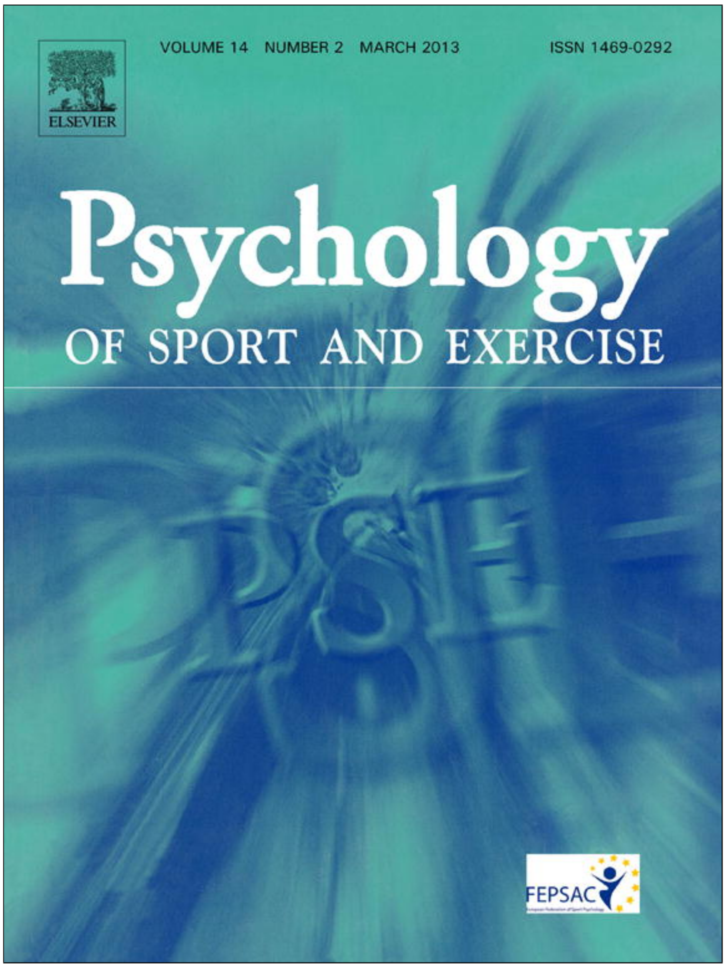
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Accurately locating one's spatial position in one's environment during a navigation task: Adaptive activity for finding or setting control flags in orienteering

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Objective: The objective of this study was to compare orienteers' modes of adaptation to different environments. Emphasis is placed on characterizing their concerns in relation to the need to accurately locate one's spatial position during orienteering.
Design and methods: The activity of eight orienteers was studied on two navigation tasks: (a) a classic orienteering task, and (b) a setting-orienteering task. The data were collected and processed using a procedure defined for course-of-action analysis. The methodology used video recordings of the orienteers in natural settings made by a glasses camera, and verbalizations during self-confrontation interviews conducted with four participants. Processing the qualitative data consisted of reconstructing the orienteers' course of experience. A further statistical analysis enabled us to identify events pertaining to map reading and pace.
Results: The analysis uncovered similarities and differences in the sequential organization of the orienteers' activity classic and setting tasks that were related to particular phases of the two courses and to time pressure. The results stress two fundamentally different modes of navigating and locating one's spatial position in one's environment.
Conclusions: The navigation activity and its adaptive nature are discussed in relation to the significant structural characteristics of the environment. The results are put in perspective in reference to the fast-and-frugal-heuristics approach, and several perspectives for skill acquisition are examined. It is suggested that this study could have broader implications for sport psychologists and sport instructors, in various sports requiring navigational skills in complex and dynamic environments.

Navigation refers to the combination of operations implemented to plan, conduct, and regulate one's movement on a course made up of different locations (Farrell & Barth, 1999). In many navigation tasks, the use of a map helps the individual (Schneider & Taylor, 1999). Any task involving navigation in an unfamiliar environment with the help of a map requires the individual to satisfy two demands. The first is to accurately determine one's location on the map (Peruch, Pailhous, & Deutsch, 1986). The second is to update one's location in the environment to avoid getting lost and to get to the targeted spot (Klatzky, Loomis, Beall, Chance, & Colledge, 1998).

Exploring navigation skills in sport domains is of great interest for sport psychologists, for two main reasons. First, such skills are required in certain sports such as mountaineering (e.g., Scarf, 2007), sailing (e.g., Devlin, 2004), scuba diving (e.g., Rouphael & Inglis, 1997), piloting an aircraft (e.g., Wickens, 1998), and orienteering (e.g., Eccles, Ward, & Woodman, 2009), where navigation plays an important part in performance. Secondly, these skills highlight unique cognitive processes and adaptations to sport situations, which are characterized by complexity, dynamism, uncertainty, and time-constraints. Indeed, navigation tasks require interpreting the current situation and making decisions while jointly considering information provided by the natural environment and by a map representing that environment. Athletes must continuously share their attention between these two sources of information, and must make sure they are consistent in order to make decisions.

The present research concerns orienteering, the "sport of navigation with map and compass" (Boga, 1997). Orienteering is an individual or sometimes team sport in which the orienteer uses

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a map and a compass to quickly find control sites, shown on the map in the center of a pink circle and marked on the field by a colored flag set in the ground (control flag). In addition to the control circle, orienteering maps are accompanied by a control description card that specifies the exact description and location of each control site (e.g., "Control 31 is on a boulder, east side"). Each control is equipped with an identification code and a specific "punch", which the orienteer uses to leave a mark on his control card in order to record his visit to the control point. The distance from one control point to the next is called a *leg*. The map is a five-color map whose scale ranges from 1/7500 to 1/15,000. It is designed specifically for orienteering and contains information coded according to the official nomenclature of the International Orienteering Federation (i.e., man-made features, water features, landforms, or penetrability of vegetation). The performance criterion in orienteering is time. But when the race is over, the orienteer is disqualified if he or she missed a control. Thus, it is necessary to be both fast and accurate in order to find the right control for each leg.

The physical environment chosen for orienteering is usually off-roads, and is always unknown to the orienteer at the time of the competition (Whitaker & Cuqlock-Knopp, 1992). However, from a cognitive point of view, the environment in which the orienteer chooses routes involves more than the physical environment. In an ecological approach to psychology, the environment is conceived more largely as a set of constraints that limits the possible actions of the athletes (Araújo, Davids, & Hristovski, 2006). In reference to Eccles et al. (2009), Vicente and Wang (1998) consider the environment in orienteering as the interaction between four levels of constraints: goal, route selection, functions, and physical environment. At the goal level, the aim for the orienteer is to find the control flags as quickly as possible. At the route-selection level, the constraint imposed on the orienteer is to construct the fastest route on each leg of the course. At the functions level, the orienteer must both move by running or walking while minimizing the risk of injury, and perform the cognitive operations of navigation like *navigational checking* (Wickens, 1998). Lastly, the physical-environment level involves three sources of constraints: the terrain (wild area), the course (composed of around 30 controls on several kilometers), and the orienteer's equipment (the map, the control descriptions, a compass and a control card).

As a result of this system of constraints, orienteering is an "inherently complex" decision-making task (Omodei & McLennan, 1994, p. 1411). During a competition, orienteers must continually divide their attention between the map, the terrain, and their own locomotion. This is problematic, especially when moving with speed (Eccles, Walsh, & Ingledew, 2002a), for the orienteer cannot handle all of the information present due to natural information-processing limitations (Newell & Simon, 1972; Simon, 1955). Eccles et al. (2002a), and Eccles, Walsh, and Ingledew (2002b) described the way in which orienteers get around these limitations through the use of heuristics. Heuristics are simple rules of thumb that enable one to reduce a complex situation to exploitable characteristics, in order to solve the problem in an acceptable way. "Acceptable" here means cost-minimizing, not "optimal", i.e., by rationally and systematically working out the costs and benefits of all conceivable solutions (Newell & Simon, 1972). When planning their route, expert orienteers are thought to use the *control-first*, *work-backward* heuristic, whereas inexperienced orienteers use intuitive and domain-general heuristics like *start-first*, *work-forward* (Eccles et al., 2002b, p. 334). These studies have brought out how experts adapt to orienteering task constraints, precisely at the route-selection level. Eccles' (2006, p. 1112) study completed these findings by focusing on the adaptations of orienteers to their physical environment. The findings showed that expert orienteers adapted their navigational equipment in order to reduce the workload during orienteering by "folding and thumbing the map, annotating the control description card and attaching it to a sleeve, and setting and re-setting the map". Macquet, Eccles, and Barraux (2012) studied the activity of the best recent elite orienteer. They showed that this orienteer's cognitive activity consisted of alternating between three typical concerns that allowed him to increase navigational efficiency by simplifying the information required to navigate. For example, he reduced the map information by selecting easily recognizable map features, so that he could quickly recognize checkpoints on the terrain, and he gave up his current strategy to adapt a safer but less efficient one only when he began to detect the onset of a navigational error (Macquet et al., 2012).

The present study was aimed, firstly, at studying the way in which orienteers adapt in a natural context, while taking into account some limitations underlined by Eccles et al. (2002b) concerning the ecological validity of the experimental conditions set up in most previous studies. On this point, Seiler (1996) had already observed differences in decision-making processes according to whether the experiment was carried out in a laboratory or in the field. Our second aim was to compare orienteers' methods of adapting to different environments, based on the assumption that an orienteer's activity is dependent upon the current environmental constraints (Bennis & Pachur, 2006). Two orienteering tasks, representing two different environments, were considered: (a) a classic orienteering task in which orienteers had to find controls as quickly as possible; (b) a setting-orienteering task in which orienteers had to set control flags as accurately as possible, but under low time pressure. The difference in environment between these two tasks in terms of (a) the goal (first constraint level), and (b) the physical environment (fourth constraint level), was the presence or absence of control flags (Eccles et al., 2009). The rationale for choosing the orienteering-setting task was that this task puts orienteers in a situation in which the control flag is shown on the map but is absent from the environment, unlike the classic orienteering task where the control flag is shown on the maps and is also present in the environment (two sources of information). The main hypothesis underlying this study is that the change in task constraints between the two tasks, although relatively small with respect to the orienteering task as a whole, might be associated with a change in the cognitive processes used to attempt to accomplish the task, thereby illustrating the subtle "situatedness" of cognitive activity in this sport. Analyzing the orienteering activity in these two tasks also falls in line with Bennis and Pachur's (2006, p. 625) suggestion to model "the various environments in which a heuristic might be used".

The present study was carried out from a phenomenological and enactive perspective (Varela, Thomspon, & Rosch, 1991). According to this perspective, the environment to which an actor gives meaning and to which he/she adapts is not predefined according to its "objective" characteristics as seen by an outside observer. Instead, it is the actor's specific world (or *umwelt*) that is perceivable and experienced from the first-person point of view, i.e., "from the inside" (Petitot, Varela, Pachoud, & Roy, 1999; Varela & Shear, 1999). In this way, the objective constraints of the task do not necessarily constitute relevant constraints from the standpoint of the actor's activity.

Course-of-action framework

The "course-of-action" framework, which is both theoretical and methodological in nature, gives concrete expression to the enaction paradigm for use in the study of daily activities (Theureau, 2003). Initially developed for research in ergonomics (Theureau, 2003, 2006), the course-of-action framework has been used for about ten years now in the field of sport psychology (e.g., d'Arripe-

Longueville, Saury, Fournier, & Durand, 2001; Poizat, Bourbousson, Saury, & Sève, 2012; Sève, Nordez, Poizat, & Saury, in press; Sève, Ria, Poizat, Saury, & Durand, 2007). In this framework, the theoretical object of the course of experience allows one to analyze the actor-environment coupling by granting a key role to the actor's point of view. This theoretical object is defined as "the activity of a given actor engaged in a given physical and social environment, where the activity is meaningful for that actor; that is, he [sic] can show it, tell it and comment upon it to an observer-listener at any instant during its unfolding" (Theureau & Jeffroy, 1994, p. 19). The course of experience represents the construction of meaning for the actor's activity as it progresses, or the history of the activity's underlying phenomena that can be "shown", "told", or "commented upon" by the actor at any point as its unfolds (Theureau, 2006). The activity experienced by the actor is studied via self-confrontation interviews. During this type of interview, participants are confronted with physical traces (essentially video and audio) of their activity, and must show, talk about, and comment on the episode they are reviewing. One way to study the process of meaning construction is to focus on the dynamic and circumstantial building of the actors' "concerns". A concern refers to an actor's practical interest and/or intention. If we assume that an actor's concerns define the scope of his/her situated activity, an investigation of concerns at a given instant helps in describing the navigation activity as it was experienced from the orienteer's point of view. Our study here was aimed at describing, analyzing, and comparing the concerns of orienteers faced with two different navigation tasks, in order to give an account of their navigation activity and their ability to accurately locate their spatial position in their environment.

Method

Participants

Four male orienteers volunteered to participate in the entire study. Four additional orienteers agreed to perform both orienteering tasks so that we would have enough data to complete the quantitative analysis. In what follows, the participants will be identified anonymously (such as Participant 1, Participant 2, etc.). They were between 18 and 23 years of age at the time of the study ($M = 20.37$, $SD = 1.81$), were working toward an undergraduate degree in sport science, and had chosen orienteering in their curriculum. All had had two orienteering units (from six to eight sessions averaging 2 h each) at their school or university, but they had never done orienteering as a competitive sport.

Procedure

The activity of the orienteers was studied for two consecutive days on an orienteering training course. Each day, the participants had to perform one of two tasks: classic orienteering or setting orienteering. The first day, four participants performed a classic task and four others, a setting task. The next day, they performed the other task. The two tasks were organized in two different areas of a forest unknown to the participants. The aim of the classic orienteering task was to complete the course as fast as possible in the order given by the map. The aim of the setting-orienteering task was to set control flags in an order predetermined by the map, within the allowed time. The maximum time was 30 min, which constitutes a low time pressure (defined according to a pre-experiment). The instructions given to the orienteers stated that their performance would be measured in terms of setting accuracy (distance of the control flag set by the participant, from the exact location of the control site) and not the time taken to complete the course. The orienteers did the course in pairs. This was meant to encourage spontaneous verbal communication (Suchman, 1987) between the orienteers during the task, even if they were not explicitly asked to do so. This method is a form of think aloud procedure used previously by Omodei and McLennan (1994).

Four orienteering courses were set up (two for the classic task and two for the setting task). The set-up was done by an expert course setter so as to have similar technical and energy-related characteristics (a distance of 1160 m and a 10 m difference in elevation). The courses were generated using cartography Ocad 9.4® software (Zupan & Franges, 2003). They included four controls of increasing difficulty, as assessed by the gradation system of the French Orienteering Federation. Each participant was given a map 2 min before the start, a control description card, a timer, and a compass. In the classic task, orienteers had a control card, whereas in the setting task, they had to set the control flags.

Data collection

Two types of data were gathered: (a) continuous audiovisual recordings of the orienteers' experience during the orienteering tasks, and (b) verbalizations during self-confrontation interviews.

Recording data in situ

During both orienteering tasks, recordings were made with camera-equipped glasses that had an integrated microphone. The centering shot was comparatively similar to the one obtained by a head-mounted camera (e.g., Eccles, Walsh, & Ingledew, 2006; Macquet et al., 2012). The total length of the recording was 6 h 27 min.

Verbalization data

The verbalization data were obtained from the individual self-confrontation interviews with the four participants who volunteered to take part in the interviews (Theureau, 2003). The average length of the interviews was 34 min ($SD = 7$ min) for the classic task and 48 min ($SD = 8$ min) for the setting task. They were conducted on the same day as each course, following a waiting period of 3–6 h after the course. During the interviews, the participants were shown the audiovisual recordings of the situation and the objects they had for the course (map, compass, timer, and control descriptions). The participant and the researcher viewed the recording together, and the participant was asked to describe and comment upon his activity step by step (what he was doing, feeling, thinking, and perceiving during the course). Prompts from the interviewer dealt essentially with actions that were meaningful to the orienteers and were designed to obtain additional information about the actions (e.g., "there, you're saying that you don't really know where you are"). The interviews were recorded, using a camera that filmed in close-up the screen on which the film recorded *in situ* was playing. A total of 5 h 26 min of verbalization was collected.

Data processing

Qualitative analysis

The qualitative analysis of the data consisted of reconstructing the participants' course of experience on each task, in six steps: (a) transcription of communications and behaviors, (b) constitution of the two-levels protocol, (c) documentation of concerns, (d) identification and categorization of typical concerns, (e) identification of sequences, and (f) graphic modeling and comparison of the navigation activity in the two tasks.

Transcription of communications and behaviors. The audiovisual recordings captured by the glasses camera of the four orienteers who took part in the interviews were retranscribed word by word using Transana® 2.42 software (Woods & Dempster, 2011). Their behaviors were described in terms of the categories generally used in the technical language of orienteering courses (e.g., orient the map, run along the ditch, etc.).

Constitution of the two-level protocol. This step consisted of synchronizing the in situ recording data (Level 1) and the verbalization data collected during the self-confrontation interviews (Level 2). The time codes inserted during the transcription were used to synchronize these two levels.

Documentation of orienteers' concerns. From the two-level protocol, the concerns of each orienteer were identified and labeled in relation to the answers to the following questions about data obtained at a given instant of the situation: What are the orienteer's meaningful interests in the situation? What is his intention? What is he trying to do? As an example, when Participant 2 said during the interview "Now, I'm spotting the dep [he shows the map] to visualize it […] because normally it should slope". His concern was labeled as "Imagine the upcoming depression with the help of the map". A total of 866 concerns were identified for the four orienteers and the two tasks.

Categorization of typical concerns. All of the concerns related to spatial navigation (e.g., locating one's position, looking for the control flag, etc.) were identified in each course of experience of the four orienteers, during the two tasks. These concerns were systematically compared and categorized using an iterative procedure in accordance with the inductive-categorization principles suggested by Strauss and Corbin (1990). The concerns were grouped in the same category whenever they pertained to the same more general type of concern, and each category was labeled as a typical concern. For example, the following two concerns at instant *t* "Imagine the footpath on the landscape he will encounter on this leg, with the help of the map" and "Imagine the stream on the landscape he will come across on this leg, with the help of the map", were classified in the same category "Imagine the feature(s) of the landscape he will encounter on this leg, with the help of the map". A total of 17 categories of typical concerns were identified and labeled (Table 2).

Identification of sequences. A global analysis was conducted to identify *sequences* that manifested the temporal construction of the activity (d'Arripe-Longueville et al., 2001). Sequences were units in the course of experience in which certain typical concerns consistently followed each other in a particular order, as a part of a more global purpose (Theureau, 2006). For example, the succession of three typical concerns "Moving toward the control", "Looking around for the control flag", and "Checking the control code and punching the control card" constituted the sequence "Quickly finding the control flag". Five such sequences were identified and labeled (Fig. 1).

Graphic modeling and comparison of the navigation activity in the two tasks. The sequences of the participants' courses of experience were compared in the two tasks in relation to the different phases of each leg. This comparison enabled us to build a graphic model of the sequential organization typical of the orienteers' activity in the classic task and in the setting task, and to identify similar and different forms in the organization of each task (Fig. 1).

Ensuring the credibility of the qualitative analysis. Several measures were taken to enhance the credibility of the data (Lincoln & Guba, 1985). First, self-confrontation interviews were conducted in an atmosphere of trust between orienteers and researchers. Trust was built during the familiarization phase, and via the establishment of an explicit contract between the researcher and the participant that took into account the respective interests of each one. Secondly, two investigators independently carried out the three main steps of the data analysis (i.e., documentation of concerns, categorization of typical concerns, and identification of sequences), and discussed any initial disagreement until a consensus was reached. This method is justified by the particular characteristics of data analysis in the course-of-action framework. Indeed, reconstructing a course of experience is not strictly a coding procedure: it requires a plausible interpretation of the ongoing construction of meaning during the actor's activity. This is ensured by the parallel data analysis by different researchers, who mutually discuss their interpretations. Thirdly, a saturation criterion was adopted for the categorization of typical concerns. This criterion was considered to be met when no new categories of typical concerns emerged from the processing of further data.

Quantitative analysis

A quantitative analysis supplemented the qualitative analysis. The 16 *in situ* recorded videos (one audiovisual recording per orienteer per task) were examined in great detail in order to (a) reconstruct the traces of each orienteer during the courses, and (b) code and tally all occurrences of behavioral descriptors of the orienteers' activity. This allowed us to perform statistical analyses of the quantitative data.

Reconstruction of orienteers' traces on each leg of the courses. The orienteers' times were measured on each leg of the courses. The trace of their moves on each leg was reconstructed by one of the researchers (an expert in orienteering) from the video recordings and from a fine-grained analysis of the map and terrain.

Coding of behaviors. The ways the orienteers read the map were coded and tallied in accordance with the coding method used by Eccles et al. (2006). Note the coding was done only from predeparture to control 4, because during the time between the last control and the finish point, most of the orienteers had stopped their orienteering activity and map reading, and were moving by deduced reckoning. The number and frequency of looks at the map, and the total time spent looking at the map was calculated as a percentage of the total time taken to complete the course. Looks at the map were classified into three categories: "furtive" looks (under 1 s), "short" looks (between 1 and 5 s) and "prolonged" looks (more than 5 s). The pace when looking at the map (stopped, walking, running) was also noted. The length of each *leg attack phase*, that is, the phase between the attack point to the control site, was timed (Eccles et al., 2002a). The orienteer was considered to enter the attack phase when he was less than 75 m from the control site. The time spent looking at the map during these phases was measured as a percentage of the length of the attack phase.

Statistical analysis. From the coding of map-reading behaviors, 13 dependent variables were obtained (Table 1). These variables were recorded during both tasks (i.e., classic task and setting task). The normality of the data was checked using the Kolmogorov–Smirnov test. Then, paired *t*-tests were performed to compare conditions on each variable. Multivariate analyses with an alpha level of .05 indicated the rate of type I errors. Bonferroni adjustment to the alpha level was applied at a level of .004 (.05/13).

Results

The results are presented in three sections. The first describes the eight orienteers' performance on both tasks. The second

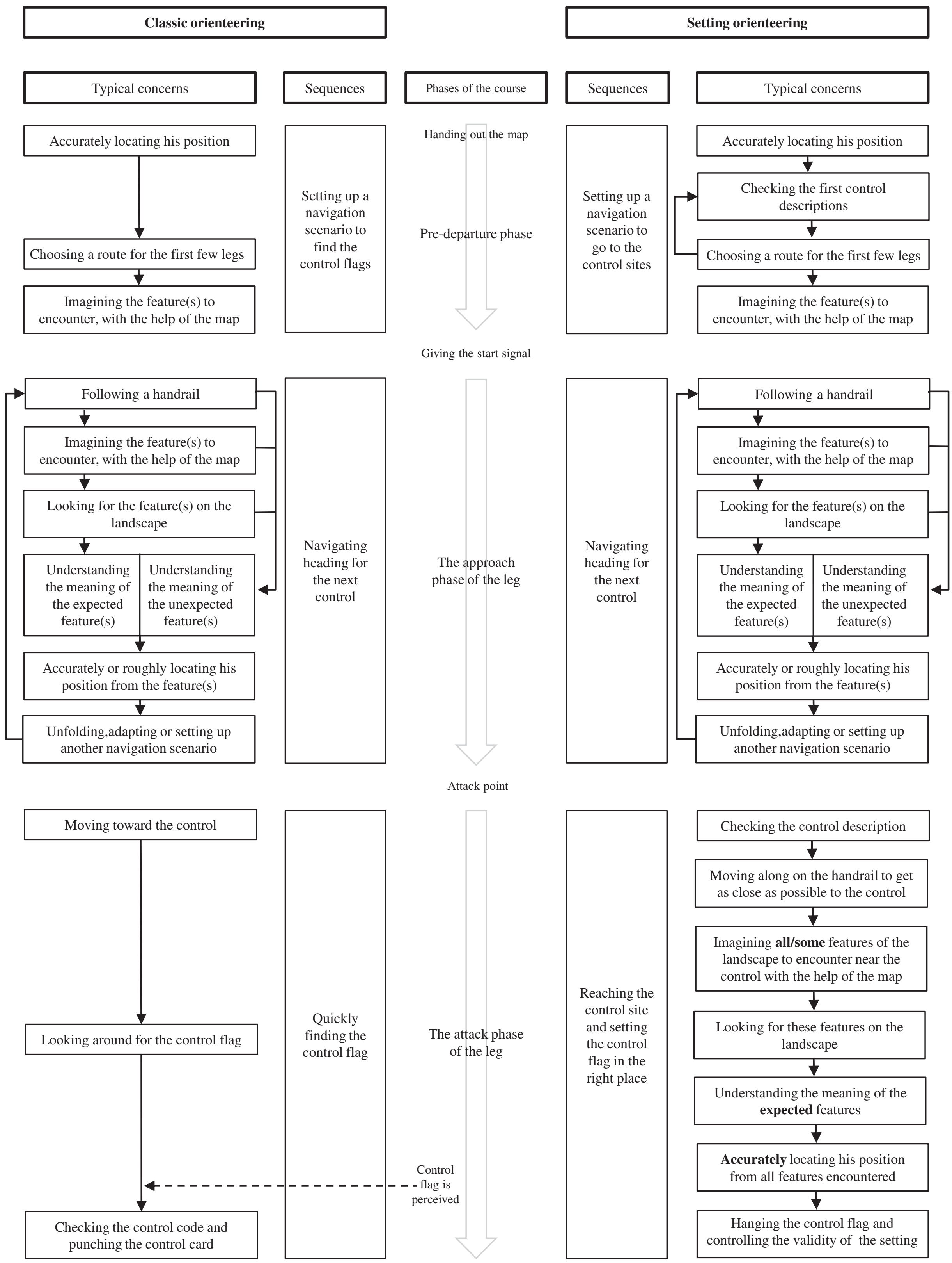

Fig. 1. Graphic modeling of the orienteers' activity in classic and setting orienteering.

characterizes the similar and different forms of sequential organization of the orienteers' activity on both tasks. The third presents the behavior differences in the orienteers' activity on both tasks, on the basis of the quantitative data analysis.

Performance on the two tasks

On the classic orienteering task, the eight orienteers reached the four controls of the course with an average time of 13.16 min ($SD = 1.23$)

Table 1
t-tests on differences in classic orienteering and in setting orienteering ($N = 8$).

Dependent variables (number and name)		Classic orienteering		Setting orienteering		*t*	*p*	*d*
		M	*SD*	*M*	*SD*			
1.	Course time from control 1 to control 4 (min)	13.16	1.23	24.46	6.28	5.57	<.001*	2.50
2.	Total time spent looking at map (min)	2.84	.98	8.30	2.68	5.5	<.001*	2.71
3.	Time spent looking at map as a percentage of course time	21.22	5.64	33.52	3.18	5.59	<.001*	2.69
4.	Number of times per minute at which map was looked at	3.80	1.15	4.95	.61	2.48	.02	1.25
5.	Furtive looks at map as a percentage of total looks at map	36.86	8.73	27.17	9.57	3.12	.009	1.06
6.	Short looks at map as a percentage of total looks at map	40.8	6.63	43.53	3.77	1.58	.07	.51
7.	Prolonged looks at map as a percentage of total looks at map	22.34	7.00	29.30	7.15	1.88	.05	.98
8.	Looks at map when stopped as a percentage of total looks at map	49.33	6.49	61.39	9.13	3.61	.004	1.52
9.	Looks at map when walking as a percentage of total looks at map	36.99	5.82	33.61	8.04	.89	.20	.48
10.	Looks at map when running as a percentage of total looks at map	13.68	7.09	4.99	3.44	6.02	<.001*	1.56
11.	Average time of attack phases on each leg (min)	1.17	.44	3.47	1.25	4.04	.002*	2.45
12.	Average time spent looking at map in attack phases (min)	.13	.09	1.04	.24	9.02	<.001*	5.02
13.	Time spent looking at map as a percentage of mean attack phase time	9.96	3.85	32.06	7.32	13.60	<.001*	3.79

*$p < .004$.

(Table 1). Four orienteers had trouble finding the fourth control. The analysis of their trace shows that they erred for several minutes in a zone of over 100 m around the fourth control. On the setting-orienteering task, all eight orienteers set the first two control flags at the exact places shown on the map. With the increase in difficulty, only four orienteers managed to accurately set the last two control flags with an average error of 15.50 m ($SD = 1.81$) on the third control site, and of 40.00 m ($SD = 21.21$) on the fourth control. These four orienteers exceeded the allotted time by 10.25 min on average ($SD = 9.54$). Lastly, the average time taken by the eight orienteers to set the four controls was 24.46 min ($SD = 6.28$) (Table 1).

Forms of sequential organization of orienteers' activity on both tasks

Similarities and differences appeared in the typical sequential organization of the orienteers' activity on classic task and setting task, in connection with different phases of the two courses. Fig. 1 presents the graphic modeling of the orienteers' activity on the two tasks. Table 2 gives a detailed presentation of the typical concerns identified in each task.

Similar forms of activity on the two tasks

The activity of the orienteers on both tasks was organized into sequences of identical structure on the approach phases of the leg. This sequence was labeled: *Navigating heading for the next control.* It began as soon as the start signal was given and ended when the orienteer got to the attack point of the control (Fig. 1). This sequence was then reopened at the beginning of each new leg. The orienteers exhibited an iterative activity for interpreting the landscape features encountered in the environment, based on features that were expected or unexpected from reading the map. Making this connection allowed them to locate their position accurately or roughly, depending on the number of map features and landscape features they connected to each other.

Different forms of activity on the two tasks

The orienteers' activity was organized into sequences that differed on the two tasks, both for the pre-departure phase and for the leg-attack phase. The differences between the sequences pertaining to the pre-departure phase, however, were less marked.

Pre-departure phase. In the pre-departure phase, two sequences were identified and labeled: (a) *Setting up a navigation scenario to find the control flags* (classic orienteering task), and (b) *Setting up a navigation scenario to go to the control sites* (setting-orienteering task). They began when the maps were handed out and ended as soon as the start signal was given (Fig. 1).

Setting up a navigation scenario to find the control flags. On the classic task, orienteers chose the route they were going to take on each leg, observing the order of the future course, that is, going from the starting point to Control 1, from Control 1 to Control 2, etc (Table 2).

Setting up a navigation scenario to go to the control sites. On the setting task, orienteers always started by checking the control description before choosing the route to take to get there (Fig. 1). They repeated this operation for the other legs, either for all of them if they had enough time, or only for the first few.

Leg-attack phase. The sequences pertaining to the leg-attack phase differed substantially between the classic and setting tasks. They were called (a) *Quickly finding the control flag* (classic task), and (b) *Reaching the control site and setting the control flag in the right place* (setting task). Both were observed on the attack phase of every control (Fig. 1).

Quickly finding the control flag. On the classic task, when the orienteers thought that the control flag was near (beginning of the attack phase), they moved directly forward in its direction in a rough way since they did not necessarily follow a line feature (Table 2). This concern ended instantly when the control flag was seen (Fig. 1). When the difficulty level was low (Controls 1 and 2), the control was sometimes spotted by chance, as explained for example by Participant 3: "I don't expect to find it necessarily there, there's a little bit of a chance factor". When the control flag was not directly visible (Controls 3 and 4), orienteers reached the control by exploring the landscape and trying to guess its position until they found it (Table 2). For example, Participant 4 explained his strategy of gaining height in order to have a better viewpoint for seeing the control flag: "I'm going to gain height in order to try to spot it [the control flag]". Once the control flag was reached, orienteers checked the control code to see if the control was the right one before punching the control card.

Reaching the control site and setting the control flag in the right place. On the setting task, the structure of the sequences in the orienteers' course of experience on attack phases was very different from that observed on the classic task (Fig. 1). When the orienteers got near a control, they were again concerned by the control description. The series of typical concerns at that point exhibited a structure relatively close to the one identified for the approach phases. However, it differed on some essential points. The orienteers moved systematically along on the handrail (line feature) to get as close as possible to the control site, even when they estimated the distance to cover to be longer than the direct route. After that, the orienteers took into account all available features on the map that were near the control, so that when they came across these

Table 2
Typical concerns identified in each task.

Typical concerns (number and name)		In which task: classic orienteering (CO) or setting orienteering (SO)	In which phase: pre-departure (PD), approach phase (AP), attack phase (AT)	Description	Examples of verbalization during self-confrontation interviews
1.	Accurately locating his position.	CO/SO	PD	Accurately determining his location on the map by spotting the start symbol, then orienting his map, relating simple features of the terrain to the map features.	"There, I'm trying to find my bearing. I'm trying to turn the map around to see where I really stand, to orient the map in connection with the paths […] I'm looking at this triangle and I'm telling myself I am standing on this path, at the junction of the two paths" (Participant 1).
2.	Checking the first control descriptions.	SO	PD/AT	Reading aloud the next control descriptions.	"There, I'm looking at the control description" (Participant 2). "Me, I look at it [the control description] when I get near the control" (Participant 1).
3.	Choosing a route for the first few legs.	CO/SO	PD	Choosing a route for the first few legs by pointing to the route on the map with his finger.	"Here, we are commenting on the route to take for each point […] for the first one, there I'm following it with my finger" (Participant 3).
4.	Imagining the feature(s) to encounter, with the help of the map.	CO/SO	PD/AP	Imagining the feature(s) of the landscape the orienteer will encounter on the leg with the help of the map.	"There, I'm just imagining each point…there I'm thinking I will follow the dry ditch, until I find the junction with the earth wall […] and there, there should normally be vegetation" (Participant 1).
5.	Imagining all the features of the landscape to encounter near the control, with the help of the map.	SO	AT	Taking into account all information featured on the map that is available around the control.	"I really look out for all the features on the map" (Participant 2).
6.	Following a handrail.	CO/SO	AP	Following a handrail (a line feature).	"Actually, I'm going along the dry ditch" (Participant 4).
7.	Looking for these feature(s) on the landscape.	CO/SO	AP/AT	Looking for the features expected on the landscape.	"The ditch, yeah, I look for the ditch yeah, I think I got it" (Participant 1).
8.	Understanding the meaning of the expected feature(s).	CO/SO	AP/AT	Understanding what the seen feature was.	"There, I'm wondering if it's the ditch I was looking for" (Participant 4).
9.	Understanding the meaning of the unexpected feature(s).	CO/SO	AP	At any moment of the navigation, identifying the meaning of the unexpected feature(s) encountered.	"It wasn't expected at all, that one [the ditch], there I'm really wondering which one it is" (Participant 3).
10.	Locating one's position precisely from (all) feature(s) encountered.	CO/SO	AP/AT	Locating his position precisely on the map from feature(s) encountered and related to the map.	"There we know we are right there at the junction" (Participant 1).
11.	Locating one's position roughly from the feature(s) encountered.	CO/SO	AP	Locating himself roughly on the map from a few features encountered.	"So there we have gotten to the road, so I know we are somewhere around there, based on the intermittent stream and the road, so I know we are around here" (Participant 3).
12.	Unfolding, adapting, or setting up another navigation scenario.	CO/SO	AP	Going back to the choice of route planned during pre-departure, readjusting it if necessary, or creating a different one.	"So there, we are doing what we thought we would do before" (Participant 2).
13.	Moving toward the control.	CO	AT	Moving roughly toward the control flag without necessarily following a handrail.	"We actually knew that the second one was in that direction there […] I keep running because I know anyway it's gonna be in that direction, and it's true after that it will be easier to see where I stand when I get to a real landmark […] so where we were exactly, we didn't know" (Participant 3).
14.	Moving along the handrail to get as close as possible to the control.	SO	AT	Moving forward along a handrail which allowed him to get nearer to the control, even if the route was not the most direct one.	"There, I'm taking a little detour […] to keep going along that ditch" (Participant 4).

(*continued on next page*)

Table 2 (*continued*)

Typical concerns (number and name)	In which task: classic orienteering (CO) or setting orienteering (SO)	In which phase: pre-departure (PD), approach phase (AP), attack phase (AT)	Description	Examples of verbalization during self-confrontation interviews
15. Looking around for the control flag.	CO	AT	Looking for the control flag by scanning the landscape.	"I'm looking, while trying to turn my head around to see if I can see it [the control flag] and if I can run across it […], I thought I would see it, that I would run across it as for the previous ones" (Participant 1).
16. Checking the control code then punching the control card.	CO	AT	Checking the control code to see if it was the right one then punching the control card.	"I'm looking to see if it is the right number because I wanted to check in case I had gone in the wrong direction" (Participant 3). "So there, I'm punching and looking at what it does on my control card" (Participant 2).
17. Setting the control flag then checking the validity of the setting.	SO	AT	Hanging the control flag then rechecking the validity of the setting.	"My aim is to set it, precisely […] I really want to set it on the ground, in the middle of the two paths" (Participant 3). "Me, I'm checking […], I'm trying to see which way I went, just to be sure" (Participant 1).

features on the landscape, they had been anticipated. The orienteers were interested in locating their exact positions near the control site until they got there. In order to do so, they would check all information available on the map and the terrain. For example, Participant 2 stated in the interview, "There, my intention is really to be precise, so I'm trying to stick to the map as much as possible […] I'm analyzing more […] I want to be sure that I'm exactly at this intersection [points out a spot on the map]". The higher the level of difficulty, the more the orienteers used the different types of features available on the map (man-made features, landform features, vegetation features, etc.) to precisely locate their position and put the control flag in the right place.

When the time pressure perceived by the orienteers became greater (notably when navigation errors had been made), their mode of functioning changed. They looked for essential information they viewed as sufficient to get to a location point, without taking into account all information on the map and the terrain. For example, Participant 1 said "There, what I want is to find the two streams [points to the spot on the map] because there, it makes a sort of 'H'. So I try to find the two streams that are nearly parallel to make sure I'm in the right place [control site], (…) I don't really look at the other map features".

Some orienteers made flag-setting mistakes when the difficulty level increased. In the self-confrontation interview they talked about how they sensed that they had made mistakes on Controls 3 and 4. The orienteers associated these judgments to an increased feeling of doubt. Doubts from the orienteers concerning their positions were associated with both the perceived time constraint and the fact that unexpected features of the terrain had disturbed the typical unfolding of the sequence. For example, Participant 3 said "It was totally unexpected. I had not expected to be there (…) so I began to doubt". At this point, they began to question their previous reasoning: "We started to wonder about which way we had taken. Did we go this way? Did we go higher on that one [points to the map], that's the question? […] And there we have lost quite a bit of time […] I've got to move on to the fourth control".

Behavior differences between the orienteers' activity on the two tasks

The quantitative analysis pointed out significant differences between the two tasks in terms of the attention paid to the map on all courses and attack phases (Table 1). The absolute time spent looking at the map for the course as a whole (variable 2) and as a percentage of the total course time (variable 3) was significantly longer in setting orienteering than in classic orienteering. Only looks at the map taken while running were significantly less common in the setting task than in the classic task (variable 10). Measurements on the attack phases revealed that the average length of the attack phases of each leg (variable 11) was 1.17 min in classic orienteering and 3.47 min in setting orienteering, the difference being significant. The most contrasted variables of the two tasks were the amount of absolute time spent reading the map in attack phases (variable 12), and this same time expressed as a percentage of the length of the attack phases (variable 13). On the classic task, orienteers looked at the map for an average of .13 min on attack phases, which corresponds to 9.96% of the average length of the attack phases. On the other hand, on the setting task, the values of these same variables were 1.04 min and 32.06%, respectively.

Discussion

This study described the similar and different forms of sequential organization of the orienteers' activity in the classic and setting tasks, and how they related to the different phases of the course.

The findings are in keeping with the results of Eccles et al. (2002a, p. 80), who pointed out a change in orienteers' mode of navigation according to their "position within the leg".

The phases in which the orienteers' activity exhibited similar forms in the two tasks were the approach phases. The orienteers were interested in getting quickly from one zone to another without considering the presence or absence of a control flag or time pressure. Their navigating activity consisted of moving from one handrail to another, carrying out a map-reading activity aimed at finding their spatial position more or less precisely. This result validates the hypothesis that on this phase, when the orienteers were far from the controls, the environment differences between the two tasks were not very significant from their point of view, since in both cases, what was most important for them was to approach (more or less accurately) the attack zone of the control site. Conversely, when they were close to the controls (in attack phases), the orienteers exhibited very different ways of organizing their activity, contrasting their modes of adapting to the constraints of each task. The discussion of these results mainly concerns the interpretation of these differences in the attack phases, which are particularly interesting as far as the analysis of the orienteers' navigating modes is concerned. The differences described in the pre-departure phase are more concisely discussed.

The differences in the organization of the orienteers' activity in the attack phases of the two tasks revealed two contrasted modes used by the orienteers to navigate and locate their position in their spatial environment. In the classic orienteering task, the orienteers adopted a specific method suited to satisfying the demands of navigating in an unknown environment, using a map to reach a goal that was "hidden", but already present before they started, and was represented by a practical device visible from a nearby zone (control flag). This study pointed out two successive periods for the activity of finding control flags. The first is an intuitive approach phase in which the orienteers moved quickly toward the control in an approximate way: they did not always follow a handrail and the map was not used much to navigate (variables 2 and 12, Table 1). The second period began when the orienteers thought they were close to the control. Their concern was to keep the control in view, so they looked for the orange and white colors of the flag, no longer using the map.

This two-phase adaptive mode can be related to the fast-and-frugal-heuristics (FFH) approach (Gigerenzer, 2004; Gigerenzer & Goldstein, 1996), and more particularly to the use of navigating and orienteering heuristics (Bennis & Pachur, 2006; Conlin, 2009). The orienteers reduced the orienteering task to those features regarded as essential for saving time and energy in a given environment. Instead of taking into account all of the map features and comparing them to the ones seen on the spot until they could find their exact location and reach the right control site, these orienteers preferred to use a clever set of simple processing rules that enabled them to reach their goal. We can infer that this adaptive mode on the orienteers' part is based on practical knowledge developed from the identification of regular patterns encountered in various environments during their previous experiences in orienteering or during everyday navigation. This adaptive behavior exhibits the main characteristics of FFH, and can be compared to the use of a particular FFH (Bennis & Pachur, 2006; Conlin, 2009; Gigerenzer, 2004): *quickly finding the control flag*. The success of this mode was made possible by the structure of the environment faced by the orienteers. The control flag and its identification code acted as objective references that allowed the orienteers to be sure that they had reached their goal. The fact that they knew that a control flag was present before they started their course offered them the possibility of orienteering roughly to save time, without necessarily looking for the control site in a precise way. They could accurately locate their position later by relating the pink circle on the map, to the control flag on the ground.

This finding reveals a fundamentally *situated* activity on the part of the orienteers, who adapted to the environment as they made the most of the environmental resources in context to reach the task goal (Suchman, 1987). Instead of trying to know their exact location in order to find the control site in an optimal and logical way, they divided the problem into two parts (head toward the control flag and then look for it), and each of these could be achieved easily. The rationality of this heuristic is "not logical, but ecological" (Gigerenzer, 2004, p. 64). The present results confirm the idea that environmental resources enable subjects to be freed from some cognitive tasks while at the same time helping to solve the problem the most successfully (Norman, 1993; de la Rocha, 1985). Thus, the classic orienteering task made a set of usual resources available by allowing for that kind of adaptation mode and enabling success when the necessary accurate-orienteering requirements were limited.

However, when the difficulty level of finding the control was higher, the control flag was not visible from a long distance (for example, in a rugged area). The objective constraints of this situation were close to a setting situation. Nevertheless, what was meaningful for the orienteers was not whether the control flag was invisible at that instant, but the certainty that it was actually located in area closely. This certainty prompted the orienteers to continue searching for their position without using the map, even if it meant losing a lot of time. At these moments, they could not use an accurate navigation mode because they were no longer following their own moves on the map.

Carrying out the setting-orienteering task with a low time constraint was done in an adaptive mode that was different from the one just discussed. The orienteers were interested in locating their position accurately so as to find the control site, not just the control flag as in the classic task. Contrary to an intuitive but quite efficient activity, the orienteers performing the setting task were engaged in a rational thinking process aimed at seeking optimality (Gigerenzer & Selten, 2001; Newell & Simon, 1972; Simon, 1990). Our results point out a recurrent structure of the setting activity, closely linked to a series of inferential operations. To get nearer to the control, the setting task orienteers chose to move along handrails, which enabled them to go ahead with assurance and get closer to the control. They precisely located themselves in the vicinity of the control until they reached it, chronologically using all the features available on the map and in the landscape as locating points. Let's keep in mind that the constraints involved in performing this task reinforced the accuracy demands while reducing the time demands. In this way, the orienteers had plenty of time to look for as many pieces of evidence as possible to justify their exact location. This was confirmed by our quantitative analysis showing that the average time spent looking at the map in the attack phases was greater in the setting than in the classic one (Table 1). This activity can be likened to a mobilized inferential strategy for solving problems under low time pressure (Beilock & DeCaro, 2007).

However, control setting for some orienteers was done under greater time pressure. In this case, the environmental constraints with which they interacted were different. The setting task orienteers adapted via another mode. Instead of taking into account all features available near the control, they picked up and examined only that information they considered sufficient for the time being in order to reach a locating point. This quick discrimination of features, seen as useful for locating one's exact position, can be compared to another FFH: *locating one's position quickly and accurately*. Since these orienteers had only limited experience in the flag-setting activity in orienteering, this FFH was not the modality they spontaneously used (especially when the time was limited).

The use of this FFH to set the control flag at the most likely place was dependent on achieving a sense of being "persuaded" (Theureau, 2006). As no objective element made it possible for the orienteers to confirm the correctness of their thinking, the validity of the flag-setting was based on the conviction they developed from more or less plausible hypotheses. This conviction was linked to the orienteers' trust in their own interpretations, hence a greater or lesser feeling of doubt when attempting to set a tricky control. The feeling of doubt was linked to the fact that they could not immediately know the result since there was no positioned control flag (Salmoni, Schmidt, & Walter, 1984).

Moreover, beyond the task and environmental constraints, a feeling of doubt could also be linked to the *organismic constraints* inherent in the human perceptual system (Newell, 1986). For the orienteers, the orange and white flag may have been an easily perceived "real-world" featural singleton (Treisman, 1991). Now in the setting task, no element of the environment was as *distinguishable* as the control flag for the orienteers (Eccles et al., 2002a). Consequently, the setting task orienteers had to use and distinguish terrain features that, comparatively, were less intrinsically distinguishable from one another (e.g., changes in foliage), in order to identify the control site.

The activity observed in the pre-departure phase indicated that the constraints of the two tasks were also seen as different in this phase. In the setting task in particular, the orienteers were clearly trying to get to know the control descriptions before planning their itinerary, which they did not do in the classic task. Referring to the study by Eccles et al. (2002b), we can advance the hypothesis that the environmental structure of the setting task made the orienteers' adaptation more usual to their route-planning activity. It may have facilitated the transition from the use of the "*start-first, work-forward*" heuristic typical of beginners, to the "*control-first, work-backward*" heuristic that characterizes more expert orienteers (Eccles et al., 2002b).

The differences and similarities in the navigation modes described by the orienteers who took part in this study, for the two tasks investigated here, reinforce the idea of task-specific adaptation to the structure of the environment (Bennis & Pachur, 2006; Gigerenzer & Selten, 2001; Kirsh, 1996). These results provide food for thought about the learning of orienteering and navigation by non-experts. The effects of the setting task, in comparison with those of the classic task, were seen at two levels in this study: the optimization of route planning and the use of precise orienteering to accurately locate one's position by using different types of information. The need to adopt more accurate navigation when the orienteer is close to the control is in fact a characteristic of orienteering expertise (Eccles et al., 2002a; Macquet et al., 2012). But more-accurate navigation must not take too much of the orienteer's time. Thus, it seems necessary for orienteers to develop navigation modes (or FFHs) that enable them to precisely locate their position solely from useful features, so that a sense of being "persuaded", without being optimal, can be *satisficing* as regards to the complexity of the task (Simon, 1955; Simon, 1957). A training program could, for example, be based on the differentiated use of two heuristics: *quickly finding the control flag* on the one hand, and *locating one's position quickly and accurately* on the other, depending on the characteristics of the environment. In fact, each of these two FFHs enabled the orienteers in the present study to succeed in a limited amount of time, but under different environmental conditions. Experts in orienteering are characterized by this capacity to "*consider the difficulties* [one] *could face finding an upcoming control*" (Macquet et al., 2012, p. 96) in order to adjust the degree of precision in their navigation. It would therefore be interesting to train orienteers to identify the environmental constraints (is the targeted control likely to be visible from afar?) associated with the use of such and such an FFH from "an adaptive toolbox" (Gigerenzer & Selten, 2001).

Some limitations of this study must be noted. First, while the setting-orienteering task seems to be interesting for orienteering learning, this study shows that a single trial of a setting task is not enough to change skills. Indeed, the classic orienteers' performance was not better among those who had previously carried out the setting-orienteering task on the second day. Further studies are needed to assess the effects of the setting-orienteering task over a longer training period. Secondly, the low expertise level of the participants in this study is an important consideration. Their contrasted performance on the setting-orienteering task could be partly due to their lack of experience, which may account for the variability of their performance. In this respect, a comparison with expert orienteers on analogous tasks might be useful. Thirdly, the fact that the orienteers accomplished the task in pairs poses a limitation on the ecological validity of the study, given that working in twos deviates from the official practices in this sport (although commonly used in sport education, e.g., McNeill, Cory-Wright, & Renfrew, 1998). It would be interesting to take new measures with orienteers performing such tasks alone. Lastly, there are certain limitations that are inherent in the method of self-confrontation interviews which allow access to cognitive phenomena that can be "shown", "told", or "commented upon" (Theureau, 2006), while at the same time masking cognitive phenomena that are unconscious and cannot be verbalized (Eccles, 2012).

Despite these limitations, the findings extend our knowledge about cognitive activity beyond the specific domain of orienteering, in various sports or everyday practices requiring navigational skills. Indeed, a better understanding of cognitive processes such as perceptual decision-making in that kind of situations that are characterized by complexity, dynamism, uncertainty and time pressure is critical for sport psychologists (e.g., Araújo et al., 2006; Bennis & Pachur, 2006; Williams & Grant, 1999). This understanding is also very important to help sport instructors to design relevant learning tasks, with respect to the characteristics of athletes' cognitive adaptations to their environments (Handford, Davids, Bennett, & Button, 1997). More generally, this study could also be of interest to other disciplines such as cognitive psychology (Moran, 2009), ergonomics (Wickens, 1998) or artificial intelligence (Kirsh, 1995).

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