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Making Sense of Decision Making in Invasion Team Sports - A Teaching/Learning Perspective in Physical Education

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Since the 1990s, decision making (DM) in sports has been extensively investigated, particularly through expert players' decisions made mostly in standardized contexts but also, to a lesser extent, in naturalistic settings. The purpose of this article is to re-examine the teaching/learning of decision making in invasion team sports in light of the contemporary research conducted with high-level performers. First, following a brief overview of the situation awareness (SA) construct, three decision making (DM) perspectives are presented: information processing (IP), naturalistic DM, and ecological dynamics (EcoD). In a second major section, invasion-team-sports (ITS) SA in PE is examined with regard to SA components and the differentiation of five SA facets. In a third major section, presenting implications for ITS DM learning in PE, the teaching/learning of ITS-DM is discussed with regard to beginner- and novice-level players in Physical Education. Constructing a shared reference-framework for DM through team reflection on game-play situations is also considered, namely with regard to critical-incidents analysis and unexpected play-occurrences. In a context of the teaching/learning of DM in ITS in school, the authors submit that precedence should be given to information processing and to recognition-primed perspectives. Resort to mental representation networks and recognition of familiar configurations of play is critical to establish situation awareness and learn to make appropriate decisions. Such an option fits well with a social constructivist view of DM learning.

Keywords: *invasion team sports, decision making, situation awareness, information processing, recognition-primed process*

Introduction

While many authors advocate a broad exposure of students to different situated physical activities (PA) throughout their physical education (PE) journey (Godbout 2021), there is no doubt that sports and games remain very present in numerous PE curricula. In relation to such activities, PE curricula recommend that students develop, among other skills, knowledge and competencies with regard to related strategies and tactics (e.g., Australian Curriculum, Assessment and Reporting Authority 2012, Department for Education [England] 2014, Ministère de l'Éducation Nationale 2010, Society of Health and Physical Educators [SHAPE] America 2014). While strategy and tactics do apply to various extents in individual

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and dual sports, these two constructs bear a particular significance in team sports, involving cooperation with teammates and opposition to opponents, both during attack and defense. Underlying and intimately linked to strategy and tactics is the notion of decision making; either while preparing for or during a match, players cannot avoid making choices, taking and enacting decisions.

In France, systematic interest for tactics and decision making in sports, as they relate to PE, can be traced back to the 1960s under the impetus of informed practitioners and PE teacher educators such as Robert Mérand, Justin Tessier and René Deleplace, themselves influenced by the German Friedrich Mahlo (1965, 1969) and the Romanian Leon Teodorescu (1965, 2013) (Bouthier 2016, Gréhaigne and Nadeau 2015). In England, the progressive development of the game-centered approach appears to have occurred in the 1970s (Thorpe and Bunker 1986), leading to the teaching games for understanding model and its "tactical awareness" and "making appropriate decisions" components (Bunker and Thorpe 1982). From then on, numerous game-centered approaches were developed in various countries (see Li et al. 2018, for a listing). In such student- and game-centered models, priority is given to game play in small-sided game setups and to tactical learning, technical skills being worked on as the need arises (Gréhaigne and Godbout 2021a). Before the 1980s, to the authors' knowledge, there was no formal and systematic PE instructional model for the teaching/ learning of tactical knowledge and decision making in sports in the USA, despite the fame of Muska Mosston's spectrum of teaching styles (Moston 1966) which could have opened a door, for instance, for the application of guided discovery and/or problem solving (now divergent discovery [Sicilia-Camacho and Brown 2008]) with regard to tactical/strategic learning in team sports.

Along with the development of game-centered instructional models, two student-centered pedagogical approaches have increasingly gained the attention of sport pedagogy researchers and practitioners, namely social constructivism (Bada 2015, Godbout and Gréhaigne 2021, Yvon and Zinchenko 2011) and nonlinear pedagogy (Chow 2013, Chow et al. 2007, Tan et al. 2012, see also an overview by Godbout and Gréhaigne 2020b, pp. 431–432).

In the 1980s, along with the increase of game-centered approaches, there developed a research area focused on decision making (DM) in sports and differences between expert and novice players with regard to knowledge-related sport performance (McPherson 1987). This era marks the beginning of an extensive and ongoing research undertaking to comprehend high-level players' decision-making process in sports. Over the last 40 years or so, there have been abundant publications on the subject as evidenced by reviews (e.g., Ashford et al. 2021b, Macquet 2016, Macquet and Fleurance 2006, McPherson 1994, Williams and Jackson 2019, Williams and Ward 2007).

The purpose of this article is to re-examine the teaching/learning of DM in invasion team sports (ITS) in light of the contemporary research conducted with high-level performers. First, following a brief overview of the situation awareness (SA) construct, three decision making (DM) perspectives are presented: information processing (IP), naturalistic DM, and ecological dynamics (EcoD). In a second major section, ITS SA in PE is examined with regard to SA components

and the differentiation of five SA facets. In a third major section, presenting implications for ITS-DM learning in PE, the teaching/learning of ITS-DM is discussed with regard to beginner- and novice-level players. Constructing a shared reference-framework for DM through team reflection on game-play situations is also considered, namely with regard to critical-incidents analysis and unexpected play-occurrences.

Three Decision-Making Theoretical Models

With regard to the decision-making domain in sports, in an extensive review, Ashford et al. (2021b) recognized that three clear perspectives have emerged, born from different views of players' behavior: (a) information processing (IP); (b) ecological dynamics (EcoD; and (c) naturalistic decision-making (NDM). They wrote: "The crux of the debate typically revolves around a player's access to memory representations in the decision-making process" (p. 1). While granting that both IP and NDM perspectives are based on a cognitive interpretation of the world, the authors felt that the two perspectives are sufficiently different to justify considering them as separate approaches with regard to DM in team sports (see authors' note 1). In this article, we will consider the three perspectives mentioned above, namely IP, NDM, and EcoD (Ashford 2021a, 2021b, 2021c). Readers will keep in mind, concerning such models, that conclusions were reached and reported with reference to diverse areas of endeavors including diverse sports, generally based on controlled situations as required by research standards to ensure internal validity of the results. With regard to sports, the models were developed to explain and predict decision making performed by expert players in high-level performance contexts. As stated by Ashford et al. (2021b, p. 2), "The presence of the three theoretical perspectives and their associated narratives presents problems for coaches [as well as PE teacher educators and PE teachers] attempting to use theory to inform their practice".

In coming sections of the article, the authors will attempt to present the core of each perspective. Readers will note that in each case, decision makers rely one way or the other on information perceived in their environment.

Situation Awareness: A Premise to Decision Making

Whatever the DM model considered, there has to be, as a prerequisite, some perception of a reality of interest calling for some remedial, maintaining or reinforcing action. Based on the work of Endsley (1995, [see also 2015]), Bedny and Meister (1999), and Smith and Hancock (1994), Macquet (2016) explored the notion of SA in sports. The SA construct relates to an individual's level of consciousness of the particular situation he is involved in, given that the situation calls for some action based on this individual's decision. As stated by Macquet (2016, p. 23), "Given an individual's limited perceptual and cognitive capacities (Simon 1996), this individual cannot understand all elements of the situation. He

must interpret elements that appear essential (Norman 1981). The SA concept makes it possible to highlight these essential elements taken into consideration by the individual at every instant" (translated in English by leading author).

Macquet's statement is closely related to Ochanine's (1978) operative-representation construct (Gréhaigne 2018, Gréhaigne and Godbout 2021c, Holgado 2011, Ochanine 1978, Weill-Fassina 2013/2016). Ochanine (1978, p. 63) wrote:

> The representation is a certain informational complex attributed to an object. It is possible to see a same object in different ways. During action, the performer does not reflect an object in all the complexity of its properties, its attributions; from his informational baggage, the performer only actualizes relevant information that corresponds to the purpose of a given action (especially in the case of a performer faced with time constraints). This reflection that corresponds to the representation in action, I call it the operative representation. (Translated from French by the lead author) (see authors' note 2)

Whereas the complete reflection of objects in all the diversities of their accessible properties has been called *cognitive representation*, the construct *operative representation* relates to selected properties likely to ensure the best task result. In this case, the operative representation is considered to be a reflection of the *operative structure*, that is the most reliable structure of the object for a given task, meaning the structure that offers, with a minimum of possible relations, the maximum relevant information on the object. Should there be several possibilities for completing the task, experienced subjects will tend toward the most efficient operative structure called *optimal operative structure* (Holgado 2011).

Coming back to SA, Endsley (1995) operationally defined it as made of three hierarchical levels: "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" (Endsley 1995, p. 36). Perception, understanding and projection lead to decision and action. In the context of ITS, elements of the environment to be perceived relate to position and movement (direction, speed, trajectory) of partners, opponents and the ball (or any analogous object) on the area of play. Understanding the meaning of the reality perceived calls for a frame of reference. Projecting (expecting, anticipating) the future status of selected elements calls for long-term memory and information-processing mechanisms or automaticity (Endsley 1995). Thus, the value of the decision made rests, for a great part, on the value of each of the three SA levels. In a sense, one may consider that a scaffold of the DM teaching/learning process rests on these three SA levels.

SA may be considered not only as an individual state but also as a shared or socially shared state at the team level. This construct has been addressed in relation with several labels: shared situation awareness (ShSA) (Endsley 2015), shared knowledge (Araújo and Bourbousson 2016), shared and coordinated cognition (Reimer et al. 2006), team situation awareness (TSA) (Macquet 2016), team cognition (Bourbousson et al. 2019, McNeese et al. 2015, Richards and Collins 2020), team coordination (Gesbert and Hauw 2019). More will be

discussed in a later part of the article (see section on differentiating facets of SA in ITS).

The Information Processing Perspective

The IP perspective considers DM as a conscious selection-process during which players display more or less efficiency in (a) extracting and processing cues from the environment, (b) recognizing and deciphering familiar configurations of play, and (c) anticipating probable changes in the environment. Players make decisions through a process of selection from mental representations (schemas), which have been formed over time and are stored in long-term memory (Araújo and Bourbousson 2016, Ashford et al. 2021b, 2021c, Moran et al. 2019). Such representations are described as chunks of procedural and conditional knowledge (or conceptual networks) representing collections of elements that have strong 'if-then' associations with each other (Moran et al. 2019). As stated in Araújo and Bourbousson (2016, p. 126), "... a key principle of cognitive science [is] that performance (whether individual or collective) is underpinned by the existence of a representation or schema, responsible for the organization and regulation of behaviours (e.g., Rentch and Davenport 2006)."

Based on a review of 16 IP studies, Ashford et al. (2021b, p. 12) reported that the decision-making process is encompassed by a player's possession of specific key perceptual–cognitive skills, namely: "(a) the utilization of domain knowledge in perceiving informational cues ...; (b) the identification of global, salient and predictive cues ...; (c) rapid retrieval of knowledge from memory representations ...; (d) option generation ...; and (e) the role of intuition in the form of the take the first heuristic ...".

As defined by Musculus (2018, p. 272), a simple heuristic is "a strategy that ignores part of the information, with the goal of making decisions more quickly, frugally and/or accurately than more complex methods". The use of heuristics plays a crucial role in time-constrained situations.

The Naturalistic Decision-Making Perspective

Naturalistic DM is meant to explain performance in time-constrained situations. Klein and his collaborators (Klein 1997, Klein et al. 2010) submitted that "decisions are made through a recognition-primed process that alters from situation to situation according to the decision maker's familiarity with the perceptual information available (visual, auditory, olfactory, etc.) and their context relevant knowledge base" (Ashford et al. 2021b, p. 2). The level of similarity between the perceived situation and a reference mental-representation of a situation is based on past experience. According to this theory, depending upon the extent to which the goals, cues, expectations and action responses are clear, DM may occur through one of three levels (Ashford et al. 2021b, Macquet 2016).

- *Acknowledge a distinct or obvious correspondence* (simple match): the decision maker recognizes a situation as typical, goals, cues, expectations, and action response presenting themselves in an obvious fashion.
- *Diagnose the situation*: the information not being provided in a typical fashion, the decision maker, through mental simulation, needs to clarify the goals, cues, and expectations through a process of diagnosis to restore typicality and come to a decision.
- *Evaluate a course of action*: the information available (goals, cues and expectations) is recognized but a course of action does not immediately present itself. A solution is rapidly mentally simulated considering intended and unintended consequences, followed by a disregard or select decision.

Revisiting the RPD model with respect to high-level sport, Macquet (2016) considered two distinct DM contexts, one when a decision is not planned ahead, another when a decision is planned ahead. She also proposed to consider the DM process based on two distinct rationales: (a) adapting the decision to the context (whether the decision was planned or not); (b) adapting the context to the decision (when the decision was planned). Within this revisited RPD model, the three initial levels (or functions) defined above are integrated under a single rationale, adapting the decision to the context. A fourth level or function is called *modify the situation*, associated to a context when a decision was planned ahead (see Macquet 2016, Figure 6, p. 74). Thus, when a decision was planned ahead based on good anticipation, the typicality of the situation is recognized as a simple match; if on the other hand, the perceived situation is not as expected, there is a need for modifying the situation so it becomes typical. Such considerations bear consequences for strategic DM and tactical DM as will be discussed in a further section of the article.

The Ecological Dynamics Perspective

From an EcoD perspective, DM continually emerges from interactions between players and their environment, due to an ongoing reciprocal relationship between *perception of information*, which hampers or delays subsequent movement, and *action*, which provides new information. This interplay (coupling of perception and action) occurs in a dynamical context where decision-makers simultaneously face or manage *constraints* while staying watchful for or taking advantage of *affordances* (readers will note a connection with nonlinear pedagogy constructs [Araújo et al. 2006, Chow et al. 2007]). The school of EcoD contends that at the time of competitive performance, decision makers, under time constraint and others, react directly to information received from the environment rather than relying on a reference to mental representations retrieved from long-term memory (Gesbert and Hauw 2019). As stated by Buekers et al. (2020, p. 6), "an ecological-dynamical approach to tactics in sports rejects the representational notions of internal models and motor commands ... In contrast, it defines tactics as

behavioral settings characterized by the set of prevailing affordances or action possibilities to achieve the tactical goals".

From an EcoD point of view, team coordination may be interpreted in terms of collective affordances. "Collective affordances are sustained by the common goals of team members who cooperate to achieve group success. From this perspective, team coordination depends on the team's collective attunement to shared affordances founded on a prior platform of (mainly nonverbal) communication or information exchange (Silva et al. 2013)" (Araújo and Bourbousson 2016, p. 133).

Invasion-Team-Sports Situation-Awareness in Physical Education

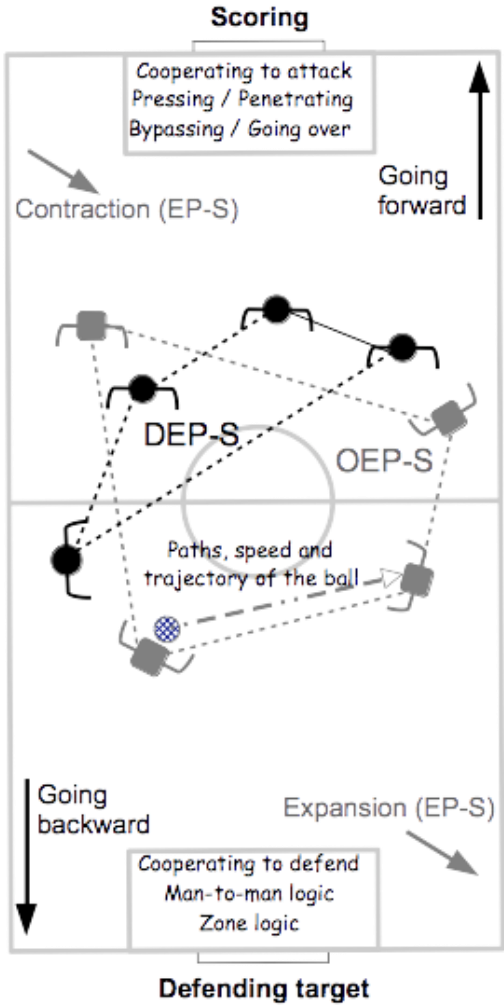
Students construct their SA based on various cues drawn from their knowledge of the internal logic of ITSs and may experience different SA facets.

Components of Situation Awareness in Invasion Team-Sports

Invasion team-sports are among the most non-linear sport activities considered in the PE curriculum, to the point they may at times appear to be chaotic (Gréhaigne and Godbout 2014). As stated by Gréhaigne et al. (1999, p. 63): "Expressed in a nutshell, the idea for each player is to cooperate with partners in order to better oppose the opponents either while attacking (keeping one's defense in mind) or while defending (getting ready to attack)". Consequently, the DM process concerns both attack and defense and so does SA.

Due to their dynamic nature, ITSs have often been looked at as complex and dynamic systems (e.g., Stöckl et al. 2017). Gréhaigne and his collaborators discussed on several occasions the challenge of teaching and learning DM in team sports, offering the point of view of complex system analysis (e.g., Gréhaigne and Godbout 2014, Gréhaigne et al. 2001, Gréhaigne et al. 2010). While considering students' SA, it may be useful to refer to three different organizational levels: (1) the match organizational (MO) level, involving both teams; (2) the partial-forefront organizational (P-FO) level, involving some of the players from both teams; (3) the primary organizational (PO) level, linking the ball holder and a direct opponent (Gréhaigne and Godbout 2013, Gréhaigne et al. 1999). Thus, the *rapport de forces*, which "refers to the antagonist links existing between several players or groups of players confronted by virtue of certain rules of a game that determine a pattern of interaction" (Gréhaigne and Godbout 2014, p. 98), may be looked at as involving both teams, two sub-groups of players, or eventually two specific players. Obviously, the more players are involved in the organizational level of interest, the more difficult it becomes to target specific meaningful clues in time-constrained conditions. Readers will note that in small-sided games involving 4 or 5 active players, we will consider only two levels, the MO level and the PO level.

Figure 1. *Components of SA in ITS with Time Constraint at Play (Adapted from Gréhaigne 2018)*

Having in mind (decision wise)	Dynamics of play organization (Arrows indicate potential evolutions in play sequence)	Observable elements at match and primary organization levels
Background references - particular rules of game play in small-sided format - offensive and defensive matrices of play - prototypical configurations of play - tactical representation library - player's physical resources - competency networks - agreed upon strategy - common frame of reference - actual rules of the game ***Evolution of game play*** - score - time to play - attacking - counterattacking - defending - losing or regaining possession of the ball		***At MO level*** **Opposition rapports** - advance / delay - block / pursuit - location and elasticity of EP-S on court - interpenetration and position of DEP-S and OER-S **Play in movement** - position, movement, direction and speed of all players - path, speed and trajectory of the object fought for - actual configuration of play ***At PO level*** - opponent's posture, speed, direction - feints - eye movements - pass opportunity

In the context of ITS, at the match organizational level, students' SA may concern the position (on the pitch or court), movement, trajectory and speed of all players and the object fought for (be it a ball, a hockey puck, a frisbee, etc.). Related constructs are: the actual configuration (play patterns); the effective play-space (EP-S) (defensive [DEP-S] and offensive [OEP-S]); the elastic state of the system (contraction, expansion); the collective strategy agreed upon; the rapport de forces and the competency network of each team; the actual rules of the game, given that it is generally played in a small-sided format (Figure 1). At the partial forefront and/or primary organizational levels (Gréhaigne et al. 2001), more direct confrontations may take place and bring about more focused SA on the part of the players directly involved, watchful of opponents' posture, moves (feints), eye

movements, in addition to background knowledge of immediate opponents' and partners' competencies and of predetermined strategies. Depending upon who becomes aware of a particular situation, the importance or significance of different aspects may vary depending on the individual concerned, as we will see below.

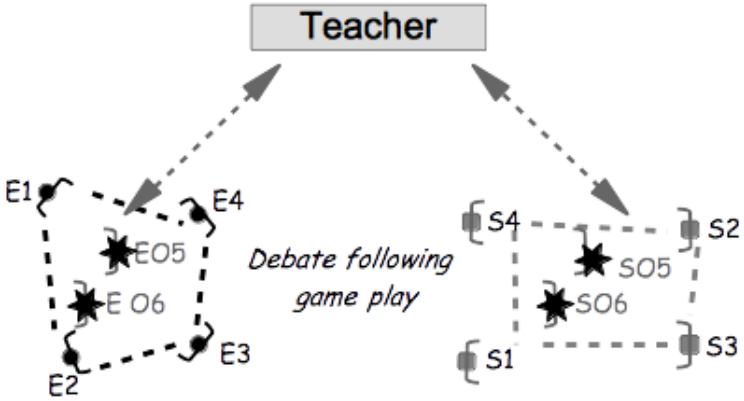
Differentiating Facets of Situation Awareness in Invasion Team-Sports

At this point, SA will be examined from two distinct perspectives: (a) its time dimension, considering tactical DM (concurrent to game play) and reflection on prior DM (done after actual game play); (b) its social dimension, considering students' individual SA and shared or socially shared SA (a collective SA involving several members of a team). Thus, on the one hand, one may speak of *current SA* and *reflected SA;* on the other hand, one may speak of *individual SA*, *shared/distributed SA*, and *socially-shared SA*.

- *Current Situation Awareness* (CSA). Unless specified otherwise, discussions about SA usually concern current SA leading to tactical DM. Although CSA is primarily thought of with regard to players actually involved in game play, it may also concern outside interested observers, such as teammate-observers from both teams and the teacher (see Figure 1). In competitive contexts, CSA might also concern independent informed onlookers (scouts and analysts for instance).
- *Reflected (Deferred) Situation Awareness* (RSA). Reflecting on prior game play is a pedagogical strategy that makes it possible for players to evoke reminiscences of last encounters and, through convergent and/or divergent thinking (Godbout and Gréhaigne 2021), assess the strategic or tactical efficiency of choices made. In order to do that, learners need to visualize significant game-play situations encountered, creating a form of reflected SA (Figure 2). Feedbacks from involved observers will provide additional cues to support players' RSA, as it has been seen during student debates-of-ideas following game play (Gréhaigne and Godbout 2021).
- *Primary Situation Awareness*. SA experienced by decision-makers (the players in action) may be considered primary in the sense that it bears a significant weight on the decision that needs to be made (current-related SA) or the decision being reflected on (reflected-related SA).
- *Distributed Situation Awareness*. SA independently experienced by observers and communicated to the decision maker(s) will be considered as distributed. Obviously, given the unlikelihood or impossibility to do so concurrently to actual game play, sharing one's SA with teammates will occur at times of further reflection on past situations and decisions. Although occurring after action, this shared SA may be seen as a form of distributed SA (Endsley 2015, Salmon and Plant 2021).
- *Socially Shared Situation Awareness*. "... socially shared regulation of learning refers to processes by which group members regulate their collective activity. This type of regulation involves interdependent or collectively shared regulatory processes, beliefs, and knowledge (...

metacognitive decision making) orchestrated in the service of a co-constructed or shared outcome" (Järvelä et al. 2013, p. 269). By analogy, one may envision the progressive development of team SA (see earlier discussion in section "Situation awareness: a premise to decision making"), or socially shared SA within a group of student-players who construct their decision-making capacity through successive debates interspaced with game-play setups and concurrent observation by teammates (Godbout and Gréhaigne 2020a, Godbout and Gréhaigne 2021, Gréhaigne and Godbout 2021a).

Figure 2. *Reflected SA Involving Players and Teammates Observers, from Teams E and S, with no Time Constraint (Adapted from Godbout and Gréhaigne 2021)*

Focus of reflection	**Reflection on situation awareness** (deferred awareness) (grey zone illustrates the reminiscence of the situation reflected on)
Specific reference situation - ball loss - ball recovery - attack - counterattack - defense - point(s) scored by the team - point(s) scored against the team - etc.	
Awareness contribution to the exchange - primary SA (specific player) - distributed SA (from teammate player and/or observer) - building S-Sh SA from common cues - teacher's SA	

Students' reflection on their SA level and the cues that draw their attention may lead to a metacognitive dimension of SA. Students may think back on the more or less effectiveness of their SA depending upon the organization level they

tend to focus on and the clues that prove to be both most useful and less time demanding. Time constraint is a major characteristic of ITS, particularly at the forefront and primary organizational levels. Time management is also crucial in the case of current SA in the sense that if players do not remain dynamically aware of the evolution of game play, they will pay a high price for reading the play in the last instant. This dynamic dimension of SA is discussed hereafter.

Implications for Invasion Team-Sports Decision-Making Learning in Physical Education

Considering students' learning of ITSs in school implies a beginner/novice perspective and having students develop a common frame of reference through reflection on their team SA.

A Perspective with Regard to Beginner- and Novice-Level Players

Given the characteristics of the three DM approaches discussed earlier, we submit that in a school teaching/learning context, both IP and NDM perspectives may be of interest. The instinctual level of DM considered in the EcoD perspective does not, in our view, fit with the social constructivist feature of DM development in beginner and novice players. It may well be indeed that endowed with hundreds if not thousands of hours of practice, expert players have developed, experienced repeatedly and embodied so many representations that these have become part of a sub-conscious level of awareness leading to what we have labeled instinctual. Having beginners and novice players develop decision-making capacities in a PE context represents a totally different challenge. In a learner-centered and social constructivist context, we will consider that three complementary teaching/ learning strategies are concerned (Gréhaigne and Godbout 2021a):

- A game-play setup, where matches are played in a small-sided game format with adaptations implemented in order to modify various constraints of game play.
- A student-observer setup, where teammates observe the unfolding of the game-play setup, based on agreed upon observational variables.
- A subsequent debate-of-idea or student-exchange setup, where players and observers of a same team reflect on the last match and plan future actions.

Through alternatively and purposefully experiencing game play, observing it and verbalizing about it (sharing reflectingly SA episodes, reflecting on decisions made and related results, planning game-play actions), students collectively regulate their learning and construct mental-representation networks to be used for further DM.

We have mentioned earlier that a scaffold of the DM teaching/learning process may rest on the three SA levels laid out by Endsley (1995), meaning perception, comprehension, and projection. Achieving meaningful **perception** of

game play implies a frame of reference, hopefully shared among teammates, players and observers. While after years of practice expert players base their perception on a selected number of clues, students need to construct such a frame of reference based on successive iterations of game-play/observation, verbalization, strategy planning, testing and reflecting. Stored representation knowledge about constructs such as offensive and defensive matrices of play, dynamic organization of play (prototypical configurations of play, effective play-spaces), competency networks, (Gréhaigne and Godbout 2014) will serve as background to analyze and eventually give precedence to and focus on specific elements of the situation. **Comprehending** (understanding, making sense of) the situation at hand implies making connections between mental representations, taking notice of momentary dynamic constraints and affordances (interpreting perceived realities as good or bad, promising or unfavorable). Through these successive iterations mentioned above, students accommodate and adapt, two meaningful steps in the construction of tactical knowledge and DM competency. As stated by Godbout and Gréhaigne (2021, p. 54), "Through exchanges with teammates, hypotheses, verifications and confirmation through game play, players *understand* that a given reality differs from what they thought and readjust their schemas accordingly; they learn through accommodation". Finally, **projection** implies a willingness and capacity to visualize the consequences of plausible decisions. Memory stored if-then algorithms (conditional knowledge) solicited through convergent thinking will be used to make a decision. Gréhaigne and Godbout (2021a, p. 562) have recently written "During the match, faced with unexpected evolution of game play and under time constraints, students can no longer rely on thoughtful tactical reasoning. They need to resort to stored procedural tactical knowledge and be able to anticipate opponents' and/or teammates' moves (Gréhaigne et al. 2001, Taylor 2016)". Readers may refer to Godbout and Gréhaigne (2021, pp. 54–58) for a more elaborate discussion on understanding game play, game-play intelligence and tactical thinking.

Team Reflection on Game-Play Situations: Constructing a Socially Shared Reference Framework for Decision Making

Narrowing the Range of Information Cues

One key aspect of developing SA is learning not to get flooded with information. Research has repeatedly shown that experts players make decisions based on much less cues than beginners or even novices. Inversely, one may conclude that beginners and even novices need to learn focusing on a limited number of cues. As mentioned before, learners need to progressively evolve from a cognitive representation of situations of play, overflowed with cues of all kinds, toward an operative representation ridden of accessory information and limited to the most meaningful (given the task at hand) and the less numerous cues, a characteristic labeled terseness by Ochanine (Holgado 2011). For instance, discussing the reference to experienced configurations of play (a primed-recognition process), Caty et al. (2007, p. 106) wrote "A good solution implies pinpointing a few characteristics of the configurations of play, a partial

arrangement of elements that will assemble all essential relations and only those". Moreover, in an ITS context, having each player and teammate-observer develop an individual operative representation, thus an individual SA, would soon lead to havoc. There is need for the development of a common SA reference framework.

Constructing a Socially-shared SA Reference-framework

In a PE context, ITS-SA concerns student players, student observers, and their teacher (Godbout and Gréhaigne 2021, Figure 1, Gréhaigne et al. 2001, Figure 4). Given the student-centered and socio-constructivist perspective of this article, we will focus more particularly on student-players' and student-observers' SA although, in reflected SA situations, the teacher may at times contribute to the exchange (see Figure 2 in this article). Considering the dynamic nature of ITSs, it is understood from the start that players' and observers' SA is also a dynamic state. As stated by Endsley (2000, p. 6), "The dynamic aspect of real-world situations is a third important temporal aspect of SA. The rate at which information is changing is a part of SA regarding the current situation, which also allows for projection of future situations." It follows that while one's SA at a given instant leads to a decision "a" and an action, it will evolve to another SA following the action. It also follows that this new SA may serve to make a further decision "b" and/or to reflect on the appropriateness of decision "a". The dynamic SA players and, to a lesser extent, teammates-observers, are involved with may be analogically compared to a car driver's SA as this individual keeps constantly glancing around, keeping informed of the dynamic environment and ready to take action if and when appropriate.

In teaching/learning setups where all teammates engage in a debate or an exchange following game play, reflection on action may well be conducive to the building of shared reflected SA among members of a same team. Then, respective players' and observers' frames of reference may progressively include common elements, leading to team cognition and team coordination (see references in earlier section "Situation awareness: a premise to decision making"). Reflection on action may be enhanced with the use of critical incident theory. As stated by Kain (2004), "it is interesting that the critical incident technique has been used as a means for reflection and enhanced understanding apart from its use as a research tool". Its framework is aimed at elucidating decision-making processes and increasing problem-solving skills (Wijaya and Kuswandono 2019). Examples of critical incidents may concern ball losses, ball recoveries, goals (pro or against), etc. The quality of the team's reflection on selected play-situation will rest on students' language and tactical understanding (see Godbout and Gréhaigne 2021 for a discussion on game-play language and game-play intelligence).

As discussed by Godbout and Gréhaigne (2020a), students' learning style (in terms of level of field dependency / independency) may influence their SA. Also, students may metacognitively react differently to various aspects of the game-play situation reflected on, sensing or realizing that, in their mind, some cues bear more significance than others (Cohen et al. 1996). Constructing a socially-shared SA reference-framework does not exclude a pairing with distributed SA.

Dealing with Unexpected Occurrences

An intrinsic characteristic of ITSs is the opposition relationship between the two teams involved in a match. The dynamic nature of the encounter entails, for instance, a constant reversibility of attack and defense, creating unexpected occurrences. Such occurrences have been labeled *emergent phenomena* in the French literature (Walliser 1977). Emergent phenomena are unexpected, even unexplained phenomena that take the shape of original entities (e.g., play actions in ITSs). Such an emergence (caused for instance by a ball loss for some players and a ball recovery for others) may bring about a more or less profound disturbance in the encounter. Unexpected game play occurrences constitute perfect examples of critical incidents that may be reflected on based on players' and observers' deferred SA. Sharing collectively individual SAs may then facilitate an understanding of the phenomenon.

Limitations

In our opinion, there are two limitations to this article. First, a discussion about the social construction of SA would normally deserve a more extensive analysis of the contribution of learners' game-play language and verbalization. Given elaborate discussions on student's exchanges, game-play language and game play intelligence related to ITSs published in recent years (namely by Godbout and Gréhaigne [2021], by Gréhaigne and Godbout [2021a], and in Gréhaigne and Godbout [2021b]) and cited in this article, the authors felt that covering this aspect of team SA construction would be redundant.

A second limitation lies in the fact that this article is focused on DM as a punctual moment in game play, along with its related SA. Reflecting repeatedly on such occurrences should hopefully bring students not only to make sense of particular game-play situations but to make sense of the game all together, meaning the internal logic of the sport concerned. Discussing sensemaking of the logic of the game as a whole, in addition to DM in game-play action, would have been much beyond the scope of a single article.

Conclusion

This article has examined three perspectives for decision making in sport. In a context of the teaching/learning of DM in ITS in school, the authors submit that precedence should be given to information processing and to recognition-primed perspectives. Resort to mental representation networks and recognition of familiar configurations of play is critical to establish situation awareness and learn to make appropriate decisions. Such an option fits well with a social constructivist view of DM learning. Reflected and socially-shared situation awareness may be seen as a powerful construct to make sense of one's DM and improve it. Iterations of (a) game play followed by (b) exchanges with teammate-observers and (c) reflection on both situation awareness experienced and related decisions are viewed as an

effective learning strategy to construct one's DM competence. All things considered, knowledge and understanding (or sensemaking) may be looked at as critical keys to learning, performance and performance appreciation with regard to ITS.

Authors' Note 1

In a PE teaching/learning context where learners must be considered at best as novices and probably most often as beginners with regard to ITSs, students will likely resort first to an information processing approach until they cumulate enough experience to build mental representations of game-play situations likely to be eventually recognized. At this time, a primed-recognition approach may be progressively put in place as a strong addendum to the information processing perspective. The evocative potential of the primed-recognition process appears sufficiently important to justify a separate treatment, a choice we have done in this article.

Authors' Note 2

Writing in French, Ochanine used the word '*image*' which we have translated by the word representation while a literal translation would have given 'picture', too physical a term to reflect the mental connotation of the concept concerned. The word 'schema' might also have been used.

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