The role of imagination in heuristic cognition

Human Ecology Education

Short paper

Simon P Walker

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1 Introduction

Heuristic cognition is central to dual-mind theories of cognition. Dual-mind theory can be said to originate from Kahneman and Tversky's heuristics and biases programme (Kahneman 2011; Barone et al. 1997; Kahneman et al. 1982; Kahneman, Tversky 1973). Dual-mind theories share the assumption that the mind runs two parallel cognitive processing systems, one which is fast, frugal but errorful (system/process/mind 1) centered around heuristic cognition and one which is slow, but effortful, accurate and rational (system/process/mind 2), (Evans, J. S. B. T., Stanovich 2013; Evans, Jonathan St B T, Frankish 2009). At the evidential core of dual-mind theories are abundant studies that the brain will deploy the minimum resources toward cognitive perception, using heuristic judgements to make decisions more speedily and at lower cost (Fiske, Taylor 1985). The precious but limited resources of mind 2 are only sometimes deployed to intervene, reign in and cross check the low-cost intuitive cognitive operations of mind 1.

Many authors, however, have focused on the errors introduced to cognition through the heuristic judgment of mind 1 (De Neys W. 2010). According to Stanovich, authors have widely applied bias research especially to fields in which decision-making errors carry a high cost (Stanovich 2009; Thaler, Sunstein 2008; Sunstein 2006). However, not all authors have consented to the orthodoxy that heuristic bias is errorful. Gerd Gigerenzer has mounted a sustained project to demonstrate that there may be numerous evolutionary advantages to heuristic perception (Gigerenzer 2008; Gigerenzer et al. 2011; Gigerenzer, Todd 1999; Goldstein, Gigerenzer 2002). Some authors have recognised the need to extend the dual-mind model to incorporate the epistemic regulatory function of rationality. Stanovich and West have proposed a conjectured tripartite mind in which the effortful slow process 2 mind is seen as having two components- an algorithmic and a reflective component (Stanovich 2011, 2009). The reflective component provides the capacity for epistemic self-regulation, a component which some authors argue is the seat of epistemic and metalogical norms and can be seen as central to framing effects (Overton, Ricco 2011).

2. Where does heuristic cognition *neurally* reside?

Surprisingly little has been written about what neural functions may fulfil existing proposals of heuristic cognition. However, insight can be gained by deconstructing the proposal of heuristic substitution. An accepted concept of heuristic cognition is attribution substitution- the replacement of a complex, difficult question with an easier mental substitute (Kahneman et al. 1982). For example, the question 'how much would you contribute to save an endangered species?' is complex involving consideration of kinds of species, spending priorities, environmental causality etc (Kahneman 2011). Dual-mind models suggest that heuristic mind 1 mentally substitutes a simpler heuristic question as an imperfect but adequate means of getting an answer to the too-difficult question; in this case 'How much emotion do I feel when I think of dying dolphins?'

Most authors describe this heuristic cognition as autonomic, intuitive and non-conscious (Stanovich 2011; Evans, Frankish 2009). However, another aspect common to heuristic substitutions is that they replace a more general, abstract, remote, theoretical scenario with a concrete, immediate, personally-experienced and affect-loaded scenario. Heuristic thought centrally sustains mental participation in the story, an act of self-identification with the issue. In so doing, heuristic thought implicates the capacity to *imagine* ourselves as first-persons into a situation, implying that imagination may be central to any proposed heuristic, epistemically plastic data bridge (Figure 6).

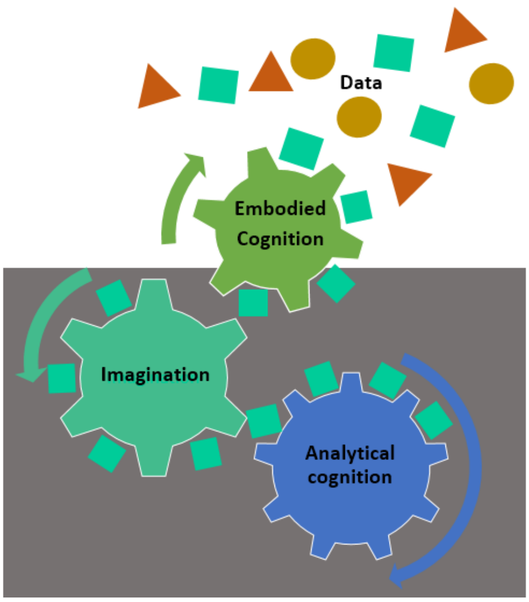

Figure 1. The imagination conjectured as data bridge between embodied and analytical cognitive processing

3 The role of imagination in heuristic cognition

3.1. Simulation

A model of *cognitive decoupling* has been proposed by several authors as a central mechanism by which the mind simulates possible scenarios in order to come to judgements (Evans, Stanovich 2013; Evans, Frankish 2009). This reflective simulatory decoupling function has been conjectured to sit outside heuristic cognition within a component that has been termed rationality (Stanovich 2011). One possibility is that such decoupled reflective simulation is in fact better understood as part of heuristic cognition, performed within the imagination. The imagination may provide the de-coupled mental environment in which experimental actions, choices and thoughts are simulated, played out, selected or inhibited. Decoupled simulation may be a critical process of heuristic imagination by which data of unfamiliar structure is mentally manipulated. Like a three-dimensions jigsaw piece might be manipulated and turned round in order to find the right orientation to fit it into the model, decoupled simulations within the imagination may play a role in the fitting of alien data into existing mental frames of reference.

From neuroimaging studies in rats and humans, Buckner (Buckner 2010) suggests that the interaction of sub-regions within the hippocampus *'could provide the neural building blocks for simulating upcoming events during decision-making, planning, and when imagining novel scenarios.'* He cites evidence that the hippocampal system is spontaneously active during task-free epochs and sleep, which suggests that the system may use idle moments to derive new representations that set the context for future behaviours (Buckner 2010). Others, such as Schacter and Addis argue from abundant studies that the hippocampus is involved in both episodic memory retrieval but also prospective, future memory (Schacter, Addis, and Buckner 2007). They assert that complex sub-regions within the hippocampus play various roles in the mental simulation of possible events and actions (Addis, Schacter 2012). Metastudies have implicated a wider set of neural bases involved in functions relating to the prospective function of memory (Spreng et al. 2009), the simulation of self and other mental states (Decety, Sommerville 2003; Decety, Grèzes 2006) including Tempero Parietal Junction (TPJ), Precuneus (PC) and medial Pre Frontal Cortex (mPFC) (van Overwalle, Baetens 2009).

3.2 Data integration

The imagination may perform integration as well as manipulation of alien data in order to transform the internal narrative (Schacter 2012). Neuroimaging studies have evidenced that remote memory retrieval is also associated with the hippocampus (Ryan et al. 2010) and involves data of different kinds- spatial, visual, somatic, auditory, emotional. Tompkins and Lawley describe a process of using the simulated imagination as an arena to re-model one's imagined self in the light of new data, as a means of obtaining control and self-agency (Lawley, Tompkins 2000; Siegelman 1990). Such approaches are used therapeutically as a prospective means of reconceiving a possible future self. In addition to the integration of new data with the internal database, a function of the heuristic cognition may be to prospect for future data which will fit with the existing internal narrative. In this regard, prospective memory may play an important role in imagining future selves (Schacter 2012).

3.3 Orientation

Prospective memory refers to mental reminders or thoughts which can be triggered by a future event or experience; it is implicated in actions of goal setting and navigation. Heuristic cognition would contribute to such a process. An increasing number of studies have identified the link between decision-making and action with imagination. Decety et al. evidence that the imagination plays a central role in organising our behaviours (Decety, Grèzes 2006; Garry, Polaschek 2000).. Schacter et al. evidence that the brain projects forward a method of self-operation prior to then enacting that projected sequence (Schacter, Addis and Buckner2007), serving as a guide or route map directing action (Schacter 2012; Stein 1994).

3.4 Heuristic bias evidence of role of imagination in data integration

Walker claimed that imagination was the locus of executive operation of a measured heuristic contribution to academic success (Walker 2014 g.). In several large population school studies (n=496), he demonstrated the correlation that the ability to accurately modulate imagination toward a known optimal state has with both cognitive ability and academic outcome (Walker 2014 g., 2014 h.) (Figures 7.1 & 7.2). Using an online predesigned assessment, candidates were instructed to imagine a mental image of the characteristics of an unprescribed open space. Rules developed by Grove and Panzer (Grove, Panzer 1989) governing the use of instructional clean language when leading candidates in mental imagery, were followed to ensure framing effects are minimised.

Following the initial imagination of the mental space, the candidate was asked to react to a series of 28 events, incidents or required tasks imagined to take place within their mental space. None of the events require technical skill or involve cognitive difficulty. Walker provided factor analysis evidence that the 28 items measure seven latent factors; three of the seven factors contribute to cognitive learner bias, two factors contribute to learner affective bias and two factors to learner social bias. Each factor is a bipolar construct in which the poles represent a heuristic biased state. Having established a candidate's *instinctive* heuristic biases for the seven factors, candidates were then asked, via recorded instructions, to imagine a series of specified *learning situations* taking place within their imagined space. By this mechanism multiple sets of heuristic bias scores were obtained for each of the seven factors: an instinctive heuristic bias score and three contextual imagined bias scores, thus tracking the regulation of the candidate's imagined bias as she moves between contextual learning activities (Walker 2014 g.).

Results indicated that the ability to modulate the bias of five of the seven factors *within one's imagination* to a pre-measured optimal state for each subject lesson contributed significantly to exam grade prediction in year 10 students. Data suggested optimal imagined bias correlated 0.39 with grade prediction, accounting for about 20% of the variance in within-school exam grade prediction in this study. A unique proportion of GCSE grade variance (9%) that could not be assigned to cognitive ability test scores could be assigned to the ability to optimally modulate imagined cognitive-affective bias.

In another small study (n= 13) of year 10 students Walker provided evidence that 1:1 coaching resulted in heuristic regulation which could be attributed to imagined prospective memory (Walker 2014 g). Over a 10 week period, students were provided with a 10 minute coaching conversation each week, focusing on specific in-lesson behaviours that could improve their individual bias regulation. The specified behaviours were identified by an assessment of the student's current limiting imagined biases in imagined maths, english and science lessons, which were undermining their academic progress. After 10 weeks, imagined bias scores were remeasured, along with changes in predicted GCSE grade. There was a moderate effect size between changes in a student's imagined bias scores and changes in predicted GCSE grade in that subject. The study evidences that students used prospective memory to trigger the enactment of agreed behaviours and learning strategies during their forthcoming lessons. Improvements in predicted academic grades evidence that some of those behaviours were successfully enacted, leading to improved academic success. That such changes in predicted grade correlated with changes in a student's imagined bias scores suggests that prospective memory and heuristic bias are neurally linked (Figure 7.1).

These results, interpreted alongside neuroscientific fMRI studies of the imagination circuits, provide support for a model of the imagination as an heuristic, epistemically plastic data manipulator and integrator.

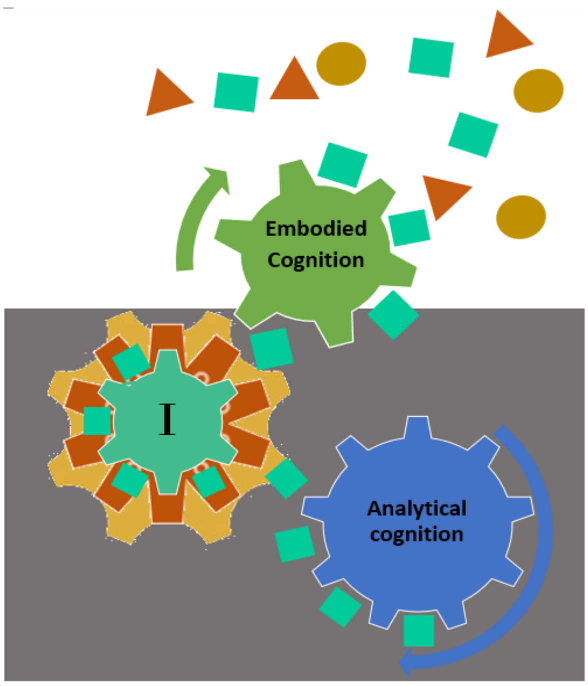

Figure 7.1 The imagination of academically successful students accurately adjusted its biases when faced with epistemically different data structures, resulting in improved predicted grades.

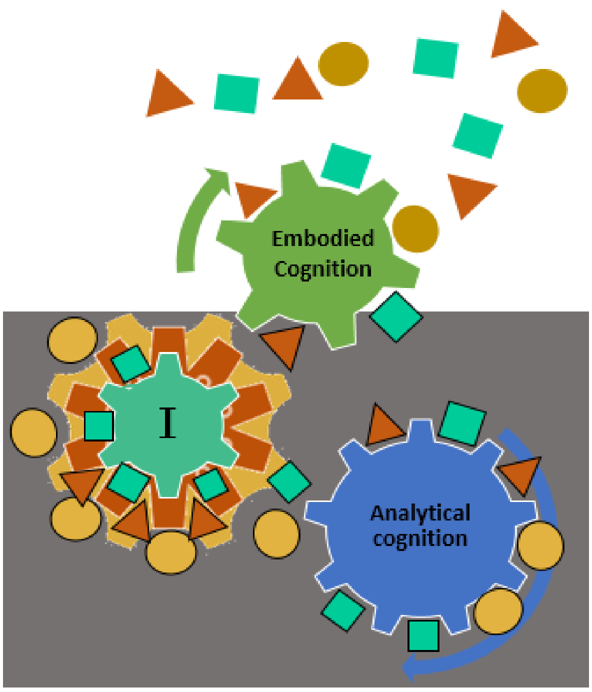

Figure 7.2 The imagination of academically unsuccessful students failed to accurately adjust its bias to epistemically different data structures, remaining either fixed or erratic in its biasing.

4. Heuristic cognition and self-regulation

Heuristic cognition has been widely proposed as a means of improving speed and efficiency of decision making in a complex world (Gigerenzer 2008; De Neys W. 2010; Gigerenzer et al. 2011; Gigerenzer, Todd 1999; Goldstein, Gigerenzer 2002; Kahneman 2003). The concept of bounded rationality- rationality in the real world when data is not universally available and known- describes the contribution of heuristic cognition toward *ad hoc* executive decision making when faced with novel circumstances. Authors implicate metacognitive ability as a central component of the Executive Function (EF) construct (Halloran 2011; Miyake et al. 2000; Fernandez-Duque et al. 2000). EF is an umbrella under which many neural circuits implicated in *ad hoc* cognition are swept (Elliott 2003; Banich 2009). Miyake and Friedman's theory proposes that updating, inhibition, and shifting are central tasks of EF, each of which relates to the capacity to adapt one's cognition to the task in hand. Updating is defined as the continuous monitoring and quick addition or deletion of contents within one's working memory. Inhibition is one's capacity to supersede responses that are prepotent in a given situation. Shifting is one's cognitive flexibility to switch between different tasks or mental states. Bull and Scerif have identified that inhibition and shifting are predictors of children's mathematical ability (Bull, Scerif 2001) and effective learning (St Clair-Thompson, Gathercole 2006). Studies on mental state switching have shown that processing speed is slowed when learners are required to switch from one mental task to another. This suggests that mental states required for mental activities may exists in a state of neural inertia or require a costly switch to be thrown to be activated (Derakshan 2010; Mayr, Keele 2001; Monsell 2003).

5. Conclusion

Increasingly, the close relationship between executive function and self-regulation is being identified (Hofmann et al. 2012). Heuristic cognition implies a central role for the imagination in executive function, metacognition and self-regulation. Close relationships in neural activation between hippocampus, ACC, TPJ, rmPFC and mPFC in mental simulation, strain management, self-other attention bias motivating, introspection-external perception switching suggest a possible coordinated heuristic executive system contributing to metacognition and self-regulation. Such a model proposes a central role for the imagination in executive function, metacognition and self-regulation. Heuristic cognition may principally be an active, executive system before it is a passive autonomic system, serving as a precursor to algorithmic or analytic cognition.

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