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The social dimension of the constraints model in skill acquisition and sports performance

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This theoretical paper develops the social dimension of the constraints model in relation to skill acquisition and sports performance. First, it presents the evolution of the constraints model since the original proposal by Newell (1986), later developed and applied to physical activities and sport by ecological dynamics. The underrepresentation and misplacement of the social dimension within the constraints model so far, leads to the proposal of a novel analysis, taking into account both the constitutive (S) and interactive (s) facets of the social. Such an analysis not only detects the social dimension of performer, task, environmental and informational constraints, but also helps to suggest two new kinds of constraints: volitional and semiotic. The paper then suggests a new enhanced model of constraints that helps to gain new insights into the question of agency in relation to the process of decision-making during the dynamic interactions of subject-environment.

KEY WORDS: Social, Ecological dynamics, Affordances, Constraints, Decision-making, Agency.

1. Introduction

On 30th June 2006 at the Olympiad stadium in Berlin, Germany met Argentina for the quarterfinals of the football World Cup. After 120 minutes, the 1-1 score led to a penalty shootout between the two teams. Jens Lehman, the German goalie, would become legendary after playing a key role in his team's victory: he saved two penalties (leading to a German win by 4-2) and he almost saved the other two. Nonetheless, what was remarkable about Lehman's performance was his use of what was dubbed as the 'cheat sheet': a piece of paper with supposed information about the penalty kick preferences of the Argentinian players that Lehman had stuck between the shinpad and the sock of his right leg. Before each shoot by the Argentinian squad,

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the German goalie would repeat the same ritual: he would take the piece of paper from the sock, study it thoroughly and conspicuously, and put it back in the sock before taking his position under the crossbar. The versions of the facts are controversial: did Lehman really have accurate information about the Argentinian players? Was it all nothing but a display of public pretended actions to confound the adversaries[1]?

This case is truly informative about how decision-making occurs in sport. Using a rational choice theory (based on choice axioms and subjective expected utility maximisation), Lehman's public display of the sheet was not really smart. Why tell your opponents that you have accurate information about their behaviour? From this detached, mere mental calculation of information, the best option for the goalie would be to hide this information to the shooter so the latter repeats the habitual pattern. Nonetheless, Lehman did precisely the opposite: he conspicuously showed to everyone that he was studying a note on the specific shooter. He even did that in the turn of Esteban Cambiasso, an Argentinian player that was not on Lehman's list. If the goalie did not have any information on the player, why follow the pretended play of conspicuously looking at the note?

Well, if we take into account an ecological standpoint on decision-making, there are many factors (constraints, see below), apart from mental calculation, that affect decisions. In the specific case at hand, there was something about the social interaction between goalie and shooter that was affecting the whole process of making decisions. The main aim of this paper is to develop further the social dimension of the constraints model in ecological dynamics to understand the dynamic relationship between subject-environment, especially in connection with the topic of decision-making and agency in sports activities.

The structure of the paper is as follows: the first section introduces the evolution of the constraints model as used in ecological dynamics and criticises the underdevelopment and misplacement of the social dimension in the model; the second section remedies the pitfalls of the social dimension and proposes an enhanced constraints model, adding semiotic and volitional constraints. It also discusses the topic of agency in decision-making, providing implications that surpass the ambit of sport performance and skill acquisition; the last section presents some conclusions and further steps for future investigations.

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[1] Thanks to Gerd Gigerenzer for bringing this case to my attention. See a presentation of the case and a discussion on the controversy at: https://www.fifa.com/tournaments/mens/worldcup/2006germany/news/the-piece-of-paper-that-helped-germany-turn-the-page-2811265

2. Ecological Dynamics and the Evolution of the Constraints-Model

In the field of skill acquisition, the research programme known as ecological dynamics (Vilar, Araújo, Davids, & Renshaw, 2012; Button, Seifert, Chow, Araújo & Davids, 2021) aims to blend Gibson's ecological psychology and dynamic systems, taking the individual-environment as the unit of analysis to study cognition of human subjects during sports and physical activities. The unit of study for ecological dynamics is the nonlinearly coupled animal-environment system (Araújo, Hristovski, Seifert, Carvalho & Davids, 2019, p. 5).

The dynamic relationship between an environment and human agents (e.g., players) engaged in the intending-perceiving-acting cycle (Kugler, Shaw, Vincente, & Kinsella-Shaw, 1990) of a goal-oriented activity is always affected or "channelled" (Araújo & Davids, 2004, p. 50) by different types of constraints, acting as boundary conditions (Newell, 1986). For instance, an action of a striker in football when a teammate has made a pass from the corner depends on the speed and height of the ball; on the light conditions in the environment; on the position and posture of the teammates and adversaries; on the jump power and fatigue of the striker; and on the pressure from the crowd when playing abroad, etc. All these constraints affect the dynamics of the system formed by striker and environment.

The model of constraints currently used by ecological dynamics (Button et al., 2021) was originally developed by Karl Newell (1986). Following the theory of action proposed by Kugler, Kelso and Turvey (1980,1982), Newell (1986) considered that coordination did not depend on prescribed instructions of a motor programme (as intended by information-processing approaches) but occurred as a consequence of the constraints imposed on action. The problem of coordination and control of action had been crucial to Bernstein (1967), an author that Newell brought to the discussion at that time. Newell considered constraints as boundary conditions that affected the optimal coordination pattern and control: "Constraints may be viewed as boundaries or features that limit motion of the entity under consideration." (Newell, 1986, p.347). Newell differentiated between internal (organismic) and external (task and environmental) constraints. Organismic constraints were divided into structural (body weight, height, shape) and functional (development of synaptic connections). Task and environmental constraints were both external and differed only in their specificity, with environmental being more global and general boundary conditions than task. Task constraints included: 1) goals; 2) rules; and 3) implements or machines; and environmental (not manipulated by the experimenter, acting as ambient

conditions for the task) included: gravity, natural temperature, and natural light (see Fig. 1).

At that time, Newell did not pay attention to perception, just the motor control and coordination aspect of action. Newell and McDonald (1992) introduced the topic of perception in the model in the form of a "perceptual-motor landscape as an interface between the kinematics of information and the kinetics of action." (p.56). (See Fig. 2).

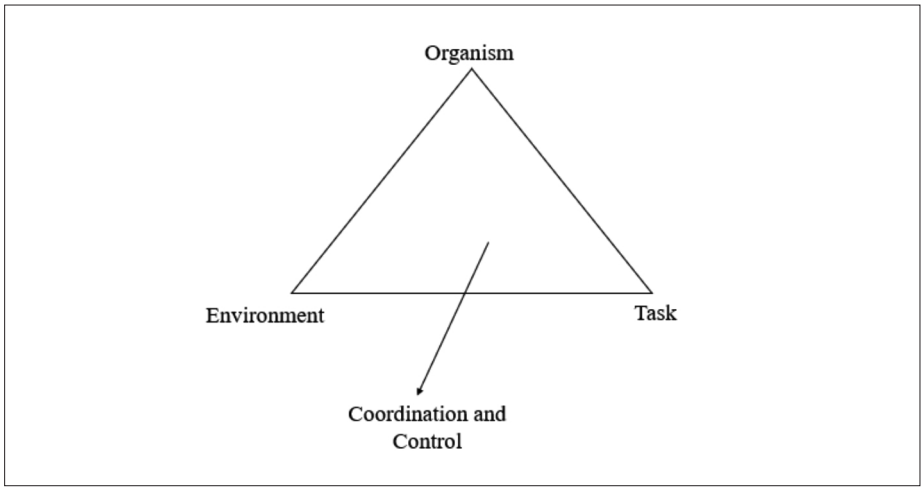

Fig. 1 - Newell's (1986) original constraints model. The model only considered questions of control and coordination of action.

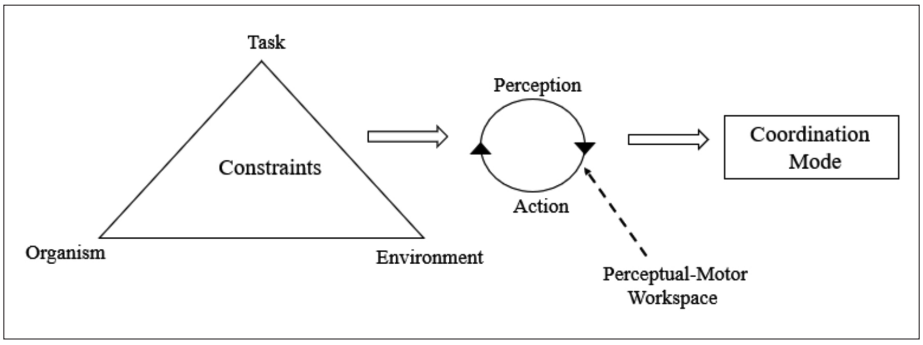

Fig. 2 - Constraints model, adapted from Newell and McDonald's (1992). The model introduces the importance of perception in the perceptual-motor workspace.

Newell (1996, p.405) developed this question further by introducing Gibson's affordances and invariants within the perceptual motor workspace, connected to decision-making. Gibson's affordances[2] relate to the specification of decision-making without the need for internal representation (affordance specifies goals) and Gibson's invariants provide online information to initiate and regulate the movement sequence.

The use of Newell's constraints model in skill acquisition from an ecological dynamics approach (see Table 1 for a synthetic view of constraints as considered in different relevant studies) blends two crucial theoretical pillars: Bernstein on motor control and coordination to specify physical constraints (organismic, task, and environmental); and Gibson on perception-action couplings to specify informational constraints (energy flows, such as light, sound, pheromones, etc.) (Davids, Button, & Bennett, 2008; Button et al., 2021).

Interestingly, the ecological dynamics approach also started to take into account the social dimension of the constraints model, introducing it within the environmental constraints, identifying the social with "family support, peer groups, societal expectations, values and cultural norms." (Davids, Button, & Bennett, 2008, p.41; Button et al., 2021, p. 37). Button et al. (2021) considered the existence of sociocultural constraints as part of environmental constraints (pp.37,107,153) in the constraints model. They considered socio-cultural factors such as family, coach, peer group influences, rituals, the prevalence of an evaluative coach or audience pressure, and the culture of clubs, regions, or countries, etc[3].

Socio-cultural constraints have found a current momentum in the ecological dynamics research community. Moy, Renshaw, Davids, and Brymer (2015) identified a persistent acculturation of current PE teachers into the past militaristic approach to gymnastics, resulting in the maintenance of the status quo of a teacher-driven, reproductive paradigm. Moreover, a broad set of body image expectations in different societies or gender expectations about certain sports and/or physical activities proved to act as strong socio-cultural constraints (Swami, 2015). Rothwell, Davids, and Stone (2018) detected historical influences of industrial working practices in professional coaches of team sports such as rugby. Uehara et al. (2018; 2021) identified

[2] Crucial as it is for the understanding of ecological dynamics, this paper does not deal specifically with the social dimension of affordances (Rietveld & Kiverstein, 2014; Correia et al., 2012). For a critical account of the concept of social affordances, see Baggs (2021).

[3] This is something that authors such as Clark (1995) stressed some time ago: "Culture also acts as environmental constraints that shape movements. Although these constraints may be more subtle than the physical ones, they are nonetheless ever-present surrounds to the actor." (p.175).

TABLE I
Constraints Considered In Different Studies.

Studies	Constraints
Newell (1986)	INTERNAL **Organismic**: structural (body weight, height, shape); functional (development of synaptic connections). EXTERNAL **Task**: 1) goal;2) rules;3) implements or machines **Environment** (not manipulated by the experimenter; ambient conditions for the task): gravity, natural temperature, natural light.
Newell (1996)	**Organismic:** biochemical, neurological, morphological, biomechanical, etc. **Task:** goal and rules. **Environment:** ambient or global to action (gravity, temperature) or local and focal to action (tools).
Davids, Button, and Bennett (2008) Button, Seifert, Chow, Araújo, and Davids (2021)	PHYSICAL (structural and functional) **Organismic:** genes, height, weight, connective strength of synapses, cognitions, motivations and emotions, customary thought patterns, levels of practice. **Task:** goals, rules, implements or tools, surfaces, ground areas, boundary markings (nets, line markings, posts). **Environmental:** (1) global physical variables in nature (ambient light, temperature, altitude, gravity. (2) Social variables: family support, peer groups, societal expectations, values, and cultural norms. INFORMATIONAL Energy flows (light, sound, pheromones, etc.).
Brymer and Renshaw (2010).	**Individual**: factors related to the physical, psychological, cognitive, and emotional make-up, e.g., body-shape and size, fitness level, technical abilities, anxiety, motivation. **Task:** goals, conventions, equipment or implements **Environment:** physical (gravity, altitude, weather conditions, cold, light or terrain) and sociocultural (peer groups and cultural expectations).
Chow, Davids, Button, and Renshaw (2016) Chow, Davids, Button, Shuttleworth, Renshaw, & Araújo (2007)	**Performer**: physical (height, weight, muscle-fat ratio, connective strength of synapses in the brain, genetic make-up, anthropometric and neuroanatomical characteristics); functional (cognitions, motivations and emotions). **Task**: rules of the game, equipment, boundary playing areas and markings, nets and goals, number of players, information sources in specific performance context. **Environmental**: physical (ambient light, humidity, altitude, temperature); sociocultural (family support networks, peer groups, societal expectations, values, and cultural norms).

certain traits of Brazilian street culture (capoeira, samba, street soccer) as beneficial influential factors in the development of highly skilful soccer players. Vaughan et al. (2021) considered that current players' intentions might privilege interpersonal competition instead of collaboration as they have been socialised in "sporting environments subject to neoliberal ideology and rampant commodification." (p.8). Taking into account that similar sociocultural constraints can shape vastly different sociocultural practices depending on the context, Sullivan et al. (2021) proposed the Learning in Development Research Framework (LDRF). This framework serves: first to detect specific sociocultural constraints that affect the sociocultural practices that emerge and persist within a specific sports organisation; and second to propose interventions to amplify or dampen specific sociocultural constraints that will enhance the quality of athletes' development within the sports organisation.

As a way to study the far-reaching sociocultural and historical constraints, Button et al. (2021) advocated for the use of the bioecological model of Bronfenbrenner (1995). The model conceptualises environment in terms of four nested subsystems (microsystem: family; mesosystem: training facility; exosystem: demography; and macrosystem: national historical context) occurring along a time scale with micro, meso and macro levels. Nonetheless, as Button et al., (2021, p.108-109) claim, the bioecological model approach is useful to investigate socio-cultural constraints on expertise development, but not that much on skill acquisition. In fact, the bioecological model makes sociocultural constraint something loose and vague, detached from the performance, distantly related to the behaviour one can observe in athletes and players in action. It fails to provide an adequate account of the multi-level and nested organisation of constraints (Balagué, Pol, Torrents, Ric, & Hristovski, 2019).

It is my claim that, until now, ecological dynamics have not addressed the sociocultural dimension of the constraints model in an adequate manner. The sociocultural dimension still lacks a coherent integration in the rationale of the model. I suggest that a better conceptualisation of the socio-cultural dimension is needed to generate a more coherent, cohesive model[4] that would help to understand performance and skill acquisition and produce a more insightful way to conduct empirical research. The following section discusses this and brings back the topic of decision-making within the enhanced constraints model.

[4] Surprisingly, the comprehensive constraints model advocated by Glazier (2017) to develop a Grand Unified Theory for sports science lacks almost any reference to the social dimension (sociocultural constraints are mentioned once in passing). The author does not even consider the social sciences as a relevant subdiscipline for the theory (see Fig.3 in p.146).

3. The Social Dimension Of The Constraints model

Consider yourself as a modern version of Robinson Crusoe. After the wreckage, you have been cast onto an island, and you only have a cell phone (no connection though) and a lighter. Apart from these sociotechnical devices that you bring with you (some of them useless (the phone), and some of them useful (the lighter) for the new situation), you seem to be out of your social world and thrown into the unknown. All the expectations connected to your social role (due to gender, age, class, colour of skin…) do not apply here, even though you bring them with you. You have also certain skills that may be useful (e.g., gardening, masonry) or not (e.g., programming, using internet). The objects, your language, your skills, in a nutshell, what anthropologist consider as culture, are part of the Social (with capital S) as a constitutive order of the human world in which you lived and have brought with you to the island.

After a while, you find some people on the island and start to interact with them. Here, something new happens. It is what George Simmel (1977) considered as society, consisting of "reciprocal actions" (actions that are mutually influenced) between elements such as – but not only – human beings. Basically, the kind of social (s) that dwells in the interaction order (Goffman, 1983). Thus, in this latter case we talk about the social (with lower case s) as the interactive feature of the situation under analysis.

Most of the times, sports activities imply social (with lower case s) actions, but they always imply the Social (with capital S) in the constitutive sense. In fact, the social (s) dimension of interaction orders (playing football, basketball, distance running, etc.) always imply the Social (S) dimension of constitutive expectations on how to interact in such social situations (Rawls, 2022).

In the constraints model so far, the social dimension has been included in the environmental constraints without taking into account the difference between social as constitutive (S) and social as the interactional feature of a situation (s). For instance, peer pressure or pressure from the audience could be considered as (s) but historical tradition of the country or culture of the club could be considered as (S). I argue that social factors pertaining to (S) should be considered as part of task and performer constraints and those pertaining to (s) should be considered as part of environmental constraints. But that is not all: the social dimension is also present in informational (S and s), semiotic (S and s) and volitional constraints (S). The following sections develop the social dimension of each of these constraints and propose an enhanced, comprehensive model (Fig. 4).

3.1 The Social Dimension Of Task Constraints

As seen in Newell's model, task constraints refer first and foremost to rules and goals, explicit or/and implicit. In sport, three different sets of rules can be identified: Rules of the game, ethics (fair-play) and praxical rules (Sánchez-García & Fele, 2015), all of them affecting the goal directed activity of the players, acting as boundary conditions of a social constitutive type (S)[5]. Of the three, maybe praxical rules need to be explained a bit further. Praxical rules can be identified with the principles of the game in the vein expressed by Button et al. (2021, p.174):

> Principles of play [praxical rules] represent a set of essential intentions that can continuously guide player interaction during competitive performance and then find tactical solutions for immediate events, transitions, and challenges that emerge (p. 174, square brackets are mine)

Praxical rules represent an idealised set of reasonable actions in a context of application. They do not state right or wrong from a logical stance or some rational deduction (see Araújo, Dicks & Davids 2019 on the critique of such unbound normativity). Thus, praxical rules are not based on rational models of optimisation, but on the accumulated knowledge about functional solutions for the intended goals of the game.

Praxical rules can act as more or less explicit boundary conditions for the intention-perception-action cycles affecting the behaviour of the player. They are prescriptive, but they are not enforced by the referee. In this case, they are informally enforced by other agents: the coach or/and team members and/or the audience and/or mass media that will consider the actions reasonable/not reasonable according to praxical rules and praise or criticise the player for acting in a certain way in a certain situation. For instance, in football it is not very reasonable to dribble in your defensive area, instead of passing or clearing the ball. Thus, players feel deterred to act like this unless the situation is desperate and demands it as an unconventional solution.

Nonetheless, apart from some kind of general principles of the game, praxical rules can also include specificities due to a national/ethnic style of play, plan/strategy of the game, playing system, etc.

The social dimension of task constraints also applies to: (1) tools and equipment (rackets, bats, balls, etc…), and (2) settings: spatial configuration referred to lines, nets, baskets, goals of different sorts, etc. These are not just physical lines, surfaces or objects made of metal, plastic, wood that

[5] These boundary conditions offer constitutive expectations of a certain "form of life" (Wittgenstein, 1953), being it playing handball, surfing, road cycling, etc.

have some materiality. They are culturally laden, carrying social (S) meaning bound to uses in the context of sports situations.

3.2 The Social Dimension Of Environmental Constraints

The study of social (s) as the interactional feature of the situation should be considered primarily within environmental constraints. Here I am not only referring to the general emotional tone provoked for instance from a loud crowd at home or abroad matches, which is clearly related to the phenomenon of home advantage (Sánchez- García & García-de-Alcaraz, 2021). Nor am I only referring to the kind of collective effervescence (Durkheim, [1912] 2008) that people express with terms such as stoke (in skateboarding, Wheaton, 2010) and kibadachi (in karate, Bar-On Cohen, 2009).

What I am referring to is the fact that people constitute true environments for each other (McDermott, 1976). The presence of others with whom we interact during a situation has been investigated in ecological dynamics applying the HKB model (Haken, Kelso, & Bunz, 1985). The HKB model captures the dynamic stabilities of rhythmic intrapersonal, environmental, and interpersonal coordination. Synchronicity of rhythmic movements acts as an interactional (social) baseline for the performance behaviour. This is true between partners (cooperative actions), as occurring between the rhythmic limb movements of two interacting individuals (Schmidt, Carello & Turvey, 1990), either intentionally or unintentionally (Schmidt & O'Brien, 1997; Richardson, Marsh, Isenhower, Goodman & Schmidt, 2007). But it also holds between opponents (competitive actions): Shimizu & Okada (2021) investigated the coordination of expert break dancers in battle scenes, measuring their rhythmic movements. The results showed that the dancers' rhythmic movements tended to synchronise in an anti-phase fashion.

Thus, (s) needs to be taken into account to understand in which environment the behaviour is taking place. Basically, the environment is not always exclusively physical; it can include agents that cooperate (partners) or/and compete (opponents) with us. Following Parlebas's (2013) canonical classification on physical activities as PAU (Fig. 3), we can enhance our understanding of the environmental constraints, including in the same model the physical environmental constraints and the social (s) environmental constraints. Parlebas produced a classification of physical activities in terms of motor actions. He used criteria bound to uncertainty: due to interaction with Partners (P); due to interaction with Adversaries (A) and due to the environment (U). Psycho-motor activities lack social interaction (lacking both P and A) and socio-motor activities (presence of P and/or A) express social interaction (s).

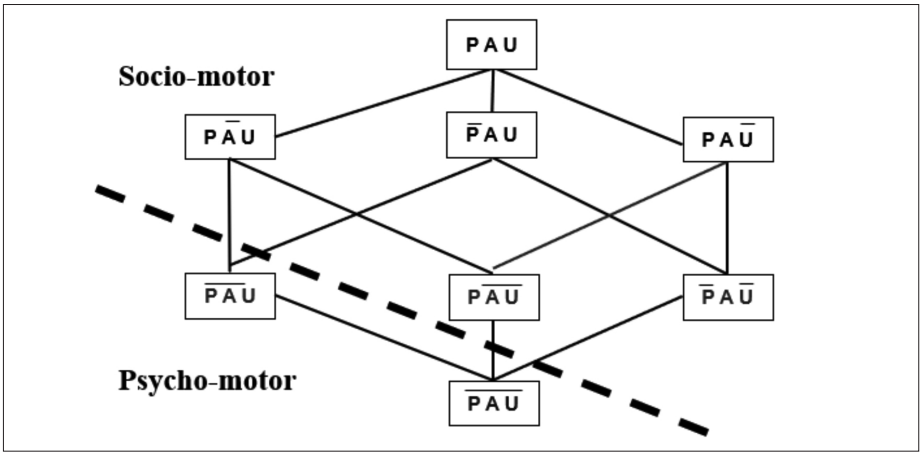

Fig. 3 - Parlebas's classification of physical activities in terms of motor actions. The criteria used refer to uncertainty: due to interaction with Partners (P); due to interaction with Adversaries (A) and due to the environment (U). The presence of — on top of capital letters indicates a lack of a given criterium. The bottom part of the figure expresses psycho-motor activities (lacking both P and A) and the top part of the figure expresses socio-moto activities (presence of P and/or A). Adapted from Parlebas (1981, 2013).

For instance, the kind of environment that subjects find engaging in outdoor extreme sports provides a high level of uncertainty due to continuous weather-driven changes (U in Parlebas's classification). Seifert, Orth, Button, Brymer, and Davids (2017) provided an ecological dynamics analysis of rock and ice climbing. In these activities, the unpredictability of the environment implied that performance may be considered as an ongoing coadaptation of climbers' behaviours to dynamically changing, interacting constraints. Nonetheless, if we consider the pedagogical relationship of a coach/leader and learners in outdoor activities, we would find a PU activity. In fact, this is how we could understand Brymer and Renshaw's (2010) statement: "From the constraints-led perspective a leader is also considered an environmental constraint" (p.35).

3.3 The Social Dimension Of Performer[6] Constraints

Task and environmental constraints are not the only places in the model that the social dimension should be taken into account. Following Pierre Bour-

[6] I rather use performer (as in Chow et al., 2007, 2016) instead of organismic constraints to remark the fact that the relationship of the subject is not only with a physical/biological environment but with a social human-made world.

dieu's (1986) discussion on the three types of cultural capital[7], we can find a social dimension not only in its objectified state (tools, implements, lines, nets) and its institutionalised state (rules, normativity) but in its embodied state: in the performer's habitus (Bourdieu, 1990), a dispositional structure that links a performer's unique capabilities to the ethnomethods (practical methods of a particular community of members) in which she/he has been socialised[8]. The performer's habitus expresses the constitutive order of society within each of us; the social (S) dimension of performer constraints.

Garfinkel's (1967) notion of ethnomethods implies habitual patterns that express an embodied and embedded understanding of the normativity of the task at hand (Camus, 2009, p. 103) and constitute a truly embodied intentionality[9]. Ethnomethods in sports are the methods of competent players, so to say, players that are familiar and fluent with the constitutive expectations of the game. Of course, the reasonability and adequacy of their play depend on the level of expertise and personal ability. The study of ethnomethods offers an alternative empirical (ethnographic) research programme to the skilled intentionality framework (van Dijk & Rietveld, 2017). In fact, the learning of certain ethnomethods implies something similar to what Vaughan et al. (2021) express within the Skilled Intentionality Framework: that during the process of athlete development, certain aspects of culture and context become embodied as value-directness, constraining the player-environment intentionality.

The embodied and embedded sense of the game (as and of the ethnomethods) refers to the knowledge of the game (instead of the knowledge about the game, Vaughan et al., 2021, p.11). Such a sense of the game helps to contextually discern not only what is possible and/or ethical from what is

[7] "Cultural capital can exist in three forms: in the embodied state, i.e., in the form of long-lasting dispositions of the mind and body; in the objectified state, in the form of cultural goods (pictures, books, dictionaries, instruments, machines, etc.), which are the trace or realisation of theories or critiques of these theories, problematics, etc.; and in the institutionalised state, a form of objectification which must be set apart because, as will be seen in the case of educational qualifications, it confers entirely original properties on the cultural capital which it is presumed to guarantee." (Bourdieu, 1986, p.17)

[8] I refer to socialisation as the process of learning the ethnomethods in a context of practice to become a competent member of a community. This praxeological understanding of socialisation developed by Garfinkel was a reaction against Talcott Parsons's view of socialisation as a process on internalisation of social norms, values, and ideas, in which the subject remained a passive agent. Garfinkel's approach provides a much more active agency to the learning of an embedded and embodied subject. A similar approach can be found in Tim Ingold's proposal of "enskilment" as opposed to passive enculturation (for an application of enskilment to skill learning in sport see Woods et al., 2021).

[9] In this sense, ethnomethods express something similar to Merleau-Ponty's [1945] (1963) motor intentionality but placing special interest in the social dimension. See Heft (1989) for an intentional analysis of Gibson's affordances in relation to socio-cultural practices.

not during the game (within the rules of the game and fair play). It also allows the performer to contextually discern what is reasonable and not reasonable during the game (within the praxical rules). To talk about ethnomethods instead of other terms such as national or club culture helps us to bring back the materiality, embeddedness and embodiedness of culture, and avoid considering the latter from a cognitivist assumption (culture as symbolic productions (science, arts, etc...) that is passed from mind to mind (inside the head). The same way we tend to think about cognition and matter in psychological terms (cognition as something ethereal inside the brain) we tend to think about culture and social practices (culture as a kind of cognitive programme that can be passed to following generations). Ethnomethods can include ethnic, national, or local habitual ways of doing things (so called national or team's styles of playing) respecting an embodied, embedded perspective.

Thus, performer constraints also include a social dimension within the habitus, understood as dispositions expressing levels of expertise (level of socialisation in ethnomethods). In a nutshell, levels of expertise imply levels of embodied socialisation in ethnomethods carrying an implicit intentional structure (a sense of the game), not in the cognitivist assumption of an internal set of rules but on the praxeological assumption of embodied/embedded know-how (Sánchez-García & Spencer, 2013). Different studies from an ecological dynamics perspective (Chow, Davids, Hristovski, Araújo, & Passos, 2011; Renshaw, Chow, Davids, & Hammond, 2010) show that specific situations afford a quite different and more limited array of action possibilities for novices than experts. A progression in their level of expertise emerges as a consequence of a history of interactions between learners and the environment; in a nutshell: a history of socialisation in the game, of learning and acquiring the ethnomethods to play the game (Sánchez-García, Villaroya-Gil, & Elrio-López, 2016).

Such different levels of expertise (novice, intermediate, expert) indicate not only a different level of technical execution, but foremost a different set of action capabilities and a different perceptual attunement: the process of learning which sources of information to attend to in each situation and when to attend to the relevant information (Jacobs & Michaels, 2007), Both in the energy flow (variants and invariants) and also in the customary regularities involving situation types (see the following sub-section on the social dimension of informational constraints). This kind of embodied (direct, perceptual) type of cognition is really different from saying that experts or novices compute a different set of (praxical) rules in their heads in order to decide how to act. In the clear distinction made by Gibson (1966), experts get a better knowledge of the environment (direct perception of affordances), not

a better knowledge about the environment (indirect perception mediated by symbols). As Button et al, 2021, p.73) express it: "To say that a basketball player 'knows' what needs to be done in a match means that a highly skilled player is perceptually attuned to events that convey information for achieving task goals at any instance of the game".

4. The Social Dimension Of Informational Constraints

Gibson's ([1979] 1986) theory of direct perception presents some problems regarding socio-cultural functional meaning. Even though Gibson acknowledged the importance of value, not simply of the stimulus, for conceiving affordances and value can depend heavily on socio-cultural aspects, he just provided a brief example of the social meaning in direct perception when he spoke about a mailbox offering an affordance for posting letters to a letter-writing human in a community with a postal system (Gibson, [1979] (1986, p. 139). Nonetheless, he did not develop the matter further, leaving us with a non-satisfactory account of the social dimension of informational constraints.

Chemero (2011) provides a solution for a theory of direct perception that includes socio-cultural meaning. He uses situation semantics (Barwise & Perry, 1981, 1983) in which constraints play a key role. According to Chemero:

> Constraints between situation types can hold in virtue of law-governed, causal connections, but they can also hold in virtue of customs, conventions, and other regularities. So, a situation with smoke of a particular type can bear information about the existence of fire by natural law, but it can also bear information about the decisions of tribal elders by conventions governing the semantics of smoke signals. (Chemero, 2011, p.116)

Constraints that connect situations are not limited to law-like connections (e.g., invariants in the energy flow) but can also be cultural or conventional, presenting customary regularities (Chemero, 2011, p.119). Thus, customary regularities express a socially constituted (S) understanding of the informationally mediated interactions (s) among players. For instance, information of a certain action (a movement of the shoulder in boxing; situation A) can specify a subsequent action (an incoming jab; situation B). This is something that cannot be specified just by the law-governed information provided by the optical flow because there is nothing in the optical array that connects a movement of the shoulder and a jab unless you are boxing, and have directly identified those as boxing actions, not simple movements. Barwise (1989) considered a progressive "attunement to constraints", to the relevant customary regularities, in the same way that Gibson talked about a progressive attunement to relevant law-like information of the environment.

Thus, returning to the previous sub-section of performer constraint, the expert becomes better attuned not only to constraints in the energy flow (invariants) but also to customary constraints (regularities in the game involving situation types) that help to select suitable affordances/actions. For instance, an expert defender is better attuned to constraints of a certain movement (situation A) as a feint or a ruse (situation B) on the attacker's side, something that cannot be specified just by the law-governed information provided by the optical flow (tau invariant).

Talking about the interactive facet (s), the organization of informationally mediated concerted actions (both collaborative and competitive) among players in socio-motor sports presents formal structures that are ordered and intelligible (Garfinkel & Sacks, 2005). For instance, even though every dribbling sequence in football is different, they all display some publicly discernible patterned order that made all of them recognisable as dribbling cases.

So far, the paper has presented the social dimension of the kind of constraints presented in the ecological dynamics model (Button et al., 2008; 2021): task, environmental, performer and informational constraints. Nonetheless, this paper also proposes an enhanced, comprehensive constraints model (see Fig. 4 in section 5) in which two more kinds of constraints can be identified: semiotic and volitional constraints.

Both semiotic and volitional could be considered special cases of informational constraints. In fact, semiotic refers to what Newell (Newell & Valvano, 1998; Newell & Rangamathan, 2010) dubbed "augmented information"; and volitional refers to (augmented) intention, being considered by Kelso (1995) a kind of informational constraint. Nonetheless, the three of them (informational, semiotic, volitional) express very different kinds of constraints, so it is more adequate to maintain different terms for each category.

The following sub-sections present semiotic and volitional constraints and explore their social dimension.

4.1 The Social Dimension Of Semiotic Constraints

Humans do not dwell only in a physical-biological environment; they dwell also in a material-semiotic human-made world. In the relationship between the environment and the human-made world we find semiotic constraints, including the kind of information that is based on human materiality and signs (icons, indexes, and symbols) but does not imply a computation between minds to make sense of the situation. Semiotic constraints are always present within human interaction, so their social dimension expresses

(s), a feature of the situation. Signs are always embodied and embedded in a situation. They are actively solicited, selected, and used by specific individuals (e.g., coaches) and addressed to other specific individuals (e.g., a particular athlete in a specific situation). Nonetheless, they do not contain any kind of random information; they always imply some information about a specific human activity, using signs bound to such an activity, referring to the constitutive (S) sense of the social.

Semiotic constraints refer precisely to what Newell considered as "augmented information", an information not directly available for the execution of the task (Newell & Valvano, 1998; Newell & Rangamathan, 2010). Augmented information is the kind of information about that Gibson (1966) differentiated from the information of the environment (this one affecting informational constraints, see above). In a nutshell, semiotic constraints imply indirect (semiotically mediated) information about the situation; a kind of information that does not prescribe, in the sense of a motor programme, but channels the use and exploitation of the information in the energy arrays and customary regularities.

Newell and Rangamathan (2010) considered instructions as augmented information and Newell and Valvano (1998) differentiated physical manipulation from augmented information, binding the latter to vocal utterances. From the point of view of semiotic constraints, there is no difference between physical manipulation and vocal utterances except from the perceptual system they are referring to. I consider both as augmented information featuring different sensory modalities (Muntanyola-Saura & Sánchez-García, 2018) and both constitute semiotic constraints. Augmented information provides an intention for channelling perception/action, as in the case of explicit attentional and search strategies. It offers perceptual goals, and it entails the education of attention. As Araújo, Dicks and Davids (2019) express it: "Intention plays a role by setting up a perceptual system to be sensitive to information appropriate for a to-be-perceived property or to-be-undertaken action. In other words, intention directs attention." (p. 572).

Nonetheless, semiotic constraints do not only appear during learning interactions. Augmented information also channels the behavioural dynamics during game time. Instructions from coaches; calls, utterances, interjections, signals, gestures from partners and/or opponents during a game provide explicit intentions affecting perceptions in a mediated, indirect way[10].

[10] The "cheat sheet" case of Lehman's case presented at the beginning of the paper falls into the category of augmented information; in this case with the aim of disturbing the intending-perceiving-acting cycle of the shooter to make him fail.

4.2 The Social Dimension Of Volitional Constraints

In the middle ground between task and performer constraints we find volitional constraints. Akin to augmented information, volitional constraints imply augmented intention, coming explicitly from a socialised subject in relation to a task. For instance, Bradshaw and Sparrow (2002) showed the variation of gait during a run-up depending on target size and participants' intentions: to make a hard or a soft impact with the foot. The hard impact was similar to a long jump approach and the soft impact to a case in which the subject approaches a target by stopping forward progression and staying close to the boundary. Even though it may seem that we are talking here only about autonomous subjects' intentions, in such an experimental setting, the social was present in the required task-goal (to make a hard or soft landing) proposed by the researchers.

Volitional constraints are also present during a game situation: e.g., a taekwondo athlete with a clear intention of scoring a point because the time is running out is facing a very different situation than the same taekwondo athlete at the beginning of the match. The former has the urge to score, his explicit intention conditioning the whole intending-perceiving-acting for good or for ill. As Button et al. (2021, p.75) remind us: "Intentions are not causes of action, but specific constraints on action." In this case, I talk about augmented intention because the subject explicitly adds something to the implicit intentional structure of the ethnomethods that oftentimes allow the subjects to make decisions without noticing (Whitagen, Araújo & de Poel, 2017, p. 12)[11].

Even though informational and semiotic constraints feature a (s) dimension, I discarded it in the case of volitional constraints. Despite the fact that intention is contextually and temporally situated, it is not publicly accountable. Thus, I consider it lacks a social dimension from the interactive (s) perspective. What is publicly accountable (interactively relevant) is the actions, the utterances, etc. (informational and semiotic constraints) that constitutes the interactive features of the situation. During the game everything happens at the same time, and we tend to infer a person's intention from the actions performed. Nonetheless, this assumption is problematic, as exemplified in the case when the referee must decide whether to sanction an action with an unsportsmanlike foul or not.

The notion of volitional constraints (augmented intention) addresses the topic of agency as conceived by Whitagen et al. (2012, 2017). For these authors, agency can be conceived of as the subject's capacity to modulate the coupling strength

[11] There is no space to discuss here this kind of activity, sometimes labelled as unreflective, unconscious, automatic as understood from a phenomenological perspective (Dreyfus, 2014). For a critical appraisal of such a Dreyfusian approach to skill see Hutto and Sánchez-García, 2015).

with affordances, which can invite behaviour (Kiverstein, van Dijk & Rietveld, 2021). In this sense, "the agent can influence to what extent each invitation influences him or her." (Whitagen et al., 2017, p.14). Nonetheless, the idea of volitional constraints restricts such a notion of agency to just another kind of constraint (avoiding the consideration of the privileged interior of the individual over the whole system) and it also includes a social dimension because the explicit personal intentions belong not to an autonomous idealised subject, but to a (more or less) socialised subject that is always in relation to a task. Thus, the social dimension of volitional constraints implies (S): the constitutive order of the human world that lies in the social within us (ethnomethods) and without us (task).

5. The Social Within The Enhanced Constraints Model

After presenting the different kinds of constraints and adding the social dimension to the whole model, this sub-section includes a graphical representation (Fig. 4) of the enhanced constraints model and discusses in more depth the topic of agency in decision-making.

The model renders visible the myriad of interacting constraints channelling the dynamic interaction between subject and environment, including the human-made world.

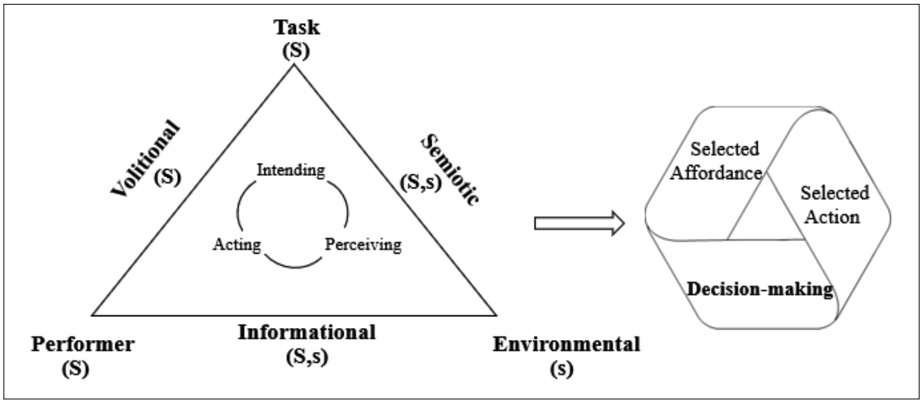

Fig. 4 - A model of constraints affecting the intending-perceiving-acting cycle within subject-environment dynamics. The two instances of decision-making (selection of affordance and selection of action) connected to the intending-perceiving-acting cycle of a subject interacting with an environment affected by interacting constraints. The social dimension of the different constraints is expressed by S (constitutive order) and s (feature of interaction).

We should be cautious not to consider agency as some kind of mediator in the hands of the performer[12] between the two instances of decision-making: selection of affordances (perception) and selection of action (realisation) (Araújo et al., 2019, p.17). By doing so, we would run the risk of reintroducing asymmetry (Davids & Araújo 2010) in favour of the interior of the subject, affecting to a greater extent the decision-making process as if an autonomous subject were confronted with a myriad of possibilities for action (affordances) to decide among them.

It is true that the selection of affordances occurs as an emergent dynamic process and could imply fleeting appearances of affordances that did not emerge finally as selected (and realised in action), resulting in being discarded. Nonetheless, this is not the consequence of a detached, autonomous deciding subject. Instead, some of the constraints that could affect discarding such affordance for selection (and realisation in action) may be a sudden flash of light (environmental constraint), fear (performer constraint), a conscious intention by a socialised subject in relation to the task (volitional constraint) or the information for the next affordance (informational constraint) of the sequence towards achieving a final goal (task constraint)[13].

Thus, both the selection of affordances and the selection of actions should be considered as two instances (perception and realisation) of the emergent decision-process channelled through a whole constellation of interacting constraints (Araújo et al., 2019, p.16) within the interaction of the subject-environment system altogether. As this paper has remarked along the different sections, the social dimension of the different constraints plays a key role for a subject that is immersed not only in a bio-physical but in a material-semiotic human-made world.

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[12] As expressed in sentences such as: "affordances can be used, motivating an organism to act, but they are not to be viewed as unique causes for behaviour because a person may not act on a perceived affordance." (Araujo et al., 2019, p.15)

[13] For instance, Esteves, de Oliveira and Araújo (2011) studied 1v1 dribbling situations in basketball and found that the exploitation of an initial affordance by attackers (body position of the defender relative to the attacker) was followed by a second affordance (the space near the basket) in order to achieve the final goal of scoring. Thus, the ongoing decision-making (selection of affordances and actions) of the players implied three concatenated goals: dribble past the defender-approach the basket-shoot to score. The sequence of selected affordances in such a goal-directed activity implies an understanding of the perception of nested affordances in multi-scale dynamics in which information for the next affordance plays a crucial role in the selection of each affordance of the sequence (Araújo et al., 2019, p.567).

6. Concluding remarks

This paper has tried to implement a truly social dimension that was lacking in the constraints model as used in ecological dynamics. By doing so, it has offered a way to maintain the unit of analysis on the dynamic interaction between subject and environment, conceiving the latter not only as a bio-physical but also a human-made world. Moreover, it has done so avoiding falling prey to cognitivist assumptions and respecting the ecological level of analysis. Instead of taking socio-cultural constraints as some distant and out-of-the-action factors (expressed in the umbrella term of culture), this paper has brought the social – both constitutive (S) and interactive (s) – dimension of constraints right into the active engagement of a subject with an (bio-physical-social) environment.

By doing so, the paper has provided an enhanced constraints model, including two previously ignored kinds of constraints: volitional and semiotic. Moreover, this enhanced model has developed further the understanding of agency, not bound to the interior of a privileged subject, but distributed among the whole constellation of interacting constraints affecting the dynamic subject-environment interaction.

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REFERENCES

Araújo, D., & Davids, K. (2004). Embodied cognition and emergent decision-making in dynamical movement systems. *Junctures: The Journal for Thematic Dialogue*, 2, 45-57.

Araújo, D., Dicks, M., & Davids, K. (2019). Selecting among affordances: a basis for channeling expertise in sport. In Massimialiano Capuccion (Ed.) *Handbook of embodied cognition and sport psychology* (pp. 557-580). Massachusetts: MIT Press.

Araújo, D., Hristovski, R., Seifert, L., Carvalho, J., & Davids, K. (2019). Ecological cognition: expert decision-making behaviour in sport. *International Review of Sport and Exercise Psychology*, 12(1), 1-25.

Baggs, E. (2021). All Affordances Are Social: Foundations of a Gibsonian Social Ontology. *Ecological Psychology*, 33(3-4), 257-278.

Balagué, N., Pol, R., Torrents, C., Ric, A., & Hristovski, R. (2019). On the relatedness and nestedness of constraints. *Sports medicine-open*, 5(1), 1-10.

Bar-On Cohen, E. (2009). Kibadachi in karate: pain and crossing boundaries within the 'lived body'and within sociality. *Journal of the Royal Anthropological Institute*, 15(3), 610-629.

Barwise, J. (1989). *The situation in logic.* Cambridge:Center for the Study of Language.

Barwise, J., & Perry, J. (1981). Situations and attitudes. *The Journal of Philosophy*, 78(11), 668-691.

Barwise, J., & Perry, J. (1983). *Situations and attitudes*. Cambridge, MA: MIT Press/Bradford.
Bernstein, N. (1967). *The coordination and regulation of movement*. New York:Pergamon.
Bourdieu, P. (1986). The forms of capital. In Richardson, J. (Ed.). *Handbook of Theory and Research for the Sociology of Education,* pp. 241–58, Westport, CT: Greenwood.
Bourdieu, P. (1990). *The logic of practice*. Stanford University Press.
Bradshaw, E. J., & Sparrow, W. A. (2002). The effects of target length on the visual control of step length for hard and soft impacts. *Journal of applied biomechanics*, 18(1), 57-73.
Bronfenbrenner, U. (1995). The bioecological model from a life course perspective: Reflections of a participant observer. In P. Moen, G. H. Elder, Jr., & K. Lüscher (Eds.), *Examining lives in context: Perspectives on the ecology of human development* (pp. 599–618). American Psychological Association
Brymer, E., & Renshaw, I. (2010). An introduction to the constraints-led approach to learning in outdoor education. *Journal of Outdoor and Environmental Education*, 14(2), 33-41.
Button, C., Seifert, L., Chow, J. Y., Davids, K., & Araujo, D. (2021). *Dynamics of skill acquisition: An ecological dynamics approach*. Champaign:Human Kinetics Publishers.
Camus, L. (2009). *Action instruite et coordination* (Unpublished Master's Dissertation). Ecole des Hautes Etudes en Sciences Sociales, Paris.
Chemero, A. (2011). *Radical embodied cognitive science*. MIT press.
Chow, J. Y., Davids, K., Button, C., Shuttleworth, R., Renshaw, I., & Araújo, D. (2007). The role of nonlinear pedagogy in physical education. *Review of Educational Research*, 77(3), 251-278.
Chow, J. Y., Davids, K., Hristovski, R., Araújo, D., & Passos, P. (2011). Nonlinear pedagogy: Learning design for self-organizing neurobiological systems. *New Ideas in Psychology*, 29(2), 189-200.
Chow, J. Y., Davids, K., Button, C., & Renshaw, I. (2016). *Nonlinear pedagogy in skill acquisition: An introduction.* Abindong:Routledge.
Clark, J. E. (1995). On becoming skillful: Patterns and constraints. *Research quarterly for exercise and sport,* 66(3), 173-183.
Correia, V., Araújo, D., Cummins, A., & Craig, C. M. (2012). Perceiving and acting upon spaces in a VR rugby task: expertise effects in affordance detection and task achievement. *Journal of Sport & Exercise Psychology*, 34(3).
Davids, K., & Araújo, D. (2010). The concept of 'Organismic asymmetry' in sport science. *Journal of Science and Medicine in Sport*, 13(6), 633-640.
Davids, K., Button, C., & Bennet, S. (2008). *Dynamics of skill acquisition: a constraints-led approach*. Champaign, IL: Human Kinetics.
Dreyfus, H.L. (2014). *Skillful coping: essays on the phenomenology of everyday perception and action.* Oxford:Oxford University Press.
Durkheim, E. [1912] (2008) *The elementary forms of the religious life.* New York:Dover.
Esteves, P. T., de Oliveira, R. F., & Araújo, D. (2011). Posture-related affordances guide attacks in basketball. *Psychology of Sport and Exercise*, 12(6), 639-644.
Garfinkel, H. (1967). *Studies in Ethnomethodology*. N.J.: Prentice Hall.
Garfinkel, H., & Sacks, H. (2005). On formal structures of practical actions. In H. Garfinkel (Ed.). *Ethnomethodological studies of work* (pp. 165-198). Abingdon:Routledge.
Gibson, J. J.(1966). *The senses considered as perceptual systems*. Boston: Houghton Mifflin.
Gibson, J. J. [1979] (1986). The ecological approach to visual perception. Hillsdale, NJ: Erlbaum.
Glazier, P. S. (2017). Towards a grand unified theory of sports performance. *Human Movement Science*, 56, 139-156.
Goffman, E. (1983). The interaction order: American Sociological Association, 1982 presidential address. *American sociological review*, 48(1), 1-17.
Haken, H., Kelso, J. S., & Bunz, H. (1985). A theoretical model of phase transitions in human hand movements. *Biological cybernetics*, 51(5), 347-356.

Heft, H. (1989). Affordances and the body: An intentional analysis of Gibson's ecological approach to visual perception. *Journal for the theory of social behaviour*, 19(1), 1-30.
Hutto, D. D., & Sánchez-García, R. (2015). Choking RECtified: embodied expertise beyond Dreyfus. *Phenomenology and the Cognitive Sciences*, *14*(2), 309-331.
Jacobs, D. M., & Michaels, C. F. (2007). Direct learning. *Ecological psychology*, 19(4), 321-349.
Kelso, J. S. (1995). *Dynamic patterns: The self-organization of brain and behavior*. MIT press.
Kiverstein, J., van Dijk, L., & Rietveld, E. (2021). The field and landscape of affordances: Koffka's two environments revisited. *Synthese*, 198(9), 2279-2296.
Kugler, P. N., Kelso, J. S., & Turvey, M. T. (1980). On the concept of coordinative structures as dissipative structures 1. Theoretical lines of convergence. In G.E. Stelmach and J. Requin (Eds.) *Tutorial in Motor Behavior* (pp. 3-47). Amsterdam:North-Holland.
Kugler, P. N., Kelso, J. S., & Turvey, M. T. (1982). On the control and coordination of naturally developing systems. In J.A. Kelso and J.E. Clark (Eds.). *The development of movement control and coordination* (pp. 1-78). New York:Wiley.
Kugler, P. N., Shaw, R. E., Vincente, K. J., & Kinsella-Shaw, J. (1990). Inquiry into intentional systems I: Issues in ecological physics. *Psychological Research*, 52(2), 98-121.
McDermott, R.P. (1976). Kids make sense: an ethnographic account of the interactional management of success and failure in one first classroom. Unpublished PhD dissertation, Standford University, CA.
Moy, B., Renshaw, I., Davids, K., & Brymer, E. (2015). Overcoming acculturation: physical education recruits' experiences of an alternative pedagogical approach to games teaching. *Physical Education and Sport Pedagogy*, 21(4), 386-406.
Muntanyola-Saura, D., & Sánchez-García, R. (2018). Distributed attention: A cognitive ethnography of instruction in sport settings. *Journal for the Theory of Social Behaviour*, 48(4), 433-454.
Merleau-Ponty, M. [1945] (1963). *The Phenomenology of perception*. London:Routledge.
Newell, K. M. (1986). Constraints on the development of coordination. In M. G. Wade & H. T. A. Whiting (Eds.), *Motor development in children: aspects of coordination and control* (pp. 341-361). Amsterdam: Martinus Nijhoff Publishers.
Newell, K. M. (1996). Change in movement and skill: learning, retention, and transfer. In M. L. Latash & M. T. Turvey (Eds.), *Dexterity and its development* (pp. 393-429). Mahwah, NJ: Lawrence Erlbaum Associates.
Newell, K. M., & McDonald, P. V. (1992). Searching for solutions to the coordination function: Learning as exploratory behavior. In G. E. Stelmach & J. Requin (Eds.). *Tutorials in motor behavior, 2* (pp. 517–532). North-Holland.
Newell, K. M., & Ranganathan, R. (2010). Instructions as constraints in motor skill acquisition. In Ian Renshaw, Keith Davids, and Geert J.P. Savelsbergh (Eds.). *Motor Learning in Practice. A Constraints-led approach* (pp. 17-32). Abindong:Routledge.
Newell, K. M., & Valvano, J. (1998). Movement science: therapeutic intervention as a constraint in learning and relearning movement skills. *Scandinavian Journal of Occupational Therapy*, 5(2), 51-57.
Parlebas, P. (1981). *Contribution à un lexique commenté de l'action motrice*. Paris: Insep.
Parlebas, P. (2013). Motor praxeology: a new scientific paradigm. In Mariann Vaczi (Ed.). *Playing Fields: Power, Practice, and Passion in Sport* (pp.127-144). Reno:University of Nevada.
Rawls, A. (2022). Situating Goffman's "Interation Orders" in Durkheim's social fact lineage. Grounding an alternative sociology of modernity in heightened awareness of interaction. *Etnografia e Ricerca Qualitativa*, 1, 27-62.
Renshaw, I., Chow, J. Y., Davids, K., & Hammond, J. (2010). A constraints-led perspective to understanding skill acquisition and game play: a basis for integration of motor learning theory and physical education praxis? *Physical Education & Sport Pedagogy, 15*(2), 117-137.

Richardson, M. J., Marsh, K. L., Isenhower, R., Goodman, J., & Schmidt, R. C. (2007). Rocking together: Dynamics of intentional and unintentional interpersonal coordination. *Human Movement Science*, 26, 867-891.

Rietveld, E., & Kiverstein, J. (2014). A rich landscape of affordances. *Ecological psychology*, 26(4), 325-352.

Rothwell, M., Davids, K., & Stone, J. (2018). Harnessing socio-cultural constraints on athlete development to create a form of life. *Journal of Expertise*, 1(1), 1-9.

Sánchez- García, R. y García-de-Alcaraz, A. (2021). Crowd Effects, Territoriality and Home Advantage: A Sociological Explanation. In Gómez, M. A., Pollard,R. y Lago-Peñas, C. (eds.). *Home Advantage in Sport:Causes and the Effect on Performance* (pp. 51-63). Abingdon:Routledge.

Sánchez-García, R. & Fele, G. (2015). Normatividad en deporte:una re-especificación etnometodológica. *Empiria*, 30, pp. 13-30.

Sánchez-García, R., and Spencer, D.C. (2013). Conclusion: Present and Future Lines of Research. In Raúl Sánchez-García and Dale Spencer (Eds.) *Fighting Scholars.* (pp. 185-192). London:Anthem Press.

Sánchez-García, R., Villaroya-Gil, A., & Elrio-López, A.(2016). Manipulating task constraints of situated normativity to study decision making in Krav Maga. *The International journal of sport psychology*, 47, 133-54.

Schmidt, R. C., Carello, C., & Turvey, M. T. (1990). Phase transitions and critical fluctuations in the visual coordination of rhythmic movements between people. *Journal of Experimental Psychology: Human Perception and Performance*, 16 (2), 227 – 247.

Schmidt, R. C. & O'Brien, B. (1997). Evaluating the dynamics of unintended interpersonal coordination. *Ecological Psychology*, 9 (3), 189 – 206.

Seifert, L., Orth, D., Button, C., Brymer, E., & Davids, K. (2017). An ecological dynamics framework for the acquisition of perceptual–motor skills in climbing. In Feletti, F. (Ed). *Extreme sports medicine* (pp. 365-382). Chamonix:Springer.

Shimizu, D., & Okada, T. (2021). Synchronization and Coordination of Art Performances in Highly Competitive Contexts: Battle Scenes of Expert Breakdancers. *Frontiers in Psychology*, 12, 1-11.

Simmel, G. (1977). *Sociología 1. Estudios sobre las formas de socialización*. Madrid: Revista de Occidente.

Sullivan, M. O., Vaughan, J., Rumbold, J. L., & Davids, K. (2021). The Learning in Development Research Framework for sports organizations. *Sport, Education and Society*, 1-15.

Swami, V. (2015). Cultural influences on body size ideals: Unpacking the impact of Westernization and modernization. *European Psychologist*, 20(1), 44–51.

Uehara, L., Button, C., Araújo, D., Renshaw, I., & Davids, K. (2018). The role of informal, unstructured practice in developing football expertise: the case of Brazilian Pelada. *Journal of Expertise*, 1(3), 162-180.

Uehara, L., Button, C., Saunders, J., Araújo, D., Falcous, M., & Davids, K. (2021). Malandragem and Ginga: Socio-cultural constraints on the development of expertise and skills in Brazilian football. *International Journal of Sports Science & Coaching*, 16(3), 622-635.

van Dijk, L., & Rietveld, E. (2017). Foregrounding sociomaterial practice in our understanding of affordances: The skilled intentionality framework. *Frontiers in Psychology*, 7 (1969), 1-12. https://doi.org/10.3389/fpsyg.2016.01969

Vaughan, J., Mallett, C. J., Potrac, P., López-Felip, M. A., & Davids, K. (2021). Football, culture, skill development and sport coaching: Extending ecological approaches in athlete development using the skilled intentionality framework. *Frontiers in Psychology*, 12, 1-14.

Vilar, L., Araújo, D., Davids, K., & Renshaw, I. (2012). The need for 'representative task design' in evaluating efficacy of skills tests in sport: a comment on Russell, Benton and Kingsley (2010). *Journal of Sports Sciences, 30*(16), 1727-1730.

Wheaton, B. (2010). Introducing the Consumption and Representation of Lifestyle Sports. *Sport in Society* 13 (7/8): 1057–1081.
Wittgenstein, L. (1953). Philosophical investigations (G. E. M. Anscombe, Trans.). Oxford: Blackwell Publishing.
Withagen, R., Araújo, D., & de Poel, H. J. (2017). Inviting affordances and agency. *New Ideas in Psychology*, 45, 11-18.
Withagen, R., De Poel, H. J., Araújo, D., & Pepping, G. J. (2012). Affordances can invite behavior: Reconsidering the relationship between affordances and agency. *New Ideas in Psychology*, 30(2), 250-258.
Woods, C. T., Rudd, J., Gray, R., & Davids, K. (2021). Enskilment: An ecological-anthropological worldview of skill, learning and education in sport. *Sports Medicine-Open*, 7(1), 1-9.

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