

Commentary

How to Assess Metacognition in Infants and Animals?

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Q1

Brinck and Liljenfors present an interesting argument backed by developmental data that metacognition emerges from intersubjectivity: Q2

We maintain that intersubjectivity plays two distinct, yet complementary developmental roles. Intersubjectivity constitutes the foundation of, on the one hand, the awareness of mind and cognition, and on the other, the awareness of cognition about cognition, or metacognition.

That intersubjectivity is an important factor for building an understanding of what goes in other people's and one's own mind strikes us as very plausible. Our concern is with how one could make this empirically testable. This is difficult for two reasons. It is not clear to us what precisely is meant by metacognition and it has become clear (Beran, Brandl, Perner, & Proust, 2012) that to show metacognition especially in non-verbal or pre-verbal creatures is extremely tricky. Q3

Like Proust (2007), the authors distance their use of metacognition from metarepresentation: 'We explain metacognition as a management of cognitive resources that does not necessitate algorithmic strategies or metarepresentation.' But unlike Proust, they do require metacognition to be recursive, referring to 'the awareness of cognition about cognition, or metacognition'. Nonetheless, in their weaker version of 'implicit metacognition', they follow Proust: 'we define *implicit metacognition* as the monitoring and control of hierarchical cognitive processes in activities that require purely causal strategies for reaching goals or completing tasks.'

Both definitions have their problems with empirical evidence. Following the definition of implicit metacognition leads to inflationary use and, what one could call, pan-metacognition, that is, the notion that just about every behaviour requires metacognition. Take, for instance, the refference model of action control in its more modern versions employing forward models (Wolpert, Ghahramani, & Jordan, 1995). In these theories, it is assumed that when a motor command is issued, for example, in order to move your hand towards an object, a forward model is used to predict where the hand should be at a certain time. A comparator process monitors the match between the predictions from the forward model and perceptual feedback to correct any errors. These processes can be hierarchically structured in terms of larger movements and their component movements

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(Jeannerod 1997). As far as we can tell, these control mechanisms would qualify as implicit metacognition. Carruthers (2008) illustrates this with a cat that gauges its ability to reach the other side of the abyss before it jumps. It looks to us that the cat is thinking: 'Will I make it or not?' If this is metacognition, then we ask why intersubjectivity would be so important for it to develop. And how could mountain goats be so adept at rock climbing more or less right after birth? In sum, if one wants metacognition defined in terms of monitoring and control, then one needs to make sure that it does not make all behaviour metacognitive. Such a definition we have not yet seen.

If we follow the standard, recursive definition of metacognition as 'cognition of cognition', we would in the spirit of cognitive science, agree with the authors and not just count thinking as cognition but any mental state with representational content, including desires, emotions, and so forth. As it stands, this definition includes cognitions about other people's cognitions (typically described as 'theory of mind') as well as one's own (metacognition in the narrow sense). There is an ongoing debate on how to show understanding of other people's mind in infants and young children who cannot yet describe their understanding in words, and one has to infer their mentalizing abilities from their behaviour. This problem is exacerbated for metacognition as we have recently tried to point out (Perner,):

If I want to predict whether you will come to our meeting I have to know whether you know that it takes place (a clearly recursive representation). So if I can make a correct prediction we have some basis for claiming that I must have a metarepresentation of your knowledge. Now we ... consider knowledge of one's own knowledge state (the central case of metacognition). If I need to predict whether I will go to the meeting I just have to know that it takes place. I do not need to know that I know it takes place. This would be superfluous. Hence, from my correct prediction of what I will do we cannot convincingly infer metacognition as a recursive concern about my own knowledge.

This problem affects much experimental evidence for metacognition based on non-linguistic behaviour, for example, the evidence that chimpanzees and 2-year-and-6-month old children look for more evidence before committing themselves to a choice. In Call and Carpenter's (2001; cited by the authors) study, children and chimps saw that one of several tubes was being baited. In one condition, they saw which tube it was, whereas in the other, they did not. They had the option to peek through the tubes to see where the bait was before committing themselves to one of them. Children and animals looked more often when they did not know the specific tube than when they did. This is taken as evidence for metacognition. Presumably, our intuition is that they need to *know* when they *do not know* in order to peek first. But is that really necessary? Simply lacking knowledge leads to exploration, whereas knowing where the bait is leads to a choice. What would it help them, in addition, to know that they do not know?

These problems have to be overcome before Brinck and Liljenfors can really put their theory to test. In particular, if we want to test whether more social (more intersubjectively experienced) species are more metacognitive than less social ones, we need a reliable measure of metacognition that does not rely on verbal report.

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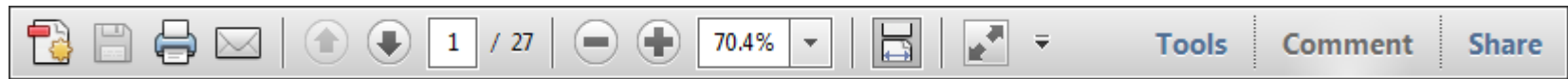
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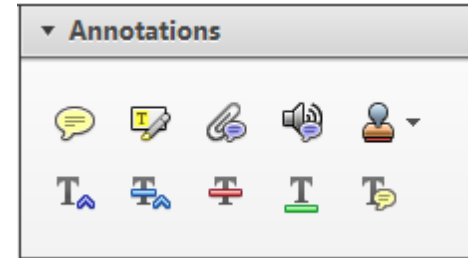
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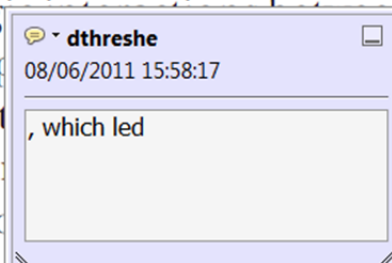


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standard framework for the analysis of microeconomics. Nevertheless, it also led to the emergence of strategic behaviour. The number of competitors in the industry is that the structure of the industry, which led to the emergence of strategic behaviour. The main components of the industry, which led to the emergence of strategic behaviour, are externalities and imperfect information. The important works on this subject by Shleifer and Vishny (1988) and henceforth we use the 'black box' model.



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there is no room for extra profits and the number of competitors are zero and the number of firms (net) values are not determined by the number of firms. Blanchard and Kiyotaki (1987), in their paper on perfect competition in general equilibrium, show that the structure of aggregate demand and supply in a classical framework assuming monopolistic competition is determined by the number of firms. Henceforth we use the 'black box' model.

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dynamic responses of mark-ups consistent with the VAR evidence.

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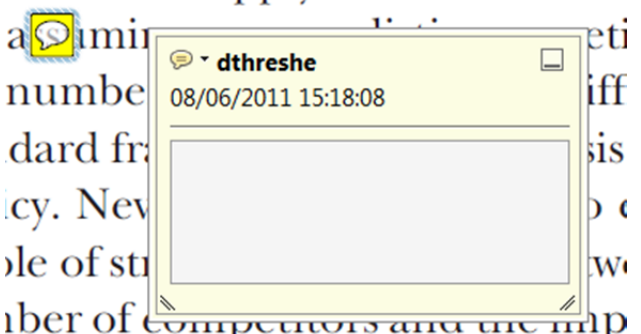


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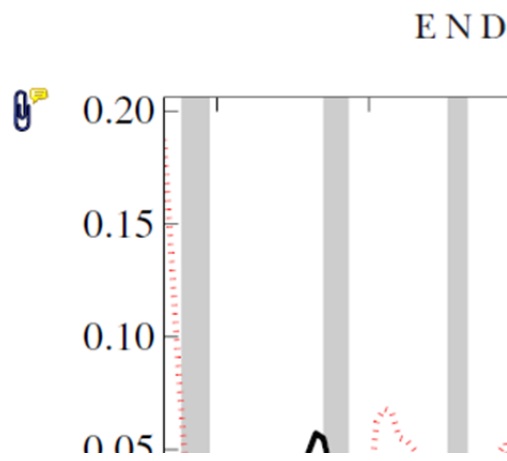
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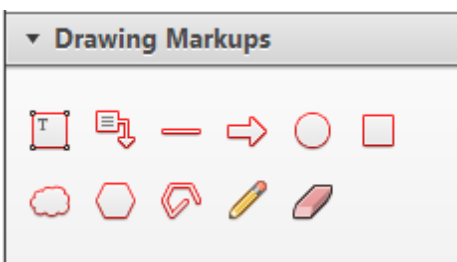


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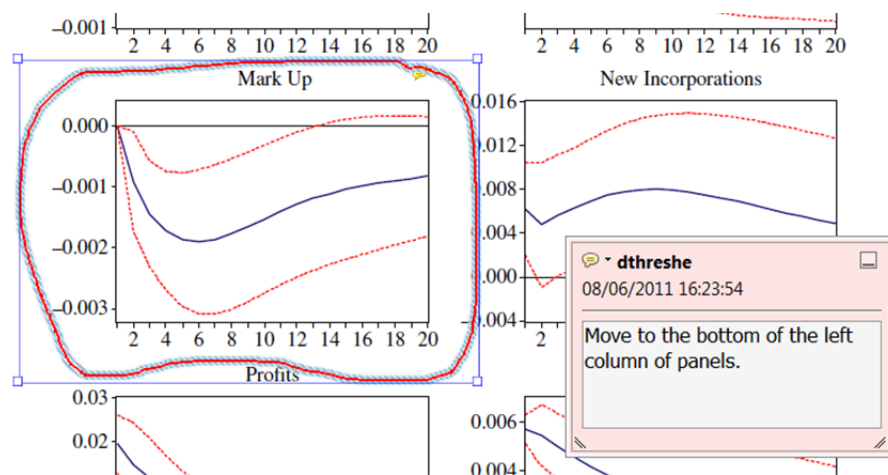


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