Applying Bohm's ideas in the age of intelligent environments

Harold Thimbleby
Swansea University, Wales
h.thimbleby@swansea.ac.uk

ABSTRACT

This paper introduces and explores design principles intended to support engaging and effective intelligent interactive environments. The paper highlights and explores the relevance of David Bohm's dialogue concepts to the design of intelligent environments, in particular, exploring the role of supporting 'cognitive proprioception.' We discuss a successful user interface, and attribute its success to its support of Bohmian concepts. The paper suggests various developments that might help extend the reach of technologies like synthetic worlds, wikis and blogs, particularly if combined with implants and other sensors in intelligent environments involving humans and intended for supporting serious thinking.

Categories and Subject Descriptors

H.1.2 User/machine systems. K.4 Computers and Society.

General Terms

Design, Human Factors.

Keywords

Dialogue, problem solving, proprioception, thinking.

1. INTRODUCTION

Intelligent environments may be defined as environments that seamlessly incorporate thoughtful and insightful uses of computer technology to improve and enrich everyday life. In this paper, we are specifically concerned with supporting human thinking — arguably, good thinking underpins all aspects of the quality of everyday life, particularly the ability of individuals to enrich their own lives.

Of course, computer technology already enriches lives on a considerable scale. There are many pervasive and ubiquitous approaches, many well known, and some still restricted to small communities. Of course, there are many social and psychological approaches to enrichment, too, such as distributed cognition and human-computer interaction. In this paper, however, we are interested in stimulating new design perspectives.

Our approach to the question of how to make intelligent environments better is based in a real question. We've built a system that supports 'thoughtful and insightful use' and which is surprisingly fun and successful. We want to work out why (we're still not sure) and we want to see how the reasons can be generalized to intelligent environments on a wider scale. The reasons we think are key, that is unique to the system rather than merely extending what has been done before, lie in a borderland between philosophy and psychology, which has not been explored much with regard to its potential in intelligent applications.

Specifically, Will Thimbleby built a very successful interactive system that significantly exceeded our expectations in terms of user engagement and enjoyment [22] (it is discussed more below). Its apparent success poses a number of open research questions; in attempting to understand why it was so successful, we were led into some unconventional areas of work in human thinking, including work initiated by David Bohm.

The gist of the present paper is that if Bohm's concepts can be taken to explain or even only partly explain the system's success, then using Bohm's ideas as principles for the design of intelligent environments more generally should be creative and generative.

2. The role of thinking

One can argue that all problems can be solved by clear thinking, or, at least, if the problems are not able to be solved in principle, that they can be shown to be insoluble or incoherent and then efforts more appropriately redirected [5]. Discovering whether a problem is incoherent is itself an act of clear thinking. 'Clear thinking' is central, then, whether the problems are of global proportion, such as the energy crisis, or whether the problems are on a local or personal scale, such as managing debt or controlling over-complex central heating timer controls in our homes — and managing heating efficiently will itself make a contribution to solving the global energy crisis!

Humanity faces some very pressing problems, such as terrorism, that we all agree need solving. Even the terrorists themselves would argue the causes of their discontent need solving. We will be able to solve such problems (often conflict resolution) only by building on clear thinking, or *perhaps* by being lucky — but, even if lucky, we still need the clear thinking to recognise and retain any lucky solution. Although it is ambitious to express it in such terms, *any* contribution to such big issues should be taken seriously.

Unfortunately, humans are not very good at thinking, especially in groups concerned about concrete problems or ones that have emotional or political content. When problems affect nations, communities or family units, it is evident that humans are frequently very poor at thinking constructively together. Think of debates at the UN: intelligent people discussing important issues, but unconstructively arguing and disagreeing with each other! We are often adversarial and have hidden agendas. We get cross, negative and emotional remarkably easily, ironically, most especially when trying to solve important problems.

In some areas, though, we are remarkably good at doing things together. Consider modern cities: they are very complex, yet houses have reliable water, gas, electricity, waste collection and access to transport systems. Some functions are organised centrally, some locally. Cities support a wide range of human activities, and in fact are amazing that they work at all — they seem robust and can cope gracefully with partial breakdown, such as power failure. Or consider the Olympic Games, which, in its modern form, has run since 1896 and constructively brings people together from everywhere in the world to perform in a shared space. In sport, we can swim together, dance together, or run together in competition. Or consider large computer programs, such as operating systems or office applications. Although we often groan at their bugs, they are the product of thousands of programmers working together from across the world — using version management software, compilers and so on. Such programs represent the most complex tightly-integrated systems ever constructed. Like cities, they work surprisingly well, especially given the unforgiving nature of computer hardware! These three very different examples show that humans can do some things very constructively together.

In contrast to these physical successes, group thinking seems very fragile. Its very fragility seems to exacerbate participants' unwillingness to listen; criticism tends to be unconstructive in terms of advancing towards a common solution.

Perhaps we might use computers to make thinking somehow harness the powerful cooperation drivers these examples exhibit, but which typical group thinking lacks. Can we use intelligent environments to expand the range of what we can do successfully together? For example, if there was a physically concrete representation of dialogue, it might appear to participants as more 'city-like' (to use the phrase very loosely) and then be more robust under criticism, and easier in some sense to progress without impasse. If we can expand 'intelligent environments' to support thinking, this would have a significant impact on solving many important problems. Hints that something may be possible are evident in synthetic worlds [7], where people build virtual cities by purely conceptual actions.

This, then, is an ambitious and open-ended 'Grand Challenge.' Success in this Grand Challenge will not come easily, and therefore we can only begin to sketch out ideas, to see which are productive and which dead ends. This paper's structure is threefold. (*i*) We flag the relevance of David Bohm's ideas to this challenge; (*ii*) We present an example of a surprisingly successful and engaging interactive system, whose success can be explained, at least in part, by Bohm's ideas; and (*iii*) We discuss technological developments that might plausibly build on these insights. In short, this paper explores what issues, benefits and ideas there are that might arise by revising or redirecting Bohm's ideas into the modern intelligent environments mileau.

There is a considerable literature on groupware and computer supported cooperative work (CSCW) [10]. There are numerous tools for supporting thinking, such as outliners, presentation tools, mind mapping, and so on — which particularly facilitate individual thinking and shared expression; many tools are available to help manage the group dynamics of meetings (including teleconferencing). Most of these tools are based on conventional lean-forward computing (e.g., desktop computers). Rather than review this diverse and interesting field, here we want to stand back and try to identify new principles of design, which might of course be reified in lean-forward environments, but which we hope could be used for creative and novel design in intelligent environments — for example, immersive or implanted. There is little empirical research behind the discussion here (except in the success of one user interface, discussed in Section 6): it is possible that our philosophising rather than being a successful end in itself is instead a provocation to some readers to find better principles.

3. David Bohm and Bohm dialogue

David Bohm was an American theoretical physicist, who died in 1992. He was working on his PhD research during World War II, at a time when the atomic bomb was being developed. Ironically security clearance was denied because of his 'alternative' social interests, and Bohm was even denied access to his own research work; indeed, he was not allowed to write his thesis nor to defend it! Nevertheless he had a successful career, finally at Birkbeck College, London University. From 1983 he developed a technique, now called *Bohm dialogue*, which encourages participants to engage in structured free-flowing dialogue to explore their thinking. Bohm dialogue relies on the participants of the dialogue learning and following certain simple conventions, some of which we mention below.

Bohm's classic book *On dialogue* summarises much of his thinking from this period of his work [5]. Striking in his approach are that, first, it is based on a deep view of thinking as a system, including an analogy with proprioception as he conceives it, and, second, that his ideas and implementation of dialogue predates any significant use of computers to support collective dialogue. Bohm's ideas have recently been taken up and used successfully by Isaacs [11], amongst others.

4. Basic ideas of Bohm dialogue

Bohm argues that in physical activities we are very clear over the distinction between what we do and what others do to us. For example, if I move my arm voluntarily, I am aware I am moving it; if you move my arm (say to make space to get past me), I know I did not move it even though it moved; and if we shake hands, we are both aware of how we combine moving and being moved by the other. Our sense of the relative position of our body and its parts is *proprioception*.

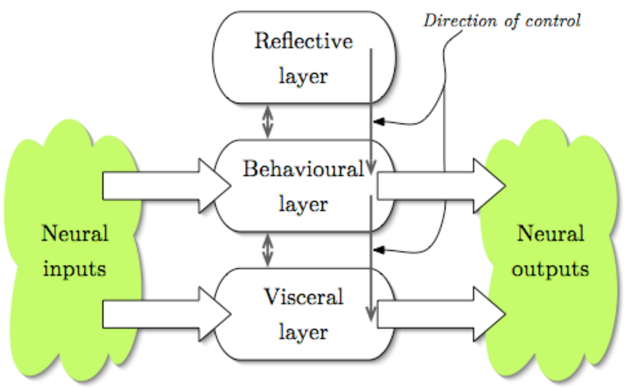
Proprioception is the sense that allows us, for example, to touch our fingers together behind our head — although we cannot see our fingers in this position, we sense where they are and can move them accurately together.

Bohm argues that we are aware of the five classic senses — sight, hearing, taste, touch, smell — but we ignore proprioception because it is so fundamental. We can imagine not seeing, not hearing or not tasting something; we are aware of ordinary senses and our need of them. We never experience the absence of proprioception, so its presence is easily ignored. We know what our bodies are doing, so we do not think we need a sense to know, but of course (if we thought about it!) we only know because we have a sense to that effect. We also ignore the importance of feedback for controlling our movement.

A few people have suffered impaired proprioception. Ian Waterman had a neurological illness at age 19 that destroyed his proprioception. Although he has now taught himself to walk, in the dark, that is when he cannot see his movements, he is unable to stand. In the absence of sensory feedback, his movements were not only uncoordinated, but at worst he had no sense that they were even *his* movements. His remarkable story is recounted in [8], and other cases are reviewed in [17].

Bohm argues that proprioception is essential in our ability to cooperate in physical group activities, such as playing physical games. Next, he argues that there is no analogue to proprioception for cognition. That is, thinking has no internal feedback loop. This, he argues is the reason for the contrast outlined earlier: that humans are successful in cooperative physical enterprise (such as building cities) and bad in cooperative thinking enterprises (such as decision making in the UN).

Norman's book *Emotional design* [14] emphasises the three layers of processing: visceral, behavioural and cognitive. His now-familiar diagram (reproduced below) omits any feedback mechanism, from motor to perception, but even if it did represent proprioception (or external feedback, such as using eyes to provide feedback from body position), note that the reflective layer is isolated from such feedback loops. One should note that Norman was using this diagram to introduce and illustrate the relationships of the three layers, not to provide a complete description including all feedback loops. For our purposes, however, it helps make the point that reflection has poor, if any, ability to reflect on itself; exactly Bohm's point of departure.



The important information, including feedback and self-other distinctions, that proprioception brings automatically to physical activity has to be obtained by conscious effort for thinking. Paradoxically by thinking about thinking, to provide a cognitive substitute for proprioception, we are no longer thinking about what we were thinking about. Bohm puts it concisely in his own words, "Thought doesn't know this. Thought is thinking it isn't doing anything … we have got to see that thought is part of this reality and that we are not merely *thinking about it*, but that we are *thinking it*."

Worse, thought *appears* to be real. Our five senses 'obviously' represent the world for us, which is out there; but our thought is not perceived as contingently derived or inferred from prior evidence or knowledge.

Suppose somebody says something to you that you think is wrong. It is very hard to distinguish between your judgment that they are wrong, which is a contingent inference from things they have said along with other facts (partly known to you), with the objective facts of the matter. If your emotions colour your judgment, or for any other reason you are making an error, this logical error is not obvious in your assessment of their wrongness. It is easier to think, "You *are* wrong," when one should more accurately think, "I currently think what you say is wrong, and I may be wrong in thinking that." In other words, routinely in thinking, we do not distinguish between others' actions and our cognitive reactions; they both seem to be equally factual and objective. In contrast, with physical action, thanks to proprioception, we need no make effort to make a clear distinction. (Sometimes we may daydream and construct an obviously interior world, but this has little connection with the exterior world except in delusional states.)

Here are two quotes from Bohm himself:

- "What makes this situation so serious is that thought generally conceals this problem from our immediate awareness and succeeds in generating a sense that the way each of us interprets the world is the only sensible way in which it can be interpreted. What is needed is a means by which we can slow down the process of thought in order to be able to observe it while it is actually occurring." [6]
- "… dialogue is really aimed at going into the whole thought process and changing the way the thought process occurs collectively. We haven't really paid much attention to thought as a process. We have ENGAGED in thoughts, but we have only paid attention to the content, not to the process. Why does thought require attention? Every thinking requires attention, really. If we ran machines without paying attention to them, they would break down. Our thought, too, is a process, and it requires attention, otherwise it's going to go wrong." [5]

Bohm's ideas simultaneously extend considerably beyond what we wish to cover in this brief paper (e.g., his thinking on the relation of quantum reality and mind-body issues, to say nothing of his wider quasi-mystical views), as well as not extending far enough (e.g., there is considerable room for doubt over his psychological science). Nevertheless, we can usefully take his ideas as coherent and provocative for stimulating further research into uncharted areas, while suspending judgment on their rigor. Additionally, there is much evidence that his practical techniques, that is, his facilitating sessions of group dialogue, were effective and popular with participants.

5. Supporting proprioception

Bohm suggests *suspension* as a deliberate method to hold normal thinking in abeyance to reflect on one's relationship to the thinking. Suspension implies inhibiting the impulse to categorise, react, classify thought, and hence to become aware of the physiological responses and cognitive reactions to the situation. Without suspension, we can make rapid but inappropriate judgments. While Bohm's writing predates email, the examples he gives sound like flaming. Somebody sends you an email, you reply, and they become livid; the recipient of your email reads into it negative emotional content that probably was not intended; if they reply, the email exchange can rapidly deteriorate into 'flame wars.'

Experienced email users know two things. First, never to reply instantly to an email (that is, to suspend action); secondly, on receiving what appears to be a flame to either ignore it or to delay responding. The worst one can do with a flame is to copy it indignantly to many other people — for amongst those others, probably some will respond without suspension, and further escalate the flame wars.

Email has developed various techniques, such as the use of emoticons (which clarify the relation of what is said to the emotional content), to increase emotional reflection — and they serve to help both the writer and the recipient: the writer may reconsider expressing a thought that needs a :-), and perhaps not send it, and a recipient laughs at any odd comment containing :-) or perhaps ignores it. Thus, :-) and other emoticons cause the writer to delay to put into physical action an otherwise unexpressed emotion. This is suspension, at least for the range of concepts covered by the user's emoticon vocabulary. Some email clients can identify potential flames automatically, highlighting dubious phrases and this may make the author of an email pause and rewrite their email.

An emoticon to express rage would be useful. For example, if -! meant 'extreme negative judgment,' and you knew it, if you ever found yourself writing it, you would probably pause and rephrase what you were writing.

We consider this simple example as a hint that computers can be used to enhance cognitive proprioception, or more generally to act as substitute or automatic support for the conventions that Bohm proposed to support in dialogue.

Bohm himself gave no indication that his conventions were complete, and clearly automating (what might be called) a Bohm-convention may not be as effective as inventing new concepts that lend themselves better to such support. In short, we want to be exploratory and effective, not slavish developers of Bohm dialogue.

Of course, Bohm can be presented or critiqued relative to many bigger pictures. Thus [as an anonymous referee kindly pointed out], the French phenomenologist Merleau-Ponty argued the primacy of perception [ponty]; indeed, his conception of what he called *radical reflection* seems to be an attempt to put in different words issues of perception concepts and concerns of which Bohm would approve. Arguably, Merleau-Ponty was concerned with personal issues of perception (as embedded in an individual's personal body, including its relation to others) whereas Bohm was concerned with dialogue (that is of several bodies in communication). Overall the difference is that Bohm had a practically-motivated rather than philosophical working out of the same sorts of issues. Our purpose in this paper, however, is not to enter philosophy, but to try to make practical progress, and in particular to relate Bohm's ideas, insofar as they are profitable, to computationally-motivated opportunities.

6. A novel calculator

Bohm's ideas support the commonplace observation that physical activity can transform a boring mental task into something engaging. In the context of computing, we could give examples from *Computer science unplugged* [3], which translates abstract computing concepts into physical games — and very successfully — but we think a more persuasive example for our purposes is as follows…

There is perhaps no more boring and familiar examples of interactive system than the ubiquitous handheld calculator. It is a tool for routine work. Apart from discovering 710 can be read upside down, there is hardly any fun or direct engagement with calculators. Calculators have hidden state, and they behave in a very indirect way: a user presses buttons, which construct Arabic numerals and mathematical expressions, and then they press = to get a numerical answer.

Problems with the technical aspects of calculator user interface design have been discussed at length elsewhere [19]. What concerns us here is that people do not particularly like them nor the subject domain.

Will Thimbleby has developed a new calculator, based on gesture recognition [22]. He found in evaluation that users made fewer errors with his design than with conventional (and familiar) calculators. He further found that users *liked* his design. Users would play and grin, laugh and try 'fooling' the calculator or try very sophisticated sums. He found that this engagement with the calculator was robust: it happened with young people, teenagers, adults, old people, whether non-mathematicians or graduate mathematicians. In a questionnaire-based evaluation of nearly 500 subjects at a public exhibition, he found 90% of users "loved it." The engagement is reminiscent of Csikszentmihalyi's *flow* [9] — the design features combine to create a self-controlled, goal-related, meaningful interface; because the design uses proprioception, it achieves a balance between sense of involvement, the act of work, and mathematical achievement.

Although we do not *know*, we attribute this surprising level of user engagement with the new calculator to the interplay of several inter-related factors:

1. The greater physical reality of interaction with it. Instead of pressing buttons, the user uses gestures and handwriting. The **affordance** of the calculator is much better, but affordance fails to explain either the greater levels of enjoyment, or the engagement to play with and to explore mathematics — which happens both for young users (who get insights into, say, fractions) and even for post-doctoral users, who have got new insights into complex arithmetic.

2. The interface is **incremental**. A conventional calculator appears to do nothing much until = is pressed, and then its result appears instantly with no connection with the user's input. Incrementality is a property of direct manipulation interfaces [18], but need not be restricted to direct manipulation. The user gains a sense of progress in solving their problem, and a stable trajectory towards their goal — they get immediate feedback whether they are closing in on their intended path towards their solution.

3. Conventional calculators make arbitrary changes to their displays that have no clear relationship to the user's actions. In contrast, the new calculator morphs (graphically transforms) equations, whether from handwriting or from drag-and-drop operations. This gives a satisfying sense (and an unusual sense for computer systems) for the user of stably converging on goals , which gives the user a **tangible sense of progress**. It does this at the 'expense' of a delay (an earlier version of the calculator that did not morph was jerky and obscure in operation). This is different from incrementality; few conventional pushbutton user interfaces can achieve any **sense of stability** — it is similar to the incrementality property of direct manipulation.

4. The new calculator is **equal opportunity** [16]: it makes no intrinsic distinction between the user's input and the calculator's output. Equal opportunity ensures that the user's input is immediately embedded in results.

5. Handheld calculators are very modey, state-dependent, that is, imperative in their operation — and much of the state is invisible to the user [19], which makes controlling them very hard and error-prone. The new calculator is **declarative**. There is **no hidden state** whatsoever. Furthermore, the domain of the calculator, mathematics (specifically, complex arithmetic with equality), is itself declarative, so being declarative ensures a much **closer task-fit** than a conventional calculator could achieve.

6. Handheld calculators require users to work out how to express their problems in terms of a sequence of commands the calculators accept — this is a process similar to compiling a programming language into assembler instructions for a computer, and it is a non-trivial exercise when done in the head (as it has to be with conventional user interfaces) — even exasperating. Instead, the new

calculator is **goal driven** in that the user expresses their problem and allows the calculator to work out how to solve it. **No compiling into individual steps is necessary**. This gives the calculator an advantage normally claimed for logic programming over conventional imperative programming.

7. The new design **exploits proprioception**. Conventional calculators obviously require a degree of hand-eye coordination for a user to press buttons successfully, but there is no dynamic interaction with the device. In contrast, the new design uses gestures. Especially on large interactive screens (e.g., 2m diagonal), the sense of engagement, from large upper body movements, is considerable.

8. The new design uses **handwriting and gestures** using a pen (or equivalent); future developments could use motion sensors on the device to extend its functionality considerably without interfering with the current interaction design. To do so might make its use even more engaging, though Sassoon is clear that handwriting is central to emotional expression [25]. The new calculator is natural. The user does not need to learn any new notation, nor the meanings of buttons (and their state-dependent interactions), commands, or new language. It works in their conventional pre-computer style, as if they were using (greatly enhanced!) paper.

Together these properties make the new calculator very impressive, and, arguably, an exemplar of a new interaction paradigm. Some of these principles were present in earlier versions of the calculator that were not so successful. It is plausible to argue (though we will devote no more space in this paper to doing so) that support of proprioception is essential, though perhaps in combination with some or all of the other properties (particularly reality, naturalness and stable trajectory). *All but point 7 is routine or almost-routine; we believe point 7 — that is, relating to proprioception — is unique or otherwise 'key' to the success of the calculator. Proprioception is independent of the other factors (which are essentially well known design principles); proprioception is also a new and little-explored factor for design.*

It is impossible to capture the way the user interface works using a static medium like paper; a detailed explanation of the new design would no more convey the fun of using it than would a detailed explanation of how to surf or ride a horse convey the fun of those activities (in fact, a detailed explanation of riding would make you think driving a car was preferable). The calculator (and some movies of it in use) are, however, downloadable [23]. (It is tempting to include a story board of it in this paper, but this could be misleading: its interactivity and its engagement of proprioception are not easily represented in a static medium like paper.)

Unlike *Computer science unplugged* [3], this example becomes engaging not by playing conventional games (albeit representing abstract computation) but by interacting with a computer, that is by changing the normal representation into one that is more physical, but still computer supported. The experience of users is that they then play with mathematical thinking in ways most have not previously done because of the normal drudgery.

7. Transforming thinking

Computers are already completely transforming the way we work and think about everything — there is no end to the possibilities on offer. The world wide web was unheard of in 1993, and few but experts knew about email and flames then, but now email and the web affect almost every activity in modern life.

Recently there has been an explosion of games toys (e.g., Hasbro's *Bop It*), which in a computer sense are utterly trivial, but socially are a huge success (with enormous sales). What will happen when these games, or the ideas behind them, move into the mainstream away from entertainment into general life? Like the novel calculator, they are showing how interactive devices can make activities more engaging — though in *Bop It's* case, unlike the calculator, the activities were trivial to start with!

Perhaps there are ways to use computers to help us think better together, and hence enable us to work together to solve some of the pressing problems humanity faces? Substituting for proprioception is of course not all that needs doing or could be done.

Technologies like blogs, wikis, instant messaging, virals, RSS (Really Simple Syndication, a technique for publishing updates), podcasting … are completely new uses of computers. Some people already have implants [24], and these will soon be integrated in novel ways with both computer systems and with other people. Possibly implants will provide new forms of feedback; indeed implants have been used both in both sensor and brain contexts.

Wikis show that certain sorts of thinking can be supported well [12]. Wikis are collaborative documents that many people can contribute to. The largest wiki is Wikipedia, an encyclopaedia with around 900,000 articles in English, and thousands of articles in both common and obscure languages (e.g., Ido, Shqip) — evidence that it is reaching into many communities of thought. Wikis are surprisingly successful; although the web is the largest single thing ever made by humans, wikis are the largest coherent and collaborative things ever made. When somebody makes a mistake (or puts up something misleading) these errors are rapidly corrected. Very little moderation is required (though wikis do not work well for all topics). One wonders whether the ideas of wikis could be generalised to help make organisations like the UN work better when writing large documents, or for governments creating legislation, or even communities participating in referenda which they create themselves?

The web to a great extent ignores location and neighbourhood; indeed, anonymity is one of its advantages (or problems for secure ecommerce). However, reliable identity enhances cooperation [2]; and of course, identity has further applications that in themselves make cooperation more appealing. We could use variations of search engines to find problems we want to solve and communities of people who want to solve them. Many problems that affect people are geographically local. It would not be difficult to use metadata to find people who are in the same region who already share the problems. By learning how to help people solve problems they really want to solve, typically ones affecting their real neighbourhood, we will learn how to help people solve problems that are harder and which, often, don't start with any sort of identifiable consensus. In other words, the right sort of identity and permanence of identity, and location is part of this, will encourage a constructive approach to cooperation.

Why are computer technologies so successful and popular in the first place? Why did the web take off so quickly, whereas some of the popular predictions of the future, involving things like monorails and space travel, still seem as remote as ever? What's the difference? Arguably, the difference is that the web lets us tell and listen to stories; to communicate narrative with each other. We have been telling each other stories for thousands of years, and we like it. (Before the web, printing was probably the fastest-ever spreading invention, for precisely the same reason.) Interestingly, technologies like wikis work well when the goal is to define facts (as in an encyclopaedia), but they do not work so well for creating stories — where people can be opinionated. Synthetic worlds work very well because they are stories people can literally get into, and become players within [7]. (We have used the *analogy* of the web — which is a conventional lean-forwards experience; there is no reason why web-like ideas cannot be immersive, a result of an intelligent environment bigger than the conventional desktop screen and browser.) Synthetic worlds are currently entirely virtual, but intelligent environments could reify features of these worlds in the real world and hence combine the attraction of the story with real interaction with the physical world.

Can intelligent environments help distinguish between different sorts of thinking? The stories example and experience of wikis suggests that imaginative and factual thinking are very different, and moreover that the difference has an important impact on the success of using computer tools to achieve certain goals. Our current technologies, such as email and the web, make no distinctions between different sorts of thinking. Normally we think differently, but never notice changes in style (for the reasons Bohm explored).

Current systems are remarkably poor at configuration to personal style; a dilemma for organisations (whether commercial or thinking organisations) is that 'good ideas' imposed from the top, particularly ones imposed in computer technology, impose an unrealistic uniformity on the community of users. There is little point in adopting an intelligent environment if it alienates the very thinkers it is supposed to support. An important area to develop, then, is personalisation of intelligent environments.

In a group, one of us may be thinking imaginatively, one judgmentally, one about today, one about 'sometime.' We may be thinking differently ourselves, never reflecting on our changes of style. Can we then focus our thinking, either in tools appropriate and perfected for particular styles of thinking, or can we better separate out our modes of thinking. Certainly, if we can think at the meta-level of which style of thinking we choose, we will be more likely to understand each other. Surely we can invent bigger ideas than emoticons? Much, and varied, work has been done in this area, e.g., [1,13,20,21], including a taxonomy by Benford *et al*. [4].

8. Conclusions

This paper has connected the unexpected success of a novel user interface with Bohmian ideas of suspension and proprioception. It has argued, further, that these ideas could be applied profitably in the design of intelligent environments.

Intelligent environments will help us turn our thinking into a new sort of doing — and thus link to proprioception. Not only will the technology help because of its intrinsic power (as it does in managing a wiki, say) but it will also help by getting our thinking out of our interior worlds in our brains and into the real physical world. Bohm argues the absence of proprioception in thinking is problematic, but for physical activity, proprioception already works. Technology thus recruits the body's existing sensory-motor proprioception to support thinking.

The priority for humans is to find ways to use computers to help us think more clearly, and hence find solutions or ways around our besetting problems. There are some very positive signs, such as the success of wikis, but more generally the creativity and diversity of the technologies being created. Certainly some of these new ideas will transform the way we think, particularly how groups of people think together, and hence how we address — and agree to address — the world's besetting problems. Hopefully these technologies will be taken up by organisations; perhaps they will be taken up by individuals arguing their own causes, such as regenerating their local neighbourhoods. The world of the future can be a better place, and we can make it so provided we use computers to help us think clearly together.

Following Bohm, we argue that to solve problems, we need to find ways to suspend while we think. We need to find ways to suspend action while we think cooperatively. There is an opportunity, then, to exploit intelligent environments to find ways to suspend, delay, slow down, increase reflection during or in preparation for group thinking. This idea seems ironic, even counter-productive: technology usually speeds up things. But if we speed up *the right* things, we will have more time to reflect. These 'right things' may or may not be things we are already doing: intelligent environments can do new things, and merely studying how people work or think may limit our creativity in designing new systems.

If this challenge can be achieved with a level of engagement or flow that the novel calculator exhibits (Section 6), then people will *want* to think and solve problems together.

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