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EMBODIED COGNITION: SOMATIC MARKERS, PURPOSES AND EMOTIONAL ORIENTATIONS

ABSTRACT. We describe the "somatic marker hypothesis" proposed by Damasio (1996) to account for the ability of most people to make decisions quickly and continually in the course of their lives. We relate this hypothesis to two other theoretical constructs, emotional orientations and purposes, which we have used in our research on students' reasoning and teachers' decision making. Given that somatic markers are a part of unconscious mental activity, they cannot be observed by introspective reflection. How then can we research something we cannot see? Beginning with the hypothesis that somatic markers influence actions, we observe, particularly, the actions of student teachers, teachers and children in mathematics classrooms at points where they make decisions. This process is illustrated through examples both of teaching and learning in mathematics, and through the account (see Op't Eynde and Hannula, this issue) of 'Frank' reflecting on his decision-making in mathematical activity. We use the case of Frank to illustrate some differences between viewing mathematical activity from our perspective and from those of some other contributors to this special issue. The connections between emotional orientations, somatic markers and purposes are further illustrated by two examples drawn from our research into teacher development and students' reasoning processes.

KEY WORDS: embodied cognition, emotional orientations, reasoning, somatic markers, teacher education

1. INTRODUCTION

In this paper, we wish to draw attention to an emotional aspect of human behaviour that we feel has been neglected. It is related to the decision-making that happens before conscious awareness of the decision to be made occurs. We will first describe the "somatic marker hypothesis" proposed by Damasio (1996) to account for the ability of most people to make decisions quickly and continually in the course of their lives. We will relate this to two other theoretical constructs, emotional orientations and purposes, which we have used in our research on students' reasoning and teachers' decision making. We will then illustrate some differences between viewing mathematical activity from our perspective and from those of some other contributors to this issue, using the case of Frank as an example. To further clarify how the idea of somatic markers enriches and connects our work on teacher decision-making and students' reasoning we will provide two other examples, one of two students making decisions as they solve a problem, and another of a teacher reflecting on his decision-making in class.

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2. THEORETICAL PERSPECTIVES

We have adopted Damasio's (1996, 1999) somatic marker hypothesis as an explanatory principle (Bateson, 1972, p. 38) to help us analyse teachers' decision-making and students' reasoning. Damasio uses the term "somatic marker" for the juxtaposition of image, emotion and bodily feeling we have that informs our decision-making:

> Because the feeling is about the body, I gave the phenomenon the technical term *somatic* state ("soma" is Greek for body); and because it "marks" an image, I called it a *marker*. Note again that I use *somatic* in the most general sense (that which pertains to the body) and I include both visceral and nonvisceral sensation when I refer to somatic markers. (1996, p. 173)

He hypothesises the existence of such markers on the basis of his work with patients with brain damage, who appear normal in most respects (including an ability to pass the usual tests of cognitive ability) but whose lives are disrupted by a tendency to make poor decisions or to be overwhelmed by options. Somatic markers inform decision-making at two stages. Before we are even aware that there is a decision to be made, many possibilities are rejected because they are associated with negative somatic markers. In many situations, this allows us to act spontaneously without pausing to consciously decide how to act. Brown and Coles (2000) describe the operation of somatic markers in this first stage, in their work on teachers' complex decision-making:

> Somatic markers act to simplify the decision as to which behaviour to try. Negative somatic markers mean that the behaviours do not even come to mind as possibilities for action. A positive somatic marker means that the behaviour becomes one of a number available for use. (p. 168)

In other situations, where there is a need consciously to decide, somatic markers are felt bodily, and help us to compare options wisely. It is in this stage that we might be aware of our own somatic markers, when we notice ourselves deciding something because "It feels right".

As we go through life some of our behaviours afford events that we experience as pleasurable. That experience changes our bodily structures in ways that mean that the behaviour becomes marked, so that in similar circumstances we are likely to behave in similar ways. Other events we experience as unpleasant, and then our bodily structure changes in ways that mean the behaviours we associate with those events are less likely to occur in the future:

> Somatic markers are thus acquired through experience, under the control of an internal preference system and under the influence of an external set of circumstances

which include not only entities and events with which the organism must interact, but also social conventions and ethical rules. (Damasio, 1996, p. 179)

Damasio's proposal for the genesis of somatic markers fits with our acceptance of the ideas of embodied cognition where cognition is seen as arising from

two interrelated points: (1) that perception consists of perceptually guided action; and (2) that cognitive structures emerge from the recurrent sensorimotor patterns that enable action to be perceptually guided. (Varela, 1999, p. 12).

Somatic markers are one example of cognitive structures that guide action. Another is the labels that we use most in naming what we perceive, the 'basic-level categories' (Lakoff, 1987), which are those that are most easily seen in the world, and are linked strongly to actions we often do. Because sitting is a frequent action, we can recognise members of the category 'chair', in spite of the huge variation in forms of chairs. Basic-level categories help us to deal with complexity through pattern recognition. Superordinate categories (e.g. furniture) and subordinate categories (my particular chair) are also linked to behaviours. We mention this to point out that somatic markers do not account for all behaviour; other cognitive structures are also involved, although here we will focus on somatic markers as we feel they provide a useful explanatory principle to account for important aspects of teacher's decision-making and students' reasoning.

Damasio's somatic marker hypothesis has also provided us with a useful elaboration of and connection between two frames we use to describe teacher development and student reasoning: 'purposes' and 'emotional orientations'.

Briefly, purposes are similar to basic-level categories in the context of teacher behaviours and their general images of teaching and mathematics. They fill a middle position of perceptually guided action between behaviours that are too specific to be used as a model for future behaviours, and general images of teaching and mathematics that are too loosely linked to actions to be useful guides. Laurinda developed the concept of purposes in her work in teacher education (Brown and Dobson, 1996; Brown and Coles, 2000). Below (Section 4.1) we will provide an example of how purposes can contribute to teacher change and how somatic markers help us to describe what purposes do.

Many communities, for example mathematicians and teachers, agree among themselves on what counts as an acceptable explanation for the phenomena of interest to that community. Different communities, however, accept different kinds of explanations. Maturana (1988a) considers emotions to be the foundation of the criteria for acceptance of an explanation by members of a community, and he coined the phrase "emotional

orientation" to refer to such criteria. David has written elsewhere about the relationships between emotional orientations and language and some elements of the mathematical emotional orientation (Drodge and Reid, 2001) and students' criteria for accepting explanations (Reid, 2002). Below (Section 4.2) we will provide an example of how somatic markers offer a possible basis for emotional orientations in the context of students' mathematical reasoning.

3. Different approaches to emotions: the case of Frank

In this section we will give a very short analysis of the mathematical activity of Frank (see Op't Eynde and Hannula, this issue) and then offer some comparisons between our analysis through the filter of somatic markers, and those of other contributors to this special issue. In doing so we intend to show how somatic markers offer a different insight into emotions in mathematical activity, as well as pointing out an issue of common concern.

In the transcript (Op't Eynde and Hannula, this issue), Frank is observing himself trying to make a decision. He sees himself moving to pick up his calculator, and describes this as a panic reaction – but in the end he does not pick it up. There is a struggle going on between two feelings:

" I panic, and then I immediately want to go to my calculator" (Turn 6)

" I always want to do as much as possible without it" (Turn 8)

We have here an unusual source of data. Frank's original actions involve somatic markers at the first, non-conscious, stage of decision-making. Many options are rejected without conscious consideration. Frank shows no sign of giving up and walking away, or asking the teacher for help, or guessing, all of which are options other students might have chosen. We infer that Frank has negative somatic markers that block these options. We may also have access to decision-making at the second, conscious, stage but it is impossible to tell whether Frank's original actions were a result of a conscious process, which he accurately reports when observing himself, or whether his retrospection includes his own interpretations. Assuming for the moment that he did engage in a conscious decision-making process, we can now describe his decision-making in terms of a conflict between a positive somatic marker and a negative somatic marker, both related to calculator use. He has a positive marker that is activated when problems become complex or numbers become large because: "I did not know immediately how I had to go from 20 km to 14 km." When he uses a calculator, however, he experiences conflict: "I did not really need the

calculator there. . . if then I stop and think for a moment, I probably know again what I have to do." The negative somatic marker, usually non-conscious, is creating dissonance.

Other contributors to this special issue have interpreted Frank's actions in different terms. We recognise the value in all of these interpretations as contributing alternative perspectives (see Reid, 1996 on the methodological importance of multiple perspectives). Of course, it is possible that what seem to be alternative perspectives are merely alternative vocabularies for saying the same things. This is certainly not the case for our use of somatic markers, as there is a clear and important difference between our approach and others taken in this special issue.

As we have noted above and discussed in the case of Frank, most decision-making does not involve conscious reflection. The somatic markers involved do not manifest themselves as feelings related to options under consideration, because they have their effect before the options are consciously considered. In our research, we find these somatic markers interesting, given that most teacher decision-making and student decision-making when reasoning or solving problems is not conscious. In contrast, the other contributors to this special issue are interested in affect, emotions that are felt and that manifest themselves in facial expressions and other physiological signs. For example, Op't Eynde, DeCorte and Verschaffel (this issue) report that "students experienced different emotions" and they use their words, tones, and expressions as a basis for their interpretation of what emotion is being experienced. Malmivuori (this issue) discusses Frank's beliefs and "self-appraisal process" referring to what Frank has said about mathematics, learning, and himself on the questionnaires and in the interview. Hannula (this issue) also bases his analysis on Frank's responses on the questionnaires and in the interview. Finally, DeBellis and Goldin (this issue) note that using "conscious, retrospective self-descriptions" such as those provided by Frank in the interview context, is unusual for them, but it is clear that their focus is on affect, and that there is no fundamental difference between what Frank observed in himself and what they would use as their data. We feel that by emphasising, in our research, the non-conscious nature of most decision-making, guided by somatic markers, we add an alternative perspective to research that uses professed beliefs and values (determined through surveys and interviews, for example) to explain behaviour.

A second difference between our approach and at least one of the other contributors' can be summed up by noting that Op't Eynde et al. (this issue) are interested in studying events that give rise to emotions, while we are interested in emotions that give rise to events.

While our approach is different, there is a significant overlap between the issues we try to address and those of some other contributors. Both Hannula

(this issue) and Malmivuori (this issue) focus on Frank's difficulty deciding whether to use his calculator or not. For Hannula, this reflects a conflict between the means for attaining two desired goals. Malmivuori notes that Frank's "behavioural reaction (i.e., intention) is automatic", "without conscious self-control activity" motivated by a negative emotion, a "restrictive affective aspect of his contextual conciousness", panic. While Hannula seems to see emotions as reflecting motivation for actions, and Malmivuori seems to see them as being inhibitors, we believe they can be either positive or negative, depending on the prior experiences of the individual. Negative, non-conscious somatic markers can still make us feel uncomfortable as we move to act.

4. Research using somatic markers

Somatic markers cannot be observed. What can be observed are the decisions that Damasio hypothesises are based on somatic markers. We observe learning focusing on points where decision-making is not smoothly accomplished, on the basis of which some of the learners' somatic markers can be inferred. Awareness of these markers informs our own decision-making in the moment of what to do next as teacher and as teacher educator.

Given the nature of our work we both become involved in longitudinal studies where it is possible to consider changes in the teachers and students' patterns of behaviour and uses of language over time often through video- and audio-transcripts.

The following two sections illustrate our research on somatic makers related to:

teachers' and student teachers' purposes
emotional orientations – criteria for accepting explanations

Through these two sections runs a thread of emotions and feelings related to 'being right', both within mathematics and for teachers' actions within the classroom.

4.1. *Somatic markers and teaching*

As teacher educators we work with student teachers of mathematics and also with more experienced teachers who are developing their practice. Part of this work is encouraging reflection, through which they can recognise behaviours that they want to change. Mathematics teachers are often accustomed, from their own education, to an image of doing mathematics that is focussed on finding right answers to given questions. This can conflict

with the situation of being a teacher, where the 'questions' are continually changing and 'the right answer' is not so simple to identify.

In this section we present extracts from several interviews with a teacher, Alan Dobson, who discusses his learning as part of a Master's in Mathematics Education course in the UK. We analyse these extracts using the explanatory principle of somatic markers and introduce the term 'purposes' (see Brown and Dobson, 1996 for an alternative analysis). The language of right/wrong emerges in this teacher's descriptions of decision points in his teaching.

Extract 1: Seeing 'right' in students

> Yesterday, I had that year 8 group of children [12 year olds] with special needs. [. . .] Lianne was having problems identifying the correct model, the correct operation to use on this particular set of questions. She had done the first couple and in fact they were all multiplications [. . .]. So, we talked through the first one and after a long piece of teaching we came to the conclusion that [. . .] the rest must all be multiplication, so she was quite happy then pressing buttons on the calculator and doing multiplication sums.

Here, implicitly, the teacher describes a decision point. He observes "Lianne was having problems identifying the correct model". For both the teacher and Lianne "the correct model" is important. We do not know the nature of his intervention, which he describes only as "a long piece of teaching," but we do know that he decided to act at this point. We also know that this action was seen by the teacher as effective in changing Lianne's feelings from "having problems" to being "quite happy then pressing buttons on the calculator". We can infer that Alan has a positive somatic marker related to getting students working again when they have problems, but there is also evidence that there is a conflict, as Alan retrospectively questions his own behaviour:

> But I knew really that I had done nothing - that I hadn't really taught her that that particular set of situations was going to be interpreted as multiplication sums. All I helped to do was get those sums right on that particular page, she was quite happy with that.

In reviewing his teaching strategy he thinks that he could have supported Lianne to understand more about what she was doing. He wants her to avoid "rules without reasons" as Skemp (1976) would describe this instrumental approach. Like Frank, Alan has the opportunity here to reflect on his actions, to report his feelings associated with them, and also, in the context of a teacher development course, to make distinctions that might allow him to change his somatic markers and hence his future behaviours.

Extract 2: Needing to do something

The child was thinking, nothing was happening, and I felt because after so many years teaching I guess there was a need for some sort of intervention, I needed to do something and inevitably after listening through tapes afterwards, my interventions were very, although I didn't think so at the time, they were very directed, they were starting to prompt the child and push the child in the direction of the answer that I wanted, not really searching out what the child knew at all. So, I guess the interventions were answer-orientated, I was thinking the answer I had this model in my head with an answer at the end of it and that was what I subconsciously said, if you had asked me that before the interview, I'd say, no I don't want to do that, that's precisely what I don't want to do.

After Alan listened to tapes of his discussions with students in his classroom he reported feeling: "I needed to do something". But reflecting on his action he sees his interventions as "answer-orientated" and "precisely what I don't want to do".

Alan's phrase, "searching out what the child knew" is an example of what Laurinda recognises in her work with student teachers as a 'purpose'. Working with student teachers at the level of images and philosophical positions does not seem to support the development of their teaching, and focussing on actions (giving a 'tip' in relation to a perceived problem) does not seem to be effective, since the complexity of the situation needs to be 'read' each time. Holding a purpose, like "searching out what the child knew", in mind guides actions, providing a framework for the development of new somatic markers.

Extract 3: Knowing what to do

In a sort of perverse way the 'not knowing what to say next' has been solved by not saying anything. The correct response might have been no response. Just to sit and wait and be patient. In terms of actually saying things, this statement: 'alright you don't know but tell me what you do know', is quite nice. And that is very powerful in the classroom, trying to get straight to a problem. That has been a definite change of behaviour, but is certainly a new technique I am using now that I wasn't using four of five weeks ago.

Now that "searching out what the child knew" is part of what Alan sees himself as doing he finds actions that support that purpose. He finds that, although he had gone through a stage of "not knowing what to say next", this had itself allowed him to explore what happens if he is sitting, waiting and being patient. He then states a change in behaviour, a new technique, using an invitation to the child to express where they are in relation to a problem. This action now has a positive somatic marker attached to it, as do the actions of waiting and being patient. We suggest that there will be a range of such marked actions available for use in the next similar, though never the same, situation.

4.2. *Emotional orientations*

Maturana (1988a, b) observes that human beings operate in communities in which there is agreement on what constitutes an explanation. For example, what is accepted as an explanation for changing weather patterns differs for meteorologists, politicians and religious fundamentalists. Membership in a community involves sharing criteria for accepting explanations (or more broadly, for reasoning in certain ways). This suggests the question of how such criteria might work.

Maturana notes that when an utterance "is accepted and becomes an explanation, the emotion or mood of the observer shifts from doubt to contentment, and he or she stops asking over and over again the same question" (1988a, p. 28). The fact that we can detect the acceptance of an explanation by feeling an emotional shift is suggestive. Also, Maturana notes that the criteria for accepting an explanation cannot be the same as the criteria for accepting the criteria, as this leads to an infinite regress. Specifically, the criteria of scientific rationality cannot be used to decide what criteria determine whether or not an explanation is rational. These two observations lead Maturana to consider emotions to be the foundation of the criteria for acceptance of an explanation by members of a community, and to coin the phrase "emotional orientation" to refer to such criteria. Here we will use the example of Bill and John's mathematical activity to elaborate how somatic markers provide a mechanism that might underlie emotional orientations.

The following transcript[1] records the mathematical activity of Bill and John, two low attaining students in a Grade 10 (ages 15–16) class in Canada. Bill and John are working with David outside of their classroom context on Arithmagon problems (in which a triangle is given with numbers marked on the three sides; the task is to find numbers to be placed at the corners so that each pair of corner numbers will add up to the number on the side between them). This is the third session in which they have worked together.

In the first session, they were given an Arithmagon to solve with the numbers 11, 18 and 27 on the sides, and the instructions, "The numbers on the sides of this triangle are the sums of the numbers at the corners. Find the secret numbers. Make up a triangle of your own, and solve it. Can you describe a general way to solve all triangles?" They found numbers for the corners of this triangle and for others by trial and error. In the second session they worked on an unrelated task involving Fibonacci numbers.

In the first two sessions David acted as a passive observer. In this third session, David provided assistance to them (see Reid, 1995) and Bill found (with help from David) a general method for solving the problem in Figure 1

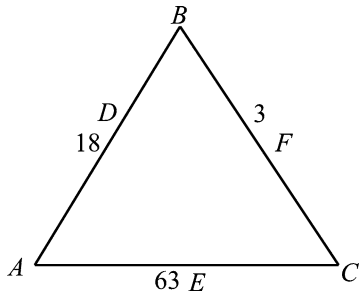

Figure 1. Labelling used by Bill and John for their formulae.

(the letters D, E, F, were added later). He has expressed his method as a formula:

$$\frac{(A + C) - (A + B) + (B + C)}{2}$$

After this, Bill and John tested Bill's formula by doing another problem, and John wrote out his alternative formula in which, instead of using A, B, and C to represent what they want to find, he used D, E and F to represent what they know (at this point he added the letters D, E and F to Figure 1). John's formula is:

$$\frac{E - D + F}{2}$$

John explains the relationship between his formula and Bill's, replacing each sum involving A, B or C, with a new variable standing for the known numbers:

96 John: Plus B plus C, which would be F. So, in other words, E minus D plus F.
97 Bill: Yeah. That's an easy way to think of it.
98 John: So, 63. So we just look. We know E is 63. D is 18. And F is 3. So it'll make it much easier to work with. I guess.
99 Bill: Yeah.
100 John: Then we can just go from there. We know that's divided by 2. So.

But then Bill raises a concern:

101 Bill: But, You, you are aware of why it is divided by 2, right? The, the, the reason this, this would make it kind of easier is 'cause you would know how much is left behind. You would see that the As cancel each other out. The Bs cancel each other out. You would know that you would have 2C. With this you wouldn't really know that you had to divide it by 2. With this you would.

102	John:	That's true. – OK. So then would it be
103	Bill:	But, uh. Once, once, once you already knew that you had to divide by 2, some brilliant genius could, uh, could go like E take way D plus F and then have it divided by 2 and that would be the whole formula. That's how they would word it. From the start. But they won't know why it works. But they would know it does. This shows why it works. That's, that's all I can say. But yeah, yours is pretty good.
104	John:	OK. So it just works. This is why it works.
105	Bill:	Yeah.

Bill and John have different emotional orientations, which can be analysed in more detail by considering the somatic markers revealed by the decisions they make when involved in mathematical activity. In lines 96 to 105 there is a clear difference in Bill and John's acceptance of the formulae they have developed, and they make some aspects of their criteria for their preferences explicit.

For Bill it is important to understand not only that there is a division by 2, but also why there is a division by 2, something he believes his version of the formula makes clear (lines 101, 103). For Bill, John's formula is not an adequate explanation of how to solve the problem, because it does not explain the division by 2 ("But they won't know why it works," line 103). This suggests that Bill's emotional orientation in this context includes a (non-conscious) expectation that each element in a process (or in a process encapsulated as a formula) should be connected to the process in such a way that the necessity for it is clear. We see this part of Bill's emotional orientation as a somatic marker, as it is non-conscious, immediate, and guides decision-making. In fact, we see emotional orientations as constellations of somatic markers.

John's decision to reformulate Bill's formula and to prefer his version to Bill's, seems to be based on a positive somatic marker for formulae that are "easier to work with" (line 98). That his formula does not make the necessity of dividing by two clear is not an issue for him, as he does not have a somatic marker like Bill's. He knows, from Bill's explanations and from David's authority, that "We know that's divided by 2" (line 100), and this matters to him enough for him to mention it. This suggests that Bill's positive somatic marker for verification by authorities is also a part of John's emotional orientation. Both require a stamp of approval as a criterion for the acceptance of an explanation/formula but Bill also has another somatic marker that translates into a criterion requiring that the formula itself clarifies the necessity of the division by two, while John has a somatic marker that translates into a criterion requiring that the formula be easy to use. What they decide to do in problem solving is based on these somatic markers. Each decision they make involves the balancing of

somatic markers, but the decisions made can be seen as being based on a set of implicit criteria for the acceptance of an explanation. In other words, their emotional orientations are formed of a constellation of related somatic markers.

The process of learning mathematics includes not only learning a set of facts, procedures and concepts, but also, and perhaps more importantly, learning to accept the explanations mathematicians accept for mathematical phenomena and to reject explanations mathematicians would reject. In other words, acquiring the constellation of somatic markers that constitute the mathematical emotional orientation. Similarly, learning to be a mathematics teacher involves acquiring the constellation of somatic markers that constitute the mathematics teacherly emotional orientation.

5. Conclusion

Damasio examines not only outer behaviours but also the neurological structures of some distinctly abnormal individuals. Finding connections between our observations and his provides confirmation that our interpretations are plausible stories to tell about how people think and act. In our observations and experiences we have seen that, for teachers in classrooms and for people engaged in mathematical reasoning, most decisions are not conscious. To become aware of the many decisions necessary in teaching and reasoning while engaged in those activities would disrupt them, and so some means of decision-making that occurs below the level of awareness is needed.

In this paper, we have illustrated how we use Damasio's somatic marker hypothesis in our research into teachers' and students' decision-making in mathematics classrooms. We have shown how identifying decision-points allows us to detect what is inherently unobservable. We have also given examples of how the somatic marker hypothesis can be used to enrich the concepts of purpose and emotional orientation that we have used in our research, and that we consider to be important to the development of teachers and mathematical reasoning. We have attempted to clarify the ways in which emotion is an essential part of cognition, specifically that somatic markers provide the emotional basis for non-conscious decision-making, decision-making that must take place prior to action and conscious reflection.

As Maturana (1987) reminds us "everything said is said by an observer" and so it should be clear that the comments made by the authors of this special issue are themselves data for the reader to examine the emotional orientations underlying our decisions to use different explanatory constructs to

describe the interplay of emotioning and reasoning in mathematical activity. As with Frank, we have the possibility, having written an analysis from our own perspective and having available analyses from other perspectives, to reflect on our own emotional processes, bringing the possibility of changing our behaviours.

Some questions arise out of this approach:

Would discussing our research method of detecting somatic markers as part of our teaching of our student teachers and/or mathematics students, be useful to the student teachers/mathematics students in their learning? How does the development of new somatic markers contribute to a transition away from simple dichotomous 'right/wrong' decision-making towards more relational complex decision-making?

NOTE

1. In transcripts, the following conventions are used: Ellipses [. . .] indicate short omissions, long dashes (—) indicate pauses in the speech, hyphens at the ends of words or lines (-) indicate interruptions, double parentheses enclose words that are unclear on the recording. Overlapping speech is not indicated.

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