SOMATIC MARKERS: TEACHERS' DECISION-MAKING AND STUDENTS' EMOTIONING IN MATHEMATICS CLASSROOMS

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Teachers and students of mathematics continually act in complex situations, often without time for reflection. Damasio (1996) develops what he calls his 'somatic marker hypothesis' to account for how people manage to accomplish this. By 'somatic marker' Damasio means a bodily predisposition that informs our decision making. Here we describe how we have used the idea of somatic markers in our previous work on teachers' complex decision-making (Brown and Coles, 2000) and students' explaining in mathematics classrooms (Reid, 1999, 2002) and share our current thinking in relation to how we are working to locate somatic markers.

The seminar is about to start. People enter the room and sit down. The leader invites individuals to try to reconstruct how they made their decision about where to sit in the room. Some people reported having a physical predisposition to sitting, say, at the back of the room in order, with their long sight, to be able to see any overhead tranparencies clearly. Some people reported an awareness of their own need for personal space. One person, who had been told both that he was going to be chair and who also knew that someone else had already spoken to Laurinda as if they were going to chair the session, said that he sat so that he could see the whole room, facing the other possible chair, so they could sort out the confusion. That other person immediately commented with words to the effect of "That's strange; you were already sitting there when I came in." Feedback from others in the group led us to wonder about the role of memory in such reconstructions of events. John Mason reported that there had been no inner speech for him in the process of deciding where to sit, and this led him to distrust some of the other reports.

In everyday life we make identifications without employing any conscious thinking process. For example, in walking down a city street we identify some people as potentially threatening, and others as potentially needing our help, while ignoring the majority of the people we pass. We do this spontaneously and unconsciously, making decisions to change our own behaviour without even being aware that we are making decisions at all. Damasio (1996) discusses the neurological basis for this process and uses the term 'somatic marker' for the juxtaposition of image, emotion and bodily feeling we have that inform 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 (p. 173).

In their work on teachers' complex decision-making, Brown and Coles (2000) state:

> 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).

As we go through life we associate some of our behaviours with 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 structures 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 though 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).

We believe that Damasio's notion of 'somatic markers' might help us to describe the development of teachers and students engaged in mathematical activity in classrooms. For example, David is interested in the process that occurs when an utterance in a mathematics class is perceived as being an explanation (see Reid, 1999, 2002; Drodge and Reid, 2001). The mathematics class is a species of community, one in which certain implicit, unconscious, embodied criteria are applied to utterances to decide whether they qualify as explanations. Agreement in a group of people about what utterances are explanatory defines what Maturana (1988) calls a 'domain of explanation' . Maturana also uses the phrase 'emotional orientation' to describe the shared implicit criteria for accepting explanations that define a domain of explanation. One feature of the activity of professional mathematicians is the offering and acceptance of explanations of a certain type, and so mathematics is an example of a domain of explanation, with an attendant mathematical emotional orientation. A mathematics class is a different but related domain of explanation, within which the emotional orientation of each individual is shaped by the experience of collective mathematical activity.

As another example, we invited participants in the session to read the following notes from a lesson observation, to try to identify points where they felt that the teacher (Alf Coles) made a decision without conscious reflection. Could the participants identify ('see') the somatic marker(s) and how they might be changing in the set of circumstances described? We invite the reader to engage in the same task before reading on from the end of the observation notes.

The time is mid-October. The class is a mixed ability Year 7 (ages 11-12 years old). Observation notes are taken by Laurinda who writes everything the teacher says (indicated by -) and as much of what the students say (indicated by ~) as is possible.

Three dots during speech indicate a pause. Three dots in brackets indicate some dialogue has been left out due to considerations of space or to clarify.

1 - I'd like someone to come up and draw another pentomino (black in Fig. 1a) that is touching it in some way. What we're trying to do is cover the board with no gaps and no overlaps.

2 - Comments first.

3 ~There's a gap.

4 ~You're not supposed to have any gaps.

5 ~ There's a hole in the middle.

6 - Is there any way we could fill that gap?

7 - Could someone else come and draw one touching? (Alice draws Fig. 1b.)

8 - Alice has performed an action that forms a pattern. Can you carry on that pattern? (A student draws Fig. 1c.)

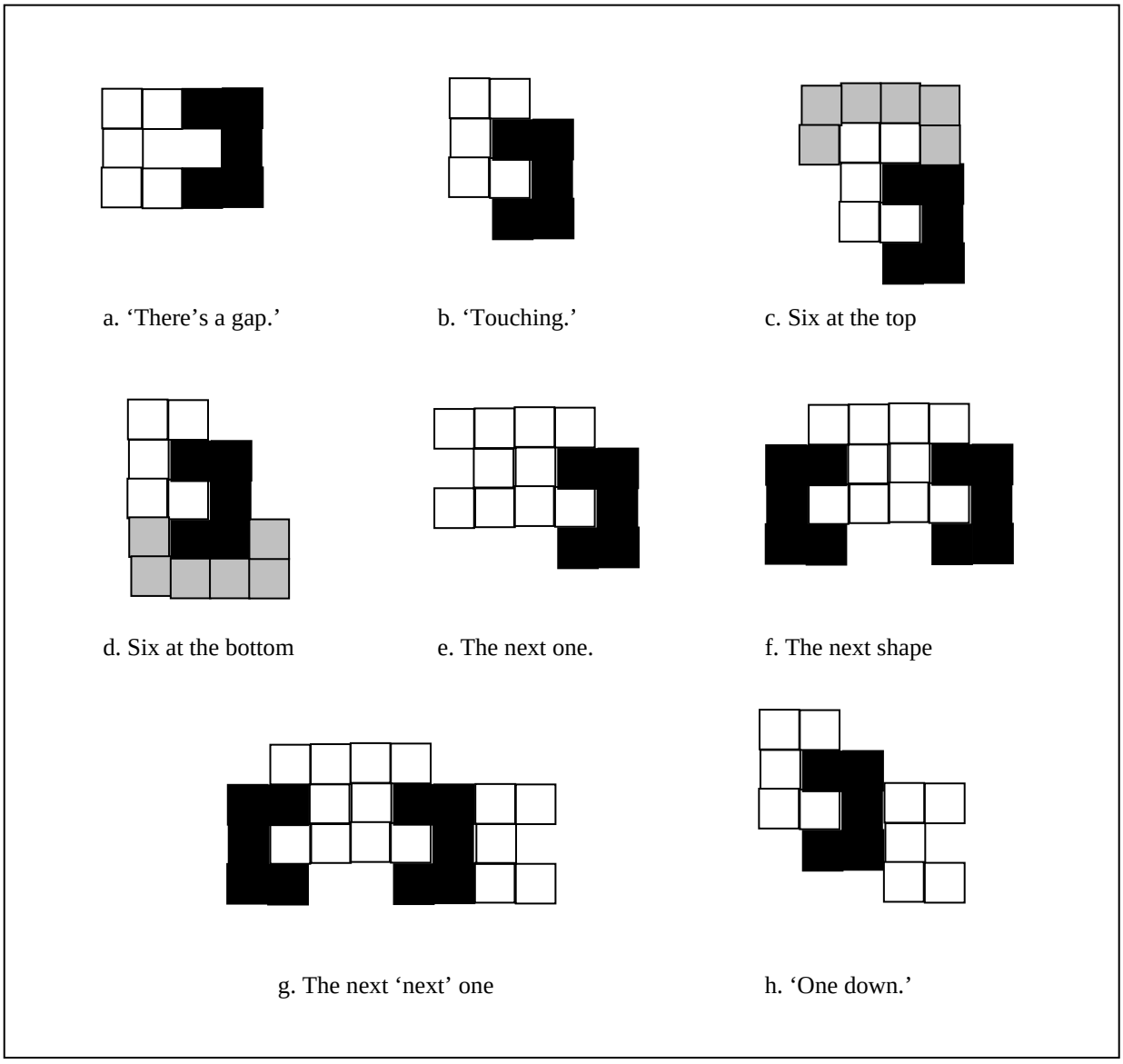

Figure 1: The sequence of pentomino images.

9 ~ There's too many.
10 - Try again. It's much harder when you come to the board. (A student draws Fig.1d.)
11 - What's the problem there again?
12 ~ It's the same but at the bottom.
13 - Could someone else come and say where the next one goes? Remember, no gaps, we're trying to do this in a pattern. (A student draws Fig. 1e.)
14 - Comments.
15 - Could someone … draw the next shape in this pattern? (A student draws Fig. 1f.)
16 - And the next one? (A student draws Fig. 1g.)
17 ~ I would have put that (last) one between the 2 'blue' ones…
18 - People seem to be placing shapes randomly … I'm going to rub all these off. (Back to Fig. 1b.).

(Some hesitation as the girl goes to place the new white C in Fig.1g.)

19 ~ I go down one each time.
20 - Why did you put that there?
21 ~ Because it's one down.
22 - Can anyone describe the action?
23 ~ Turning it round as we go down…
24 - Can someone come and draw that action again?
25 ~ Moving one space down and reflecting, like the posters.
26 - Excellent, one thing that mathematicians are doing all the time is trying to make connections between all the things they've done.
27 - Can someone come and perform the inverse action?

There was some discussion about every one of the teacher's comments being evidence of his decision-making. However, the event that most attracted the attention of the participants in the session was Alf's comment that the students seemed to him to be "placing shapes randomly" and his subsequent rubbing off of most of the shapes that had been drawn (contribution 18). This is clearly a decision point. Laurinda asked Alf, immediately after the lesson, what had stayed with him and he raised the fact that he was pleased that he had made the decision to rub off what had been done and return to the first pair of Cs: "I knew it was going random so we wouldn't be able to track back." ("do the inverse action", contribution 27). This gut feeling (not inner speech) informed the decision-making. His awareness was of "this isn't going to work if people think they're just putting shapes on (anywhere), it has to be much clearer than this". It was the actions that Alf was seeing as random not the pattern being created.

John Mason then offered that with this background he now thought he could see another decision point. Looking back we see Alf comment on the first addition of a pentomino: "Alice has performed an action that forms a pattern. Can you carry on that pattern?" (contribution 8). He was wanting the students' attentions to be on the

action this time, although in previous lessons using this activity he has worked with the language of pattern. So, the behaviour that is habitual and has accrued positive somatic markers is the 'use of pattern'. Alf's focus after contribution 8 and before contribution 18 is on 'pattern': "we're trying to do this in a pattern" (contribution 11), "Could someone come and draw the next shape in this pattern?" (contribution 13). So the decision is not only to interrupt the adding of pentominoes to the pattern, but also to shift the attention back to the action of adding rather than the pattern produced. One interpretation of this event is that by contribution 18 Alf is feeling the randomness as a visceral sense and by rubbing off everything on the board back to Fig. 1b he is able to find out what happens with a focus on action not pattern. This pleased him and so he is now in the process of acquiring a new somatic marker in relation to 'action'. Contributions 22, 24 and 27 indicate that this focus on the action continues. Here we would suggest that Alf is not developing a negative somatic marker that would lead him to avoid talking about patterns in the future, but is instead developing a positive somatic marker related to 'action' that will make it likely that he will focus on actions in similar contexts in the future.

Our current collaborative research looks at the ways in which somatic markers influence teachers' decision making and students' reasoning, and the degree to which those markers can be observed by us, by colleagues, and perhaps by the teachers and students involved. Because somatic markers are a part of unconscious mental activity they cannot be observed by introspective reflection. In fact, the stories we tell after the fact about our decision making are likely to include inventions to account for the influence of somatic markers of which we are not aware. How then can we research something we cannot observe? The process described above, of examining decision points in a person's actions, seems to hold promise. We can observe changes in behaviour, indicative of unconscious decision making, and consider what markers based on past experience might account for those decisions. The BRSLM session suggests that colleagues see similar events as suggesting the sort of unconscious decision making accounted for by Damasio's hypothesis of somatic markers. This leaves us optimistic that it will be possible in our work to observe the effects of somatic markers in a range of contexts, to distinguish positive and negative somatic markers, and to suggest ways in which they form and evolve in mathematics classrooms.

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