

Metacognition and diagrams in marking-for-self

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Abstract: Metacognition relies on representations, which are commonly viewed as internal knowledge structure. We explore the idea that external embodied diagrams (marking), rather than monomodal symbolic-based entities, can provide an accurate description of metacognition in choreographic dance. When marking, dancers use their bodies to represent properties, dynamics, or structures of complete dance phrases. Marking-for-self occurs when a dancer marks the dance in their own unique manner, potentially allowing for real-time reflection through the manipulation of external signs. These manipulations can be considered as diagrammatic semiosis, as diagrams signify through shared relational parts analogous to the parts of their objects. Based on Peirce's semiotics, we argue that semiosis, in a rich, physically and culturally distributed multimodal form, is crucial for metacognition. This paper is structured to first review marking and marking-for-self, followed by an overview of metacognition. We then define marking-for-self as a metacognitive phenomenon and introduce Peirce's concept of semiosis and diagrams. Finally, we describe marking as a diagrammatic sign and explain how marking-for-self is an embodied metacognitive process achieved through the manipulation of diagrammatic structures. Metacognition treated as semiosis allows us to consider metacognition as a relevant part of our ability to use experience and body knowledge in creative ways.

Keywords: Marking, Diagram, Metacognition, External Representation, C.S.Peirce

1. Introduction

Marking-for-self is a metacognitive artifact. It can be described as an iconic sign performed to represent and communicate structures of motor behavior in choreographic dance. It can also be defined as an embodied diagram. As a diagram, marking "stands for" dancing phrases structures, such as body part-part relation and spatio-temporal positioning.

Marking is used as a cognitive artifact to ease, constrain, and sometimes allow, specific types of thinking processes, as considered in distributed cognition framework (Hutchins 1996, 2013; Clark 2008; Kirsh 2009; Fusaroli and Paolucci 2011; Davies and Michaelian 2016; Anderson et al. 2019). Using external and embodied representations, dancers reduce the cognitive load that occurs when comparing or experimenting with novel possibilities of movement (Kirsh 2011). Examples of external representations include "diagrams, illustrations, spoken instructions, or written problem statements" (Kirsh 2017: 171). In marking, those external representations are "anchored" (Hutchins 2005: 1557) in the body of the dancer (Kirsh 2011: 187; Warburton et al. 2013). This process allows marking to scaffold learning, memory, and the creation and comparison of represented motor activities in choreographed dance (Warburton et al. 2013). The reduction of the cognitive load by the use

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of external representations leads dancers to more effectively self-evaluate their performances. This characteristic of self-evaluation is more prominent in marking-for-self. Kirsh (2011: 207) defines marking-for-self as a type of marking used for “personal reflection”, considered to be “much like an externalized version of a simulation” (Kirsh 2011: 197-198). We argue that the manipulation of the diagrammatic structure of marking-for-self is a distributed metacognitive process. A metacognitive process is a process of self-evaluation that allows a cognitive system to anticipate a cognitive output and evaluate if they are accurate (Proust 2014a: 703). We treat marking-for-self as a case-study for investigating the use of embodied and externalized diagrams that take part in (or even allow) metacognitive processes in choreographed dance, considering that the external diagrammatic signs are artifacts that can be manipulated in order to generate anticipation and evaluation.

The definition of 'representation' or 'metarepresentation' is not typically the focus of investigations into metacognition. Instead, they are usually considered as internal knowledge structures, rather than external-oriented semiotic processes. According to Peirce's cognitive semiotics, marking is semiosis (process of sign in action). Manipulation of embodied relational parts of marking as a sign (what is being manipulated “stands for” relational structures) enables metacognition through a process of diagrammatic reasoning. This is the explanatory scenario that interests us most here. But, as we shall see, our description of marking (especially -for-self) as semiosis differs from the models used to explain it. We provide a detailed investigation of this phenomenon, leading to a more precise description of the semiotic nature of it, and guiding new considerations about marking as a metacognitive process. This paper is structured as follows: (i) first, we review marking and marking-for-self, followed by (ii) a brief overview of metacognition. Then (iii) we define marking-for-self as a metacognitive phenomenon, (iv) and introduce Peirce's concept of semiosis and diagrams and (v) finally, we describe marking as a diagrammatic sign and marking-for-self as an embodied metacognitive process through the manipulation of the diagrammatic structures in the conclusion.

2. Marking in choreographic dance

Choreographic dance is based on pre-determined sequences of movements (Pakes 2020: 161). These patterns are created to be repeated as closely as possible, in a sequence (Butterworth and Wildschut 2018). In choreographic dance, marking is commonly described as “a process where a movement is sketched rather than fully executed” (Homans 2010;23

Stevens et al. 2019). It is used to communicate, generate new ideas, and rehearse, forming an intrinsic part of the dancing experience (Stevens and McKechnie 2005).

From a distributed cognition approach, marking is a cognitive artifact that enhances the performance of dancers. It can be used when “mastering a choreography”, since it “enhances memory and integration of multiple aspects of a piece” (Warburton et al. 2013: 1738). Marking saves energy, avoids strenuous movement and facilitates the review of specific aspects of a dance phrase, such as *tempo*³ (Kirsh 2011: 179). Investigations about marking often adopt the “embodied-cognitive-load theory” (Ginns and Leppink 2019). According to this framework, particularly effortful body movements impose a cognitive load. The distribution of the cognitive process has three different cost structures: the cost of the “inner process”, the cost of “outer process”, and the cost of “coordinating inner and outer process” (Kirsh 2017: 174). One strategy to minimize the cognitive cost is to reduce body movements. Smaller-scale movements with low energetic costs can also provide cognitive benefits when a high level of performance is required. Although these movements may result in a less faithful execution of a dancing phrase, these “embodied dancerly thoughts” imposes less cognitive load and can be “more effectively learned, processed, thought about, and understood” (Warburton et al. 2013: 1733; see also Wilson et al. 2008). Through marking, dancers are able to schematize movements using external representations. An example (see figure 1) is the use of “hand marking”, when dancers represent an aspect of a dance phrase they are thinking about using the motion of their hands (Kirsh 2011: 179).



³ In dance, *tempo* refers to the rate at which the beats correspond to the movements, it is usually divided into fast, medium, or slow.

Figure 1 (adapted from Kirsh 2011): We see a movement made by Irish river dancers (left) and the respective marking for that movement (right), in which one hand stands for the movement and the other for the floor.

For Warburton (2011: 161), the dancer uses “her implicit memory to prime in correct sequence a ‘turning’ motor program by taking it off-line”. This process occurs through a situated movement⁴ in which the dancer is “in relationship to self (and instructor)” and thinking “in real-time”, and requires “continuous reciprocal influence between perceptual flow and motor commands”. The dancer is able to manipulate the movement, for example by reducing it to a hand gesture, which allows them to exploit predictability in the task situation and automate a previously effortful process of skill acquisition (Warburton 2011: 161). Marking is considered a part of the dancing experience and creates a shared physicality and a common felt experience, freeing up the dancer to “imagine what can be” (Warburton 2017: 136). Marking can be used to “exemplify, reduce, and reflect the psychological and physical complexity inherent in dancing” (Warburton 2017: 136). Through this situated action and reduction of complexity, the dancer is able to “understand something deeper about the phrase’s structure than through imagination or mental imagery alone” (Warburton 2011: 169-171).

Kirsh (2011: 207) categorized marking into three different types: marking-for-others, marking-for-coordination, and marking-for-self. The first is a method used to “show a dance phrase to others in a sufficiently clear manner”. The second serves as a “method of group coordination”, while the third is a “method of practice and personal reflection”. Marking exhibits “five distinguishable dimensions” (Kirsh 2011: 187-190): 1) it requires less energy and displays fewer dynamics; 2) it can vary in size; 3) it is aspectival, representing an aspect of the full dancing phrase, such as tempo or spatial position; 4) it presents “conventional gestures” - dancers are taught to use certain gestures to mark specific moves; 5) it has “substitutability” - the use of a movement in one body part to represent another movement, such as using a hand gesture to stand in for a leg movement or tilting the head to represent a torso turn (Kirsh 2011: 188).

Substitutability is related to projection, which is the intentional augmentation of a physical structure (Kirsh 2011: 203). This results in an addition of extra elements to the physical structure, partially caused by the individual, as demonstrated by a chess player projecting the movement of the pieces before actually moving them. In the case of marking,

⁴ As posed by Warburton (2013: 157), the *therme* refers to actions and movements that “i.e., takes place in the context of a real-world environment. An enactive approach emphasizes the emotional and relational nature of thought in action”, as used in enactivists approaches - “the conjunction of “dance” with “enaction” defines the knowledge domain and real-world context of dancer action and performance”.

movements only need to be as complete as necessary to support the projected additional structures. Dancers use their bodily movements to anchor projections of their desired movements (Kirsh 2011: 204). Kirsh (2011: 204-205) distinguishes projection from perception and imagination, stating that the projected element has both an imaginative component, as it is conjured by the subject, and a perceptual component, as it is anchored on what is present. Projection requires a physical basis, as it involves adding intentional content to what is already there, and can only occur when the perceptual experience is sufficiently conceptualized, allowing the subject to choose what part of the visual scene to augment. Conceptualization is necessary as the projection must be anchored in something the subject recognizes (Kirsh 2011).

The concept of “anchoring”, as proposed by Hutchins (2005: 1557), emphasizes that thinking “involves complex manipulations of conceptual structure”, which must be represented in a way that allows some parts to be manipulated while others remain stable (Hutchins 2005: 1557). Embodied external representations are used to reduce the cognitive load of keeping and comparing two different representations, the movement that is happening and how the dancer projects the movement to happen, resulting in a more controlled thinking process (Kirsh 2011; Muntanyola-Saura and Kirsh 2010). The ability to anchor and manipulate projections makes marking an “interactive strategy” and a “powerful mechanism of thought” (Kirsh 2011: 203). This process involves “recalling an image, realizing it physically, conceptualizing what is now external, and then reconsidering whether that is the best conceptualization” (Kirsh 2011: 203). The projected representation allows dancers to create a “shared object”⁵ that can be manipulated by a group of people. Its materiality gives it physical persistence, which facilitates the creation, rearrangement, reformulation, and comparison of more stable and complex structures using multiple representations (Kirsh 2017: 187). These stable representations are particularly useful in marking-for-self when dancers are engaged in self-evaluation.

2.1 Marking-for-self: marking as an individual cognitive artifact

For Kirsh (2011: 185), marking-for-self reinforces “memory”, “reflection on sequences” and “personal scrutiny of spatial relations”. Muntanyola and Kirsh (2010: 10) differentiate between two types of marking-for-self: recall and reflection. Although Kirsh (2011) doesn't hold this distinction, it is a useful way to highlight key features of marking-for-self. Recall helps with memorization of a phrase, with focus on the physical

⁵ See also Clark (2008), for shared external representations as shared objects.

aspect of the movement, such as leg positioning. Reflection is used to examine a phrase, for example, to improve or add to it. Kirsh argues that marking-for-self is similar to an externalized version of a private mental simulation, as dancers are not concerned with communicating the phrase to others (Kirsh 2011: 197-198). The movements in marking-for-self are performed without speech and are idiosyncratic, each dancer using marking for their own personal purposes (Kirsh 2011: 189). Although marking-for-self is often only understood by the dancer who created it, this does not mean it is free from any form of influence. Even dancers who are not formally trained in ballet still mark in a way that is reminiscent of ballet marking (Kirsh 2011: 189) (see Table 1).

Table 1: Types of Marking

Type	Objective
Marking-For-Coordination	Directs the joint attention of dancers to structural elements of a phrase.
Marking-For-Others	Shows another person some facet of a movement.
Marking-For-Self	Encodes an aspect of a phrase for themselves. It is used to activate deeper processing about movement, working things out, or grasping a phrase better.

Font: Based on Kirsh (2011).

Marking-for-self is a metacognitive process. During the process of marking-for-self, dancers are stabilizing their monitoring and control processes by offloading or distributing part of these processes to their bodies, anchoring representational structures for thorough manipulation and investigation. This consideration leads us to think about metacognition not as an internal process, but an externalized one, which differs from some views discussed below.

3. Metacognition - a brief overview

There are three ways to approach metacognition: as a metarepresentational process, as a control and monitoring process, or as both, as in dual theories (Arango-Muñoz 2019). The beginning of metarepresentational theories are attributed to the works of Flavell (1979)⁶ and Nelson and Narens (1990)⁷. A common way to refer to metacognition in metarepresentational theories is to consider it as “think about thinking”. According to Carruthers (2020: 1),

⁶ Flavell (1979: 906) defines metacognition as “cognition about cognitive phenomena”, and consider metacognition important for “oral communication of information, persuasion and listening, reading and writing, language acquisition, attention, memory, problem-solving, social cognition and various types of self-control and self-instruction” (Flavell 1979: 906).

⁷ Nelson and Narens (1990: 125-127) developed a model based on “three abstract principles”: (i) the division of the cognitive process into two levels - ‘meta-level’ and ‘object-level’; (ii) the hypothesis that it is necessary that the meta-level contain a “dynamic model”, called “mental simulation”, of the object-level; and, (iii) that there is an “information flow” between the levels.

metacognition involves “metacognitive judgments” that are “always metarepresentational”, and involve “representations of mental states or processes in themselves”, and “have an implicit model or ‘theory’ of the operations of the mind itself”. Metacognition is considered to form a “propositional attitude” (Beran et al. 2012) towards the agent own thought process — “there is meta-representation of the belief that ‘p’ only if both the content ‘p’ and the attitude (the belief) are represented in a higher-order mental state” (Browne 2004: 634).

For control and monitoring theories, metarepresentation is not needed for metacognition. Instead, metacognition is based on noetic feelings (Proust 2013), which start a process of evaluation of mental dispositions. Accepting or rejecting these dispositions forms epistemic and motivational commitments (Proust 2010). Dual-process theories consider that there are two types of metacognition, each with its own nature. The first uses “the ability to mindreading⁸ directed towards oneself”, while the second “corresponds to the way in which humans and some animals intuitively control our cognitive processes” (Arango-Muñoz 2019). Another way to classify metacognition is to consider the functional role of “representations” and “metarepresentations” (Beran et al. 2012; Proust 2013).

Beran (et al. 2012: 5-6) define three conceptions of metacognition: (i) “pure-blooded representationalists” defend the idea that metacognition “goes hand in hand with metarepresentation and the conceptual constraints that Dretske places on understanding representational facts”; (ii) “moderate representationalist” consider that there are representations that do not “invoke contentious mental states”, or that are “non-conceptual representations”; and (iii) “non-representationalists” consider that metacognition does not involve representation (see table 2).

Table 2: Divisions about metacognition

Type	Position regarding metacognition
Metarepresentation / Pure Blood Representationalists	Metacognition requires the intention to alter the cognitive process itself. It forms meta-representations of representational mental states. There is metacognition only if there is a meta-representation of a belief in a higher-order mental state.
Monitor and Control / Moderate Representationalists	Metacognition represents a first-order state, without representing its specific representational function, it uses contextual-dependent clues to generate metacognitive feelings.
Dual Theory	There are two independent structures of metacognition, one is metarepresentational and the other uses noetic feelings.
Non-representationalists	Metacognition has distinct causal antecedents from simple cognitive processes.

⁸ According to Barlassina and Gordon (2017), “‘mindreading’ is understood in philosophy of mind and cognitive science as the capacity to represent, reason about, and respond to others’ mental states. Essentially the same capacity is also known as ‘folk psychology’, ‘Theory of Mind’, and ‘mentalizing’”.

For Proust (2013, 2019), there are two distinguishable strands to classify metacognition (Table 3): (i) the “self-attributive” considers that metacognition “depends on judgments based on beliefs and theories about the self, the task, and the competences that it involves or seems to involve” (Proust 2019: 311). This view regards metacognition as the ability to represent one’s own thoughts, that is, to “meta-represent”. (ii) The “self-evaluative” considers that metacognitive capacities can be performed by procedural mechanisms, that allows “the agent to monitor a first-order cognitive action without representing it conceptually” (Proust 2019: 311).

Table 3: Division - Proust (2013)

Questions	Self-attributive	Self-evaluative
Does metacognition use the same mechanisms as mind-reading?	Yes. It uses the same mechanisms that allow us to know about others' mental states.	No. It is a functionally distinct system.
Does access as control require access as representation?	Yes. Metacognition is guided by the content of mental states, requiring representation. The state must be known to be controlled.	No. Evaluation of a cognitive process generates noetic feelings that are not representational.
Does access to our mental states depend on propositions?	Yes. Meta-representational mechanisms accesses represented mental states. Those are capable of representing the propositional content of the attitude.	No. Noetic feelings indicate the accuracy of a first-order output and trigger the appropriate response.
Is access to our mental states inherently associated with mental action?	No. Access to mental states generates knowledge (i.e. knowing what I perceive count as metacognition), but this is different to the action we take.	Yes. Access to a mental state occurs in the context of a mental action. A procedural self-assessment is attached to each instance of mental agency.

Font: Based on Proust (2013) and Castro and Manrique (2020) review.

Since children appear to develop metacognitive capacities around the same age that they develop a stronger social cognition (Tomasello 2019, 2018; Carruthers 2008), it has been proposed that in order to have metacognitive processes as human adults, the ability to mindread is needed (Koriat and Ackerman 2010). Based on this argument, Carruthers (2008) argued that the studies about mindreading in non-human animals are inconclusive, and thus it is also inconclusive that they have metacognition since mindreading is ontogenetically and phylogenetically⁹ prior (see also Carruthers 2009, 2011).

⁹ A main friction point of this debate is if non-human animals are capable of metacognition. Considering that they are not

Heyes et al. (2020: 2-3) have shown that cumulative cultural learning is likely to be involved in our metacognitive abilities. They categorize metacognition into two types, explicit and implicit (as shown in Table 4). Metacognition operates through representations and evaluations of cognitive states, when these representations and evaluations are “non-conscious” it is referred to as “implicit” metacognition, and when they are “conscious”, it is considered “explicit” metacognition. Our explicit metacognitive capacity has been strengthened through human cumulative cultural learning, while other non-human animals may possess implicit metacognition.

Table 4: Division of metacognition into Explicit and Implicit (Heyes et al. 2020)

Types	Representation	Phylogenetic specificity
Explicit Metacognition	Represents properties of cognitive processes in a conscious and reportable way.	Typically human.
Implicit Metacognition	Represents properties of cognitive processes in a non-conscious and non-reportable way.	Shared with other animals.

Font: Based on Heyes et al. (2020).

One way to resolve the debate over metacognition is to propose that it is a dual system, comprised of two distinct systems: System 2, which is based on "theory", and System 1, which is based on "noetic feelings". According to Arango-Muñoz (2019), each system has a different structure, content, and function in the cognitive architecture. System 1 corresponds to the way humans and some non-human animals control their cognitive processes, while System 2 corresponds to the use of the ability to read one's own mind (Arango-Muñoz 2019; Proust 2013; Shea et al. 2014).

The role of the body in metacognitive processes is a more recent topic of investigation. This endeavor is mainly addressed by monitoring-and-control and dual theories, as the one proposed by Proust (2013). Clark (2008) has also proposed an embodied and externalist approach, where he argues that the materiality of language is crucial for metacognition.

4.1 Clark and Proust -- externalist metacognition

For Clark (1998, 2008), the internalization of public language is responsible for our metacognitive capacities. Clark (2008: 48-58) considers that language is a “supper cognitive

able to meta-represent, if they present metacognitive capacities this could be evidence that metacognition is not dependent on metarepresentation. Chimpanzees (Call and Tomasello 2008; Uller 2003; Karg et al. 2015); primates and great apes (Call and Carpenter 2001); macaques (Martin and Santos 2014; Hampton, 2001); dolphins (Smith et al. 1995; Herman et al. 1999; Tschudin et al. 2001; Reiss 2012) and crows (Bugnyar et al. 2016; Bugnyar et al. 2007; Dally et al. 2006; Emery et al. 2004) appear to present some metacognitive capacities, but the studies conclude that they are not as capable as human adults.

niche". Public language, written or spoken, constitutes a cognitive niche that is able to create new cognitive niches through the use of concepts and categorization. When public language is internalized, following the Vygotskian model of "internal discourse" (Vygotsky 1998), it serves the purposes of self-assessment, self-inspection and self-criticism. Once the public and internal language system is fully developed it also enables "non-linguistic thought forms and encodings" (Clark 2008: 44). Language labels the world, opening new computational opportunities and discoveries of patterns that support the development of expertise that are not possible otherwise, including our ability to reflect on our own thoughts (Clark 2008: 44). There is a "causal coupling" between language and other active elements, and as a result, the removal of any of these coupled elements can affect the "competence of the system" (Clark and Chalmers 2010: 29). For Clark (2008: 58), the material structures of language, "from sounds in the air, to inscriptions on the printed page, [...] reflect and then systematically transform our thinking and reasoning about the world". According to Clark (2008: 44), "surrogate situations" and cognitive functions of language are related. Surrogate situations are created when material structures allow "human reason to disengage", in the sense of dealing with something that is "absent in some way", and at the same time, it allows the use of "highly situated, engaged perceptual and motor routines that explore the world" (Clark 2008: 154). In those cases, we have "actions that are disengaged from their ultimate goal, but not disembodied" (Clark 2008: 155). What happens is that "linguistic forms and structures are initially found simply as objects (additional structure) in our world" (Clark 2008: 59). But once discovered, these linguistic forms and structures create a powerful layer that effectively and iteratively reorganizes the space for biological reasoning and self-control. In the relationship between metacognition and language, internal and external activities jointly shape metacognition .

A non language-centric view is provided by Proust. According to Proust (2013: 4), metacognition is defined as "the set of capacities through which an operating subsystem is evaluated or represented by another subsystem in a context-sensitive way". Proust (2008: 263) argues that from the externalist standpoint we should consider that metacognition develops evaluations based on an extended sequence of dynamic couplings that were performed in previous interactions between mental actions and monitored results. She notes that both the social and physical dynamic environment play a crucial role in properly calibrating self-evaluation, stating that "a mental agent depends on others and on the world for her self-knowledge" (Proust 2008: 264). Proust proposes a dual-process theory of metacognition, dividing it into procedural (System 1) and analytic (System 2). Procedural metacognition is a

“specialized control function for the epistemic domain (perceptions, beliefs, reasoning)” (Proust 2013: 72), which in its “normative governance” does not necessarily “requires conceptual training and communicational purposes”, unlike “analytic metacognition” (Proust, 2013: 59). She (2013: 57) highlights the difference between agents basing their “trust judgments on their analytical beliefs, such as: 'I am competent in the history of Napoleon's wars')”, versus their experienced effort”. Analytic belief allows agents to use inferential knowledge rather than just procedural clues (Proust 2013: 57). On the other hand, procedural metacognition requires engagement, as dynamic cues generated by the activity serve as reliable predictor of cognitive outcomes, such as perceptual discrimination, memory retrieval or learning (Proust 2013: 57). In conclusion, engagement resources “are absent in meta-representation”, but “are constitutive of procedural forms of metacognition. Even if their highest analytical forms may fail to reflect them” (Proust 2013: 57).

According to Proust's theory (2014b: 382), agents can switch from procedural to analytic metacognition if they have reason to believe that the noetic feeling associated with an epistemic action is unreliable, lacking, or discordant. To engage in analytical metacognition, four requisites must be fulfilled: (i) awareness of biases in the noetic experience; (ii) belief that the biases are significant enough to discredit the experience; (iii) a desire to put in effort to reach a correct judgment; and (iv) the resources for the correction process, such as time and attention. An evaluation is only successful "if the agent truly believes -- rather than just feels – that her epistemic sources and mediators are reliable and is aware of the conditions of correctness applying to the outcome of her current epistemic actions" (Proust 2014b: 382).

The definition of metacognition as “thinking about thinking” overlooks the fact that it involves active engagement in self-evaluation, where a person evaluates their performance on a cognitive task while they are thinking "with" the thought, not simply "about" it (Proust 2013: 62). Activity involvement in procedural metacognition involves a form of normative orientation that guides the control of current performance and creates a direct link between the normative orientation and the decision to act (Proust 2013: 63). While procedural metacognition is “independent of the content of first-order cognitive performance”, meta-representations “take off iconically (and transparently) accessing the content of an embodied representation” (Proust 2013: 63). According to Proust (2013), the concept of "iconicity" is defined by Recanati (2000) as the idea that "metarepresentations resemble the representations they are about”, meaning that a metarepresentation of an object-representation "must be about both the object and the representation" (Recanati 2000: 11). Based on Recanati's "metarepresentational theory" (2000), Proust (2013: 55) explains that in order to

meta-represent an object, the attributor must engage in a first-order iconic representation of the object. This is because in order to evaluate the first-order representation in relation to the real world, the attributor must first simulate and understand the world as represented by the first-order representation. This simulation allows for transparent access to the content and provides insight into the specific perspective of the world that the content embodies (Proust 2013: 55). However, in a procedural metacognitive process, simulation goes beyond merely simulating a primary situation. It requires actual performance, the intention to perform a primary task, and motivation to succeed in it (Proust 2013: 55). On the other hand, engagement in analytical metacognition is more limited, only involving the simulation of being in someone else's position in relation to a particular representation (Proust 2013: 55). Despite the difference in the level of engagement, both types can be present in the process of marking-for-self.

5. Marking-for-self as metacognition

Here we explore marking-for-self as a metacognitive process based on four points: 1) marking-for-self is used for self-evaluation; 2) it employs procedural cues; 3) it includes metarepresentations as part of the evaluation; 4) it is used to predict outcomes. As we argued, metacognition is often considered to be an inner process, being so its representations and metarepresentations can only be indirectly analyzed, by means of analyzing the behavioral changes considered to be caused by the metacognitive process.

In this study, we approach marking-for-self as a metacognitive process within an externalist and distributed framework. We do that by bringing focus on how metacognition can use the body and environment to reduce the cognitive costs of its processing. The (meta)representations present in metacognition in its distributed state are investigated considering that they are materialized and thus made observable in an embodied pattern. This allows us to further classify its function and nature using a cognitive-semiotic approach. Although it can be argued in an internalist perspective that there is no possibility to know what the dancers are thinking while marking, in an externalist notion marking is thinking, it constitutes, as Kirsh puts, “thinking with the body”. This is not to disconsider the role of process as “inner speech”, but is to argue that a relevant part of metacognition is directly achievable by coupling with material structures, and not only mediated by those.

Marking-for-self is used by dancers to personally review aspects of a dancing phrase, aiding memory and understanding of the full-out dancing phrase. To do so, dancers engage in a process of self-evaluation, comparing the body-part representations created during marking

to the choreography or other established goals. Self-evaluation must be adjusted with relevant feedback, as positive and negative results are often contextual. As Kirsh (2011: 18) notes, dancers “rarely if ever mark a phrase they have not already seen full-out”, and in the cases that this is done the dancers “know the success conditions and what is expected”. Effective self-evaluation, guided by feedback, can lead to better problem-solving performance (Desoete et al. 2001; Ortner et al. 2013), and learning (Loon and Roebbers 2017). The feedback process can lead a dancer to develop confidence in his own decisions, that is, the adjustment of “a subjective probability of a decision being correct” (Fleming and Dawn 2017: 91). Through feedback, learning and experimentation, built confidence can guide self-evaluations in marking-for-self, even if the dancer is not receiving feedback from others at the moment of the marking. This consideration leads us to the second point – if the dancer is not receiving external feedback he is using his own feedback for self-evaluation. This feedback is being generated and processed by forms of analytical and procedural metacognition.

According to Muntanyola-Saura and Kirsh (2010: 19), “thought does not exist in the word sequence or in the dance movement, but the interaction between mind and physical object is essential to the controlled process of thinking”. While the dancer is engaged in the process of marking-for-self he is using procedural cues, such as the “noetic feeling”¹⁰ of “knowing or not knowing” (Koriat 2000), “certainty or uncertainty” (Smith et al. 2003), “confidence” (Winman and Juslin 2005), and even “familiarity” (Whittlesea et al. 2001a, 2001b) as feedbacks for self-evaluation. Based on these feelings, the dancer determines the likelihood of their decisions being correct. For an example let's consider a less than satisfactory full-out passage. This leads the dancer to believe that more effort is required to understand certain movements. In this case, the dancer can engage in analytical metacognition and still rely on their embodied representations to ease the cognitive load — for example: while marking-for-self a specific part of the normative choreography of *Odile/Black Swan*¹¹, the dancer can compare the representations and form the belief that she knows that the solution for gaining stability is a change in the leg position and adjust accordingly.

It is important to note that when a dancer marks-for-self, they are testing movements that are not yet part of the full-out phrase. Marking-for-self, as a metacognitive process, is used to predict outcomes by agents who expect a specific result from their actions. Memory and evaluations upon previous experiences play a significant role in this predictive process, as self-evaluation provides cues for predicting future performance (Baars et al. 2014).

¹⁰ For a revision, see Dokic 2012.

¹¹ *Odile* or *Black Swan* is a main character in Tchaikovsky's *Swan Lake*, a well known dance piece in classical ballet that demands technical mastery.

Marking-for-self is a form of self-evaluation that allows systematic experimentation of predictions. By reducing the cognitive load needed to “recall and reflection” (Muntanyola and Kirsh 2010: 10), marking-for-self allows the dancer to do more tests without considerable loss of movement precision. Additionally, because marking-for-self is performed using the body, it is closer to the final result of the full-out phrase than relying on internal mental imagery. This makes it more open to unpredictable interferences of body constraints, such as unexpected difficulty with a particular jump, making it a more reliable method for predicting future outcomes. Further research is necessary to better consider how predictions are formed and used in marking-for-self.

We propose that "marking-for-self" is a valuable case study for embodied metacognitive processes. Whereas further investigations could focus on the function of procedural metacognition in marking-for-self, it is clear that a relevant aspect of it is the use of representations, but what is the nature of those representations?

In order to address those questions it is needed to consider semiotic models and theories. Although there are many theories about metacognition, there is still little agreement about the definition and nature of representations and metarepresentations in metacognition. Most discussions do not employ a semiotic framework, and even when they do (e.g. Proust 2013; Carruthers 2020), representations and metarepresentations are frequently regarded as internal knowledge structures rather than as semiotic processes oriented towards the external world." Kirsh (2011: 9) argues that "marking-for-self" differs from iconic gesturing since there “is a collapse of elements in a manner that distorts their appearance” (i.e substitution of one leg for two), although this might be true considering iconicity in its pictorial aspects, we are going to argue that marking-for-self is an iconic sign, and considering Peirce’s classification it is, more specifically, a diagram.

6. Marking-for-self as semiosis

Peirce, one of the main founders of pragmatism, is considered a philosopher of process (Rescher 1996). His definition of semiosis as a sign in action is strongly associated with the ideas of habit, dynamic relation, and process (Atã and Queiroz 2016; Queiroz and Merrell 2006). The implications of Peirce's ideas on semiosis include the situatedness and spatiotemporal distribution of the meaning-making process. According to Peirce, semiosis can be described as an triadic relation (sign-object-interpretant) through which a constraining factor (object) acts on cognitive system (interpretant) because of the mediation of a certain entity (or group of entities) or process (sign) -- a sign "is determined by the object in relation

to the interpretant, and determines the interpretant in reference to the object, so as to produce the interpretant to be determined by the object through the mediation of the sign" (MS 318: 81, CP 5.484, EP 2: 171).¹² There are three fundamental types of signs underlying meaning processes – icons, indexes, and symbols. The concept of icons is of particular interest, as they are signs (S) that represent their objects (O) through similarity, regardless of any spatiotemporal connection they may have with existing processes or entities (CP 2: 299). If S stands for O due to a shared quality between them, then S is an icon of O. When S is an icon of O, it communicates a quality or a qualitative property of O to an interpreter (I). An essential feature of icons is that they allow us to discover new attributes or properties of their objects through manipulation and observation (Hookway 2002: 102).

An icon is considered a diagram when it is observed to be made up of interrelated parts and the relationships between those parts (and not the parts themselves) are subject to controlled modifications, regulated by laws or rules, to represent relationships.¹³ A diagram is an icon of relations, representing "a definite form of relationship, often one that exists, as in a map, or is destined to exist, as in a Plan" (NEM 4:315-316n1). The object of the diagram is always a relationship, and the related parts of the diagram represent the relationships that make up the object represented. This notion plays an important role here. Diagrammatic signs are defined as any kind of representation (either visual or not) that makes available on themselves relations analogous to those in their objects. Hence, the object of a diagram is always a relation.

In dancing, marking-for-self is an embodied diagram that is manipulated to anticipate, monitor, and control the relational structures, and can subsequently be evaluated. What the diagram anticipates is a mereological (part-part / part-whole) spatio-temporal relationship. The parts that constitute a motor sequence, and the anticipation of a relational structure, is defined by an ordered succession of discrete entities (dance steps), performed in time and space (the scenic space) as a predefined sequence. Marking (as a diagram) *stands for* a phrase (anticipated dancing object) in order to determine certain effects (interpretant). This

¹² We follow the practice of citing from the *Collected Papers* of Charles Sanders Peirce (Peirce 1931-35, 1958) by volume number and paragraph number, preceded by CP; the *Essential Peirce*, by volume number and page number, preceded by EP. References to the *Annotated Catalogue of the Papers of Charles S. Peirce* (1967) will be indicated by MS, followed by the manuscript number and pages.

¹³ For a detailed introduction to the concept of diagram in Peirce's philosophy, see: Stjernfelt (2007).

irreducible triadic relation gives us a new level of description of marking as a cognitive-semiotic phenomenon, by considering it as semiosis.

The categorization of diagrams as a subtype of iconic signs opens up new possibilities for our understanding of meaning-making processes. By considering that the object doesn't have to "look like" its sign, we can expand the scope of iconic representation to include more abstract and functional forms of representation. The ease of examination and manipulation of the relational parts in diagrams might even allow a better performance of the diagram as a cognitive artifact (Tylén et al. 2014). By simplifying the visual elements and focusing on the relational parts, the diagram becomes easier to manipulate and understand, as shown in the case of metro maps (Atã et al. 2014) – the simplifications of the railroads eases the reading of the map and makes it more functional. This emphasizes the need to examine the underlying relationships between the parts, rather than just the parts themselves, in order to understand the representation. By recognizing that objects can stand for their signs through shared relational qualities, rather than just shared visual qualities, we broaden the scope of what can be considered iconic representation.

It is specifically because of the diagrammatic structure that marking allows the distributed cognitive process to unfold in such a way that eases the cognitive load and enables the scrutiny of different aspects of the movement. In short, because marking is a diagram, the structure can be manipulated as intelligible relations, allowing the dancer to think about his own thinking. Peirce (NEM 4:315-316n1) defined an intelligible relation as one “that there is between them, not merely one of those relations which we know by experience, but know not how to comprehend, but one of those relations which anybody who reasons at all must have an inward acquaintance with”, or a “definite form of relation” (NEM 4:315-316n1). That is, a diagram is a stable relational structure to which subsequent signs can attach in a process of semiosis. As the object of a diagrammatic sign is always an intelligible relation this allows some properties that are noticed in marking, as described by Kirsh (2011). First, since they are intelligible relations it allows precise ‘anchoring’ of projections (signs). Second, as they are projected in a physical structure dancers can easily manipulate this structure manipulating the intelligible relations, which leads to the third characteristic, it allows dancers to learn from the manipulation of this structure. It is precisely because marking is a diagrammatic sign, serving as an “interactive strategy and powerful mechanism of thought”, that it can lead to new “conceptualizations and discoveries” (Kirsh 2011: 23).

Specifically, in the case of marking-for-self, we argued that this process can be considered a metacognitive one. It is not easy to consider the metacognitive process as

happening “outside of our heads”. When we look at the traditional examples of metacognition it is a very private endeavor of self-assessment. Even considering Proust’s (2013) concept of procedural metacognition, it could be argued that the ambient and actions are still only providing inputs for the inner process, as the information gathered through them merely guides the metacognitive process to reach a more accurate result. In the case of analytical metacognition, Proust argues that the engagement is almost unnecessary - it plays “only a minor contingent role” (Proust 2013: 57). While we acknowledge that the distinction between types of metacognitive activity is helpful, it does not fully embrace an externalist perspective. We have two considerations in that regard: the centrality of the cognitive system and the nature of the representation in the metacognitive process, or more precisely our considerations about the nature of the representation are also about the centrality (or discentricity) of a cognitive system, and this is due to semiosis.

The distinction between procedural and analytical metacognition becomes less relevant when metacognition is viewed as semiosis. This is because the spatiotemporal distribution of semiosis results in a continuous chain of processes that are engaged with the world and the body, both in the moment and retrospectively, also using previous interactions and learned patterns to act in retrospect, in the moment, or for planning ahead. Furthermore, treating metacognition as semiosis expands its role beyond just a mechanism of monitoring and control, to a relevant part of our ability to creatively use experience and knowledge to generate new solutions. For instance, in dance, marking serves as a highly context-engaged sign to monitor, control, and analyze dance steps in real-time. This process is a creative endeavor, in which the interplay between predictions and actions generates iterations that result in new solutions to the dance challenges they face.

7. Conclusion

How does our approach push the discussion on marking-for-self in a (if any) new direction? The implications are related to radical semiotic externalism. As we have claimed in several papers, Peirce can be considered a forerunner of distributed cognition approaches, emphasizing that we think with signs - semiotic tools and artifacts -- it can be gestures (Mittelberg 2019) or range from alembics and cucurbits to ink and paper (Atã and Queiroz 2021). Peirce's cognitive externalism compels us to consider cognition as an active relationship between situated agents and semiotic artifacts. There is a substantial body of literature in philosophy of mind and cognitive science, and related fields that supports the idea that cognitive artifacts can enhance our cognitive abilities and modify our cognitive niche.

Many authors argued that tools modify our cognitive environment. Tools make us (and dancers) smarter. Dancers manipulate their environment to turn memory problems into perceptual problems (see Tribble 2005; Aguiar and Queiroz 2018). Choreographic dance is a demanding and complex cognitive phenomenon. The precise repetition of a pre-determined pattern of motor activities performed on performance space requires the dancer to possess a set of cognitive skills related to spatial perception, attention, and memory to their own bodily sequence of movements, self-deliberative monitoring, and evaluation of the final results. Learning and memorizing movement sequences, as well as evaluating the final results, are complex tasks that require the dancer to possess a set of cognitive skills related to spatial perception, attention, and memory, as well as self-monitoring and evaluation of their own bodily movements.

Our aim here was to provide a more precise description of the semiotic nature of marking, leading to new considerations about marking as a metacognitive process. Embodied diagrams have remarkable epistemic functions in choreographic dance. The relationship between the epistemic property and iconicity is evident because iconic signs allow for their objects to be presented "as they are in themselves" (Ransdell 1983: 72), as they share common characteristics with the object through "partaking in the character of the object" (CP 4.531). Icons preserve the structure of their objects by representing them, either partially or not, through their own characters. It is crucial for diagrams to maintain this structure, as it embeds the cognitive rules for manipulating them to extract new information. The way in which the material properties of diagrams shape the formal structure of a problem during situated problem solving aligns with a criterion for iconicity in Peircean semiotics. Marking-for-self is a metacognitive artifact and a diagrammatic operation. Diagrammatic reasoning allows for manipulation of relational structures in dance, leading to personal reflection, self-evaluation, and anticipation of performances. Through self-evaluation and feedback, marking-for-self helps dancers to develop confidence in their own decisions, leading to better problem-solving and learning. The diagrammatic structure of marking allows for the distributed cognitive process to unfold in a way that eases the cognitive load and enables the scrutiny of different aspects of a movement (body and spatial position, *tempo*, group coordination), thereby potentializing the rehearsal process.

In line with Heyes et al. (2020: 2-3) suggestion, we consider marking-for-self an explicit metacognitive phenomenon of semiosis, since it is rooted in conscious and reportable cognitive states. However, in contrast to Heyes et al., and in agreement with Proust (2008: 263-264), we are considering that those states are based on an extended sequence of dynamic

couplings. Our contributions advance this discussion by suggesting that evaluations are not only generated as a posterior process that examines previous interactions between mental actions and monitored results, but can also occur in real-time as an ongoing feedback loop between predictions and resulting outcomes. These predictions occur by manipulating a distributed representation, the embodied diagram, and are not solely based on noetic feelings. The use of embodied representations blurs the line between procedural and analytical metacognition. Marking-for-self can be considered a case of a "surrogate situation" (Clark 2008: 44). The diagram allows for the disengagement of the full-out-phrase, in the sense that it stands for specific parts of the performance and leaves others absent, but at the same time it is engaged, as its manipulation depends on body movements and situatedness. In choreographic dance, the marking of movements stabilizes an external diagram of the full dance in the dancer's body, reducing the cognitive cost of real-time evaluation and monitoring. Peirce's semiotic theory of sign, when applied to metacognition, highlights the critical role it plays in our ability to creatively generate new solutions based on our experiences and knowledge.

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