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Thinking with the Body

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Abstract

To explore the question of physical thinking – using the body as an instrument of cognition – we collected extensive video and interview data on the creative process of a noted choreographer and his company as they made a new dance. A striking case of physical thinking is found in the phenomenon of marking. Marking refers to dancing a phrase in a less than complete manner. Dancers mark to save energy. But they also mark to explore the tempo of a phrase, or its movement sequence, or the intention behind it. Because of its representational nature, marking can serve as a vehicle for thought. Importantly, this vehicle is less complex than the version of the same phrase danced ‘full-out’. After providing evidence for distinguishing different types of marking, three ways of understanding marking as a form of thought are considered: marking as a gestural language for encoding aspects of a target movement, marking as a method of priming neural systems involved in the target movement, and marking as a method for improving the precision of mentally projecting aspects of the target.

Keywords: Marking; multimodality; thinking, embodied cognition, ethnography.

1. Introduction

This paper explores how dancers and choreographers use their bodies to think about dance phrases. My specific focus is a technique called ‘marking’. Marking refers to dancing a phrase in a less than complete manner. See fig. 1 for an example of hand marking, a form that is far smaller than the more typical method of marking that involves modeling a phrase with the whole body. Marking is part of the practice of dance, pervasive in all phases of creation, practice, rehearsal, and reflection. Virtually all English speaking dancers know the term, though few, if any, scholarly articles exist that describe the process or give instructions on how to do it.¹

When dancers mark a phrase, they use their body’s movement and form as a *representational vehicle*. They do not recreate the full dance phrase they normally perform; instead, they create a simplified or abstracted version – a model. Dancers mark to save energy, to avoid strenuous movement such as jumps, and sometimes to review or explore specific aspects of a phrase, such as tempo, movement sequence, or underlying intention, without the mental complexity involved in creating the phrase ‘full-out’.

Marking is not the only way dancers ‘mentally’ explore phrases. Many *imagine* themselves performing a phrase. Some of the professional dancers we studied reported visualizing their phrase in bed before going to

sleep, others reporting mentally reviewing their phrases while traveling on the tube on their way home. Our evidence suggests that marking, however, gives more insight than mental rehearsal: by physically executing a synoptic version of the whole phrase – by creating a simplified version externally – dancers are able to understand the shape, dynamics, emotion, and spatial elements of a phrase better than through imagination alone. They use marking as an anchor and vehicle for thought. It is this idea – that a body in motion can serve as an anchor and vehicle of thought – that is explored in this paper.

It is a highly general claim. It has been said that gesture can facilitate thought, [Golden Meadow 05]; that physically simulating a process can help a thinker understand a process [Collins et al 91], and that mental rehearsal is improved by overt physical movement. [Coffman 90] Why? What extra can physical action or physical structure offer to imagination? The answer, I suggest, is that creating an external structure connected to a thought – whether that external structure be a gesture, dance form, or linguistic structure – is part of an interactive strategy of bootstrapping thought by providing an anchor for mental projection. [Hutchins, 05, Kirsh 09, 10]. Marking a phrase provides the scaffold to mentally project more detailed structure than could otherwise be held in mind. It is part of an interactive strategy for augmenting cognition. By marking, dancers harness their bodies to drive thought deeper than through mental simulation and unaided thinking alone.

Hand Marking



Fig 1a



Fig 1b

In Fig 1a an Irish river dancer is caught in mid move. In 1b, the same move is marked using just the hands. River dancing is a type of step dancing where the arms are kept still. Typically, river dancers mark steps and positions using one hand for the movement and the other for the floor. Most marking involves modeling phrases with the whole body, and not just the hands.

¹ Search by professional librarians of dance in the UK and US has yet to turn up scholarly articles on the practice of marking.

2. Methodology

To explore the role of physical activity in dance cognition we were fortunate to study the creation of a new dance piece by the noted choreographer Wayne McGregor, the resident choreographer of the Royal Ballet in London. WM created the dance we studied with his own company, Random Dance, a group of ten extremely talented dancers. An eleventh dancer from a different company in Europe joined the group for the first period of dance creation.

The dance company's process of creation occurred in two phases: a three week episode at the University of California, San Diego (UCSD) in the winter of 2009; and a second period in London, in the late summer of 2009, just preceding the official premiere at Sadler's Wells Theater.

Method: During each phase, written notes were taken in real-time. During the UCSD phase, fifteen students took notes; during the London phase, a single experienced ethnographer took notes. Both phases, UCSD & London, were exhaustively videotaped using five high definition video cameras placed on the walls, and, whenever possible, two standard video cameras were placed on the ceiling. The whole rehearsing process, 11AM to 5PM, five to six days a week was captured. Video footage exceeds 110 hours (times 5-6 cameras) and captures all scheduled interactions between choreographer and dancers during the dance making process.

Cognitive ethnography requires acquiring a detailed knowledge of a community of practice, and then using that knowledge to illuminate specific episodes of activity. [Williams 06]. To acquire knowledge of the community of practice we interviewed the choreographer as well as the dancers repeatedly. We also reviewed all notebooks, and used our interviews as an opportunity to discuss specific moments of creative activity. The choreographer was interviewed for between forty and sixty minutes on digital video each morning and night. The dancers were interviewed at the end of each rehearsal, Our aim with the dancers was to have them reflect on specific elements of the rehearsal that day, and wherever possible, to show us through movement the dancerly decisions they made. Four dancers were selected and interviewed for thirty minutes each day. About 70 hours of interviews, in total, were videotaped.

To code the video we used ELAN, a free software system developed by the Max Planck Institute for Psycholinguistics, designed originally for studying gesture and small-scale interactions. Systematic audiovisual analysis depends on having a well-defined vocabulary of coding – a classification of activity and phenomena. After a few days of ad hoc coding a formal vocabulary was established by the whole team (20 people) to characterize ongoing activity. After the UCSD phase of capture, we reviewed the video data and selected special phenomena, such as marking for more detailed coding. In the London phase, we interviewed dancers explicitly about marking to probe them on their own views about marking. These interviews were undertaken in addition to the normal 30

minute ones we conducted. In several such sessions, we had the dancers come before the camera and dance *in full* a phrase they knew well; we then asked them to show us several ways they might *mark* that same phrase, and to describe the reasons they would mark one way versus another. We also interviewed them in a less structured manner, often returning to the question: “When do you mark, and how?” which led to multiple follow up questions and nuances of speech, as well as spontaneous performances from the dancers. The videotaped answers, with the corresponding gestures and markings, were transcribed and analyzed in detail with ELAN. On this basis, we created a hierarchical taxonomy of marking, yielding the three parent groups reported below. Intercoder reliability in distinguishing these parent marking types exceeded .9, on a sample of 25 video snippets of marking among our most experienced coders (n=3).

3. The Gross Function and Structure of Marking

At the highest level, three *functions* of marking can be distinguished.

1. *Marking-for-self*: dancers use their body to encode an aspect of a phrase for themselves. This may be for reinforcing memory, reflecting on sequence, or for scrutiny of spatial relations, among other reasons.
2. *Marking-for-others*, dancers use their bodies to encode an aspect of a phrase that others can focus attention on. For example, before a new performance, choreographer, choreographic assistant, and lighting manager review all phrases on stage for space.
3. *Joint-marking*: two or more dancers run through a phrase as a tightly coupled team, verifying timing and grips jointly for each other.

Small vs. Large Marking

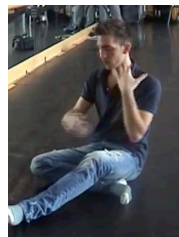


Fig 2a



Fig 2b

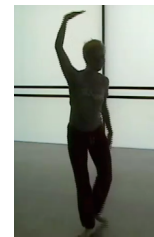


Fig 2c.

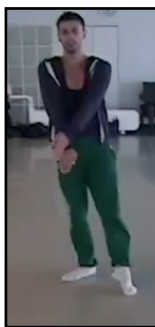
Figs 2a, 2b, 2c show the contrast between small and large marking. In 2a, a male dancer is remembering a step, using his hand to small mark it. In 2b, a female dancer is showing how she marks a pirouette. She uses a formal gesture for a pirouette that she learned as a ballet dancer. Her marking is small and conventional. In 2c, a second female dancer marks a phrase using movements that are of comparable size to those in the full phrase. She is clearly modeling the phrase.

There are also a few things to note, at the highest level, about the *structure* of marking.

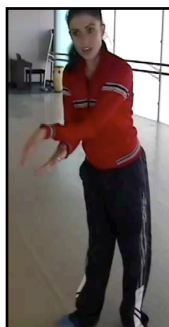
Variability of size: Marking comes in a continuum of sizes, from very small to full size (but less energetically). In ‘small marking’, the amount of movement is minimal; the marking movements tend to be in the upper body (hands and head mainly), and the objective is to review the steps, the relationship between simultaneous movements (arm and leg together), and occasionally to attend to timing. See figs 2a and 2b. In extreme cases, such as Irish river dancing (fig 1), marking may be done exclusively with two fingers marking foot rhythm, position, and movement. When marking is very small, it is a form of gesture. In larger marking, especially when the function is to show the floor space required by a movement, or to show off the structure of a phrase to someone else, the movements may be full size but with less intent, emotion, or energy than the real movement (fig 2c). They are imperfect models of the complete phrase, but lacking certain attributes, such as intensity, motion dynamics, or fine detail.

Substitutability: A movement in one body part can represent the movement in another. Hand movements and head tilts regularly stand for the motion of different body parts: a hand movement may represent a leg movement, a head turn may represent a torso turn or a whole body turn; if the legs perform in parallel, one leg may stand in for two. This too is shown in figs 2a and 2b. See figs 3a, b for a standing version and fig 1 for finger version.

Idiosyncratic vs. Conventional Marking



3a.



3b.

Fig 3. In 3a a dancer marks a leg movement with his hands in his own idiosyncratic manner that is a hybrid of conventional ballet marking and personal style. In 3b A dancer from a strong ballet tradition offers a conventional small marking with her hands.

Conventional: In classical ballet and other formalized dance forms, dancers are taught to use specific gestures as ways of marking certain moves. These are a conventionalized form of small markings. For instance, as seen in fig 2b, the female dancer marks for the interviewer with her hand to show that, at a certain point in the phrase, a pirouette is required. In fig 3b she shows us a gesture for a *pas de bourrée*. These small gestures refer to a complex sequence

of full moves well known by ballet dancers. We observed that dancers who do not rely on a ballet vocabulary still mark in a way that is reminiscent of ballet marking; but each dancer has personal idiosyncrasies that violate convention. In fig 3a, for instance, a dancer with deep training in both modern and ballet represents a leg movement with his arms, a hybrid marking that is part conventional and part personal gesture.

Aspectival: Marking typically represents an aspect of the full phrase, with some forms of marking focusing solely on tempo, others focusing on sequence, still others focusing on spatial position. For instance, when dancers mark for space they will keep the scale of the full phrase, but other aspects will be ignored or only partially represented, such as the dynamics of the phrase. At other times, just the movement of the upper body or the torso orientation may be marked and the movement of a leg or arm is left completely unmarked. Evidently, when dancers mark they are attending to only certain aspects of the phrase.

4. Analysis

Is it plausible to see marking as a vehicle of thought? There are a few promising ways to approach this question. Perhaps the most obvious line is that marking is a type of gestural semiotic system, possibly like a linguistic code. If gesture can function as a vehicle of thought, as some have argued, then why not marking?

It is useful to classify gestures according to where they lie on ‘Kendon’s Continuum’ (McNeill 92). At one extreme, there are ‘gestures of the kind that Kendon has called ‘quotable’ ... gestures that must be configured according to pre-established standards of form in order for them to function as signs, such as the OK sign among North Americans’ (McNeill & Duncan 2000). These are compositional and behave in many respects like words or phrases in a language. At the other extreme are ‘gesticulations’. These are idiosyncratic, created on the fly, and motivated by imagery rather than convention.

In dance, marking in the classical tradition of ballet is convention-driven and quotable. Despite individual differences in marking style, dancers still conform to general norms. Although marking conventions vary from ballet company to company, it does not take long for a professional dancer to pick up the idiosyncrasies of a company. This suggests there are rules determining the structure of ballet marking, and that local differences in marking style should be viewed as akin to differences in accent or handwriting. They need to be learned but are not different in principle than dialects of a common language.

In contemporary dance, the *reference* of marking – the phrases full-out, or aspects of those phrases – are not easily segmented. Movements in contemporary dance are freer, often novel. There are also far fewer conventions governing how dancers should mark. But not none. In the group we studied, for instance, there were quite strict rules about how to mark for the choreographer or his assistant. The spatial

dimensions of the phrase were to be preserved, though energy, and pace could be lessened.

The implication is that marking might well lie nearer the language side on Kendon's continuum than the gesticulation side. This needn't be a surprise. If there are written notation systems for encoding dance, such as Laban notation, then as long as marking is as expressive as these notation systems, anything that can be encoded on paper can be encoded through marking. The one requirement is that there be semantic rules for interpreting the paper notation and semantic rules for interpreting marking.

It is here, however, that the analogy with language fails. Marking is a reliable language only when a) dancers are *marking for others* – the other forms of marking lack adequate semantic rules; and, b) only when the point of marking is to display space, position, and structural form, all aspects of the full-out phrase that the choreographer or his assistant can directly see in the marking itself. If the point of marking were to call attention to movement sequence or to motor preparation, external observers would often be unable to infer the movements being sequenced or prepared for.

This is perhaps the key point. If someone states, "there is a circle with radius 30 meters", a competent interpreter need not have seen such a circle beforehand to know what the sentence means. It is enough to know the meaning of the terms 'circle', 'radius', '30 meters' to generate an interpretation. That is what semantic rules are for. By contrast, in marking, because there is so much idiosyncrasy in marking when dancers are marking for themselves, or when marking an aspect of a phrase that is not visibly similar to the full-out phrase (space), observers cannot 'see' the full-out move 'in' a marked version unless they already know what the full-out looks like. This explains why dancers rarely, if ever, mark a phrase they do not already know, and why choreographers never request dancers to show them novel phrases by marking – they insist on a full-out. Evidently, both parties need a clear idea of the target in advance of the marking. They have to have seen the full-out phrase to be able to 'project' it from its marking.

I believe this proves that much if not the majority of marking is not language like. It relies on prior acquaintance with the target, and then matching the mark to its target. That process more closely resembles a pattern completion process than a generative process of constructing the target. Languages are essentially generative, the point of marking is to avoid generating the whole target.

But if marking does not behave as a language this raises a paradox: if a dancer, or an observer, needs a clear idea of the full-out phrase in order to correctly interpret its marked version, why bother with the marking? How can marking ever be more powerful than inner visualization or imagination alone? What more can the physical manifestation of a movement add to the target already 'mentally grasped' through imagination?

One answer is that physical movement is helpful when one wants to measure the distance covered in a phrase. External distance is not guaranteed to be accurate in a

mental representation. [Ledermen 87]. And there may be other physical dimensions available in the physical execution of a phrase that are only implicit in its mental representation (for instance, the physical tension in leaping off the floor or lifting another person).

But, beyond making physical attributes measurable, [see Kirsh 10], what extra *cognitive benefits* can physical marking provide that surpass mental rehearsal?

Here are two possibilities. They offer a different take on how marking might serve as a vehicle of thought.

1. Marking is a way of *anchoring projection* to a target. By providing a marked version of a target, a dancer can project a better representation of the target than imagination unaided. Marking, therefore, is a causally important way of augmenting thought. It is a component of a *distributed vehicle of thought*, consisting of an inner part and an outer part, which enables clearer thoughts. (cf. Hutchins 05)
2. Marking is a way of *priming* the neural system of a dancer, thereby enhancing imagination (or projection) by activating cortical elements that would be involved in the full-out movement. Marking is a way of enhancing the vividness and detail of imagination.

Marking as a method of anchoring projection. In the phenomenology of perception, a distinction can be drawn between perception, projection, and imagination. See fig 4.

- When we *perceive* an object, our experience is that we are seeing an object that is really there; we feel it is what causes our perception.
- When we *project* onto an object, we experience ourselves intentionally augmenting the object; we feel we partially cause our experience.
- When we *imagine* an object, we feel as if we are the sole cause of our imagined experience.

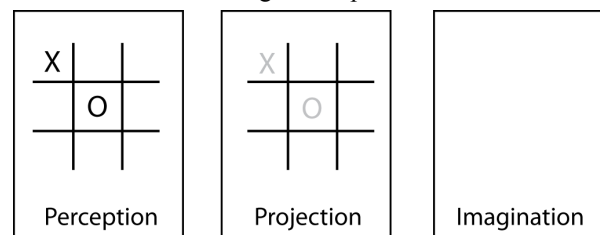


Fig 4. The difference between perception, projection, and imagination is represented here by three conditions of a tic-tac-toe game. Perception: subjects *see* moves. Projection: subjects see only the tic-tac-toe grid, and mentally *augment* it with moves. Imagination: subjects see a blank page and all aspects of the game are imagined – no external stimuli to scaffold or structure imagination.

The application to marking is shown in Fig 5. If the full-out phrase is represented by the complete triangle in 5a, marked versions are represented by 5b – 5e. The marked versions are either fractions or distortions of fractions of the full. But they support projection to full-out, if one has been exposed to the full-out already.

This form of projection is not a standard completion process. In completion, the target is a superset of the fragment. For example, *tang_ _ _* is a *stem* that supports completions like *tangent*. The fragment *ta_g_ _s* supports the completions *targets* or *tangles*. In both cases, the target completes the fragment. In projection, the structure that augments the fragment need not complete it because it may produce a new structure that has none of the subset structure. For instance, in 5c, the completion is larger in all dimensions except corner angle. In 5d and 5e, even the angles are not preserved. Projection is not completion.

Kirsh [09] showed that it is easier to conceptualize a target, or recover more memory of a target's structure, if there is something outside that one can 'lean on' for support. It is easier to project than to imagine if there is something helpful outside to support the projection. Recall is better for projected imagery than imagined imagery [ibid].

Marking as Projection

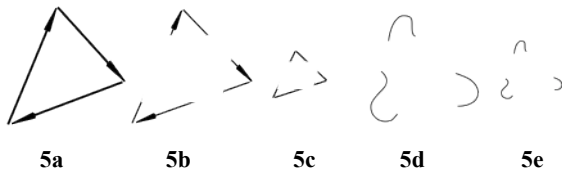


Fig 5. The idea of marking as a sequence of illustrations of decreasing verisimilitude to the full phrase. 5a: a complete path at full scale. 5b: same path, full scale, shown by vertices and directions. 5c: smaller path, the interpreter must now know the scaling function. 5d: a stylized version of 5a. 5e, a smaller version of 5d, interpreter must project both shape, angles, and know the scaling function.

The relevance to marking is that when dancers mark, they may be creating a physical scaffold that facilitates projection. This would explain what 'extra' a dancer gets by physically marking a phrase rather than mentally rehearsing it. They get an external structure they can extrapolate from. This enables them to generate a conception of the final target that is more vivid, complete, and requiring less mental effort, than when they mentally rehearse without the support of overt movement. Moreover, dancers are able to choose how much extra memory support they want, just by marking more completely. When their mental image of the target is already clear, their marking may be minimal. When they have a weak mental image of the target, they may mark it more extensively, thereby increasing the vividness and control over their conception of the target.

Marking as a method of priming. A second benefit of marking may be that it involves more brain activity than mental rehearsal alone. It may facilitate muscle memory of details or deeper processing of movement goals.

The importance of muscle memory in dance is part of standard teaching. Muscle memory refers to the system of motor procedures – motor schemata – that have been stabilized through practice and are activated during performance. [Krakauer 06] Initial movements prime later movements. Priming also facilitates projection. Priming refers to an increased sensitivity to a stimulus due to prior exposure to a related stimulus. For instance, subjects who recently hear, see, think, and especially perform a particular movement will recognize aspects of that movement, sooner than those who have not. (Koch et al 04) The extent of priming is also a function of the depth of processing involved in the earlier exposure. [Challis, 92, Smith et al 83]. A person who thinks hard about a dance phrase – its energy, sequence, rhythm or spatial extent – will prime more choreographic relatives of the phrase, and prime them more deeply, than someone who merely sees the phrase briefly. Since motor preparation, spatial planning, and proprioceptive monitoring are involved in marking, it is likely that even more areas of cortex are involved in marking than in mental rehearsal alone. This suggests that during marking, there will be more opportunities for deeper processing – more chance to see deeper relations among movement components – than during mental rehearsal. Marking should prime the phrase more deeply, making it easier to remember it in the future.

If marking helps a dancer to envision the target phrase better, it helps to explain why marking is beneficial. Given the importance of internal processes, however, marking is best understood as the external part of an internal-external process. It is best seen as the external part of a distributed vehicle of thought.

5. Conclusion

I have argued that marking is a form of physical thinking. A dancer creates a partial version of a phrase, attends to it while creating it, and because of processes like priming and projection, the dancer is able to understand something deeper about the phrase's structure than through imagination alone. When dancers mark, they are closely coupled with the dance product they are externalizing. *They rely on that product to think with.* Their performance of the marked phrase is part of their ongoing process of grasping the phrase. In some ways, their relation to marked material is reminiscent of what E. M. Forster (27) said about language: "How can I know what I'm thinking until I see what I say". For Forster, the external vehicle of a thought – its linguistic formulation – was a real time achievement of putting the thought into words. It made the thought more precise in virtue of the constraints of language. There was no point asking whether the articulated content was the same as some internal version already encoded in an internal language intrinsically understood, as suggested by Fodor (75) and others. For Forster, as well as for Wittgenstein (51), the articulation is part of the thinking process.

My suggestion, here, is that for a dancer, Forster's rhetorical question can be rephrased as: "How can I know

what my phrase really is until I see what I do?" A dancer's thought of his or her phrase is partly shaped by what is marked. Dancers do think about their phrases without dancing them or marking them. But, by *marking-for-self* dancers *think better* about their full-out phrase. Physical movement replaces mental computation. Instead of imagining transformations, they execute them externally. Marking is part of a distributed vehicle of thought with internal and external parts closely coupled.

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References

- Challis, B; Brodbeck, D. (1992). Level of processing affects priming in word fragment completion. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. Vol 18(3), May 1992, 595-607
- Clark, A. (2008). *Supersizing the Mind*. Oxford: Oxford University Press.
- Coffman, D., (1990). Effects of Mental Practice, Physical Practice, and Knowledge of Results on Piano Performance. *Journal of Research in Music Education*, Vol. 38, No. 3, 187-196
- Collins, A., Brown, J. S., A Holum. (1991) Cognitive apprenticeship: Making thinking visible. *American Educator*, 1991
- Fodor, Jerry A. (1975). *The Language of Thought*, Cambridge, Massachusetts: Harvard University Press.
- Forster, E.M. (1927) *Aspects of the Novel*. Orlando: Harcourt.
- Golden-Meadow (2005) *Hearing Gestures: How Our Hands Help Us to Think*. Harvard University Press.
- Hutchins, E. Material anchors for conceptual blends. *Journal of Pragmatics* Volume, 37, Issue 10, 2005, pp. 1555-1577
- Kirsh, D. (2009a). Projection, Problem Space and Anchoring. In N. A. Taatgen & H. van Rijn (Eds.), *Proceedings of the 31st Annual Conference of the Cognitive Science Society* (pp. 2310-2315). Austin, TX: Cognitive Science Society.
- Kirsh, D. (2010). *Thinking With External Representations*. AI and Society: *Journal of Knowledge, Culture and Communication*. London Springer. Vol 25.4
- Kirsh, D. (2009a). Problem Solving and Situated Cognition. in Phillip Robbins & M. Aydede (eds.) *The Cambridge Handbook of Situated Cognition*. Cambridge: CUP.
- Kirsh, D, et al. (2009c). *Choreographic Methods for Creating Novel, High Quality Dance*. *Proceedings, DESFORM 5th International Workshop on Design & Semantics & Form*.
- Koch I., Keller P., Prinz W. (2004). The Ideomotor Approach To Action Control: Implications For Skilled Performance. *Int. Journal of Sport and Exercise Psychology*, 2, 362-375
- Krakauer, J.W., & Shadmehr, R. (2006). Consolidation of motor memory. *Trends in Neurosciences*, 29: 58-64.
- Lederman, S. J.; Klatzky, R.; Collins, A; Wardell, J. (1987). Exploring environments by hand or foot: Time-based heuristics for encoding distance in movement space. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. Vol 13(4), Oct 1987, 606-614
- McNeill, D. (1992). *Hand and mind: What gestures reveal about thought*. Chicago: University of Chicago Press
- McNeill D. & Duncan S, (2000) *Growth Points In Thinking-For-Speaking*, D. McNeill (ed.), *Language and Gesture*, pp. 141-161. Cambridge University Press
- Muntanyola, D, Kirsh, D. (2010) *Marking as Physical Thinking: A Cognitive Ethnography of Dance*. Donosti.
- Newell, A, Simon, H., (1976), "Computer Science as Empirical Inquiry: Symbols and Search", *Communications of the ACM*, 19
- Polyshyn, Zenon, (1986) *Computation & cognition: Toward foundation for cognitive science*. Cambridge: MIT Press.
- Smith, M C., et al., (1983). The relationship between contextual facilitation and depth of processing. *Journal of Experimental Psychology: Learning, Memory, & Cognition*. Vol 9(4), 697-712.
- Williams, R.F. (2006). *Using Ethnography to Study Instruction*. *Proceedings 7th International Conference of the Learning Sciences*. Mahwah: Lawrence Erlbaum.
- Wittgenstein, L (1951). *Philosophical Investigations*. Oxford: Basil Blackwell.