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David Kirsh

How Marking in Dance Constitutes Thinking with the Body

> "I mean it is in between, it is somewhere between doing it and thinking it, it's just like thinking it with the body
> (Professional dancer in interview about marking, 2009)

In dance, there is a practice called "marking". When dancers mark, they execute a dance phrase in a simplified, schematic or abstracted form. Based on our interviews with professional dancers in the classical, modern, and contemporary traditions, it is fair to assume that most dancers mark in the normal course of rehearsal and practice. When marking, dancers use their body-in-motion to represent some aspect of the full-out phrase they are thinking about. Their stated reason for marking is that it saves energy, avoids strenuous movement such as jumps, and sometimes it facilitates review of specific aspects of a phrase, such as tempo, movement sequence, or intention, all without the mental and physical complexity involved in creating a phrase full-out. It facilitates real-time reflection.

In figure 1, a specialized form of marking, called "hand marking", is shown. In hand marking, the timing and movement of the fingers represents the timing and movement of leg movements. Most marking uses more parts of the body than the hands alone, and the movements made during marking are closer in size to "full-out" dance.

Figure 1. An Irish river dancer is caught in mid move. In 1b, the same move is marked using just the hands. River dancers typically mark steps and positions using one hand for the movement and the other for the floor.

This essay is an inquiry into the phenomenon of marking and, in particular, into what it teaches us about distributed thinking – thinking with body and world. It is clear that dancers, at times, use their body as a way

to sketch movements, sometimes for others, sometimes for themselves, and sometimes to facilitate coordination in duos or larger groups. When marking is used as a tool for *communication*, it resembles iconic gesturing, though with features that differentiate it from classical accounts of iconic gesture. When marking is used to facilitate *coordination* in duos or trios, it provides a convenient shareable structure for joint attention and negotiation. It grounds speech and slows down activity to make it easier for participants to "work things out". When marking is used behind closed doors, it acts as a tool for a solo dancer to explore a phrase in private, and the way it functions is more complex and diverse. It is a *mechanism of thought*. Marking-for-self raises fundamental questions about the role of bodily movement in the cognitive economy of dancerly thinking. I will discuss all three forms of marking here, but focus, above all, on the private form – marking-for-self.

The practice of creating a simplified version of a process – a *personal model* to work and think with – is found in countless activities beyond dance. Children play act at cooking, keeping house, driving a car. They walk through the motions of working with utensils and artifacts even though the utensils they use are miniatures or toys. Often they operate with nothing more than imaginary artifacts, moving them around and talking. They do this together in social play; but they do it alone too. Adults who play tennis, golf, or basketball, also can be seen running through a "practice" swing or shot for themselves, as if to prepare for the real thing. Sometimes they do this with the appropriate racket, club, or ball in their hands. But sometimes they too go through the motions – as dancers or children do – without any artifact at all. In all cases, the action performed is more mock than real. There is no ball actually stroked, no club making impact, basketball tossed, or actual dance phrase being performed. The list of modeling for oneself goes on. Cellists will sometimes practice their part on their arm, running through finger positions on their "right forearm held upright in front of the chest, as a substitute for the neck of the cello" (Potter 1980: 109) in a manner reminiscent of an Irish river dancer hand marking a jig. No sound merges. Theatrical performers, too, can often be seen muttering their lines, or executing "practice" moves before stepping out on stage. It is a standard activity in theater to do an "Italian run-through" – a slang phrase for saying one's lines and moving about the stage extra fast when staging a play to clarify the timing and relative positions of the actors. All these cases are related to marking. In the case of staging, the process is identical with a version of marking-for-others. The common element throughout is that people seem to prefer working with a simplified version of a procedure to practicing the full-out version.

There is something provocative about these forms of partial physical simulation. It is clear how marking has a useful function when its purpose is social and communicative. When marking-for-others or marking-for-coordination, the physical movement constitutes a material object for

joint attention; it serves as a shared vehicle of thought and common focus, helping everyone to "get on the same page". But when a dancer is marking entirely for him or herself what function does it serve?

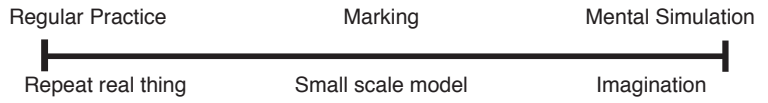


Figure 2. Three ways of Practicing: regular full-out practice, partial simulation by making a smaller scale model of the full version and by using one"s imagination to mentally simulate the full-out version or some aspect of it.

An obvious idea is that marking-for-self is yet another form of practice. We understand why people rehearse skills in their full-out version. They are practicing in the standard sense. The closer a study behavior is to the test behavior the better the performance when tested (Lockhart & Craik 1990). It is also clear that running through future performance without overt action – purely through mental simulation – can also improve skills, at times. (Suinn 1984). Mental rehearsal is, by now, a recognized form of practice (Meister et al 2004, Schoenberg 1987). Is there also a middle ground? If there are both inner and outer versions of practice might there not also be an intermediate form of practicing, one that is not completely internal simulation, but not completely external production either?

What extra might this mock practice, this middle ground, confer? Is it merely an extra accompaniment to mental simulation, done simply because, for instance, a dancer is standing when mentally simulating, and their bodies naturally move when they are running though movements in their head? Or is marking-for-self done intentionally for its cognitive benefits, to help memory, for instance, or to improve critical reflection?

From interview, we were told that marking often helps memory, much like singing a song aloud helps someone to remember the lyrics, or reciting part of a speech helps an actor pick up their part midway through.

... marking is rather for the memory than for the movement, it doesn"t work like we mark some of the movements and the others we don"t do. It is just the matter of not wasting so much of energy if you are not sure enough what you have to do. So before you gonna go full out you need to make sure exactly what the choreography is, and which arm goes there, which leg goes first, is it the left or right, the grips, just to kind of touch each other, especially for the duets. Just make sure to know what you are doing, what the choreography is, and then you can go full out. (Dancer A in interview)

It is a retrace, a scrape in your head. You could learn a monologue, a 5 min monologue, but you don"t have to do it fully, you can just sort of

- you don"t have to say it you can just go over it in your head to be able to know. So in movement terms I can know that the arm is here, [dancer gestures] but all I have to do is go like that so that the ... I am just setting the small movements to trigger the pathway that has already been already placed, you know, rather than having to do the whole thing. (Dancer N in interview)

For some, it helps reflection, much like the way verbalizing a thought aloud helps a thinker to reflect on what he is thinking, or the way summarizing a paragraph may help an author to rewrite it.

... sometimes even when you know something it is good to mark it through - to rework it in your brain, to make another idea of what the movement is. (Dancer M in interview)
... sometimes it is good to come back, you know even if you know it to think about it, again, to visualize everything...sometimes it helps a lot.. Like, you are home or you are in the tube for one hour and sometimes we catch ourselves doing (subject gestures and makes sound to show how he thinks and marks) because you are thinking. (Dancer A in interview)

As can be inferred from these quotes, my bias is to see marking-for-self as having a direct and intentional value. Mock practice is real practice; it is not an epiphenomenon or mere accompaniment. It is intentional, done for its conscious benefits.

This question of function does not arise when the function of marking is social and communicative. When marking-for-others or marking-for-coordination, the physical movement constitutes an object of joint attention and serves as a shared vehicle of thought, creating a common referent and common focus. It helps others to get on the same page. Can we be equally clear about the function marking–for-self serves? This is the driving question behind this study.

The paper is divided into three parts:

1. In part one, I describe our empirical approach to the phenomena of marking. The data presented here were derived from a major effort to understand the creative process in choreography. We used 5-7 video-cameras to tape the complete creative process of a contemporary dance company and ethnographically coded hours of interview and terabytes of dance footage.
2. In part two, I explore the phenomena in detail. Marking, as mentioned, comes in three flavors: marking-for-others, marking-for-coordination, and marking-for-self. Each is described and analyzed.
3. In part three, I take up the question of why marking-for-self might be more powerful than mental simulation by itself. There are several possible ways recruiting the body might increase the power of thought. These would explain what "extra" dancers get from marking.

My conclusion, overall, is that a body-in-motion can serve as a dynamic vehicle of thought for a dancer, much like trying out a musical phrase on a piano might help a composer think compositionally. By externalizing a form their author is able to entertain thoughts faster and more deeply than otherwise possible. Marking provides a material structure that supports projecting deeper, enables more detailed mental simulation, and serves to facilitate motor learning.

1. Part One: Our Empirical Approach

The basis for this study was initial research conducted as part of an ongoing collaboration between the choreographer Wayne McGregor, (hereafter WM) and the author, on the topic of distributed creative cognition and choreographic thought. WM holds the position of resident choreographer at the Royal Ballet in London. He also has a private dance company, consisting of ten extremely talented dancers and a long-standing expert choreographic assistant, Odette Hughes.

The piece we observed being made, and which forms the basis for the data and analyses presented here, was created in two periods: a three week episode at the University of California, San Diego (UCSD) from January 26th to February 15th 2009; and a second episode in London, August 24th 2009 to September 7th. Following Sept. 7th there were intermittent rehearsals until the official première, a month later, at Sadler"s Wells Theater, on October 13th 2009. In total, there were 27 days of videographic observation and interview, spread over six and half weeks in both UCSD and London.

During each phase, written notes were taken in real-time. During the first phase, fifteen students took notes; during the second, a single experienced ethnographer took notes. Both phases 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. The choreographer was interviewed for between forty and sixty minutes on digital video most mornings and evenings. The dancers also were interviewed. At the end of each rehearsal, four dancers were selected and interviewed in groups of two, for thirty minutes each. Our aim with the dancers was to have them reflect on specific elements of the rehearsal that day. Whenever possible we had them describe their experience during the day and then show us through movement what they meant. By requesting physical display rather than speech alone we sought to avoid encouraging the dancers to theorize and speculate unduly, a standard risk inherent in interviews.

At the outset, the goal of our research was to understand the way creativity is distributed over a group. We were also interested in the nature of

choreographic thinking. We had prior beliefs about distributed creativity; but we came with few preconceptions about choreographic thinking. Our hope was that a few clear phenomena would stand out, providing the basis for a more focused study. We found three such phenomena related to choreographic thinking: marking, sketching,[1] and riffing.[2] Only marking is discussed here.

Our research method combines cognitive ethnography with quantitative analyses. Cognitive ethnography requires acquiring a detailed knowledge of a community of practice, and then using that knowledge to illuminate specific episodes of activity. See Williams (2006). To acquire knowledge of the community of practice we interviewed the choreographer as well as the dancers repeatedly. To understand specific episodes of activity as they arose, we videotaped all scheduled interactions between choreographer and dancers during the time they worked together over six weeks. We also reviewed all notebooks, and used our interviews as an opportunity to discuss specific moments of creative activity. Because of our extensive videotaping and post-analysis of the footage we were able to compare marked and full-out versions of phrases.

To code the video we used ELAN (see figure 3), 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. We developed ours by reviewing videos individually then collectively building a single code which all coders practiced using. After our initial analysis/coding of ongoing activity, we discussed "special" phenomena such as marking and returned to the video data to code for these as well. The filmed observations and interviews allowed us to create an informed taxonomy of marking. To gather more data, specific to marking, we requested supplementary interviews to probe the dancers" own views on marking. These were undertaken in addition to the normal interviews we conducted at UCSD and in the first days in London. In several sessions, we had the dancers come before the camera and dance *full-out* a phrase they knew well and then show us several ways they might *mark* that same phrase. We followed this

[1] *Sketching* occurs whenever a dancer tries to imitate another dancer"s performance in real-time. If the phrase is not yet known there are too many elements to be imitated at once, so dancers do their best to capture the essence of the phrase. This necessarily means "sketching" the phrase in a coarse manner, though the focus of the dancer's sketch may be the dynamics or emotional force of a phrase, as much as the kinematic form of the phrase

[2] *Riffing* is a term we invented ourselves, to refer to a practice by the choreographer in which he tries out phrases he has just seen his dancers performing. When riffing he seems to not only be appropriating those phrases by running them through his own body, but playing with them and altering them. Riffing was clearly a component of his creative process, reminiscent of musicians taking a theme and "running" with it.

up with questions about their reasons for marking 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 by the dancers. The videotaped answers, with the corresponding gestures and markings, were transcribed and analyzed in detail with ELAN.

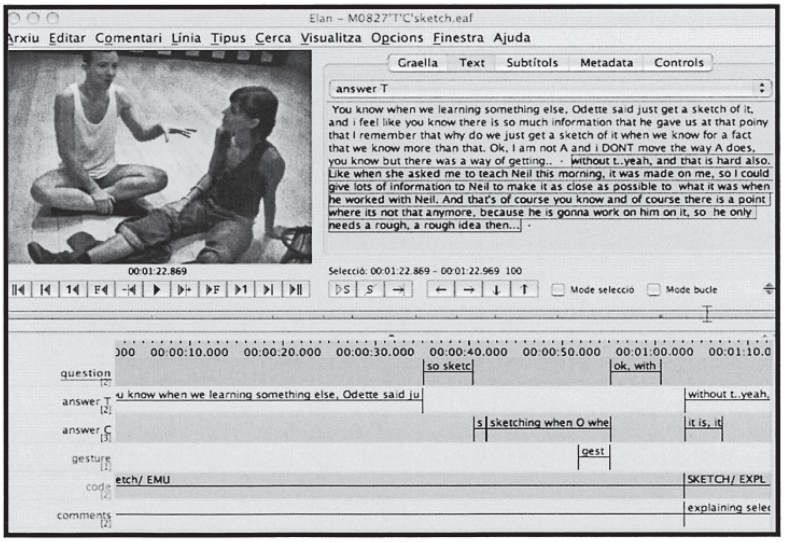


Figure 3. Snapshot of ELAN software used for analyzing marking.

After sustained review of our footage and analysis of the interviews, it became clear that there are three distinguishable *functions* of marking. These were first reported in (Kirsh 2010b). They are:

1. *Marking-for-self:* dancers use their body to encode an aspect of a phrase for themselves. They are not concerned with communicating their phrase to anyone (other than to themselves). Marking-for-self may be for reinforcing memory, reflecting on sequence, or for personal scrutiny of spatial relations, to name a few. These last functions seem related to activating deeper processing about movement, about working things out, or grasping a phrase better.
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. They need to explore the visual feel of putting lights in one position or another, to see the

effect of shadows and illumination on dancers and set as the dancers move about, reach up, and step around one another. To support exploration of these issues dancers need only model their form and relative positions. They are free to ignore tempo, emotional valence, and dynamics. At other times, the choreographer and assistant will require greater resolution; in their role as director or reflective critic they seem to have their own goals and agenda, asking the dancer to show specific aspects of a phrase. Again, even in response to direct comment, dancers will perform their marked phrase with less energy and emotion than the full-out version.

3. *Marking-for-coordination*: here two or more dancers run through a phrase as a tightly coupled team, verifying timing and grips jointly for each other. The function of the different bodies-in-motion is to facilitate team coordination, to support negotiation of positions, and to enable one team member to remind the other of constraints, moves, and problematic elements. Marking-for-coordination also creates a safer, more relaxed space in which partners can talk about aspects of a phrase while they"re working on it. In full-out practice, or when they are showing a phrase to the choreographer, talk has little place unless making sound is part of the dance phrase itself. Words have no place in full-out practice because dance phrases are often so energetic and require so much attention – at least the phrases we observed in this piece – that there is little headroom left for discussion. When dancers and choreographer do talk, accordingly, we found that it is usually in the pauses between full-out efforts, or, as we observed, during this sort of joint marking.

Although these three functions are logically distinct, we found that, on any given occasion, a single marking episode might serve more than one function. For instance, marking on a new stage lets "choreography" and "lighting" scrutinize the bodies-in-motion to note stage positions, changes in light and shade, and the overall feel of the interaction with the set. The primary function of marking here is marking-for-others.[3] Yet, in addition to this marking-for-others function, the dancers also learn something useful about the look and feel of dancing on a particular stage. They, too, need to be familiarized with deviations from standard spatial relations and lighting. This is a big reason dance companies require a complete run through before each performance. One act of marking, here, serves a dual function: simultaneously as marking-for-others and marking-for-self.

On occasion, the same act of marking can even serve all three functions.

[3] It is worth noting that the context imposes slightly different goals for the dancers than when they mark-for-others to remind the choreographer of some aspect of a phrase. These differences in types of marking-for-others can be captured in a more refined taxonomy that identifies species of marking-for-others.

For instance, if dancers mark duets or trios and they run through grips and mutual positioning on a new stage, they may create a situation where there is marking-for-coordination, marking-for-others, and marking-for-self, though admittedly this situation is unlikely to occur. The logic is that, as before, the choreographic team has the opportunity to observe lighting and angles, each dancer personally benefits from reviewing timing and coordination for themselves, and joint marking occurs as well because each dancer needs the physical presence of their duet or trio partners to experience the full feel of coordination.

Part Two: The Phenomena in Detail

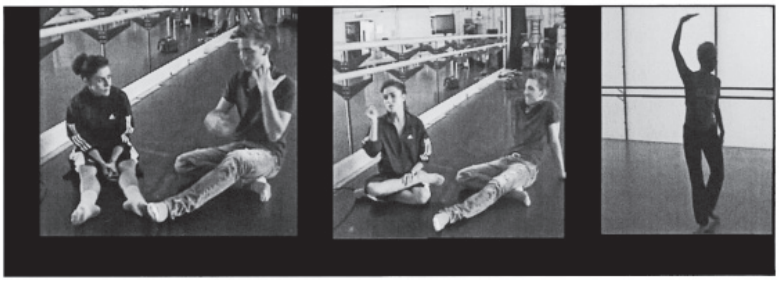
Despite their important functional differences, all three forms of marking differ from dancing full-out in much the same ways, though often in different degrees. We can distinguish five such dimensions: all are ways marking falls short of full-out execution whatever its form and function.

Requiring less energy and displaying fewer dynamics is perhaps the most universal difference between marking a phrase and dancing it full out, regardless of function. Executing dance phrases over the course of a day is fatiguing, and in many circumstances, unnecessary. For instance, when working with others in a duet or trio, many of the key decisions of relative position must be solved through negotiation and coordinated testing. Movements must be slowed down, tried out and talked about. By marking together two dancers can help each other to recall grips and positions. In marking-for-others, the key elements to be externally reviewed may be spatial rather than dynamical, shape rather than speed of motion. Choreographers typically do not review phrases in marked form. They prefer viewing movements full-out (from interview with WM). But when they do accept marked versions, it is invariably because they do not want to overtax their dancers. Lastly, in marking-for-self, a dancer's reason for marking ranges from marking the run up to a phrase to situate him or herself, to set the conception of the phrase's structural shape before practicing the problematic step over and over; to create a convenient synoptic version for reflection; or simply to practice some aspect of the phrase that can be rehearsed without all the simultaneous elements of the phrase. Whatever the reason, though, by marking a dancer saves energy.

Variability of size*:* Marking also comes in a continuum of sizes, from the very small to full size (but less energetically). Whatever type of marking we observed – for-others, self, or coordination – we found huge variance in marking size. 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, in general, is to review the steps, the relationship between simultaneous movements,

such as when an arm and leg move in parallel, and occasionally to attend to timing. See figure 4a and 4b. In extreme cases, such as Irish river dancing – a form of step dancing where the arms are kept still during the full-out performance, see figure 1 – marking may be done exclusively with two fingers of one hand tapping on the knuckles of the other hand to mark foot rhythm, position, and movement. It is hard to imagine finger marking used for anything other than marking-for-self, though in river dancing two dancers might synchronize timing by hand marking together. In larger marking, especially when the objective 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, showing the spatial extent of the move, but with less intent, emotion, or energy than the real movement (figure 4c).

The bottom line: reduced size is a clear indicator of marking, and the easiest to identify when coding for marking in video. But it is not required. Marking size varies depending on whether it is for-self and determined entirely by a solo dancer, or whether it is negotiated between dancer and choreographer, or dancer and partner. If marking is full-sized then other factors, such as speed, emotion, and dynamics, must be used to differentiate it from dancing full out.



Figures 4a, 4b, 4c. *The images here show the contrast between small and larger marking. In 4a, the male dancer is remembering a step, and using his hand to small mark it. In 4b, the female dancer is showing how she marks a pirouette. She is using a formal gesture for a pirouette that she learned as a ballet dancer. Her marking is small and conventional. In 4c, a second female dancer is marking a phrase using movements that are of comparable size to those in the full phrase. They preserve the form but not the dynamics of her full-out.*

Substitutability: It is common during marking to use a movement in one body part to represent a movement in another. Hand movements regularly stand in for leg movements; head tilts or head turns often represent a torso turn or a whole body turn. When legs are moved in parallel, one leg may easily stand in for two. This is shown in figures 4a and 4b. See figure 5 for a standing version, where a dancer marks a leg movement with his hands. See also marking an Irish river dance,

as seen in figure 1, where fingers stand in for legs. The substitution of one leg for two is one way marking differs from iconic gesturing, where rarely if ever will there be a collapse of elements in a manner that distorts their appearance.

Figure 5. A dancer marks a leg movement with his hands in his own personal manner that is a hybrid of conventional ballet marking and personal choice.

Figure 6. A dancer from a strong ballet tradition offers a conventional small marking with her hands.

Conventional gestures: In 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 figure 6, the female dancer marks for the interviewer with her hand to show that, at a certain point in the phrase, a *pas de bourrée* is required. When marking-for-self her gesture would be unaccompanied by speech. This one small gesture refers to a complex sequence of full moves well known by ballet dancers. When marking-for-self, 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 figure 4a, for instance, a dancer with deep training in both modern and ballet represents a leg movement with his arms. His marking appears to be a hybrid: part conventional, and part personal gesture. The point, again, is that in most marking by professional dancers there is an element of conventionality whether they are marking for themselves, for-others, or for-coordination. Honoring convention, at least in part, is not required for marking to be meaningful, but among our sample of dancers, it is what we observed.

***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. Even when they cover the same space as dancing full out, or they move in

a complete manner, covering a full arc with their arms or a full movement with their legs, their movements are less expressive, requiring less energy and containing fewer dynamics. 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. As they reported in interview, reduced form is often the outcome of attending to only certain aspects of the phrase. Indeed, because marking is by definition incomplete it is hard to conceptualize it as anything but an abstraction along one or more dimensions. Only some aspects of the full out version are preserved in its marked form, though these may vary with function and occasion.

These elements can always be found in marking. They are of particular interest because they show how a motor program defining a full phrase can be reduced, altered and truncated while still being of value to a dancer. I explore why this might be so in later sections. I now turn to how the primary types of marking differ.

3. Marking-for-others

Marking-for-others rarely increases personal insight or enhances recall; it is meant to show another person some facet of a movement – its range, shape, formal structure, its sequence or rhythm. Sometimes, it is performed to remind the choreographer of some element of a phrase; or it may help him to think through a passage by acting as a light run-through on analogy with "an Italian run-through" in theater. In such cases, the function of marking-for-others is to support dancer-choreographer dialogue, or to provide the choreographer himself with an abstracted structure to reflect on. It never seems produced to facilitate deeper processing by the dancer personally.

In the company we studied there were strict rules or conventions about how to mark "properly" when marking for the choreographer or his assistant. Movements were supposed to be "complete"; they were to cover most of the space and form of the full-out phrase. Dynamics and tempo could be altered, but the end points of each movement were supposed to be clearly marked. Sometimes, the approximate tempo was to be preserved as well as spatial extent. During interviews with the company each dancer was asked if the way they marked for the choreographer or his assistant was the same as the way they marked for themselves. To a person they replied that the two were different, that the norms they were held to were strict, and that marking was to be far more complete than when marking-for-self. Despite these formal requirements, however, movements were rarely energetic or dynamically correct. The one sure element we observed always missing in marking-for-others was emotional intensity.

Figure 7. Five dancers are marking for the choreographer, WM, and his assistant, OH at the end of a session. Another is stretching. As WM and OH watch, they also discuss elements of what they are seeing. OH has set very strict norms for marking. Movements must retain their form and extent, despite low energy.

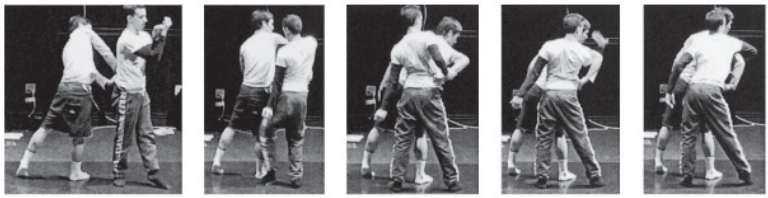
4. Marking-for-coordination

In marking-for-coordination the focus is on directing the joint attention of two or three dancers to structural elements of a phrase, such as grips, timing, relative position, tempo, sequence, and body orientation. Typically all dancers have a good idea of their phrase before they mark-for-coordination, but there remain fine details of who does what, when, and where that need to be sorted out. And, of course, the act of marking makes distributed memory possible; two or more people can cue, remind and prompt each other in ways that help each to recall his/her part.

For example, in the sequence of images 8a-g below, a gestural, body, and conversational dialogue takes place between two dancers as they work out how they should execute their duet. The dancers have been tasked to create a sequence of movements – a score – whose parts are shared among them, though at times both may perform the same elements. On the first day of making this phrase, they worked for an hour to create new movements. Shown is an 83 second snippet taken on the second day. They are 40 minutes into the one-hour session allocated to consolidating the phrase. The two dancers are marking their parts, at times for themselves to help them remember their own movements, but primarily they are marking to facilitate coordination. Until now they have been marking for coordination unproblematically. This stops because P is confused over the movement sequence and timing and this leads to a breakdown in position and over timing. P is not in the right position to start at A"s shoulder and run his hand down A"s arm to the elbow. P"s arm and torso must be oriented to let him move from shoulder to elbow behind

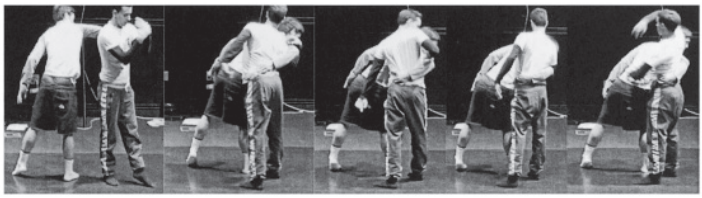
his back. A is partly in the way and P"s body orientation is wrong. The timing issue concerns whether P should begin to reach around for A"s elbow while A is still putting his hand near P"s left hip. The problem, they discover, is that A must lower his shoulders more and stay in that bent position longer, P"s feet should be more parallel to A"s, and then P must wait for A to finish his grip. It takes them a little more than a minute of marking-for-coordination to jointly recall the timing, and also to figure out how to adjust their foot, hand and hip positions. Thes sequence shows how they resolve their confusion, mixing talk, gesture, and most importantly large marking.[4] In about 60 seconds A and P were able to sort out a difficult sequence of grips and positions.

A and P Duet - Steps 1, 2, 3 & 4



Step 1 00:03 **Step 2** 00:10 **Step 3** 00:11 **Step 3** 00:14 **Step 3** 00: 15

Figure 8a. 20 second segment. In this first segment, P and A are marking the first attempt of steps 1, 2, 3 and 4 of their annotation phrase. They get stuck at 3. At 10s. they try the second and third steps in quick succession. Because step 2 is incorrectly executed they get stuck when trying to do step 3. P makes multiples attempts to transition from 2 to 3, tucking his arm under A's arm, crossing it over afterwards, but both A and P"s positions are wrong. Feet and hip positions are wrong; so P cannot rotate his torso and complete his step, nor reach for the right grips on A's body.

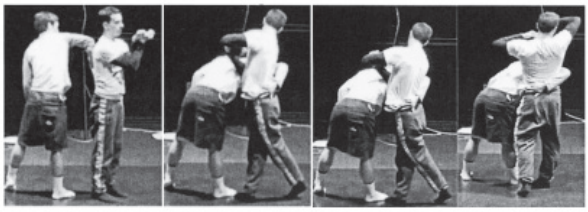


Step 1 00:21 **Step 2** 00: 22 **Step 3** 00:25 **Step 3** 00: 29 **Step 3** 00: 34

Figure 8b. 15 second segment At 21s, they try a second attempt at steps 1, 2, 3. This time, step 2 includes the grip on A's left shoulder that will be part of the final phrase; P's feet position are improved; but P's hip is still off, and A is not bent over low enough to make it possible for P to twist as he must. The breakdown emerges again in the transition from 2, where P must grip A's left shoulder), to step 3, where P 's hand must slide from A's right shoulder to his elbow.

[4] This collection of images also shows distributed memory, since both dancers are working jointly to remember the phrase.

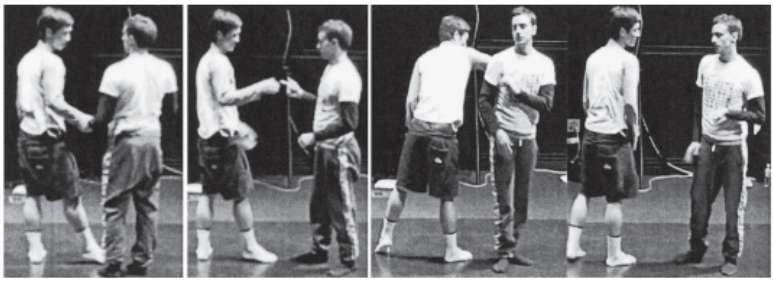
19 second segment



Step 1 00:36 **Step 2** 00:39 **Step 2** 00:43 **Step 2** 00: 46

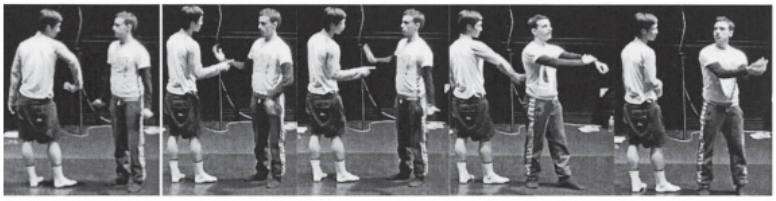
Step 3 00:49 **Step 3** 00:52

Figure 8c. 19 second segment P & A are again marking the same sequence of steps, now for the third time. They get stuck again in step 2. At 39s, we see how P's foot position, P's arms and A's torso angle are wrong. At 43s, still in step 2, P gestures a small "no" with his head, he cannot get into 3. At 49s, we see P still trying to get into 3, griping A's right shoulder correctly, but then tucking his arm under A's, instead of descending to A's elbow. P is confused, and A doesn't adequately lower his head.



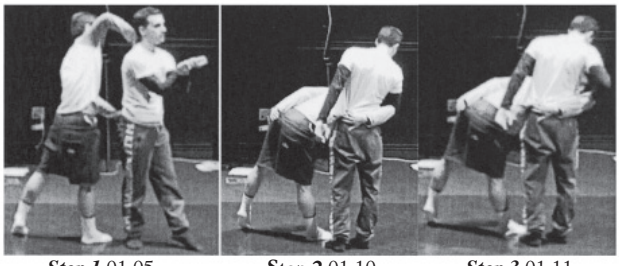
Three 00:56 ***One, two*** 00:58 **Step 1** 00:56 **Step 1** 1:01

Figure 8d. 5second segment At 56s, A corrects P saying No, Three! (Laughs), and they both stop marking. At 57s P gestures two with his fingers, and says So its one, two? At 58s A says yes, while P is still gesturing. P starts marking for coordination with step 1 again at 1:00, while P is still marking for memory from step 1. P is marking for self in an exploratory manner in order to figure out the moves and timing. He seems confused. At 01:01 A asks P Should I go, should I follow you after One? Paolo stops and turns to A.



Step 2 01:02 ***One*** 01:03 ***Two*** 01:03 ***Three*** 01:05 ***One*** 01:04

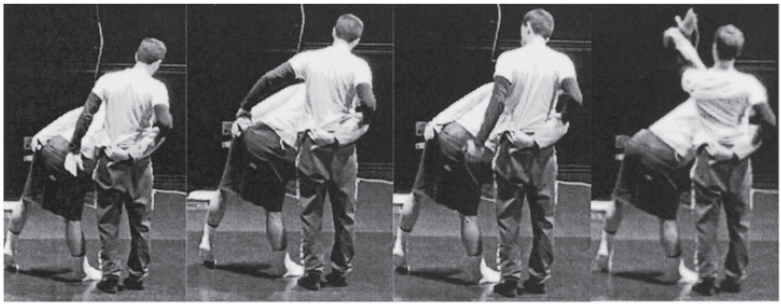
Figure 8e. 13 second segment At 1:02, A marks the grip for step 2 with a specific transformation, a translation of his waist in 90 degrees - with his right arm. At 1:03, A suggests: And we go from two to three. P agrees, and marks for himself up until 1:05, saying aloud the numbers: One, Two, Three, One which refer to the steps. At 1:04 A nods in agreement. The problem has been resolved.



Step 1 01:05 **Step 2** 01:10 ***Step 3*** 01:11

Step 3 01:13 **Step 3** 01:15 ***Step 3*** 01:16

Figure 8f. 11 second segment At 1:05, A marks step One for coordination for the fourth time, while P is in the first position marking for self. They both say out loud One! At 01:10 A & P mark for coordination step 2, and say aloud Two!. At 1:11, P says Three. He repeats until 00:17 the marking for the step 4 times, while A stays in the correct position from 2.



Step 3 01:17 ***Step 4*** 01:20 ***Step 3*** 01:21 ***Step 4*** 01:22

Figure 8g. 5 second segment At 1:17 P seems to have problems to transition from 3 to 4. A failed attempt because of working arms and grips is rectified in 01:22, after repeating step 3 for the 5th time in this final attempt.

The image sequence shows that slowing down a phrase and working on parts in semi-isolation is a natural way to study and reflect on key aspects, while sharing awareness about what has to be done together. In this respect, marking resembles practicing *aspects* of a move, whether in music, sports, or art. In most fields, mastering technique involves using practice time to focus on the difficult parts. Marking, as I have defined the term, is almost always present in such cases, though not always for long. A solo violinist may slow down a phrase to concentrate on a particular transition or technical element, then speed up or add more feeling once core technical elements are understood and mostly memorized. The difference between a solo violinist's actions when marking-for-self and two or more dancers" marking-for-coordination is that when individuals mark together they must coordinate their marking to ensure focus is on their mutual problem. This is found in musical duets and ensembles too. Together, the participants, alter tempo, slowing and telling each other things that lead to better performance. This means that unlike marking-for-self, where marking is under one person's exclusive control, during marking-for-coordination people there must be agreement on pace, resolution, detail and focus.

To sum up so far, in *marking-for-others* and *marking-for-coordination* there is an obvious point to marking: to provide a vehicle, an anchor (Hutchins 2005, Kirsh 2009), or a material structure (Alac & Hutchins 2004, Kirsh 2010b) that can serve as a common reference for all parties. Marking as a body-in-motion, in these shared contexts, is a public structure that can be used to focus and manage joint attention. It facilitates discourse because it is easier to stop, identify, and isolate attributes of a phrase. In the case of marking-for-coordination, it provides a shared

structure for two or more dancers to feel and ratify. One dancer will apply a grip, for instance, the other will accept it, then both enter a state of common knowledge where A knows that B knows that both know the grip has been accepted. All this can be done without dancing full-out, as long as the target structure is sufficiently well marked that both parties know they are thinking about the same full-out structure. By no means is achieving this common knowledge trivial. But joint memory, coordinated execution in the marking phase and later in the full-out version, as well as the final ratification by the choreographer, seems to insure that the proper phrase is mastered.

5. Marking-for-self

In marking-for-self, the function marking serves is less evident than when marking is for-others, or when marking is for-coordination. For this reason it is both provocative and potentially of special interest. We cannot assume that during marking-for-self dancers are *just* practicing, because as stated before, there are many reasons a dancer may decide to mark-for-self: to situate themselves in a phrase, to review the phrase synoptically, to focus on a particular aspect of the phrase, such as foot or arm movements or step sequence. Even when the function of marking-for-self is known, there remains the puzzle of why anyone should bother to mark – to move their body – instead of standing quietly and just mentally simulating themselves dancing their phrase. In mental simulation, dancers can slow down a phrase too. They can situate themselves, or fixate on aspects and look for imperfection, possibly just as easily, and certainly with less physical energy. What cognitive extra does marking give them? Why do they mark-for-themselves?

Sports advertising is replete with reasons to mark and practice in slow motion, and therefore to buy videos of slow motion golf swings, tennis strokes, archery, etc.. As one website put it:

> Why is the slow motion golf swing the best way to practice your golf swing? The reason is simple enough – a golf swing done in slow motion helps you see if you are doing it correctly for maximum effect. Golf is a highly technical game that involves learning a lot of details to make the perfect grip, the perfect swing and so forth.
> If you make your practice golf swings at regular speed, you will not be able to see if you are doing it correctly, as in holding the golf club in the right way, pivoting your body just so, and swinging the club at the right angle and with the right force. When you practice with slow motion golf swings, you will be able to see what you are doing clearly. Thus, when you catch yourself making a mistake, you can just stop at mid-swing and correct your mistake immediately. [http://golfswingtips.grovetech.com/slow-motion-golf-swing/]

Unless a slow motion swing is fundamentally different in form than a full-pace swing, the commentary provides a prima facie reason for slowing movements down during practice. Dancers might benefit from slowing things down when practicing, or when reflecting on form, *if there is a clear exemplar of the proper way the phrase should be performed*. But these reasons fail to explain why one might mark if there is no external norm. Even more importantly, they do not explain why one might mark in a "different" way than the normative full-out phrase. The point of using a video that slows down a movement is that the practiced movement resembles the "referent" movement shown in a slowed down or stepwise form. A coach could look at both and point out discrepancies. In marking-for-self, however, the way a dancer marks may be such that no third party can tell whether the phrase being marked is correct. Too much is going on in the head.

The problem can be restated like this. When dancers mark-for-self they are free to mark in their own idiosyncratic manner and for their own personal reasons. Whereas there are conventions when a dancer is marking-for-others and there is the need for joint agreement when dancers are marking-for-coordination, there are no public constraints on how someone may mark-for-self. This means that when dancers mark-for-self they may mark in ways that are understood only by themselves. They are the sole beings who know how to interpret those markings correctly. It is a very private act.

This makes marking much like an externalized version of mental simulation, which too is private. Both mental simulation and marking require dancers to have a clear idea of their full-out phrase – or at least a good approximation of it. Dancers rarely, if ever, mark a phrase they have not already seen full-out. On the odd occasion when they have not already seen a phrase correctly executed, they at least know the success conditions of the component parts and how they are to be assembled. The choreographer in showing them, or making on them, (Kirsh et al. 2009), established what he expected. And, if the phrase was the product of a task assigned to them, rather than being the outcome of the choreographer's direct involvement in shaping movement, then the requirements of the task will be sufficiently explicit that each dancer should know what is expected. So why mark? What more can the physical manifestation of a movement add to the target already "mentally grasped" through imagination? How can marking ever be more powerful than inner visualization or imagination alone?

6. Part Three: How can marking be more powerful than mental simulation?

There are several ways recruiting the body might augment the power of dancerly thought and attention, ways that marking manages to

deliver cognitive benefits that surpass those from mental simulation alone.

Let us start with some intuitive distinctions. Dancers in interview mentioned marking for different reasons: to help them recall, to help them memorize, and to help them explore the overall shape of a phrase. For our purposes, recall differs from memorizing in that a phrase to be *recalled*, presumably, is already in body or "muscle memory" whereas a phrase still to be *memorized* has been practiced but is not yet fixated in motor memory. The notion of body or muscle memory, so popular in dance[5] and sports[6] literature is typically understood as a form of motor learning that involves automatizing or consolidating a motor procedure through repetition. [7]

Exploration of a phrase, by contrast, is less about memorizing or recalling than about understanding the structural and intentional elements of a dance movement.

It is good to mark it through - to rework it in your brain, to make another idea of what the movement is. (Dancer M in interview)

This requires conceptualizing aspects of it. As before, a dancer will have seen and practiced a phrase, but unlike memorizing, where the goal is to lock in an already mastered phrase, in exploration the phrase has not yet been fully mastered and the goal of marking is to improve understanding of the shape, dynamics or intention of the phrase. When they are marking for exploration, dancers behave as if they have norms concerning the phrase's form, perhaps because they recall instructions given by the choreographer, or because they have seen others perform the phrase well.[8] As they mark, they seem to be asking themselves, "am I meeting the norms?". This might equally be done through mental simulation, but the question asked here is whether by marking, dancers are in a better position to explore the phrase.

I will not discuss our observations of marking for recall or for memorization, despite their relevance to research in motor learning. I think these observations constitute a valuable type of support for contemporary theories of hierarchical motor programs, especially those that explain how a motor program, normally executed through the legs, can be rerouted and adapted

[5] Solway, Diane. "How the body (and mind) learns a dance". New York Times, May 28, 2007.

[6] Taras V. Kochno. "Muscle Memory and Motor Learning In Golf". Sports Medicine & Rehabilitation, International. Sept 10th, 2010. http://www.drkochno.com/muscle_memory.htm

[7] Krakauer,J.W., & Shadmehr, R. (2006). Consolidation of motor memory. Trends in Neurosciences, 29: 58-64.

[8] Celnik, P., Classen, J., Cohen, G.L., Duque, J., Mazzocchio, R., Sawaki, L., Stephan, K., & Ungerleider, L. (2005). Formation of a Motor Memory by Action Observation. The Journal of Neuroscience, 25(41), 9339-9346

so that it is executed (in rough and analogous form) through the arms. In our discussion earlier, it was noted that a phrase may be marked in various sizes, it may focus on an aspect of the full phrase, and arms and legs may be intersubstituted. To have a motor program that can be run in so flexible a manner puts heavy constraints on motor learning and rehearsal.

My focus, here, instead, is on how marking-for-self facilitates *exploring* a phrase more than mentally simulation. To presage what follows: the answer, in brief, is that creating an external structure connected to a thought – whether that external structure be a marked dance form, a pencil sketch, a gesture, or an uttered linguistic structure – is part of an interactive strategy of bootstrapping thought (Kirsh 2009, 2010a, 2010b). It works by providing an understructure, or material anchor (Hutchins 2005), for mental projection. When there is something aptly structured outside we are able to hang more mental imagery, or more complex propositions, on it than we could without it. Marking a phrase, therefore, serves to empower dancerly thought because it provides the scaffold to mentally project more detailed structure than could otherwise be held in mind.

7. The argument from externalization

Here is one reason to work with external versions of thought: through *externalization,* dancers are able to *attend* more effectively to difficult aspects of their movement than by mentally simulating that movement alone. Attention works differently on the outside than the inside. Physical structures have more details to cue off of and monitor than internal ones. They generate more elements to attend to, more opportunities to be surprised. Because one cannot literally *monitor* a mental rehearsal, creation of an external model of a dance phrase permits monitoring its execution.[9]

To appreciate the cognitive extras that physical simulation offers, we first must understand the power of mental rehearsal. Try this little experiment. Mentally say the following tongue twister several times quickly.

Stitsky's textile center. Stitsky's textile center. Stitsky's textile center

Don"t just read it quickly. Say it internally. As experts at speaking, we have a powerful capacity to mentally rehearse sentences. Close your eyes and say it internally again. Now say it out loud in quick sequence.

A few things should be apparent. First, it is possible to have difficulty saying the phrase internally, though how much trouble depends on the vividness of inner speech and the number of times you say the phrase internally. Fluent readers often gloss over words, understanding them, without stumbling on speech complexities. At high reading speeds, vision

[9] Slezak, P., 1995. The "philosophical" case against visual imagery. In: Slezak, P., Caelli, T. and Clark, R. (Eds.) Perspectives on Cognitive Science: Theories, Experiments and Foundations. Ablex, Norwood, NJ, pp. 237-271.

is paramount and auditory imagery is low, (Pintner 1913) and readers do not really formulate sounds, or formulate them very completely, as they read. If you are like me as your reading speed approaches speaking speed, the sound structure of sentences becomes more fully resolved in inner speech, and if there is going to be any articulation trouble, it starts to show. This is the case when you explicitly say a tongue twister in inner speech (Oppenheim 2008). Say the sentence quickly in your outer voice and if you have trouble saying the sentence aloud you should find you also have trouble saying it internally. The reverse is also true: trouble saying a sentence internally predicts trouble externally.

Based on this experience, it might seem that mental rehearsal resembles overt performance. If you are going to stumble outside then likely, you will stumble inside. Accordingly, it may also confer most of the benefits of overt practice: practicing on the inside often yields improved performance outside (Decety 1996, Meister 2004).

Nonetheless, there is still an important difference between saying things out loud and saying them internally. This is my second observation. The tongue and other physiological parts used in speech have a physical dynamics that are not perfectly simulated internally. Each overt speech performance encounters physiological parameters not duplicated in mental rehearsal, such as how wet or dry the mouth is, and some higher order effects of movement and muscle control, such as the interactions between jaw, tongue, mouth, and vocal chords (McGuire et al. 1996). Mental simulation does not improve performance when these factors matter significantly.

Now, try a second experiment concerning mental simulation. Do a mental walkthrough of getting dressed in the morning. Choose a level of detail that involves imagining each piece of clothing, where it is found in your room, and where you will put it on. In the mental simulation literature, this is called simulation for preparation (Markman et al. 2009).

Here's my version. To speed up my morning ritual, I lie in bed a moment longer, thinking through exactly what I am going to wear, where I am going to find each piece of clothing, and then I briefly see myself putting each one on. By informal measures, this substantially increases the speed of my morning rituals, especially if I include in my mental simulation, the sequencing of shower, drying off, shaving, tooth brushing, and the rest.

Yet, the world still surprises me. This is the third observation. As good as my mental simulations may be, there are invariably aspects of the way things really are that I did not anticipate. Maybe my mentally selected socks are not there, or buried amidst others. So now, there is an extra step I did not rehearse: searching. Maybe my pant pockets contain things I have to remove, or there are socks in the legs that should have been placed in the laundry bin. If I were to "dance" around the room, marking my later performance, I'd see these extra steps, I'd know more perfectly how things are this morning, and not rely on default assumptions.

What does this tell us? That there are limits to the realism of mental simulation? Certainly. That doing in the world is still more fine-grained and informative than doing in the mind? Yes. But even more, it points to the value of *physical* simulation for structuring attention. Physical simulation involves letting the outside go its own way and then periodically conceptualizing what is happening. It adds something extra. At first, this extra might seem to be the outcome of simple monitoring - a reality check that comes from observation. But, in addition to updating our world knowledge, the process of doing in the world invites reconceptualizing the observed events.

The opportunity to reconceptualize things is something mental simulation does not offer. It is a major reason "externalizing" what is in mind is a more powerful strategy than working with things in the mind alone.[10] For instance, given a physical object, such as a chair, and a mental image of the same chair, our perceptual system will be far more active in the way it *probes* the external chair than the way our imagery system will probe a mental image of that chair. There is more to be discovered when a structure is external than when it is internal. It has greater causal depth. Thus, when we look at a scene, the patterns, or figures we see initially may be replaced over time by different patterns or figures, as our eyes follow cues and notice details as they move over the external structures. This is especially evident in figures that are ambiguous and whose interpretation typically reverses after a minute or two. See figure 9.

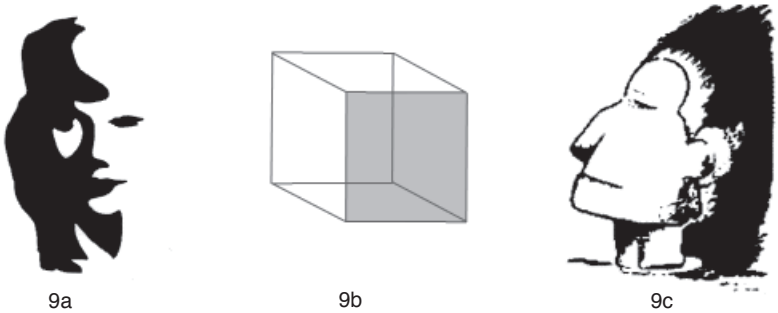


Figure 9. Fig 9a is a classical ambiguous image of a saxophonist and a woman's face. Can you see both? Fig 9b is a Necker cube. The ambiguous figure in 9c is harder to reverse. After an initial period of "interpretation lock", people normally toggle between the different interpretations of images like these. Not so when these figures are recreated in mental images. They don't toggle. Whereas the perceptual system interacts with external cues and attributes to actively look for consistent interpretations, often leading to change and surprise; the mental imagery system creates and sustains an object under an intention. It doesn't "look" at the internal image, it creates it.

[10] Kirsh (2010a) discusses eight ways externalizing helps thinking.

The lesson to derive from ambiguous figures and from scenes that take time to "fully" discern is that what is discoverable through perception is not always discoverable in mental imagery of the same structure (Chambers & Reisberg 1985). Studies have repeatedly shown that when mentally imaging a reversible object, even one as simple as a Necker cube, see figure 9b, the interpretation a subject starts with remains the sole interpretation long after the figure would toggle if observed with open eyes. It is as if mental imagery, and by extension mental rehearsal or mental simulation, cannot escape its own "intentional envelope". A mental image is sustained by a conception of the thing or process to be conjured. Thus a subject's own idea of the target object is the driving force determining what the object seems to be. In principle, this conceptualization could change. But, as an empirical matter it does not. The mental object has no autonomy from the subject. It is sustained by the subject and has no reality independent of the subject.

When there is a real object present, however, the intentional envelope – the manner of perceiving and conceiving a scene – is partly driven by the way the subject actively probes or interacts with the object as well as the subject's active conceptualization. When there is an external object it can "talk back". Accordingly, as perceptual attention moves to different parts of the object, new cues and attributes come into focus. The resulting interactive dynamic, when applied to vision, has been called by Noe "enactive" vision (Noe 2004, See also Hurley 1998). In enactive perception, both agent and world are in active dialogue: what one see's depends in part on where and how one looks, and where and how one looks depends on what there is to see, on one's motivations, tasks, skills, and activities. This can easily lead a subject to look at an "unchanging" object and see things in it, even see it in a new way. That is, the interactive dynamic of perception can cause a subject to reconceptualize the overall structure and identity of a scene.

The obvious implication for marking is that by externalizing their movements, dancers are able to create an object of perception that can be conceptualized and reconceptualized in ways that go beyond mental simulation. They can harness their movement, and their attentional system, for further cognitive ends: trying out forms that can be seen in new ways, then exploring those new ways in further ways of moving.

Perhaps the best analogy of this interactive dynamic is graphical sketching. Suppose a graphic artist is given a simple object – a pair of scissors – then provided with paper and cardboard and asked to make a few cuts. After a minute, the scissors is removed and the artist asked to make an illustration of the scissors. In making concrete his mental image of the scissors, questions arise for the artist about details of the scissors. How much of the whole length is blade and how much handle? How thick is the blade? What is the shape of the finger holes? By having the chance to interact with a slowly evolving pencil sketch, one that can be constructed, erased and redone, the artist has a chance to recreate the

scissors with attention to details that before may have gone unnoticed. He can reconceptualize parts interactively. Creating the pencil sketch forces an interactive level of engagement with his memory of what he saw that cannot be matched by pure imagination. The external artifacts and representation help him to interactively explore his visual memory of what he saw, and perhaps more; the interaction may even force a greater integration of knowledge about scissors, leading him to infer details he never noticed, attributes that must be there.

This interactive strategy of recalling an image, realizing it physically, conceptualizing what is now external, and then reconsidering whether that is the best conceptualization, is a powerful mechanism of thought. In dance as well as most thoughtful activity, it can lead to new conceptualizations and to new things being noticed.

It depends on a second process – projection – to which I now turn.

8. How Projection adds power to externalization

I have been arguing that physical simulation – specifically marking a phrase – provides the material basis for triggering attention and reflection, making reconceptualization possible. It supports interactive thinking. This a key process in using marking to help explore and rethink a dance phrase. It is easy to see how interactivity might help explain how a subject can learn from full-out practice. But isn't it necessary that the target of interactive inquiry be close to the "real" thing? How can small or incomplete movements facilitate rethinking a phrase?

My conjecture is that a movement need only be as complete as is necessary to support *mentally projecting additional structure*. Marking, even small marking, can provide the material basis for this sort of projection. When dancers mark they use their bodily movement to "anchor" projections of how their target movement ought to look and feel. Because this anchor is external, they can distribute the complexity of mentally simulating ways of performing a phrase. They can use the external structure as a scaffold or support, much the way a designer when sketching his current idea can use a simple curve to both encode current thoughts and as a support to prompt new ways of thinking. A sketch constitutes the external object for interactive inquiry, and it doesn't matter that it is incomplete because it's function is to stimulate further projection. By analogy, marking, even small marking, ought to permit a more interactive engagement of full-out moves than mental simulation unaided by external support because it constitutes the external thing that a dancer needs to monitor, probe and rethink. Bodily movement acts as a scaffold that supports better mental rehearsal and mental exploration.

To expand this idea it is necessary to define our terms.

In the phenomenology of perceptual experience, a distinction can be drawn between perception, projection, and imagination.

Perception: When we perceive an object, our experience is that we are seeing an object that really is there; we feel it is external to us, it is *the independent cause* of our perception, and our experience is, in some sense, involuntary.

Projection: When we project onto an object, we experience ourselves intentionally augmenting the object; we feel that there is both the external thing causing part of our experience and, in addition, there is an extra element *caused* or *partially caused* by us. Part of our experience is under our control.

Imagination: When we imagine an object, we feel as if we are the *sole cause* of our imagined experience. We know our image is internal, that it is generated and sustained by us, and that there need be nothing external that is present at the moment.

Projection lives somewhere between perception and imagination. See figure 10. Projection has an imagination component because the projected element is conjured by the subject – the subject augments the external structure. But equally, projection has a purely perceptual component because the projected element is somehow superimposed or anchored on what is perceptually present and so must make contact with the external structure.

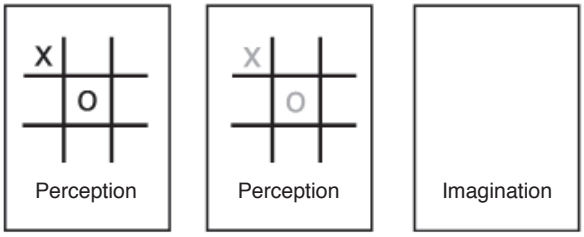


Figure 10. The difference between perception, projection and imagination can be understood as the difference between playing tic tac toe when you can see all moves written on a board (perception), vs. playing the game where all you can see is the board grid with nothing marked on it (projection), vs. playing with a blank page in front of one or blindfolded (imagination). Kirsh (2009) found that projection helps weak imagers in a 3 by 3 game and both weak and strong visualizers in 4 by 4 games.

Projection needs a physical basis because by definition it is adding intentional content to what is already there. The simplest way to think of projection is to treat it as the psychological equivalent of augmented reality. This involves engaging some part of visual experience,[11] though just

[11] In 1910 Perky performed a set of experiments in which subjects fixated on a screen while visualizing objects, such as a tomato. Simultaneously, a faint patch of color, of an appropriate size and shape, and just above the normal threshold of visibility, was back projected onto the screen. The subjects thought the projected images were in fact the product of their own imagination.

where in the chain of visual processing this intentional augmentation occurs is not yet clear. Presumably, projection does not add to early perception, because that would require subjects to insert conceptualized content into a pre-conceptual process. Present day theory holds that early vision is involuntary, and "cognitively impenetrable" (Pylyshyn 1999). So, we do not have intentional access to early vision (Pylyshyn 2002). Nonetheless, at some point, perceptual experience is sufficiently conceptualized that a subject can intentionally choose a part of the visual scene to augment. Conceptualization, of some sort, is required because a subject must anchor his or her projection in something they recognize.

We found support for this idea in an experiment we ran recently (Kirsh 2009). Subjects were taught to play the game of tic-tac-toe by identifying their chosen move by calling out its cell number (which they were trained to learn). There were two main conditions: projection and imagination. See figure 8. There was no condition equivalent to perception because performance is invariably better when the entire state of the board is visible, and cognitive strategies can be perceptually driven in ways that are difficult in mental simulation. So having such a condition would be uninformative. To account for differences in imagery ability all subjects were given a VVIQ2 imagery test.

Our results were surprising. We expected everyone to benefit from a visible tic-tac-toe grid, but this was not what we found. Only weak visualizers benefited, and even so, their benefits only trended to significance in the pilot experiment we ran. When we increased the problem complexity by increasing the game to a 4 by 4 board – where winning requires getting four in a row rather than three – we found that weak visualizers clearly benefited from the grid; their projection was statistically better than imagination. Strong visualizers trended toward improvement and we predict with more subjects they too would have performed significantly better. The inference we drew was that people make use of external structure to project possibilities when they have difficulty visualizing those possibilities. Augmenting a scene enables them to perform better than relying on their imagination alone without the help of an external scaffold.

What does this tell us about marking? Nothing directly. We cannot reliably infer from this experiment that by creating an external scaffold, dancers should be able to hold in mind structures of greater complexity than would otherwise be possible by mental simulation without external support. The lesson of tic-tac-toe is only suggestive in the dance domain because it directly applies only to those cases where it is hard for subjects to visualize possibilities. Dancers may have no difficulty in visualizing or mentally simulating their dance phrases.

On the other hand, if better performance in tic-tac-toe occurs in the projection condition because subjects can use an interactive strategy in that condition, then marking may facilitate dancerly cognition because it provides an external structure to interact with. Dancers can use their

bodies-in-motion as sketch-like structures to interactively elaborate their conception of their phrase. Marking, in that case, will act like a graphic artist's sketch, the difference is that in dance, movement is ephemeral while in sketching an illustration is persistent and supports a different set of interactive strategies. This might lend support to the claim that marking enables dancers to keep in mind structures of greater complexity.

The second point is that by creating an external structure that can be actively probed and interactively conceptualized, marking partially explains how a dancer can improve full-out performance through error-driven motor learning. One of the larger challenges in understanding motor learning today is to explain how a subject can create an error signal that marks the difference between a normative "description" of the target movement and actual movement. Subjects must be able to tell the respects in which their performance falls short of the ideal, and then use a measure of that "error" to modify the underlying motor program so that generates behavior closer to the ideal. On standard accounts, this motor program is updated by back-propagating the error signal to improve motor output next time (Jordan & Rumelhart 1992, Wolpert et al. 1995). The driving question, though, is where does that error signal come from?

In dance, the normative model of a phrase must be constructed from the original learning context. Either a choreographer will have shown or shaped a phrase, or the dancer himself has created it. In either case, there are observational components of the phrase – what it looks like visually when well executed – and there are conceptual ideas associated with what is involved in performing the phrase well. For instance, a dancer may have created a move by enacting what it is like to climb out of a barrel. Research done to date on how explicit thoughts shape motor behavior falls under the theory of hierarchical motor learning (Botvinick 2008). It is in an early stage of development. The effect of observation on movement, meanwhile, has been discussed in the mirror neuron literature. (Stefan et al. 2005). It, too, is in an early stage of development. The relevance of both approaches is that they offer an account of how a normative model can drive motor learning.

But there is a wrinkle. In order to extract an error measure the activation of a normative model must not draw down on the resources needed when practicing full, or marking, or mentally simulating. Else it will not be possible to create an error signal or the quality of the signal will decline. It is here that marking shows its superiority to mental simulation. For, presumably, to note that a given mental simulation of a phrase is incorrect a dancer must simultaneously create an image of the ideal and compare it with the actual imagery of movement. In [reference] it was shown that it is hard if not impossible to simultaneously hold different mental images. It is here that marking shows its value. If a dancer can offload most of the cost of imagining a phrase by "leaning on" the external form created by marking, then there are more internal resources available for comparing

the projection of the phrase with the image of the normative phrase. The result is that a better error measure can be generated. This means that marking behaves as an element in a distributed representation of a phrase, and the cognitive cost of distributed representations is lower than comparable representations generated and sustained internally.

9. Conclusion

Marking is part of the practice of dance: it is a component of the creative process, prevalent during the rehearsal process, involved during practice and reflection, and common when people are nervous and waiting in the wings. Processes analogous to marking are found in most activities requiring physical technique, such as sports and musical performance. The general phenomenon is remarkably prevalent and yet little studied.

I discussed three types of marking: marking-for-others, marking-for-coordination and marking-for-self. They are distinguished by their function. Marking-for-others is a method of showing one's dance phrases to another in a manner that is sufficiently clear, despite being less energetic and less emotional, that the form of the phrase can be clearly seen and the remainder of the phrase can be inferred. It is usually performed for the choreographer or his assistant. In dance companies, there are often norms for marking-for-others.

Marking-for-coordination is a method of working with a duet or trio partner to work through grips, positions, and timing. Dancers go through the motions of their part, and they practice, jointly recall, discuss, and negotiate. Often they slow down the phrase they are marking.

In marking-for-self, dancers use their body-in-motion to represent for themselves some aspect of a "full-out" phrase. It is a method of practice and personal reflection, though it too covers diverse phenomena, such as running through a phrase to reach the part needing practice, slowing the phrase down, and so on.

I have argued that marking-for-self is an example of interactive cognition – an extremely prevalent activity. People often think by means of an interactive strategy of creating external structure, then projecting meaning onto that structure, and then creating additional external structure. Projection is another way of saying mental augmentation. It is the extra we "see" in a scene when we look into possible futures, into the effects of actions we envision ourselves doing.

Noe has called this anticipation of the future, which he sees as an essential component of vision, to be enactive perception. Projection differs from perception, even in this enactive sense, however, in that it allows envisioning actions that might change the thing perceived, such as reshaping or elongating a movement, or penciling in a mark on an illustration, or an X on a perceived tic tac toe board. In perception, our

anticipated actions do not change the thing perceived. Projection, nonetheless, shares with enactive perception, the assumption of an active agent making sense of the world through continuous engagement: an agent sees the world, anticipates how it might be changed, then changes the world. This ongoing cycle, I contend, let's dancers and people, in general, outperform themselves. They harness the outside to bootstrap thought to new heights. And because marking can be fast, it constitutes a suitable vehicle of thought.

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