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Professional handball coaches management of players' situated understanding during official games

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ABSTRACT

Objectives: This study, based on the team cognition approach, investigated the information content expressed by coaches when helping players build or update their understanding of the unfolding game. The focus was on how this content fits into the usual task-work/teamwork and procedural/declarative taxonomies.
Design: The data were collected through the audio and video recording of the communications and behaviors of three professional head coaches throughout a total of 15 games. We used deductive content analysis, crossing information contents related to task-work or teamwork with information contents related to declarative or procedural knowledge across the five game periods (first and second half of the first and second half-time, break-time period), and the three score differentials between the teams (favorable, balanced, and unfavorable).
Method: We first performed a multivariate analysis of variance (MANOVA) using a 5 (Game Periods) × 3 (Score Difference) factorial design. Follow-up ANOVAs with repeated-measures were performed to identify the variables contributing to the multivariate effect. We then performed a repeated-measures analysis of variance for information contents related to declarative and procedural knowledge in occurrences of task-work and teamwork categories.
Results: The results showed that the coaches expressed information related more often to players' procedural knowledge than to their declarative knowledge. We discovered two main effects (game periods and score differences) in coaches' information contents delivered to players. Information related to procedural knowledge was not addressed to the team as a whole, but to certain players.
Conclusions: This suggests that an information flow was more distributed than shared.

According to findings of in-situ coaching practice (Macquet & Stanton, 2013; Saury & Durand, 1998; Smith & Cushion, 2006), many researchers considered the coaching process to be complex, dynamic and context dependent (e.g., Debanne & Chauvin, in press; Lyle, 2002). As a result, coaching expertise requires flexible adaptation to constraints (Saury & Durand, 1998). For instance, coaches are required to adapt their activity to the score and to game periods. Indeed, using verbal cueing stimulated recall interviews (Lyle, 2003), several researchers have shown the influence of the score on interactive coaches' decision-making during games (Debanne & Fontayne, 2009; Gilbert, Trudel, & Haughian, 1999). Other researchers, through systematic observation of team coaches' behaviors in a variety of team sports, have also shown the influence of the score on coaches' behavior (e.g., Gomez, Jimenez, Navarro, Lago-Penas, & Sampaio, 2011). A recent study on coaches' decision-making processes also showed the influence of game periods and the score on decision-making (Debanne, Angel, & Fontayne, 2014).

However, although coaches' activity appears to be crucial for team performance in a competitive situation (Horton, Baker, & Deakin, 2005), few studies have dealt with coaches' activities in a competitive context (Lyle & Vergeer, 2013). Competition is characterized by uncertainty of outcome and high stakes, and team-sport competitive situations are considered to be dynamic and complex environments (e.g., Lyle, 2002). They make up a specific subclass within the generic class of dynamic situations. In this kind of situation, the state of the process can change irrespective of

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operator action (Cellier, Eyrolle, & Mariné, 1997). In a literature review comparing novice and expert operators in a dynamic situation, Cellier et al. (1997) highlighted the greater skill of experts in anticipating future events. Therefore, a player's ability to anticipate appears to play an important role in performance. Furthermore, the coach's role must be to help his players build or update their understanding of the unfolding game. In a recent study on hammer throwing and rowing, Macquet and Stanton (2013) compared the consistency of athletes' and coaches' situated understanding at each point in time during training sessions and competitions. They indicated that the coach and the athlete might interpret quite differently the situation in which the athlete is involved and the athlete's behavior. This can be problematic because in collective activities, individuals need to perceive, interpret and anticipate situated understanding elements in relation to their role within the team (e.g., Salas, Prince, Baker, & Shrestha, 1995).

The team cognition approach focuses on how cognitive activity is shared or distributed among two or more interdependent individuals in the context of a complex and dynamic setting (Cooke, Gorman, & Winner, 2007). It refers to some of the processes that enable a team to function harmoniously, and can be investigated with a focus on the information flow (i.e., communication processes) that occurs during the course of coordination (e.g., Cooke et al., 2007). More precisely, Mohammed and Dumville (2001) argued that managing cognitive resources is perceived as a way to improve team adaptation to complex and dynamic environments (Mohammed & Dumville, 2001). So, the aim of this study was to investigate the information content expressed by coaches when helping the players of a handball team build or update their understanding of the unfolding game. The focus was on how this content fits into the task-work/teamwork taxonomy usual in team cognition research and the procedural/declarative knowledge taxonomy from cognitive psychology.

Situated understanding of players and underlying processes in teams

During their activity and in light of events that arise, team members have to adjust their behaviors in real time in order to optimize team performance. These real-time adjustments can be performed through explicit coordination modalities (e.g., verbal communication) when the opportunities for coordination (Cannon-Bowers & Bowers, 2006) available to the players are sufficient (e.g., the coach can speak freely and has time to do so).

Salas, Dickinson, Converse, and Tannenbaum (1992) defined a team as a set of two or more individuals who interact interdependently and adaptively toward a common goal or objective. From this definition, we included the coach as a team member, considering that the opportunities for coordination with the players are several, and a heuristic approach was utilized to assess verbal communication during the unfolding game. In order to provide players with information and ensure a collective understanding of the way the game is evolving, the coach can speak to a given player or to all team members, which has been named “talking to the room” in medical emergency settings (Waller & Uitdewilligen, 2008). These communications aim to manage the situated understanding that each team member builds of the events, and *in fine* contribute to challenging their knowledge.

Understanding and shared understanding

The knowledge mobilized by each individual player to understand the game at a given instant makes it possible to generate expectations and plan future courses of action (Klein & Hoffman, 2008), recognize and remember relationships among components of the environment, construct expectations of what is likely to occur next (Rouse & Morris, 1986), draw inferences, make predictions, and finally experience events vicariously (Johnson-Laird, 1983). Although situated understanding is an individual-level phenomenon, to enhance our understanding of team cognition in teams, researchers have examined the extent to which knowledge is similar among team members (e.g., Cannon-Bowers, Salas, & Converse, 1993; Klimoski & Mohammed, 1994). The concept of shared understanding (Eccles & Tenenbaum, 2004) refers to the way team members are on the same page and thus are able to make similar sense of the unfolding events (e.g., Cannon-Bowers et al., 1993; Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000). It fosters mutual expectations that allow team members to coordinate and make predictions about their team members' behavior and needs (Cannon-Bowers et al., 1993). Its function is to allow team members to draw on their situated situation model, and subsequently select actions that are consistent and coordinated with those of their team members (Mathieu et al., 2000).

However, some researchers have argued that in organizational settings, there are many situations in which understanding was more efficiently distributed among team members than shared by them (e.g., Banks & Millward, 2009). Indeed, many teams, especially in real-world contexts, do not need to share a collective understanding, because they require distinct roles or expertise and thus cannot fully adopt a similar view of the task. As a result, the concept of distributed situation awareness (Stanton et al., 2006) has provided a basis for understanding situated cognition in distributed systems, specifically cognition that relies on making sense of a collective and shared setting, naturalistic decision-making, the cognitive basis of teamwork, etc. (Banks & Millward, 2009). This standpoint is of interest for sport science studies, in that sport teams are usually organized in such a way that roles have been defined. Some studies in a team sport context supported the idea that individual situated understandings were more efficiently distributed among group members than shared by them. Indeed, Bourbousson, Poizat, Saury, and Sève (2010) revealed that in the dynamics of the match situation and at the level of activity that was meaningful for the players, mutuality was infrequently observed and team coordination was not based primarily on this mechanism. Players were often engaged in dealing with a direct opponent or interacting with certain preferred partners, leaving little time for interaction with teammates in a mutual or exhaustive manner. Bourbousson, Poizat, Saury, and Sève (2011) highlighted that mobilized knowledge was rarely shared by all members of the team. Debanne and Fontayne (2009), using a video-cueing recall simulated interview approach (Lyle, 2003), found specific types of exchanges related to team organization between a top-level handball coach and his playmaker. These results suggest the importance of a “local sharing of understanding” (Bourbousson et al., 2010, 2011) in team sports, albeit only by certain players.

Shared understanding components

Many researchers have found that shared understanding is based on (a) task-work and teamwork, and (b) declarative and procedural knowledge (see Eccles & Tenenbaum, 2007). Indeed, for many years, the theoretical literature on shared understanding in organizational psychology has maintained that team members' understanding of their setting can be related to two distinct domains (Cannon-Bowers et al., 1993). Indeed, during a performance episode, team members engage in both task-work and teamwork processes. Individual task-work is defined as the components of a team member's performance that do not require interdependent interaction with other team members. In contrast, teamwork is defined as the interdependent components of performance required to effectively coordinate the performance of multiple individuals (Salas, Cooke, & Rosen, 2008, p. 244). This taxonomy has been highlighted as being most frequently used and fruitful in the literature on team cognition (Uitdewilligen, Waller, & Zijlstra, 2010), as mobilized in various empirical studies (e.g., Lim & Klein, 2006; Mathieu et al., 2000). Furthermore, the theoretical literature on shared understanding has also focused on the forms of shared understanding that are declarative or procedural knowledge. Declarative knowledge is defined as “things we are aware we know and can usually describe to others” (Anderson & Lebiere, 1998: 5), whereas procedural knowledge is defined as a process-oriented understanding of a given problem domain (Glaser, 1984). It is implemented by production rules (Anderson, 1996), and associated with “how” teammates coordinate their actions in order to improve team performance (Klimoski & Mohammed, 1994).

Team cognition and team performance: the need to update shared understanding

Abundant previous research suggested that shared understanding enhances team performance (e.g., Lim & Klein, 2006; Mathieu et al., 2000; Mathieu, Rapp, Maynard, & Mangos, 2010). More specifically, several previous investigations have established a link between the task and the team-related shared understanding possessed by team members, and team processes or effectiveness (e.g., Mathieu et al., 2010). Using a sample of 422 air traffic controllers representing 43 Navy teams from land-based towers, these researchers drew from Smith-Jentsch, Baker, Salas, and Cannon-Bowers (2001) account of air traffic controllers team coordination requirements and the work of Smith-Jentsch, Mathieu, and Kraiger (2005) to develop their shared situated understanding measures for air traffic controllers teams. Their index of task-related shared understanding was based on the cue–strategy association shared understanding measure as well as a thorough task analysis of Navy ATC environments, and their index of team-related shared understanding was also assessed using a measure (i.e., positional-goal interdependencies shared understanding) developed by Smith-Jentsch et al. (2005). Team effectiveness was assessed using another scale developed by Smith-Jentsch et al. (2001). They found a significant positive correlation between task-related shared understanding and team effectiveness, and that team-related shared understanding did not positive correlate with team effectiveness. However, assessing the relevance of the task-work/teamwork distinction on team effectiveness, Lim and Klein (2006) underlined that while team members may all subscribe to similar situation models, these may nevertheless be quite inaccurate. This research highlighted the importance of situation-shared understanding accuracy to team performance. The results of this research suggest mainly that (a) a shared understanding of the setting is not sufficient to ensure team performance, and (b) the accuracy of the knowledge about the unfolding events held in common by team members is a critical factor of shared understanding efficiency. The concept of accuracy has been discussed previously in sport sciences by Bourbousson et al. (2011) in their study of shared understanding within a basketball team. They proposed that this concept could be discussed by investigating the way in which team members update their individual and shared understanding of their evolving and uncertain common setting. This updating implicitly spotlights the accuracy of the shared knowledge to be refashioned in light of new events. In their exploratory study, Bourbousson et al. (2011) made use of individual self video-cued recall interviews to obtain a temporal and step-by-step description of how each individual player experienced dynamically his game. Then after, the authors synchronized the individual courses of action respectively to highlight how and when their understanding was shared: they pointed out that, most of the time, players refashioned their knowledge similarly without using explicit communication. However, they also stressed a specific case of shared understanding (called “fragmentation of a shared knowledge element”) in which players did not update their understandings similarly, leading the authors to encourage an investigation of real-time shared understanding management. In the present study, we assume that a focus on the coach's activity might be a first step in this direction.

Banks and Millward (2007) have explored the relationship between the organization of knowledge in teams and team performance by differentiating between declarative and procedural knowledge. They investigated dyadic team performance on a PC-based tank simulation game, and concluded that (a) accurate procedural knowledge was positively associated with team performance, and (b) shared procedural knowledge was negatively associated with team performance. Moreover, Banks and Millward (2007) supported the idea that while declarative knowledge should be shared, it was most efficient and effective for team members to hold only the procedural knowledge that is relevant to their task. This means that if team members have distinct roles, it might not be necessary for team members to share all procedural knowledge. While a procedural and declarative knowledge taxonomy was highlighted as an important feature for understanding performance settings, we should also note that this taxonomy has not been imported to date from organizational psychology to a sports team cognition investigation. For all of these reasons, and because this taxonomy appears to be particularly relevant in light of distributed situation awareness assumptions, the present study incorporates these concepts in the contents analysis of the information flow that the coach directs to players.

The aim of the present study was to investigate the information content expressed by coaches, and analyze how this content fits into usual task-work/teamwork and procedural/declarative taxonomies in order to help handball team members acquire or update their situated understanding. Based on this rationale, we make the following hypotheses:

1. Coaches will express more information intended to manage the players' situated understanding that is directed toward task-work as opposed to teamwork;
2. Coaches will express more information intended to manage the players' situated understanding that is directed toward procedural knowledge as opposed to declarative knowledge;
3. Differences will exist in the type of information expressed by the coach in relation to moments of the game and relative ability of the two teams;
4. When managing the players' teamwork understanding, coaches will communicate more procedural knowledge information to the playmaker than to the other players;
5. When managing the players' task-work understanding, coaches will communicate the information related to procedural knowledge more to individual players than to many players or to the entire team.

Method

The research was approved by the local Ethics Committee of first author's university.

Participants

We contacted all of the French professional first- and second-division coaches ($N = 28$) by telephone, presenting them the general purpose of the study. We asked them to participate in the study and wear a Dictaphone belt and a lapel microphone during the game (starting about 30 min before throw-off) so that their comments could be recorded throughout the entire game. Each game was video recorded in order to determine precisely with which player the coach communicated. For the sake of confidentiality and to protect anonymity, the coaches were informed that the time of data submission would be shifted from the time of collection by at least one sports season and that no information would identify them. Despite these precautions, only three first-division head coaches, aged ($M = 44.33$ years, $SD = 6.02$), and with ($M = 12.00$ years, $SD = 6.53$) of experience as professional coaches, known personally by the first author, agreed to participate in this study. Nevertheless, before the start of the study, they were asked to test the device during a non-official game, to ensure that they would not be hindered. Other coaches justified their refusal by stating that what happens within the team concerns team members alone and no one else. This difficulty to approach coaches during the competition period has been already noted by Gomez et al. (2011).

Procedure

Data collection

We chose the games to be included jointly with the coaches prior to the study. These were held during the 2010/2011 season, between the 14th and 24th day of the French men's championship. The first coach was monitored during four games, the second during six, and the third during five, for a total of 15 games, all of which were home games. Data were collected between the first and the final whistle of the game. Verbal communication was collected using the digital voice recorder connected to the microphone. All audio recordings were transcribed and constitute a corpus of 122 pages.

Preparation of the data

We removed (a) all communications between the coach and all other actors (referees, his assistant, medical staff, officials [scorekeeper, timekeeper, delegate]) of the game, except for his own players, (b) criticism or praise, and (c) truisms (i.e., comments made by the coach stating the obvious), as mentioned by Hastié (1999), in order to select only information provided by coaches that allows players to acquire a situated understanding.

Definition of the unit of analysis and division of the corpus into elementary units

Before dividing the corpus into elementary units, we defined the unit of analysis, one of the most fundamental and important decisions (Weber, 1990). As is usually the case, we chose a meaningful theme as the unit of analysis rather than physical linguistic units, such as words or sentences. In this sense, a meaningful unit would be a “segment of text that is comprehensible by itself and contains one idea, episode, or piece of information” (Tesch, 1990, p. 116).

Based on this definition, the first author and another sport psychology researcher ([Ph. D], specializing in team sport contexts and experienced in qualitative methods of research) randomly chose one of the 15 matches and separately divided the corpus into meaningful units. The first author divided the match transcript into 214 meaningful units, and the sport psychologist into 216 meaningful units. Of these, 198 meaningful units were shared by both coders, indicating satisfactory inter-coder agreement (92.5%). Special attention was paid to the parts of corpus that were not divided similarly by the coders and the discussion that ensued systematically resulted in a consensus on the interpretation. Then, on that basis the corpus was divided into meaningful units ($n = 3204$).

Data analysis

In a first step, a deductive content analysis was performed to analyze the transcripts. Content analysis is a research technique used to make replicable and valid inferences from texts to the contexts of their use (Krippendorff, 2004). The deductive approach is based on theoretical constructs and categories used as a basis for categorization (Biddle, Markland, Gilbourne, Chatzisarantis, & Sparkes, 2001). Thus, the transcript was divided into (a) teamwork understanding (coded A), (b) task-work understanding (B), and (c) miscellaneous (M). They were also divided into four first-order themes (a) Teamwork Understanding × Procedural Knowledge (T_{eU}_P_K [for example: “Put pivot on right and play inversion for Olivier”]), (b) Teamwork Understanding × Declarative Knowledge (T_{eU}_D_K [for example: “They use zone-defence. The antidote is: wings in the corner and play inversion between playmaker and back”]), (c) Task-work Understanding × Procedural Knowledge (T_{aU}_P_K [for example: “Shoot up or down but not in the middle.”]), and (d) Task-work Understanding × Declarative Knowledge (T_{aU}_D_K [for example: “This goalkeeper goes on the primary intention.”]), (see Table 1).

In a second step, in order to test the reliability of the coding scheme, 50 semantic units were selected randomly and classified by the first author and the sport psychologist. Special attention was paid to meaning units that were not assigned to the same categories by the coders, and the discussion that ensued systematically resulted in a consensus on interpretation. Then, on the basis of this analysis grid, the two coders classified all of the semantic units ($n = 3204$) in the various categories. Reliability points were estimated using a Kappa index (k) which represents the normalized proportion of inter-observer agreement in excess of what would be expected on the basis of chance or random assignments. Because of the utilized software's limited computational capacity, 999 units were chosen randomly using the alea function of Excel software. We then used MacKappa software to calculate both general and conditional coefficients and to test the statistical significance of agreement among many observers assigning objects to nominal scales as based on Fleiss' (1971) computational formulae. The overall Kappa revealed a considerable rate of agreement between the coders ($k = .85$; $z = 33.76$, $p < .0001$). All of the conditional coefficients were also high and significant (see Table 1). Taken as a whole, these results showed acceptable reliability of the coding.

Trustworthiness of the content analysis

The trustworthiness of this content analysis was reflected in investigator triangulation. This consisted of independent data coding and comparison and discussion of the coding until consensus was reached (Sparkes & Partington, 2003), in order to minimize any possible experimenter bias in the interpretation of the data (e.g., Gould, Eklund, & Jackson, 1992).

Statistical analysis

The first step consisted in dividing the attack and defense phases of each of the 15 observed games ($n = 1823$) into sequences in order to take two variables into account:

1. The following game periods, (a) first half of the first half-time (coded P11), (b) second half of the first half-time (P12), (c) break-time period (BTP), (d) first half of the second half-time (P21), and (e) second half of the second half-time (P22).
2. We assigned the score difference between the two teams (Δ score) to each of these game periods. It was (a) unfavorable when the mean of the score difference between the teams ($M_{\Delta\ score}$) was strictly less than two (coded UNFAV), (b) balanced when $-2 \leq M_{\Delta\ score} \leq 2$ (BAL), and (c) favorable when $M_{\Delta\ score} > 2$ (FAV), (see Table 2).

Table 1
Content analysis of transcripts.

Categories	1st Order theme	2nd Order theme	Example	Code	N (%)	Kappa	Z
Teamwork understanding	Procedural knowledge	Playmaker	Put pivot on right and play inversion for Olivier.	$T_{eU}\_P_{K\_PM}$	227 (7.17)	.79	9.30**
		Other players or Team	When Cédric goes inside, he is between the $n°2$ and the $n°3$.	$T_{eU}\_P_{K\_OP}$	268 (8.46)		
	Declarative knowledge		They use zone-defence. The antidote is: wings in the corner and play inversion between playmaker and back.	$T_{eU}\_D_K$	45 (1.42)	.39	2.29*
Taskwork understanding	Procedural knowledge	One specific player	Run to the goal. Speeds.	$T_{aU}\_P_{K\_OSP}$	365 (11.52)	.72	8.57**
		Many players or Team	Shoot up or down but not in the middle.	$T_{aU}\_P_{K\_MP}$	329 (10.39)		
	Declarative knowledge		This goalkeeper goes on the primary intention.	$T_{aU}\_D_K$	223 (7.04)	.61	5.98**
Miscellaneous	Miscellaneous		Encouragements. Negative feedbacks. Communications with (a) referees, (b) assistant, (c) federation delegate, etc.	M	1747 (54.01)	.88	9.15**
Overall					3204 (100.00)	.85	33.76**

Note. *$p < .05$; **$p < .01$.

In the second step, we divided the data analysis into two sub-steps. First, in order to determine the effects of variance in situated understanding and thereby verify the first, second and third hypotheses, we performed a Multivariate analysis of variance (MANOVA) using a 5 (Game Periods: P11 vs. P12 vs. BTP vs. P21 vs. P22) × 3 (Δ score: BAL vs. FAV vs. UNFAV) factorial design. Where a significant MANOVA was observed, follow-up ANOVAs with repeated-measures and Fisher's post-hoc were performed to identify the variables contributing to the multivariate effect. Finally, in order to test the fourth and fifth hypotheses, we added second-order themes to determine the player(s) with whom the coach communicated. For procedural knowledge in teamwork understanding, second-order themes are (a) playmaker (coded $T_{eU}\_P_{K\_PM}$), or (b) other individual players, group or the team ($T_{eU}\_P_{K\_OP}$). For procedural knowledge in task-work understanding, second order themes are (a) one specific player ($T_{aU}\_P_{K\_OSP}$), or (b) many players or the team ($T_{aU}\_P_{KMP}$). Data analysis was performed using a repeated-measures analysis of variance with Fisher's post-hoc for $T_{eU}\_P_{K\_PM}$, $T_{eU}\_P_{K\_OP}$, $T_{aU}\_P_{K\_OSP}$ and $T_{aU}\_P_{K\_MP}$ occurrences, (a) without distinguishing between game periods, and (b) for the two match half-times (excluding the break-time period).

Results

Variance in information

The 5 × 3 MANOVA performed on first-order themes (i.e., $T_{eU}\_P_K$, $T_{eU}\_D_K$, $T_{aU}\_P_K$, $T_{aU}\_D_K$) revealed (a) a significant main effect for game period, Wilks' $\lambda = 0.38$, $F(16, 174.77) = 4.04$, $p < .0001$, $\eta^2 = .27$, and a significant main effect for Δscore, Wilks' $\lambda = 0.76$, $F(8, 114) = 2.07$, $p = .04$, $\eta^2 = .13$, and (b) one significant Game Period × Δscore interaction effect, Wilks' $\lambda = 0.55$, $F(32, 211.80) = 1.15$, $p = .27$, $\eta^2 = .15$.

Depending on the two significant main effects, follow-up ANOVA with similar repeated measures were then conducted separately for information.

The 5 × 3 ANOVA with repeated measures on the four first-order themes (i.e., $T_{eU}\_P_K$, $T_{eU}\_D_K$, $T_{aU}\_P_K$, $T_{aU}\_D_K$) revealed a significant difference, $F(3, 180) = 74.56$, $p < .0001$, $\eta^2 = .55$, in the information provided by the coaches ($ps < .01$). Indeed, coaches expressed more information corresponding to $T_{aU}\_P_K$ ($M = 9.25$, $SD = 5.47$) than information corresponding to $T_{eU}\_P_K$ ($M = 6.60$, $SD = 4.41$), and $T_{aU}\_P_K$ ($M = 2.97$, $SD = 3.23$), or $T_{eU}\_D_K$ ($M = 0.60$, $SD = 1.14$). These results are shown in Fig. 1a.

ANOVA with repeated measures revealed a significant main effect of game periods on the information (i.e., $T_{eU}\_P_K$, $T_{eU}\_D_K$, $T_{aU}\_P_K$, $T_{aU}\_D_K$) expressed by the coaches, $F(4, 60) = 12.34$, $p < .0001$, $\eta^2 = .45$. Fisher's Post hoc comparisons revealed significant differences between the second half of the first half-time ($M = 5.12$, $SD = 2.12$), the break-time period ($M = 5.92$, $SD = 1.59$), and all other game periods ($M = 2.81$, $SD = 1.47$, for P11; $M = 2.87$, $SD = 0.85$, for P21; and $M = 2.70$, $SD = 1.10$, for P22), ($ps < .001$). These results are shown in Fig. 1b.

Fisher's post hoc comparisons of ANOVA with repeated measures, $F(2, 60) = 3.42$, $p = .04$, $\eta^2 = .10$, revealed significant differences ($ps < .05$) in the information provided by the coaches, between a balanced Δscore ($M = 4.40$, $SD = 2.29$) and an unfavorable Δscore ($M = 3.60$, $SD = 1.66$) or favorable Δscore ($M = 3.57$, $SD = 1.93$).

ANOVA with repeated measures revealed a significant Information × Game Periods interaction effect, $F(12, 180) = 2.31$, $p = 0.009$, $\eta^2 = .13$. Then, Fisher's post-hoc tests ($p < .05$) were performed, comparing information and game periods two by two. These tests revealed many significant effects (see Table 3).

Next, ANOVAs with repeated measures, with intra effect of game period, were performed, comparing information two by two. These

Table 2
Number of game periods per types of ratio of strength.

Game periods	Ratio			
	BAL	FAV	UNF	TOTAL
P11	11	1	3	15
P12	4	4	7	15
BTP	6	4	5	15
P21	5	5	5	15
P22	1	6	8	15
TOTAL	27	20	28	75

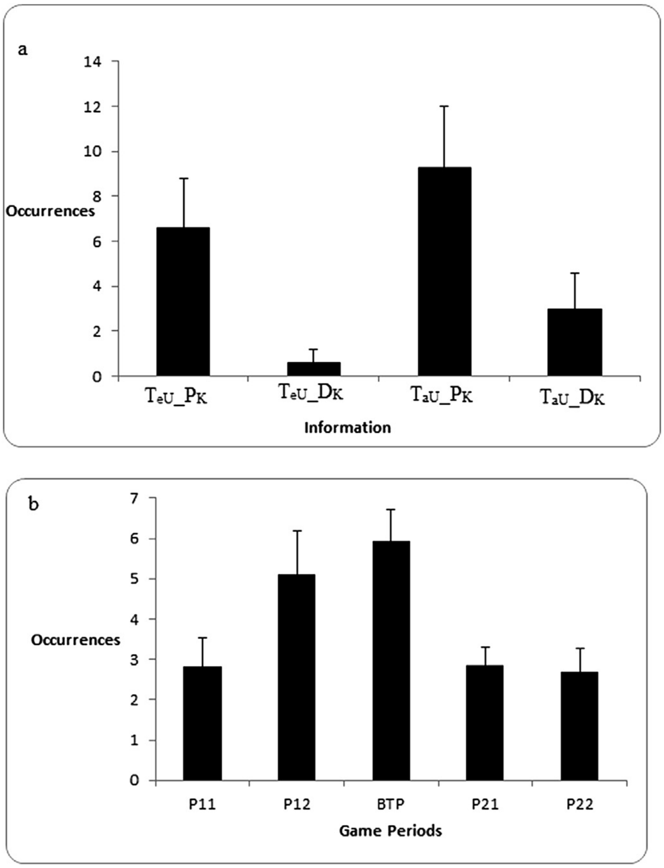

Fig. 1. Breakdown of information.

ANOVAs revealed (a) a significant Information ($T_{eU}\_D_K$ vs. all other first order themes) × Game Periods interaction effect, $F(4,70)$ ranged from 3.36 to 6.74, $ps < .01$, η^2 ranged from 0.16 to 0.28, and (b) a trend Task-work Understanding ($T_{aU}\_P_K$ vs. $T_{aU}\_D_K$) × Game Periods interaction effect, $F(4,70) = 2.19$, $p = .08$, $\eta^2 = .11$.

In order to more comprehensively explore the change in information between the various periods, ANOVAs with repeated measures were performed, comparing information and game periods two by two. These tests revealed many significant effects (see Table 4).

ANOVA with repeated measures revealed a significant Information × Δscore interaction effect, $F(6, 180) = 2.7$, $p = .01$, $\eta^2 = .08$. Then, ANOVAs with repeated measures, with intra effect of Δscore, were performed, comparing the types of information two by two. These ANOVAs revealed:

1. A significant (a) Procedural Information ($T_{eU}\_P_K$ vs. $T_{aU}\_P_K$) × Δscore interaction effect, $F(2,72) = 4.56$, $p = .01$, $\eta^2 = .11$, (b) Declarative Information ($T_{eU}\_D_K$ vs. $T_{aU}\_D_K$) × Δscore interaction effect, $F(2,72) = 3.47$, $p = .04$, $\eta^2 = .09$, and (c) Information ($T_{eU}\_D_K$ vs. $T_{aU}\_P_K$) × Δscore interaction effect, $F(2,72) = 3.92$, $p = .02$, $\eta^2 = .10$.
2. A trend (a) Teamwork Understanding ($T_{eU}\_P_K$ vs. $T_{eU}\_D_K$) × Δscore interaction effect, $F(2,72) = 2.81$, $p = .07$, $\eta^2 = .07$, and (b) a trend Information ($T_{eU}\_P_K$ vs. $T_{aU}\_D_K$) × Δscore interaction effect, $F(2,72) = 2.78$, $p = .07$, $\eta^2 = .07$. Descriptive statistics are showed in Table 5.

Finally, to explore the difference more completely, ANOVAs with repeated measures were performed between each type of information and each difference in score between the two teams. These ANOVAs highlighted seven interaction effects (see Table 6). Concerning the information directed to procedural knowledge, when the score difference is unfavorable, coaches expressed more information corresponding to $T_{eU}\_P_K$ ($M = 7.50$, $SD = 4.67$) and less information corresponding to $T_{aU}\_P_K$ ($M = 7.46$, $SD = 4.77$) than when the score difference is balanced ($T_{eU}\_P_K$ [$M = 6.93$, $SD = 4.89$]; $T_{aU}\_P_K$ [$M = 10.93$, $SD = 5.84$]) or favorable ($T_{eU}\_P_K$ [$M = 4.90$, $SD = 2.79$]; $T_{aU}\_P_K$ [$M = 9.50$, $SD = 5.36$]). Concerning the information directed to declarative knowledge, when the score difference is unfavorable, coaches expressed more information corresponding to $T_{eU}\_D_K$ ($M = 0.79$, $SD = 1.26$) and less information corresponding to $T_{aU}\_D_K$ ($M = 2.29$, $SD = 2.46$) than when the score difference is balanced ($T_{eU}\_D_K$ [$M = 0.26$, $SD = 0.53$]; $T_{aU}\_D_K$ [$M = 3.93$, $SD = 4.00$]). Concerning the information directed to team-work understanding, when the score difference is favorable coaches expressed less information corresponding to $T_{eU}\_P_K$ ($M = 4.90$, $SD = 2.79$) than when the score difference is unfavorable ($M = 7.50$, $SD = 4.67$) or balanced ($M = 6.93$, $SD = 4.89$); and when the score difference is balanced, coaches expressed less information corresponding to $T_{eU}\_D_K$ ($M = 0.26$, $SD = 0.53$) than when the score difference is favorable ($M = 0.80$, $SD = 1.47$) or unfavorable ($M = 0.79$, $SD = 1.26$). Concerning the information directed to $T_{eU}\_P_K$ and $T_{aU}\_D_K$, when the score difference is unfavorable, coaches expressed more information corresponding to $T_{eU}\_P_K$ ($M = 7.50$, $SD = 4.67$), and less information corresponding to $T_{aU}\_D_K$ ($M = 2.29$, $SD = 2.46$) than when the score difference is favorable ($T_{eU}\_P_K$ [$M = 4.90$, $SD = 2.79$], $T_{aU}\_D_K$ [$M = 2.65$, $SD = 2.85$]). Concerning the information directed to $T_{eU}\_D_K$ and $T_{aU}\_P_K$, when the score difference is unfavorable, coaches expressed more information corresponding to $T_{eU}\_D_K$ ($M = 0.79$, $SD = 1.26$), and less information corresponding to $T_{aU}\_P_K$ ($M = 7.46$, $SD = 2.46$) than when the score difference is balanced ($T_{eU}\_D_K$ [$M = 0.26$, $SD = 0.53$], $T_{aU}\_P_K$ [$M = 10.93$, $SD = 2.85$]).

Table 3
Means and Standard Deviations (in parenthesis) of type of information expressed by coaches per game period.

Game period	Information			
	$T_{eU}\_P_K$	$T_{eU}\_D_K$	$T_{aU}\_P_K$	$T_{aU}\_D_K$
BTP	$9.47^{a,b}$ (4.61)	$1.13^{a,c,d}$ (1.64)	$12.13^{c,e}$ (5.14)	$6.87^{b,d,e}$ (4.12)
P11	$3.87^{a,b}$ (3.09)	$0.13^{a,c,d}$ (0.352)	$8.47^{c,e}$ (5.49)	$1.60^{b,d,e}$ (1.59)
P12	$9.27^{a,b}$ (4.49)	$0.87^{a,c,d}$ (1.46)	$12.20^{c,e}$ (6.61)	$3.27^{b,d,e}$ (3.10)
P21	$5.20^{a,b}$ (3.00)	$0.53^{a,c,d}$ (0.91)	$7.00^{c,e}$ (3.23)	$1.60^{b,d,e}$ (1.12)
P22	$5.20^{a,b}$ (3.78)	$0.33^{a,c,d}$ (0.62)	$6.47^{c,e}$ (3.85)	$1.53^{b,d,e}$ (1.51)
Total	$6.60^{a,b}$ (4.41)	$0.60^{a,c,d}$ (1.14)	$9.25^{c,e}$ (5.47)	$2.97^{b,d,e}$ (3.23)

Note. Significant difference ($p < .05$) for Fischer is noted: (for teamwork understanding) a = difference between $T_{eU}\_P_K$ and $T_{eU}\_D_K$; b = difference between $T_{eU}\_P_K$ and $T_{aU}\_D_K$; c = difference between $T_{eU}\_D_K$ and $T_{aU}\_P_K$; (for declarative knowledge) d = difference between $T_{eU}\_D_K$ and $T_{aU}\_D_K$; (for task-work understanding) e = difference between $T_{aU}\_P_K$ and $T_{aU}\_D_K$.

Breakdown of coaches' information related to procedural knowledge

In this section, the aim is to test our fourth and fifth hypotheses (i.e., coaches communicate more information related to procedural knowledge allowing players to understand teamwork with the playmaker than with other players, and coaches communicate more information related to procedural knowledge allowing players to understand the teamwork with the playmaker [$T_{eU}\_P_{K\_PM}$] than with other players [$T_{eU}\_P_{K\_OP}$], and more information related to procedural knowledge allowing players to understand the task-work with individual players [$T_{aU}\_P_{K\_OSP}$] than with many players or the entire team [$T_{aU}\_P_{K\_MP}$]).

Table 4
Information expressed by coaches per game periods.

Game periods	Variables									
	T_{eU} (T_{eU}_P_K − T_{eU}_D_K)		T_{eU}_P_K − T_{aU}_D_K		T_{eU}_D_K − T_{aU}_P_K		Decl. Know. (T_{eU}_D_K − T_{aU}_D_K)		T_{aU} (T_{aU}_P_K − T_{aU}_D_K)	
	$F_{(1,28)}$	η^2	$F_{(1,28)}$	η^2	$F_{(1,28)}$	η^2	$F_{(1,28)}$	η^2	$F_{(1,28)}$	η^2
P11–P12	11.53^{**}	.29	4.94^{*}	.15						
P11–BTP	9.14^{**}	.25					11.29^{**}	.29		
P12–BTP							4.79^{*}	.15	3.87^{+}	0.12
P12–P21	7.64^{**}	.21			6.50^{*}	.19				
P12–P22	5.83^{*}	.17			6.85^{**}	.20				
BTP–P21	5.97^{*}	.17			7.27^{**}	.21	13.54^{***}	.33		
BTP–P22	4.68^{*}	.14			7.56^{**}	.21	12.79^{***}	.31		

Note. * = $p \le .05$; ** = $p \le .01$; *** = $p \le .001$; + = $p = .06$; T_eU = Teamwork Understanding; T_{aU} = Task-work Understanding; Decl. Know. = Declarative Knowledge.

A significant ANOVA with repeated measures for T_{eU}_P_{K_PM}, T_{eU}_$P_{K\ OP}$, T_{aU}_P_{K_OSP} and T_{aU}_P_{K_MP} occurrences, $F(3, 222) = 4.72$, $p = .003$, $\eta^2 = .06$, revealed no significant Fisher's post hoc comparisons ($ps > .05$) between (a) T_{eU}_$P_{K\ PM}$ and T_{eU}_$P_{K\ OP}$, and (b) T_{aU}_P_{K_OSP} and T_{aU}_P_{K_MP} .

However, during the two half-times (excluding the break-time period), Fisher's post hoc comparisons of significant ANOVA with repeated measures for T_{eU}_$P_{K\ PM}$, $A1_{OP}$, T_{aU}_P_{K_OSP} and T_{aU}_P_{K_MP} occurrences, $F(3, 177) = 15.71$, $p < .0001$, $\eta^2 = .24$, revealed significant differences ($ps < .05$) between (a) T_{eU}_$P_{K\ PM}$ ($M = 3.35$, $SD = 2.72$) and T_{eU}_$P_{K\ OP}$ ($M = 2.53$, $SD = 2.04$), and (b) T_{aU}_P_{K_OSP} ($M = 5.39$, $SD = 3.78$) and T_{aU}_P_{K_MP} ($M = 3.15$, $SD = 2.24$).

Discussion

The aim of this study was to investigate the information content expressed by coaches when helping players of a handball team build or update their understanding of the unfolding game. The focus was on how this content fits into the task-work/teamwork taxonomy usual in team cognition research and the procedural/declarative knowledge taxonomy from cognitive psychology.

First, in accordance with hypotheses one and two, the results were consistent with the expectation that coaches would primarily provide information related to procedural knowledge and task-work understanding. Indeed, it was expected that the coaches would provide more information fostering acquisition of task-work understanding than information fostering acquisition of teamwork understanding, and more information allowing players to acquire procedural knowledge than information allowing them to acquire declarative knowledge. These results contrast with those of Bourbousson et al. (2011) who, in analyzing the knowledge that is mobilized and shared by teammates in an official basketball game, pointed out that most of the knowledge implicated in team cognition was related primarily to the team itself, rather than the task (i.e., game characteristics of the opposing team). In highlighting that the coaches were mostly involved in task-related activities when they manage the shared understanding that should be built by the players during the ongoing game, our study thus call for further investigation of how players' and coach's understandings can complementary be built respectively (teamwork and task-work combination across team members).

Table 5
Means and Standard Deviations (in parenthesis) of use of type of information expressed by coaches depending on score difference.

Score difference	Information			
	T_{eU}_P_K	T_{eU}_D_K	T_{aU}_P_K	T_{aU}_D_K
FAV	$4.90^{a,b}$ (2.79)	$0.80^{a,c,d}$ (1.47)	$9.50^{c,e}$ (5.35)	$2.65^{b,d,e}$ (2.85)
BAL	$6.93^{a,b}$ (4.89)	$0.26^{a,c,d}$ (0.52)	$10.93^{c,e}$ (5.84)	$3.93^{b,d,e}$ (4.00)
UNF	$7.50^{a,b}$ (4.67)	$0.79^{a,c,d}$ (1.25)	$7.46^{c,e}$ (4.77)	$2.29^{b,d,e}$ (2.46)
Total	$6.60^{a,b}$ (4.41)	$0.60^{a,c,d}$ (1.14)	$9.25^{c,e}$ (5.47)	$2.97^{b,d,e}$ (3.23)

Note. Significant differences ($p < .05$) for Fischer's comparisons are noted: (for teamwork understanding) a = difference between T_{eU}_P_K and T_{eU}_D_K; b = difference between T_{eU}_P_K and T_{aU}_D_K; c = difference between T_{eU}_D_K and T_{aU}_P_K; (for declarative knowledge) d = difference between T_{eU}_D_K and T_{aU}_D_K; (for task-work understanding) e = difference between T_{aU}_P_K and T_{aU}_D_K.

The third hypothesis, pertaining to the different effects of game periods or the score difference between the two teams and the information provided by the coach was also supported: our results highlight a game periods main effect, in that coaches provided more information allowing players to update their situated understanding during the second half of the first half-time and during the break-time period than during all other game periods. There can be many reasons for this game period main effect. Indeed, as indicated by Smith and Cushion (2006), during the first half of the first half-time, coaches observe the interactions between the teams and compare their game plans to game reality. Following this game observation phase (P11), the coaches provide the greatest quantity of information allowing their players to update their situated understanding during the second half of the first half-time (P12).Then, the coaches continue to provide additional information during the BTP because, during this period, the players are not directly focused on the game, so they are more receptive, and coaches have time (15 min) to consult, think and decide. Finally, during the second half-time (P21 and P22), the quantity of information allowing players to acquire situated understanding decreases as they apply that received during P11.

This decrease in occurrences is comparable to studies describing players' individual activity in table tennis. Sève, Saury, Theureau, and Durand (2002) observed that players spent a great deal of time at the beginning of their match testing the validity of their knowledge, and deconstructing and reconstructing this knowledge in order to build as accurate a situation model as possible. This knowledge construction/deconstruction activity stopped as the end of match approached and it became difficult for the players to rebuild a new strategic schema, at the risk of losing the match. As they approached the end of the match, the players preferred to apply the knowledge they held as certain and which they had updated during the previous part of the game. This same type of phenomenon can be observed in the information that the coaches provide their players. During the second part of the game, they provide much less information allowing the construction of situated understanding. Everything takes place as though it has become too risky for the team to change its strategy. This approach is supported by the fact that during numerous communication possibilities taken during the half-time, the coach provided a greater amount of information that the players had to take into account. It was assumed that this information would regulate the team's adaptation to the game proposed by the opposing team. So,

Table 6
Information expressed by coaches per match and per ratio of strength.

Score difference	Variables									
	TeU ($T_{eU}\_P_K - T_{eU}\_D_K$)		$T_{eU}\_P_K - T_{aU}\_D_K$		$T_{eU}\_D_K - T_{aU}\_P_K$		Decl. Know. ($T_{eU}\_D_K - T_{aU}\_D_K$)		Proc. Know. ($T_{eU}\_P_K - T_{aU}\_P_K$)	
	F	η^2	F	η^2	F	η^2	F	η^2	F	η^2
UNFAV-BAL $F_{(1,53)}$	001		2.58		7.65**	.13	5.52*	.09	5.52*	.09
UNFAV-FAV $F_{(1,46)}$	5.65*	.10	4.91*	.09	2.05		0.2		7.50*	.14
FAV-BAL $F_{(1,45)}$	4.57*	.09	.39		1.38		3.13		0.12	

Note. * = $p \leq .05$; ** = $p \leq .01$; TeU = Teamwork Understanding; Decl. Know. = Declarative Knowledge; Proc. Know. = Procedural Knowledge.

during the second half, it is probable that the coaches preferred to reduce the amount of new information given in order to guarantee minimal control of the information issued up to that point.

More precisely, the results highlight an Information × Game Periods interaction effect. Indeed, the information relating to structures of knowledge varies in different ways depending on the game period. The most interesting variations are those between P12 and BTP. Between these periods, the amount of declarative knowledge related to task-work understanding increases significantly in comparison with the procedural knowledge of the same models. This result supports the existence of a period during which it is particularly advantageous to provide explanations on the game via declarative knowledge. In the same manner, between P11 and P12, the increase of procedural knowledge related to teamwork is significantly greater compared to other declarative knowledge (i.e., $T_{eU}\_D_K$ vs. $T_{aU}\_D_K$). This result supports the existence of a period during which it is particularly advantageous to modify team organization in relation to the experience of the real game. The results also highlight a Score Difference main effect (the coaches communicate more information allowing players to acquire or update situated understanding when the Score Difference is balanced than in other contexts of Score Difference) and an Information × Score Difference interaction effect on the types of information expressed by the coaches. Indeed, the structures of knowledge vary in another way depending on the Score Difference. When the Score Difference is balanced or favorable, the coach can envisage the status quo, but cannot do so when the Score Difference is disadvantageous. In the first scenario, since everything is alright, the coach does not focus on his team's collective performance, but rather tries to provide information that will improve the players' individual performance ($T_{aU}\_P_K$). In the second case, the coach has to act in a more structural manner in order to rebalance the Score Difference. To this end, coaches increase the amount of information allowing the players to acquire or update their procedural knowledge with regards to team organization ($T_{eU}\_P_K$). It seems appropriate that coaches act in a more directive manner when their teams are struggling. These results are consistent with those of Debanne and Fontayne (2009).

Finally, the results support our fourth and fifth hypotheses. Indeed, during game periods (excluding break periods), the coaches' information related to procedural knowledge allowing players to understand teamwork is directed primarily to the playmaker rather than to other players. This result seems to agree with descriptive team running presented by Bourbousson et al. (2011), in which one team player was more sensitive to team organization than other players. Moreover, this result is also consistent with Debanne and Fontayne (2009) who showed that the coach placed great importance on the playmaker's position, both as a key point and tactician, and made adjustments through him. This specific player seems to act as an intermediary between the coach and his teammates. On the other hand, the results showed that the coaches communicate more information related to procedural knowledge allowing players to understand the task-work with individual players than with many players or the entire team. Thus, in accordance with Bourbousson et al. (2010), information allowing players to acquire procedural knowledge in task-work understanding is more distributed among teammates than shared, because on a handball team, each player has a specific position to play (goalkeeper, back, wing, pivot, playmaker) and the techniques used are very specific to each.

Practical implications and future research

Our results suggest some practical implications for coaches. These implications assumed that the coaches' activities under study were of high-level, and that their understanding is fruitful enough to guide and inspire handball coach teaching programs. First, it might be recommended to distinguish between game phases where coaches need to communicate with a view to managing team organization (second half of the first half-time when the Score Difference is unfavorable), and game phases where they must communicate with a view to managing individual player behavior (when the Score Difference is favorable). Second, it could be proposed to focus on the specific player-related procedural knowledge content communicated by the coach. More precisely, it seems indicated to construct specific relationships with the playmaker(s) so that he/they can direct the game by himself/themselves and/or pass on the coach's instructions. In order to effectively transmission and a minimal cognitive distribution of information issued by the coach, the playmaker could devote himself to sensitizing his teammates or communicating with them on the task's characteristics.

With regard to the decrease in the amount of information issued by the coach during the match, it would be interesting to develop team management methods allowing this decrease to be adapted to the situation throughout match. For example, empirically studying the information effect provided by the coach during the break-period on his ability to preserve efficient communication oriented by adapting to opponent pressures may be the focus of future endeavors. Moreover, an investigation of how team members perceive and take the coach's communication into account will also be quickly needed to advance our knowledge. For instance, recent studies have used verbalization data processing to account of the way a game can be experienced by participants (e.g., Poizat, Bourbousson, Saury, & Sève, 2012), and can interestingly help researchers to pursue this area of research.

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