakoshi 1990, 17, Murakoshi 1994, 30.)

For example, when a map fragment of a Nordic terrain is presented, the expert will be able to correctly assume the characteristics of certain objects, like rocks, streams, and forest density, whereas a novice would build the mental model of the terrain based on their limited previous experience. If one has never been in such terrain, the model will be based on the terrain representation of a map that closely resembles the new one. Expert orienteers have developed complex and highly refined mental representations through extensive practice. These models reduce the cognitive load and fatigue by reducing the need to attend to the map constantly (Eccles, Walsh & Ingledew 2002a, 82).

2.1.2 Behavioural and cognitive strategies

The task of navigating to a control by understanding and interpreting the map remains consistent for every orienteer, but there are differences in the way the problem is solved. As it is with a math problem, there are multiple ways to solve one. In the orienteering context, differences are visible in the way athletes tackle the complex task to accurately interpret the information provided by the map, determine their location, and navigate by constantly updating and comparing the mental representation of the terrain with reality.

While the task of navigation appears the same to every athlete, studies of elite junior orienteers demonstrate different behavioural strategies in map use. Some athletes rely on short but frequent map checks, maintaining continuous and detailed contact with the map and constant updates of the mental model, while others prefer fewer but longer map-reading periods, focusing on key features. Fewer technical periods allow for higher running speed but involve a lot of trust in oneself and one's mental model of the terrain. (Ottosson 1986, 90.)

A study examining visual attention in orienteers at different experience levels concluded that expert orienteers tend to have shorter and more frequent map reading periods compared to less experienced orienteers (Eccles, Walsh & Ingledew 2006, 85). This is a part of their adaptive strategy to manage attentional demands and improve performance. The authors found that expert orienteers were moving 73.14% of the time they spent reading the map, while for novices it was only 38.09%, and the time proportion spent attending to the map was the same for both groups. (Eccles et al. 2006, 82).

While acknowledging that individual behavioural differences exist, there is a clear correlation between the map-reading and behavioural strategies used and the performance level of the orienteer. One might question whether the cognitive strategies used by experts are acquired through experience or whether experts excelled in the sport due to possessing a certain cognitive skills and behaviour. However, there is research (e.g., Spelke, Hirst & Neisser 1976) suggesting that the ability to perform multiple complex tasks simultaneously is a skill that can be acquired with extensive practice (Eccles et al. 2006, 78). Additional findings (Guo, Liu & Kan 2024, 9) suggest that training interventions can be designed to teach novice orienteers the cognitive and behavioural strategies used by experts.

2.1.3 Training map-reading skills

Map reading skills and associated behaviours, such as map-terrain-map interpretation, mental models, technical period frequency, and navigating while moving, although acquired and trained through long-term practice and participation in orienteering, can be accelerated through specialised training (Batista, Paludo, Gula, Pauli & Tartaruga 2020, 8).

Orienteering training specifically improves the ability to accurately recognise objects and landforms, and it is thought to be the easiest skill to acquire (Uyar, Yayla & Zunber 2022, 267). Various authors (Bao, Liu & Liu 2022, 17; Seiler 1996, 63) suggest training map reading skills by drawing one's own interpretation of the map, including just enough information to navigate, and completing the leg based on the self-drawn map. Ottosson (1986, 97-98), based on his conclusion that taking short and frequent glances at the map is the strategy that results in the most accurate navigation, advises practicing this behaviour, while acknowledging the importance and usefulness of training map-memory. He believes that the construction of mental models can be trained by map-making, which is a process placing high demand on creating accurate representations (Ottosson 1986, 98).

Seiler (1996, 63) encourages orienteers to incorporate deliberate repeated comparisons between the map and terrain in orienteering practice. Additionally, he suggests that using contour-only maps facilitates the development of terrain representations and that line orienteering (continuously following an imaginary line through the terrain instead of navigating to controls) demands constant updating of mental models. (Seiler 1996, 63.)

While orienteering is an outdoor sport, it is possible to practice certain cognitive skills without being in the forest. Based on authors conclusions regarding map reading (Murakoshi 1990, 21-22; Uyar et al. 2022, 272) a training strategy can be derived, which involves watching a video taken from a head-mounted camera of a person completing an orienteering course in real time and comparing it to the map (which is usually placed side-by-side on the screen with the terrain video). This facilitates the development of a map-terrain association. Orienteers with less experience in different terrains may experience more benefit from watching another person complete a course than those who have already built a broad knowledge base of various terrains and have fairly accurate mental representations. This type of training can prove to be useful for youth and junior athletes when preparing for international competition, such as Junior World Orienteering Championships, as their experience and training opportunities in terrains abroad might be limited. Seeing the unfamiliar terrain side-by-side with the map facilitates the creation of new and more accurate mental representations or models of the specific terrain, where its unique characteristics are acknowledged.

2.2 Perception and spatial navigation

Perception can be described as a fundamental cognitive skill that involves obtaining, interpreting, and making sense of the information acquired from the map and the environment (Liu, Lu, Liu, Zhao, Chao & Kang 2022, 1). It is the initial step in cognitive processing (Guo et al. 2024, 1). Perception and attention, being a part of map-reading ability, involve the recognition of various features, object symbols, routes on the map, and correctly matching this information with the actual environment (Liu et al. 2022, 1). This includes the relation of what is observed in the environment to map symbols and identifying any inconsistencies. Expert orienteers demonstrate enhanced sensitivity in this perceptual matching (Liu et al. 2022, 2).

2.2.1 Perceptual organisation

Perceptual organisation refers to the processes by which the human mind organises visual information into meaningful and coherent patterns rather than seeing separate objects. In orienteering, perceptual organisation plays a key role in map-reading, navigation, and decision-making, especially under time pressure. Expert orienteers demonstrate more efficient grouping and simplification strategies, which improve performance and speed (Guo et al. 2024, 1-2; Guzman, Pablos & Ljabos 2008, 163).

The concept is central to visual perception and the dominating principles are Gestalt laws, including the law of proximity (elements close together are perceived as a group), similarity (similar elements are grouped), closure (the mind fills in gaps to complete figures), continuity (tendency to perceive objects as smooth and continuous rather than disjointed) and figure-ground (differentiating the object from its background). (Eysenck & Keane 2010, 80-85.)

Viewing orienteering through the lens of Gestalt laws allows orienteers to group map features into clusters and patterns, identify coherent routes, and support efficient information extraction. In an experiment (Hempel 1987), orienteers were asked to navigate to a control based on a self-drawn map in which they included just enough features to successfully execute the route. The findings suggest that a higher quantity of elements drawn did not indicate a better performance; instead, the importance lies in the selected information. Better orienteers seemed to exhibit faster and more accurate information selection mechanisms. (Hempel 1987.)

Gestalt laws provide a better understanding of the internal information organisation processes and explain the strategies expert orienteers have adopted, such as simplification. This strategy helps orienteers be efficient in attention management and allocate cognitive resources to task-relevant stimuli and ignore irrelevant ones, which reduces cognitive load and increases processing efficiency (Guo et al. 2024, 9). Simplification can be understood as the process of selecting minimal but specific map information to compare to the environment (Eccles et al. 2002a, 78). Based on Gestalt laws of proximity and similarity, the orienteering map can be simplified into clusters and regions rather than individual features. Recognising and identifying a rocky area and navigating based on it would take far fewer cognitive resources than attempting to locate every individual rock and cliff.

2.2.2 Spatial perception and processing

As orienteering is fundamentally a task of transforming information from the map (a 2D representation) into actions in the terrain (3D reality), spatial perception and processing are core cognitive skills for the sport. Spatial perception is the ability to recognise, interpret, and interact with visual relationships in one’s environment, like direction, distance, position, and orientation (West, Järvinen, Fieandt & Korkala 18 April 2024). It is considered one of the several factors of broader spatial abilities, often studied alongside mental rotation and spatial visualization (Roca-González, Martín-Gutiérrez, García-Dominguez & Carrodeguas 2017, 444).

Spatial processing refers to the storage and processing of spatial information, and is considered crucial for higher cognitive brain activities, such as spatial representation, navigation, and decision-making (Liu et al. 2022, 1). Effective spatial processing allows orienteers to plan and execute optimal routes, considering factors like distance, ascent, runnability, and obstacles, and detect inconsistencies when comparing the map with the environment (Eccles et al. 2002a, 79). Spatial processing in orienteering relies on two complementary reference frames: egocentric, which involves defining spatial locations based on one’s own position and point of view, and allocentric, where locations are defined relative to other features in the environment (Waddington & Heisz 2023, 2).

Egocentric processing relies on cues from one’s own body, such as turns, directions, distances, and speed, while allocentric spatial processing involves remembering, and recognizing landmarks

(Fernandez-Baizan, Nunez, Arias & Mendez 2019, 1). The latter is an “object -based or third-person perspective” (Waddington & Heisz 2023, 2), that relies on landmarks and spatial parameters to build a cognitive map that is stable (Kozhevnikov & Puri 2023, 1). Successful orienteering demands the integration and fast transitions of both spatial strategies (Waddington & Heisz 2023, 2). Switching between these spatial processing strategies is a resource-demanding process, and studies have shown that transitioning from an allocentric reference frame to egocentric requires higher cognitive load compared to a switch in the opposite direction (Orti, Iachini, D’Agostino, Ruotolo & Ruggiero 2025, 10). Additionally, it has been found that using an allocentric spatial frame of reference places significant demands on spatial working memory, especially when retrieving spatial relations, and one’s performance relies on visuospatial working memory capacity (Kozhevnikov & Puri 2023, 21-22).

2.2.3 Visuospatial memory and navigation

The temporary retention and processing of visual-spatial information, which facilitates the retention, refinement and application of this information in complex cognitive activities, is defined as visuospatial working memory (VSWM) (Zhu, Guo & Liu 2025, 1). Effective visuospatial working memory is crucial for successful orienteering performance, where there is a high demand for visuospatial processing – orienteers must obtain effective information from the map, process and encode it, efficiently recognizing features, symbols and routes, memorizing and adjusting it with the environment in real-time (Bao et al. 2022; Zhu et al. 2025, 1-2). As continuous map reading is impractical while running, orienteers with strong visuospatial memory navigate based on brief glances of the map, in which they identify most critical feature and are able to execute a part of the route based on their memory.

In orienteering, athletes primary employ two types of spatial navigation strategies: survey strategies (allocentric) and route strategies (egocentric or procedural) (Kozhevnikov & Puri 2023, 1). Both are linked to aspects of spatial memory, and expert orienteers can switch between both to achieve optimal performance. The survey strategy, also known as cognitive mapping (Batista et al.2020, 7), can be defined as a navigation strategy based on allocentric spatial processing reference frame, where the determination of one’s location is based on the spatial relationships between landmarks and objects in the environment. Route strategy manifests in a procedural form, which involves memorising a “temporal sequence of associations” and coupling landmarks with actions (Kozhevnikov & Puri 2023, 2).

Orienteers navigating by a survey strategy update their location and mental representations based on the objects in the environment and the distance between them. A cognitive map or a mental representation is built, which facilitates a broader, “bird’s-eye” view, and allows to understand locations and directions relative to each other within a larger space. Route strategy is based in remembering a series of turns and objects encountered along the way. Individuals adopting this strategy are more focused on the sequence of steps needed to travel from one point to the other, rather than a global understanding of the spatial layout. A study (Bao et al. 2022) examining gender differences on spatial memory abilities concluded, that male orienteers more often adopt survey strategy, whereas females prefer route strategy. Additionally, it was found that a 12-week orienteering training program more significantly improved spatial memory in males than in females. (Bao et al. 2022, 9.)

2.2.4 Training perceptual and spatial skills

Perceptual and spatial skills aften involve activities that require continuous processing, encoding, and the transformation of visual and spatial information. Studies have shown that experience and specialised practice develop cognitive adaptations and individual memory strategies (Liu et al. 2022, 12). Orienteering itself is considered a valuable tool for training spatial and perceptual-cognitive abilities and fundamentally, long-term orienteering practice is necessary to build advanced cognitive skills because achieving expertise requires cognitive adaptations and restructuring of neural processing that only occur through sustained, specialised, and often extensive deliberate practice (Eccles et al. 2002a, 84-85; Eccles et al. 2006, 78; Liu et al. 2022, 12).

Keeping in mind, that the best adaptations occur through long-term practice, specialised training and deliberate practice lead to acquisition of knowledge and skills that allow for maximal adaptation to task constraints, which reduces the processing demands on limited-capacity visual and neural systems (Eccles & Arsal 2015, 610). Studies show that perceptual and spatial skills are highly malleable (i.e. easily influenced) and trainable across the lifespan, particularly through targeted training programs (Yang, Liu, Chen, Xu & Lin 2020, 10-11). Targeted training based on virtual technologies, such as virtual orienteering games, has shown to improve components of spatial ability, including spatial visualization and orientation in engineering students (Roca-González et al. 2017, 463).

One of the key mechanisms of training for orienteering is combining vigorous-intensity exercise (instead of moderate) with cognitive demands to achieve additional benefits on spatial cognition (Waddington, Allison, Calabrese, Pekos, Lee, Walsh & Heisz 2024, 1). This implies that the intensity of training is of great importance when developing cognitive and spatial skills in the context of orienteering. High intensity orienteering intervals provide an optimal amount of cognitive challenge while not overly straining the body. The fast-paced movement paired with the necessity to perform decision-making requires efficient switching between the allocentric (map-based) and egocentric (body-cantered) spatial processing in real time, and frequent practice in using allocentric-to-egocentric translation develops these processes (Waddington & Heisz 2023, 2).

When it comes to spatial memory, Thierry Georgiou (Into the forest I go 26 February 2023, min. 42-44) describes his practice as mentally running a line-shaped course and visualizing the planned route; later, using a new map of the same terrain - that contains a few controls instead of the line, the mental image is recalled and compared, and the goal is to identify which controls did the line connect. While this strategy focuses on the spatial memory of the terrain, memory drawing (Bao et al. 2022, 4) targets spatial memory of the map. It can be trained by taking a glance at a map segment between controls for a short period of time and then drawing on paper the most important features one would use to navigate. Even though cognitive abilities are trainable without the presence of physical activity, for optimal effect and transferability for complex skills like anticipation, there should be a high level of similarity between the environment and real-life performance conditions (Broadbent, Causer, Williams & Ford 2015, 328).

2.3 Attention

In orienteering, attention refers to the skill of focusing on key visual and spatial cues to guide navigation and decision-making processes. Eccles et al. (2002a, 75-76) defined three sources of information that an orienteer must attend to: the map, the environment and the travel (running over obstacles, avoiding falling and slipping). These sources are referring to attention in a broader context, but when an orienteer is attending to the map, there are differences in ways which one does so. Considering the high attentional demand that existents in orienteering, the fundamental task constraint is the limited capacity of attentional resources. Novice orienteers cope with this constraint by being stationary 62% of the time they spend map reading, while experts are moving 73% of the time when attending to the map (Eccles et al. 2006, 82).

The cognitive strategy used by expert orienteers to optimize attentional resources is using low-demand periods for reading the map ahead (Eccles et al. 2006, 78). The low-demand windows, also named as “quiet periods”, are sections of the orienteering course where attentional and cognitive demand is low, such as when running on even surfaces like roads, fields, or trails (Eccles & Arsal 2015, 611). This technique allows to direct more attentional resources toward attending to the map, since the travel is almost automatic.

Research in cognitive psychology, especially Norman and Shallice’s “supervisory attentional system” model demonstrates that attentional load can be minimised when behaviours become automatic (Mackie, Van Dam & Fan 2013, 4-5). They require fewer mental resources and allow for other tasks. In orienteering, automation provides benefits for map reading, route selection, and error management; more resources can be saved for unexpected events, problem-solving and adapting (Eysenck & Keane 2010, 193-194). The actions, which automatization one should strive for, are the processes that are highly demanding of cognitive resources but are frequently required to achieve goals. These actions include performing mental rotation, terrain feature identification (which forms the basis of simplification), attending to travel (running over terrain), reading the map and moving at the same time, as well as switching and dividing attention (Eccles et al. 2002a, 75-76).

According to load theory of attention, high-load tasks are less interrupted by distractors than low-load tasks. This poses the idea, that an optimal amount of challenge is needed to achieve best performance, as there are no cognitive resources left for processing irrelevant stimuli. When the perceptual and attention load is high, a load-induced blindness takes place, where most cognitive resources are used for the task. When the attentional demand is low (due to infrequent targets or low task demand), greater emotional interference exists and with it – a higher risk for errors. (Chen et al. 2023, 9-10; Lavie, Beck & Konstantinou 2014, 8; Mäki-Marttunen, Pickard, Solbakk, Ogawa, Knight & Hartikainen 2014, 1042.)

This theory explains both the feeling of “flow” athletes might experience and the common errors on seemingly easiest controls of the course. This places emphasis on the need to develop the ability to automatically and rapidly process navigational information, while efficiently filtering out the irrelevant.

Training attentional patterns involves modifying the use of limited-capacity mental resources to enhance efficiency and reduce cognitive uncertainty (Eidelman-Rothman et al. 2023, 25; Mackie et al. 2013, 3-4). Mackie et al. (2013, 12), who identified that attention plays a role in cognitive control, suggests that training should focus on improving the efficiency and interactions of brain networks – alerting (vigilance), orienting (spatial selection), and executive control (conflict resolution)- which contribute to cognitive control necessary for reducing uncertainty.

Alerting increases vigilance in anticipation for upcoming stimulus (Mackie et al. 2013, 4), which, in orienteering, can be understood as the process of boosting readiness and attention toward specific map cues (such as attack points) and anticipating the moment. Training this means striving to improve the ability to switch between a steady state of sustained attention and focused readiness and alertness. The key principle to training this ability is to simulate unpredictability and critical moments (approaching the control), which can be done through varied leg difficulty and increasing the complexity in the control region (placing the controls in information-dense areas). Multi-technique trainings, where one course consists of different tasks (line orienteering, corridor orienteering, short and long legs, contour map etc.), can serve as attention management training, where one must adapt to different task constraints.

The attentional function of orienting involves the mechanisms that select the most relevant information in space and executive control involves focusing on the relevant information while suppressing distractions or competing strategies. When encountering a distraction, one must be able to disengage and shift to task-relevant targets (e.g., seeing another control, ignoring it, and focusing on relevant terrain features). This can be practiced in training by providing distractions (setting up false controls, using other runners), briefly identifying main relevant features before executing the route choice or reflecting on the relevant/ irrelevant features after the leg or course is completed.

In general, attention training should simulate the complex and information-dense conditions of competition, including many distractions and high-speed, which increases the task difficulty. One should strive to create automatic cognitive behaviours, that allow to use cognitive resources for more complex tasks and perform. Based on load theory, one could conclude that automated processes might lead to a higher susceptibility to distractions, but being able to use less resources for complex tasks allows for higher speed. An orienteer must be aware of the fact that low task demand increases emotional interference, anticipate such periods, and prepare by increasing vigilance to remain attentive and minimise the risk for errors. Additionally, the low-demand periods can be utilised for reading and planning ahead of time. With this strategy, the attentional demand is more constant and evenly distributed along the course, potentially minimising the risk for errors.

2.4 Decision making and planning

Decision-making in orienteering is a process where the athlete must quickly select a course of action based on information provided by the map, environmental conditions, and their current physical state. The underpinning processes in decision-making in orienteering are:

- route planning and choice – primary navigational decision that involves considerations like distance, runability, amount of ascent, and the presence of obstacles (Eccles et al. 2022a, 69),
- location calibration – decisions around processing and encoding map information and correctly matching map elements with environment (Liu et al. 2022, 1),
- performance regulation – decisions around managing attention to achieve optimal balance between running speed and navigational accuracy (Batista et al. 2020, 8).

Route choice and planning is considered a definitive factor for success in orienteering, as it directly influences performance time - one of the two main performance criteria.

One of the main strategies used by expert orienteers in decision making is to prioritise the identification of a distinct terrain feature (also called an “attack point”) near the control flag. Navigating to this easily noticeable feature simplifies the process and minimises time spent moving cautiously (Eccles & Arsal 2015, 612).

Stemming from this strategy is the tendency for experts to attend to the control area first (on the map) and then plan the route backward from the control to the start triangle, which is a counter-intuitive process. This approach is used to identify the optimal approach to the control, which is considered to be the “crux of the problem” within the entire leg. The main objective of this strategy is to identify the attack point to simplify the problem and reduce the burden on processing resources, which allows for a faster pace during the leg (Eccles, Walsh & Ingledew 2020b, 335).

Additionally, Kübler (1985, 44) found that high-level orienteers have made the decision before they have reached the course segment, whereas novices tend to stop at the control and make the choice while being stationary. This behaviour is linked to previously mentioned attentional strategy, where expert orienteers use “quiet periods” for map-reading and planning ahead (Eccles & Arsal 2015, 611).

Training decision-making skills should fundamentally focus on employing the strategies used by expert orienteers. This involves training methods that focus on identifying the attack point and planning the leg back from the control. One can practice this by consciously taking extra time to identify a distinctive feature near the control. Coaches can support athletes in this development by “shadowing” the orienteer and using guiding questions and prompting the athlete to always identify an attack point.

Many factors are involved in the decision outcome, which Kübler (1985, 44) notes as individual abilities, emotional disposition, presence and decisions of other competitors, and the timing of when a choice is made. Additionally, in his attempt to determine whether a “best” route exists, Myrvold (1996, 31) concluded that it is impossible to identify one, as no statistically significant differences between different route choices exist. He noted that athletes usually find the route choice that suits them best depending on their individual strengths and weaknesses, but it is the coaches that strive to find the ultimate “best” route (Myrvold 1996, 34).

As a method for choosing the most suitable route choice, Martland (1986, 119) suggests a training strategy of choosing two or more route choices and “trading them off” by gathering as much information as possible about the problem and considering individual factors.

While these methods, like taking time to evaluate routes and choose on based on own individual differences, are suitable for forest orienteering, sprint orienteering relies on the speed of the decision and (mostly) choosing the shortest route. In this case training can involve taking short glances at a single leg and re-drawing the route on blank paper highlighting key features and turns or looking at pre-drawn routes and identifying the shortest one. As with any training, specificity is a key principle to maximise adaptations. In this case the decision-making practice, if not conducted in the real environment, can be supplemented during running by creating a task that mimics the specific demands of orienteering.

2.5 Relocation

Orienteering is a matter of navigating through the terrain by constantly using the map, environment and mental representations to navigate. When one becomes aware that the terrain does not match their mental map model, the process of relocation begins. This involves actively perceiving the surroundings and forming a two-dimensional image of the terrain and attempting to find a replica on the map. During this process, the orienteer scans the environment for distinctive and easily recognisable features and new information to establish one's location. (Seiler 1996, 61-62.)

Crampton (1988, 41) investigated the underlying cognitive processes of being "lost" and hypothesised that there are "different degrees of lostness":

- Functionally found – ability to successfully navigate and function,
- Corridor found – an approximate location within a known corridor,
- Known lost – being aware of misplacement and employing relocation strategies,
- Unknown lost – one has deviated from the route but has the belief that the position is known.

Each of these four values "imply different behaviours in the individual" and differ in the ease of which one can determine their location (Crampton 1988, 41). Relocation is particularly difficult as it requires complex cognitive processing under pressure. Murakoshi (1988, 19) identified three types of errors, which include the poorly executed plan, incorrect extraction of information from the map and the terrain, which lead to a mismatch between information.

Following the ideas of Crampton (1988, 44), "parallel error" – mistaking two similar features – is the most common among errors in orienteering and occurs due to the mental model of the map being insufficient. This directly places one in a position of "unknown lost", where one cannot solve the mistakes since it has not been recognised. A way to avoid these costly errors is to employ a "corridor" style wayfinding strategy, which, instead of navigating based on specific features in a linear manner, involves identifying an imaginary corridor based and its boundaries. This implies that one has an approximate knowledge of one's location within the corridor and allows for small deviations without causing one to "get lost". Since it is a method of simplification, the cognitive load is reduced as well as the error tolerance is higher than for those navigating using individual features. Linear navigation can directly lead to “parallel errors” as one can easily mistake the anticipated feature for another similar one or become worried when a slight deviation from the route occurs.

Errors in orienteering are inevitable, and relocation skills determine how efficiently one can recover. Once lost, an orienteer must acquire new information and look beyond the immediate problem to re-establish their position (Crampton 1988, 43).

Relocation skills can be deliberately practiced by running without updating one’s location, stopping at a random point and by observing the surroundings for distinctive features and finding a match on the map. An orienteer can practice with others, by following a coach/other runner to a certain location or incorporating it in interval training – running the interval without looking at the map and relocating during rest time.

Many errors happen close to the control area, especially when an attack point has not been identified, an accurate bearing has not been taken, or features were mistaken which caused a “parallel error”. An orienteer must identify and practice strategies that one can employ in situations when being “lost”, like re-tracing to last known location and/or actively searching for distinctive features and building a mental model of the map.

Crampton (1988, 44) suggests that one should train the “corridor” style of navigation as a method of error prevention, since navigating between larger features, such as two hill systems, streams or valleys, reduces the cognitive load, stores less information in the map model, and allows to cover the terrain quicker. Training methods include orienteering with contour maps, where most irrelevant information left out and one must navigate based on a larger mental model.

2.6 Reflection and analysis

Post-performance analysis and reflection provide crucial coaching opportunities in orienteering, as it is impossible to provide live feedback unless one is following the athlete throughout the course. Reflection should be seen as a part of cognitive and technical training for orienteering, as it is crucial for developing robust cognitive structures and richer mental models, which leads to improvements that go beyond what practice alone can achieve (Di Stefano, Gino, Pisano & Staats 2023, 2).

A survey (Sirakov & Belomazheva 2018) of world elite orienteers revealed that all athletes share the belief that analysis of their technical performance after a race is of high importance. When asked about their methods of reflection and analysis, drawing the route and comparing the split times is the strategy used by 56% of orienteers (of which 52% only compare the split times). Only 32% of the athletes reported that they hold detailed discussions around route choices and performance. While drawing the route and comparing split times provides valuable feedback, a deeper reflection is needed to maximise learning, since these methods do not capture the underlying decision-making and cognitive processes, and their effectiveness. (Sirakov & Belomazheva 2018.)

Most people intuitively believe that taking part in additional practice leads to superior performance improvements compared to reflecting on prior experience, in fact, 82% of participants in a study on reflection chose to gain additional experience (Di Stefano et al. 2023, 1). Reflection, contrasting with practice, which is described as automatic, is a controlled and conscious process which involves the articulation and codification of prior experience, and its' marginal benefits outweigh the marginal benefits of additional practice (Di Stefano, Gino, Pisano & Staats 2014, 1). Notably, individuals with little experience benefit most from additional practice instead of reflection (Di Stefano et al. 2023, 17). Considering this, youth and junior athletes would acquire great benefit from reflection as it provides a smarter way to learn than continuous, unguided practice. Additionally, reflection enhances self-efficacy by increasing confidence in one's ability to perform tasks successfully leading to improved performance, one striving for higher goals and managing challenges effectively (Di Stefano et al. 2023, 1).

Orienteers often analyse their performance later the same day or even several days after the event. However, a successful replication of the Ebbinghaus' forgetting curve from 1850 (Murre & Doros 2015) highlights the speed at which information is forgotten and points to the importance of immediate reflection. Across studies, a significant decline in retention is observed between 20 minutes and one hour after learning, with a significant portion of information still preserved at the 20–30-minute mark (Murre & Doros 2015, 3). This points to the importance of immediate analysis after performance.

Additionally, after an experience, memory is susceptible to change for a certain period and can be distorted by new incoming information, which can be incorporated into the memory trace, leading to misinformation effect, where incorrect information is retrieved (Schacter, Guerin & St. Jacques 2011, 5). Delaying the articulation and codification of the experience allows more time for interference and for the memory updating mechanisms to distort the original memory (Lentoor 2023, 260). In orienteering context, this often occurs when athletes discuss the course with others before reflecting individually, unconsciously incorporating others' experiences or viewpoints in their own memory of the event.

Coaches usually encourage the orienteer to talk through their performance after the event. As the survey of world elite orienteers showed, most draw their route on the map and compare the split times (Sirakov & Belomazheva 2018, 2131), but this method is highly subjective, and inconsistencies are present when comparing the athlete's reported route to the actual GPS (Walsh 1997, 49).

Walsh (1997, 49-50) experimented with multiple reflection methods and found the "think aloud" technique – where the athlete is reporting and recording thoughts in real time using a video camera and a microphone – to be particularly effective, though for some orienteers the race performance was inhibited. This method proved to facilitate more thorough discussions and an accurate analysis of the performance, since the thoughts that occurred throughout the course were not modified with time passing (Walsh 1997, 49). Using a head-mounted camera it is possible to record the events from the participants perspective and one's behaviour. When rewatched, the race film (ideally combined with the participants verbalisations) stimulates the athlete to re-experience the race during a post-performance analysis, which provides a more detailed and accurate recollection of the events and through processes (Macquet, Eccles & Barraux 2012, 7; Walsh 1997, 51).

In the pre- and post-performance discussions Walsh (1997, 50) using phases – problem recognition, alternative solutions, choice of solution, action, and completion – as a guide, facilitated the engagement in thorough discussions regarding each phase of the decision-making process in orienteering. More specific phases, using protocol analysis, were used to identify errors in the "problem recognition" part of the discussion – error initiation, error recognition, recovery plan, and recovery action. In orienteering the depth of the discussion relies on the effective questioning abilities of the coach, and effective feedback mechanisms are essential, as the coach cannot directly observe the performance. (Walsh 1997, 50-51.)

To conclude, when analysing and reflecting on own experience, one must do it soon after the event and before other events have intervened with the memory. Coaches play a crucial role in facilitating discussions, but one can reflect alone by writing or recording the analysis of events and thought processes that took place during performance. A recorded video, ideally including verbalised thoughts and decisions, filmed from the athlete's point of view, facilitates better recall and leads to a more valuable reflection and less distorted memory. Reflection as a method of cognitive training should not be overlooked and ought to become a habitual practice, especially for youth and junior athletes, who may benefit from it the most.

3 The Aims of the Project

In orienteering, most athletes train on their own, with the focus being physical development. Many available training examples are designed for beginners, primarily aiming to teach the basic concepts of the sport. Intermediate athletes, however, have enough experience to navigate courses but often struggle to refine their skills and further improve their abilities.

With this project we aim to create an online guide that helps orienteering coaches and intermediate athletes understand and train cognitive skills in a purposeful way. The material provides practical exercises that focus on key cognitive aspects of orienteering such as map reading, spatial perception, attention, decision-making, relocation, and reflection. Developing these skills can help athletes make better route choices, navigate more efficiently, and reduce errors, ultimately improving their performance.

We hope that this guide will give athletes and coaches the know-how to design sessions that truly develop these skills and help in closing the gap between mediocrity and expertise. Too often, orienteers complete a course without really knowing what they trained or how it helped them improve. This project encourages athletes to become more aware of their own thinking, to identify where their weaknesses lie, and to train with intention and quality, turning practice into meaningful learning instead of simply completing the courses.

While the research in this area is extremely limited, we hope that this material will support athletes and coaches, raise awareness about the importance of cognitive skill development, and possibly lay a foundation for further testing and research. Instead, this guide focuses on practical, evidence-informed exercises that coaches and athletes can apply immediately. Coaches have often overlooked cognitive development, and this project aims to address that gap. We strongly believe that training should have quality, and quality comes from intention.

4 Empirical Work

4.1 Project planning – Choice of platform

In the initial stages of planning this project, one of the most important decisions was choosing the right platform to build the product. After brainstorming different formats such as a PDF guide, a printed handbook, video tutorials, mobile applications, podcasts, and interactive presentations, we ultimately decided to develop the product as a website. This choice was motivated by its accessibility, the existing digital infrastructure that supports easy distribution, and the flexibility it provides for organizing and updating content.

Since the aim of the thesis is to create an easily accessible material for coaches to use that presents cognitive training strategies for orienteering, the platform needed to meet some clear requirements: it had to be simple to use, easy to access for users, flexible in how we could organize the content, and sustainable in the long term. After considering different possibilities, we decided that Google Sites was the best fit for what we wanted to achieve.

There were several reasons why Google Sites stood out. First, it is very straightforward to use, which meant that we could focus our time and energy on developing and presenting the training content instead of struggling with complicated and technical design. This was important for us, because the central value of the project lies in the strategies we present, not in impressing with advanced web development skills. Google Sites gave us the tools to create something good-looking and practical without unnecessary barriers.

Another major factor was accessibility. One of our goals was that the website should be available to as many orienteers and coaches as possible, regardless of whether they use a computer, tablet, or phone. Everything is online, simple to reach, and free for the end user. This makes it much easier for the content to reach a broad audience, which was one of our priorities.

We also considered the long-term future of the website. Since this project is not just a one-time experiment but something that could continue to be useful, it was important that updates and changes could be made without too much effort. Google Sites allows for collaboration, meaning we could work together while building the site and still have the option to revise or add material later on. Its integration with other Google tools (like Docs or Forms) also makes it easy to include supporting materials and interactive elements in a smooth way if necessary.

Before coming to this decision, we looked at other options such as WordPress, Wix, or creating a site from scratch. These alternatives do come with more advanced design and customization features, but they also require higher technical knowledge, more time, and sometimes additional costs for hosting or premium services. Since our focus was on the effectiveness of the training strategies rather than technical experimentation, these platforms offered more than we realistically needed. In the end, Google Sites struck the best balance.

To sum up, we chose Google Sites because it allowed us to concentrate on what really mattered: designing a resource that is clear, practical, and useful for our audience. It provided the right combination of accessibility, user-friendliness, and sustainability, making it the most logical choice for developing this product-based thesis.

4.2 Project planning – exercises divided into environments

We decided to divide the exercises according to the environments where athletes typically train and spend time, rather than by specific cognitive skills. This makes the website more practical and user-friendly. The four chosen environments are: while orienteering, outdoors (for example, trail running), at home (such as desk-based exercises), and indoors (for example, in a sports hall). These cover the main situations a young athlete faces in training and everyday life. Organizing the exercises by environment allows users to easily find suitable tasks based on where they are, making cognitive training more accessible and adaptable to real-life conditions.

4.3 Project development – design of the website

Our goal was to design a simple and easy-to-navigate website. For the landing page ('Home') we went with a title of the thesis continued by text 'selling' the idea of cognitive skills importance. After that we introduce the four environments in which the exercises are divided into and pursue the user to proceed to the next page called 'Exercise List’. Here we have a brief description of each environment followed by a button which takes to the corresponding list of exercises. Each exercise in the list has a title, description and colour-based tags of cognitive skills targeted in the exercise. In order to give the user a chance to learn theory behind selected cognitive skills, we added a page called 'Theoretical background', where a summary of theoretical background of each cognitive skill is presented. As mentioned above, each cognitive skill has an assigned colour (coloured heading text) for easy navigation through the exercises. Below summaries of theory, we decided to add our full bachelor thesis document available for reading for anyone who is interested. Finally, the last page of the website is called 'Contact', where one can find our contact details or send in their own ideas of training cognitive skills using Google Forms which we can then review and possibly add to our website.

5 Product description

The website serves as a comprehensive online collection of exercises designed for both coaches and athletes, focusing on cognitive skill development among youth and junior-level competitors. It features a wide variety of tasks organized into four distinct training environments: indoor, outdoor, home-based, and orienteering-specific settings. This structure allows athletes to practice and enhance their cognitive and technical abilities in any context, regardless of location or available resources.

A dedicated theoretical background section provides users with the opportunity to deepen their understanding of the concepts underlying the materials. Visitors can explore summaries or access the full thesis for more detailed explanations. Each summary addresses the identified cognitive skills crucial for orienteering performance—map reading, visual perception, attention and memory, decision-making, executive function, relocation, and reflection.

Additionally, the website features a contact page that encourages communication and collaboration. Coaches, athletes, and other visitors can share feedback, suggest new exercise ideas, or inquire about concepts presented on the platform. Through these interactive elements, the website aims to foster development and exchange of knowledge within the orienteering community.

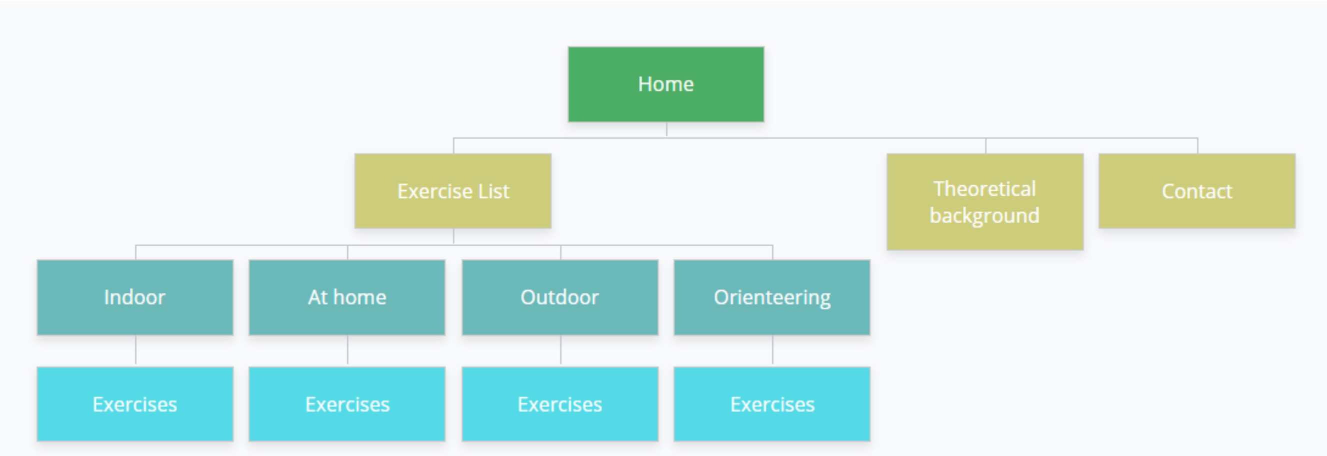

Figure 1. Cognitive Training Strategies for Orienteering: An Online Material website structure.

6 Discussion

The aim of this thesis was to develop a practical cognitive training material for orienteering athletes and coaches. The focus was on identifying cognitive skills that influence performance, such as map reading, spatial perception, decision-making, attention, relocation and reflection, and on suggesting training methods that would strengthen these abilities.

The material was created based on available existing research in orienteering and cognitive science, as well as strategies used by expert orienteers. Through this approach, we aimed to bridge a gap between theoretical understanding and practical application. There were clear themes emerging from existing research in orienteering regarding cognitive performance, which we identified as the cognitive skills to be developed. Most of the exercises were retrieved from the suggestions or observations given by research authors. Some of the exercises were designed specifically for this thesis, based on identified cognitive processes involved in orienteering.

The material features exercises designed to be used in different contexts – at home, indoors (sports hall), outdoors (while running), and during orienteering training – allowing athletes and coaches to adapt to various environments and learning situations. By offering flexibility and a range of options, the material aims to make cognitive training accessible and easier to integrate in regular training routines.

We saw it as important to create this kind of material, as cognitive training in orienteering has received limited attention despite its central role in performance. At this point, there are not structured resources available for intermediate athletes that wish to further develop their cognitive skills. Most of the available guides are targeted at young athletes or complete beginners. Having a practical guide for refining cognitive skills could help junior athletes transition to elite courses and elevate their performance. Considering that many athletes train without a coach, we saw it as important to provide guidance and support them through exercises that can be carried out in various contexts and develop different cognitive skills on their own.

While the exercises in the thesis are structured based on the cognitive skill that each one targets, in real orienteering situations the cognitive skills are used simultaneously. One exercise can target multiple cognitive skills. This overlap reflects the reality of orienteering, where cognitive processes rarely occur in isolation, but interact continuously. When designing training, it is important to recognise these connections rather than trying to separate skills too rigidly. Exercises that engage several processes at once reflect the competition demands and support more transferable learning. Training should aim for a balance between isolated exercises and those that involve several skills. Early in the learning process, focusing on one cognitive aspect may help athletes understand it and control it better. More experienced athletes may benefit from combining multiple demands in one task.

The effectiveness of these exercises can vary between athletes based on their experience level. An experienced athlete may benefit more from exercises that challenge their decision speed under pressure, while a less experienced orienteer might gain more from exercises that focus on basic map-terrain comparison, spatial awareness and building mental models. Coaches should adapt the exercises to the athlete’s individual needs and development, ensuring appropriate challenge.

While the thesis achieved the main aim of developing a practical training material for orienteering, there are several limitations that should be considered. Identifying these limitations highlight the areas for future improvement and development.

As the thesis was focused of product development, the effectiveness of the cognitive training material was not tested with athletes or coaches. Exercises were gathered from suggestions made by researchers and academics in the context of orienteering, though their actual effectiveness and impact on performance remains to be studied.

Another limitation relates to the availability of research on cognitive training in orienteering. Many researchers have discussed the cognitive processes involved, but little insight is given on applicable training methods. Much of the existing literature is quite dated, and the suggested exercises are based on theoretical assumptions, suggestions from available studies and strategies reported by expert orienteers. Due to limited research, some training examples were adapted from general cognitive and sports psychology sources. Orienteering coaching has traditionally emphasised physical development, with the assumption that cognitive skills improve automatically through running the courses. This highlights both a gap in current research and an opportunity for further study on structured cognitive training methods in orienteering.

Despite the limitations, the thesis provides a foundation for integrating cognitive training into orienteering. It offers a base for future development and testing. It provides coaches and athletes with a structured and practical framework to understand and train cognitive skills, encouraging a more holistic development. Future studies should explore how these exercises affect performance and cognitive development in different athlete levels. While these exercises are grounded in existing research, more research is needed to understand how orienteers train and develop their navigational skills, and to identify which training methods are most effective for improving cognitive performance in the sport. It would also be valuable to explore digital or virtual-reality tools that replace navigation challenges in a controlled environment, and to follow athletes longitudinally to observe how structured training contributes to performance improvement.

This thesis highlights that orienteering is not only a physical sport but also a cognitive challenge that requires deliberate training. Our hope is that this project encourages further exploration, dialogue, and innovation. The future of orienteering involves even more complex courses and maps, and faster racing, which calls for advanced cognitive skills. Through cognitive training athletes can improve mental endurance, focus under pressure, and the ability to process complex, dynamic information quickly, which can directly affect performance time.

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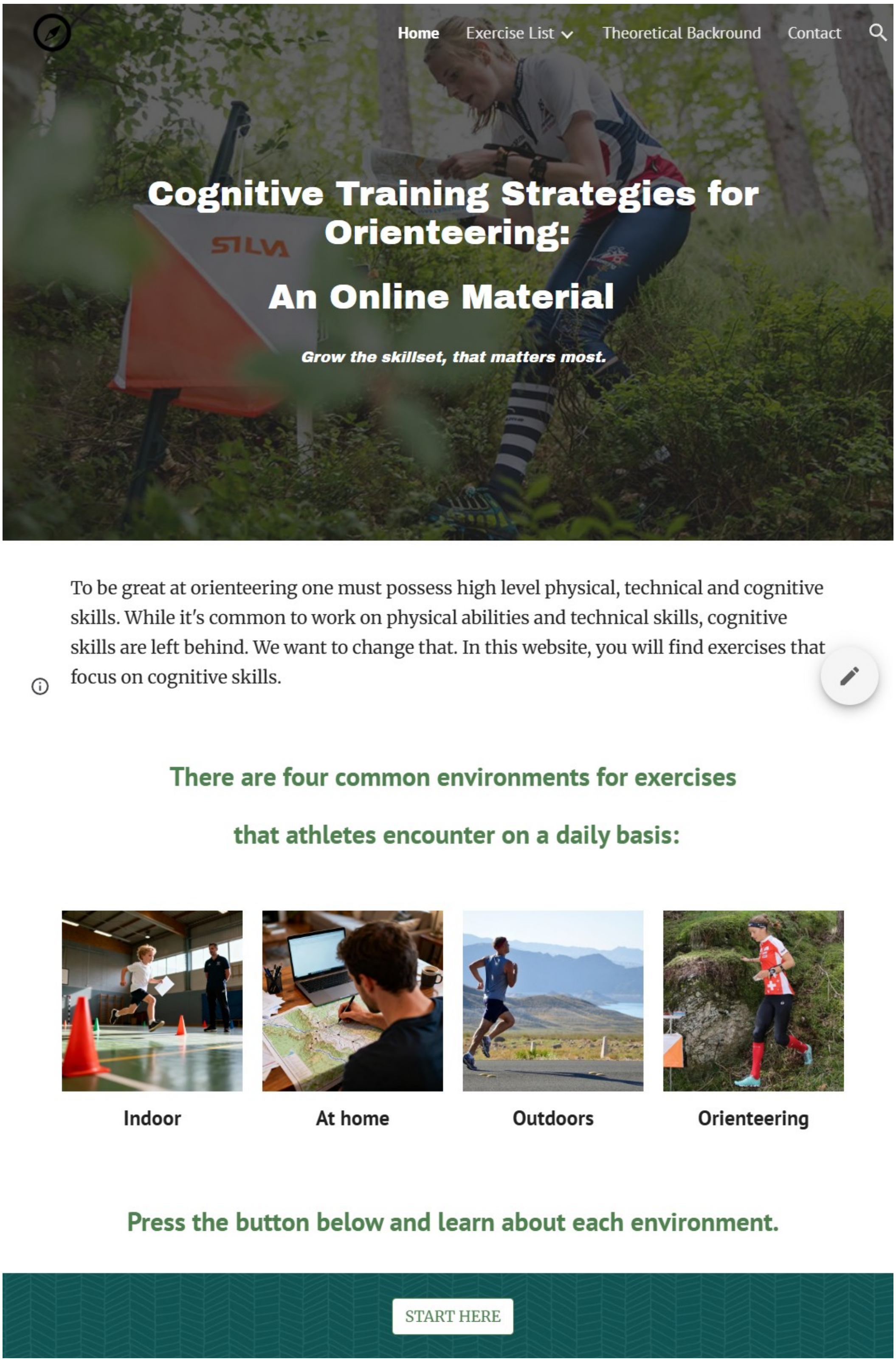
Appendices

Appendix 1. Website pages



Exercise groups:

While we have given a list of exercises that are done a certain way, does not mean it's the only or best option, we encourage adapting and improving the exercises to get the most out of them.

Indoor

Exercises that can be performed indoors—in a gym, sports hall, or similar facility—when weather conditions or the time of year prevent outdoor training.

Exercises for indoor use

At home + post race

Exercises that can be done at home while sitting at a desk, requiring no coach or special setup.

Exercises for home use

Outdoor

Exercises for outdoor settings, excluding orienteering—for example, trail running.

Exercises for outdoor use

Orienteering

Exercises to implement in orienteering training sessions. Some of them can easily be combined in to one training session.

Exercises for orienteering

Indoor.

Exercises that can be performed indoors—in a gym, sports hall, or similar facility—when weather conditions or the time of year prevent outdoor training.

Draw map by memory

Place a map with a marked course on side A of the gym and a blank sheet on side B. The athlete must reproduce the course on the blank sheet, accurately including all features necessary for completing it. Add physical exercises or other tasks to either extend the time taken to move between sides or to increase the cognitive demand of the activity. Begin with courses designed for 12-year-old participants and progress up to elite level.

Attention&Memory Map reading Decision making&Executive function

Draw course by memory

Similarly to exercise above, athlete has to redraw a course, but this time on an existing map. The more controls athlete has to remember - the harder. Add physical exercises or other tasks to either extend the time taken to move between sides or to increase the cognitive demand of the activity.

Attention&Memory Map reading

Match description to control

Place a map with controls on side A of a gym and control descriptions on the B side of the gym. Athlete has to match the control description to a control on the map, each control has a number which has to be written next to the control description on the side B. Make it a competition, not only it's fun, but also increases cognitive load as athlete wants to be faster than others. This exercise works great on memory and perception, it might be easier to visualize the control from description and then match it to the map, not by just description.

Attention&Memory Perception

Plan the leg from the control

Have pieces of paper with longer legs on them, one leg per piece, cover the piece of paper with a blank sheet of a paper. When an athlete arrives at the paper, one has to slide the paper from top to down - slowly revealing the leg from finish to start. The exercise is to start planning the leg while sliding the paper, start by identifying an attack point, then analyze middle stage of the leg and then the start of it. This encourages the athlete to learn to plan the leg from the end to beginning.

Include the exercise between physical exercises or any way you see fit.

Map reading Decision making&Executive function

At home.

Exercises that can be done at home while sitting at a desk, requiring no coach or special setup.

Expanding terrain knowledge

Watch a video with side-by-side map and terrain (first person view) to get more experience on the unfamiliar kind of terrain and it's characteristics. Suitable for those young athletes, who plan to compete in competitions in unfamiliar type of terrains (EYOC, JWOC, etc.).

Visit the following link for an example - https://www.youtube.com/watch?v=zheFbRtJYm4.

Perception

Analyzing maps

Simple yet effective way to have some repetitions of decision making and visualization is analyzing maps that one comes across. It could be deliberate search of maps or having them appear from time to time by following social media accounts of orienteers or orienteering pages on Strava, Instagram, Facebook or other.

Decision making&Executive function Attention

Film your run

Film the training session or race and review the footage while taking detailed notes (or discuss with a coach) on the decisions made and the thought processes behind them. Pay special attention to critical moments where key choices influenced performance. Use this review to reframe and refine your thinking patterns, envisioning ideal decision-making scenarios to improve future navigation and strategy.

Reflection

Follow the athlete

A coach or training partner follows the athlete through the course, stopping them at each control point (or every other) to encourage reflection on the previous leg or any mistakes made. During these pauses, the athlete is asked to explain their thought process and actions, promoting deeper awareness and understanding of their navigation choices. This immediate feedback loop helps uncover decision-making patterns and supports targeted improvement through collaborative discussion. Ask questions like: What was your plan for this leg? Did you execute the plan? Did you experience any moments of uncertainty or hesitation? What caused them? What could have been done better/differently?

Reflection

Analysis

After completing a training session or race, the athlete should analyze their course performance by assessing what was needed to successfully complete each leg, how well they executed their plan, and what led to any mistakes. If errors occurred, it's important to outline a revised strategy or plan for how the leg should've been done. This reflection should be done within the first hour after finishing, as research shows details from the activity are quickly forgotten within the first hour.

Reflection Memory

Simulate quick decisions and simplification

You'll need a map and a timer. Set a timer for a short time, for example, 5 seconds. During this time one has to analyse a leg on the map and redraw on a paper the most important features that would lead to control. The time on the timer can be adjusted for shorter or longer legs.

Map reading Attention&Memory

Orienteering virtual games

There are quite a few online games, where an athlete can improve from home, following is a list of games ranging from simple routechoice or memory games to full virtual orienteering games:

- Virtual-O - the most recent virtual orienteering game with lifelike graphics. Link Steam store: https://store.steampowered.com/app/529020/VirtualO/.
- Catching Features - the original virtual orienteering game with old school graphics, but active community with competitions taking place all the time. Link to website: https://www.catchingfeatures.com/.
- Running Wild - online tool for orienteering that allows users to draw and compare route choices on a map with a time constraint that encourages fast decison making, providing a platform for analyzing, visualizing, and discussing navigation decisions . Upload any map and draw or choose from list. Requires setup for own maps. Link to website: http://3drerun.worldofo.com/2d/runningwild.php.
- Route choice game - simple route choice game, requires quick decision-making. Link to website: https://www.routechoicegame.com/login.php.
- Route memory game - based on ski-orienteering maps, where athlete must memorize route to control and get there by memory. Link to website: https://catchingfeatures.com/b/skiomapmemory.html.
- Orienteering simulator 'Simurastit' - primitive simulator with new courses every week. Link to website: http://routegadget.net/simurastit/.
- Labyrinth game - basic, but very hard and demanding game, requires a lot of attention. Link to website: https://routegadget.net/laby/.

Map reading Attention&Memory Decision making&Executive function Perception Relocation Reflection

Plan courses

Planning courses gives an athlete a different perspective on orienteering, instead of thinking how to complete the course, one has to think how to challenge someone who would run that very course. One must analyse the terrain in a different way and understand how can it be used best. When planning courses, visualization of the terrain takes place without much effort. When a course is planned, reflect on the quality of the course - could it be done better? Why and how? Use the free software 'Purple Pen' - https://www.purple-pen.org/.

Perception Reflection

Run through a line

Have two maps of the same terrain - one with a line, other with a few controls on the line. Run through the line, visualize everything you can. Switch to the controls map and identify which controls did the line pass through. The goal is to improve visualization. This exercise requires setup by a coach or a third person.

Perception Reflection Attention&Memory

Outdoor.

Exercises for outdoor settings, excluding orienteering—for example, trail running.

Run while reading

Try jogging while reading a book or newspaper, and concentrate on truly understanding the content—not just scanning words as you move. Focus on grasping the main ideas, following the storyline or arguments, and connecting information as you read, rather than simply recognizing text. This exercise challenges both your reading comprehension and your ability to multitask, helping develop deeper cognitive processing while in motion. Tell somebody the information you learned after training.

Map reading Attention&Memory

Run while reading a map

Find any map or maps, that have courses from different terrains/countries that athlete hasn't ran. The task is to read the map as in competition, thoroughly plan the leg starting from the control and back, make routechoice decisions and visualize running the course.

Map reading Attention Perception Decision making&Executive function

Memorize

Exercise takes place on a loop, the length of it can be set accordingly to the training group level. Every athlete gets a map with no controls on it. Place a map at the beginning of a loop with controls or a course, athlete memorizes a place of a control or leg, then runs the loop and at the end draws the memorized control on the map. Repeat the process as many times as needed. The loop could be run as an interval. Possible to make it a race - who draws the course first. Set a time limit for looking at the map.

Map reading Attention&Memory

Orienteering.

Exercises to implement in orienteering training sessions. Some of them can easily be combined in to one training session.

Draw your own map

Before an orienteering training session, athlete draws ones own map from the original map containing all necessary terrain features to complete the course. Athlete runs the course. After finish, analyse what could have been done differently - Were any features missing? Was there too many details drawn? Could there be a different approach to choose what features to draw or not?

If training in a group, divide athletes into pairs, athlete draws the map for his partner, making the athlete think how well the map needs to be drawn.

ps. if possible, print the course on blank paper without the map, the drawing process will be easier as the athlete only needs to fill in the gaps.

Decision making | Reflection

Work on map reading cadence

More map reading equals less made mistakes. Set alerts on watch that beep every 5-10 seconds, athlete has to read the map every beep even if there is no need. For those who don't have a device for reminders, it's up to the athlete, to put focus on deliberate frequent map reading.

Map reading

Use maps that bring out certain actions

- Run using contour-only maps to isolate and train the cognitive process of matching perceived elevation changes in the terrain to the corresponding contour lines on the map, the aim is to narrow attention to a single class of features—relief—while minimizing distraction from other cues.
- Run using a corridor map. Orienteering in corridor requires increased amount of attention to the map and the environment. To successfully complete a corridor without leaving it, one must have a constant contact both with the map and the features around.
- Run using a map with only specific features, if terrain allows. Like running with a counter map, it's also possible to use, for example, a map only with boulders/cliffs.
- All of the options mentioned above and more, can be combined into one training, changing the map settings every few controls.

Map reading | Attention | Perception

Map reading while moving

An important skill in orienteering is to read the map while running, it allows the athlete to save lots of time. The exercise is to read the map only while running or walking which puts some extra cognitive load of having to pair moving in the terrain with reading the map.

Map reading

Orienteering intervals

O-intervals are a great way to not only work on physical capacity, but also technical and cognitive skills. For this exercise the length of the interval is important, it has to be short enough to sustain a pace faster than race speed. The training goal is to overload multiple demands simultaneously - running speed, map reading, decision-making, map interpretation and information processing at high pace.

Map reading | Attention | Decision making | Perception

Proactive vs reactive orienteering

Proactive orienteering means planning and anticipating in advance - choosing a route choice, features leading to the control, attack point - meaning, being ready for what's ahead at all times to prevent hesitation and parallel errors, whereas reactive orienteering means adapting on the fly - reading terrain first and matching it to the map, making rapid decisions under pressure. While the goal is a combination of both, the main underlying reason for clean, fast and mistake free orienteering is proactive orienteering.

While it's not an exercise, we recommend to shape your or an athletes way of orienteering in a proactive way. Always aim to be in control and react where necessary.

Read Raul Ferra article on proactive vs reactive orienteering.

Map reading | Attention | Decision making | Perception

Ask questions

Asking questions is the best way to provoke athlete to think by themselves. Before a leg or two, ask questions to the athlete that provoke thorough planning of the leg, identify route choice, key features and an attack point to complete the leg. When task is completed, shortly reflect on the made plan and it's execution, then plan the next part.

Decision making | Reflection

Simplification

In maps with many details, simplification is of importance to not waste time in small details. Before the leg, note/highlight/simplify the features that should be identified from further away and used for navigation.

Map reading | Decision making

Compare route choices

Select two or more routes for a leg and "trade them off", clearly identify pros and cons of each and choose the best one, anticipate running speed over different terrain, features to be used and an attack point. Plan the leg from the end to beginning. Exercise works better for long legs since there is more to choose from.

Map reading | Decision making

Orienteering on memory

- To further improve memory, run a leg (or even multiple) by memory. Try to simplify and remember main features that lead to the control. If one leg is too hard to remember, start by setting a limit on the amount of looks at the map allowed each leg.
- Plan a course and divide it in to one leg fragments, put the following leg fragment at each control - at the start, athlete memorizes the route to control 1, at control 1 athlete memorizes the route to control 2 and so on. Plan the course difficulty according to the level of athletes.

Map reading | Memory&Attention | Decision making

Control picking

Control picking, although primarily a technical exercise, requires sustained attention and rapid decision-making from the athlete. This training challenges multiple brain networks at once, promoting efficiency and sharp coordination between perception, memory, and problem-solving. Frequent changes in direction and quick identification of terrain features create a strong cognitive workload, making control picking an effective method for achieving cognitive overload and developing mental agility within orienteering. Control picking is an exercise, where a course has many short distance controls with lots of direction changes, the distance between controls typically is 50-150m.

Map reading | Decision making | Memory&Attention | Perception

Relocation

- Athlete follows a coach or a partner without using a map, at a random moment, the partner stops and the athlete must relocate based on the features around and information gathered while running. Athlete only knows the starting location before the exercise.
- Relocation exercise combined with terrain intervals. Complete an interval in terrain without reading a map, as interval ends, athlete must relocate based on the features around and information gathered while running. Athlete only knows the starting location before starting each interval. The length of interval can be varied, the longer the interval, the harder the exercise.

Memory&Attention | Reflection | Relocation

Relocate on edited map

The map can be edited in various ways to make relocation compulsive. Simply cut out parts of the map that the athlete must cross. Different kind of patterns can be used to make the map more fun or theme based.

Relocation | Attention | Map reading

Post race re-run

If situation allows, re-run the course or part of it analyzing and reflecting on thought processes and actions that happened during the race. Correct any mistakes or determine and rehearse the optimal behavior and thought process that should have been executed.

Reflection | Memory

Follow the athlete

A coach or training partner follows the athlete through the course, stopping them at each control point (or every other) to encourage reflection on the previous leg or any mistakes made. During these pauses, the athlete is asked to explain their thought process and actions, promoting deeper awareness and understanding of their navigation choices. This immediate feedback loop helps uncover decision-making patterns and supports targeted improvement through collaborative discussion. Ask questions like: What

Map reading

Map reading is the central cognitive skill in orienteering, forming the link between the map's abstract representation and the real terrain. It involves more than recognizing symbols—it is an active process of interpretation, navigation, and adaptation. The map acts as a tool for anticipating the environment, guiding athletes in transforming map information into real-world understanding. Just as reading text involves constructing meaning from individual words and sentences, map reading integrates various landscape features into a coherent mental image of the terrain.

A key element in successful map reading is the development of mental models. Orienteers constantly build and update internal representations of both the map and the surrounding environment. These models allow them to plan actions, predict terrain details, and make quick navigation decisions. Experts, through extensive experience, form highly refined models that enable them to anticipate features such as streams or vegetation density with minimal effort. By relying on these well-developed mental representations, they reduce cognitive strain and maintain performance efficiency even in complex terrain.

Behavioural and cognitive strategies play an essential role in how orienteers apply these mental models during navigation. Although the task is the same for everyone—to interpret the map and move accurately through terrain—athletes differ in their approach. Some use short and frequent map checks to continuously align their mental model with reality, while others rely on fewer but longer reading moments, emphasizing trust in their internal representation. Studies show that expert orienteers tend to move more during map reading and manage multiple tasks simultaneously, reflecting their advanced attentional control. Research also indicates that these expert strategies can be developed through targeted training, enabling novices to adopt the efficient habits used by experienced athletes.

Perception

Perception is a key cognitive skill in orienteering that involves obtaining, interpreting, and matching information from the map and the terrain. It forms the foundation for recognising symbols, features, and routes and identifying inconsistencies between map and environment. Expert orienteers show enhanced sensitivity and accuracy in perceiving these relationships, enabling faster and more precise decisions while navigating.

Perceptual organisation allows orienteers to group and simplify visual information into meaningful patterns, improving speed and attention management. Drawing from Gestalt principles—such as proximity, similarity, and closure—skilled orienteers group map features into clusters rather than processing each individually. This simplification reduces cognitive load and helps focus on task-relevant information. Research shows that effective performance depends more on the quality of selected information than on the quantity of details processed.

Spatial perception and processing are equally essential, as orienteering requires translating two-dimensional map data into actions in three-dimensional terrain. Orienteers interpret direction, distance, and position using two spatial reference frames: **egocentric**, based on one's own movement and viewpoint, and **allocentric**, based on environmental landmarks and their relationships. Efficient navigation depends on the flexible integration of both strategies and quick transitions between them, supported by visuospatial working memory.

Visuospatial working memory enables orienteers to briefly extract and retain map information during running, allowing them to navigate between short glances. Athletes with strong visuospatial memory can hold essential features in mind and adapt effectively to terrain changes.
Two navigation strategies—the **survey** (allocentric, "bird's-eye" view) and **route** (egocentric, step-by-step) approaches—support successful navigation. Expert orienteers combine both for optimal performance. Training has been shown to improve spatial memory and enhance the integration of these strategies, forming the cognitive foundation of precise and efficient navigation in orienteering.

Attention&Memory

In orienteering, attention is the skill of focusing on key visual and spatial cues while managing limited mental resources between three sources: the map, the environment, and movement. Expert orienteers use their attention more efficiently than novices, staying in motion while reading the map and adapting quickly to changing conditions. They often use "quiet periods" on easy terrain to plan ahead, taking advantage of moments when running requires little concentration to allocate more focus to decision-making and map interpretation.

Automation plays a vital role in managing attention load. When skills such as map reading, terrain recognition, and movement become automatic, fewer mental resources are required, allowing faster reactions and better adaptability. This efficiency supports the athlete during high cognitive demand and helps maintain focus even under fatigue or stress.

According to the **load theory of attention**, performance improves when cognitive load is balanced—high enough to block distractions but not so overwhelming that it causes errors. This balance helps explain both the sense of "flow" experienced in optimal performance and the mistakes often made on easier controls where concentration lapses.

Memory works closely with attention in navigation. Short-term and working memory allow orienteers to hold map details, routes, and terrain features in mind while running. Experts rely on their visuospatial memory to retain key map information between glances, integrating it with environmental cues. Together, attention and memory form the foundation of efficient, precise, and adaptive navigation in orienteering.

Decision making&Executive function

Decision-making in orienteering is the continuous process of selecting the best actions based on map information, terrain conditions, and one's physical state. It involves three main components: **route planning and choice**, **location calibration**, and **performance regulation**. Route choice is especially critical, as it directly affects overall performance time and success in competition.

Expert orienteers rely on specific decision-making strategies to save time and reduce cognitive load. One key technique is identifying a distinct **attack point**—a noticeable feature near the control flag—to simplify navigation to the target. They often plan routes in reverse, starting from the control and working backward to the start, to determine the most efficient entry into the control area. This backward planning minimizes uncertainty and supports faster, more confident execution.

Experienced athletes also plan ahead using low-demand sections or "quiet periods" for decision-making, enabling them to maintain running speed while thinking strategically. This anticipatory planning reflects high-level **executive function**—the ability to manage multiple cognitive processes, such as attention shifting, working memory, and inhibitory control. Strong executive functioning allows orienteers to evaluate options quickly, adapt to unexpected obstacles, and maintain focus under physical strain.

Effective decision-making in orienteering, therefore, depends on the integration of executive processes with perceptual and attentional control, creating a balance between speed, accuracy, and adaptability.

Relocation

Navigation relies on constantly integrating information from the map, the terrain, and one's mental representation of the environment. When an orienteer realizes that the terrain no longer matches their mental map, the process of **relocation** begins. This involves scanning the surroundings for distinctive features, forming a mental image of the area, and comparing it with the map to re-establish location. Successful relocation depends on perceptual accuracy, spatial reasoning, and the ability to manage stress and uncertainty.

Crampton identified four "degrees of lostness": being **functionally found** (navigating effectively), **corridor found** (knowing the approximate position), **known lost** (realizing the error and using relocation strategies), and **unknown lost** (believing the location is known when it is not). Each state demands different cognitive and behavioral responses, and the deeper the lostness, the harder it is to relocate.

Errors leading to disorientation often stem from mismatches between map interpretation and terrain perception. Among these, the **parallel error**—confusing two similar features—is one of the most common and occurs when the mental model of the map is too narrow or simplified. To reduce such errors, experienced orienteers use a **corridor strategy**, visualizing a broad, imaginary route with defined boundaries rather than relying on single features. This approach offers more tolerance for minor deviations, lowers cognitive load, and reduces the likelihood of parallel errors that can cause complete disorientation.

Reflection

In orienteering, reflection and post-performance analysis are essential parts of cognitive and technical development. Since live coaching feedback is rarely possible during a race, structured reflection serves as a powerful learning tool. It helps athletes strengthen cognitive frameworks, refine mental models, and achieve improvements beyond what practice alone can provide. Research shows that elite orienteers universally value performance analysis, though many limit their reflection to route drawings and split-time comparisons, which capture results but not the underlying thought processes behind decisions and navigation.

Reflection is a controlled, conscious process that involves articulating and codifying prior experiences. While most athletes intuitively assume more practice yields greater improvement, studies reveal that reflection often produces higher marginal benefits, particularly for skill understanding and long-term growth. For youth and junior athletes, reflective learning provides an efficient path to improvement,

Let's add more ideas and exercises!

Contact us and share your thoughts, ideas and experience!

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