Project Title: The social and structural foundations of group innovation

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Project Summary. The recent growth in new social media technologies and applications (e.g. Wikipedia, Zopa, Linux) places a premium on understanding how groups create and leverage social capital to foster innovation and creativity. Current research on group cognition and innovation is ambivalent. Although in principle groups can engender forms of emergent intelligence that exceed the cognitive abilities of individual members, they can also stifle innovation through such effects as 'groupthink', 'group pressure' and 'social loafing'. This project will pilot a new method for exploring the dynamics of the socio-cognitive processes that generate these paradoxical outcomes. We will combine expertise in cognitive modelling and organizational innovation with a unique 'chat tool' platform (the DiET platform, Healey et. al., 2003) that enables real-time experiments on social processes. The novelty and viability of the method will be demonstrated by configuring the chat tool to enable three pilot studies exploring the effects of i) group size, ii) communication processes, and iii) social network structure on innovation and creativity. We will use tasks developed in cognitive psychology for individual problem solving and scale them to group settings, allowing for the comparison of group behavioural outcomes with years of research based on individuals. This will provide the foundation for large-scale proposals combining computational modelling, network analysis, organizational theories, and real-time analysis of human behaviour, targeted at EPSRC's Communities and Culture theme and ESRC's Innovation theme.

Project Background, Aims, Objectives, and Justification Crowd sourcing on a global scale is one of the salient phenomena of the last decade. Open-source software (Linux), collective archives (Wikipedia), consumer-driven content (Lego mindstorms), crowd-sourced finance (Zopa) and even group-managed sports teams (Ebbsfleet United FC) all rest on the hypothesis that groups can outperform individuals under a variety of circumstances. While some research suggests this is possible (Kerr & Tindale, 2004; Wilson, Timmel, & Miller, 2004), there is an equally substantial body of research suggesting the opposite (Mullen, Johnson, & Salas, 1991). Moreover, it has been shown that failures of group processes, such as groupthink (Janis, 1972), group pressure (Asch, 1955), and risk propensity (Kahneman & Tversky, 1979) played a crucial role in major foreign policy disasters, such as the Bay of Pigs and the Vietnam War. Potentially negative effects of groups include free-riding/social loafing, diffusion of responsibility, and lack of innovation due to imitation. Group cognition is a double-edged sword: it can reduce the limits and biases of individual judgment, but can also aggravate them.

The conditions that give rise to these divergent effects are unclear. The bulk of group behavioural research has focused on performance and outcome rather than the underpinning socio-cognitive processes, thus providing only limited evidence for practical applications and the generalization of claims beyond individual tasks. Our proposal aims to draw on, and extend, more than fifty years of research on group and organizational innovation (Pietro Panzarasa) by applying computational methodologies from cognitive science (Thomas Hills) alongside state-of-the-art tools for carrying out controlled experiments on real-time group interaction (Pat Healey). The main objective of this project is to provide proof of principal that we can characterize and explain complex socio-cognitive processes underlying group innovation.

Proposed Methodology and Project Plan. We will exploit three well-understood individual problem-solving tasks: The Remote Associates Task (e.g., find the word common to these three words: 'Place', 'Storm', and 'Camp'; answer 'Fire'), the category fluency task (e.g., 'name all the animals you can think of'), and divergent thinking tasks (e.g., 'novel uses for a brick'). New group versions of these tasks will be implemented in the DiET chat tool. This will ease the execution of the studies, reduce transcription costs, and ensure comparability across sites/studies. DiET provides real-time analysis of semantic and syntactic structure of each contribution/turn in a conversation as they are produced. This will be extended to take advantage of new large-scale statistical analyses of text that can represent semantic memory and the structure of problem spaces (Hills, Jones, & Todd, 2012; Hills, Todd, & Goldstone, 2008). This will facilitate fine-grained experimental interventions and provide additional cognitive, linguistic and interactional measures for analysis. The reconfigured platform will be deployed at Warwick and at QMUL to enable three new pilot studies:

1. Hills: The impact of group size on innovation. Individual actors and groups of size ranging from two to five individuals will be asked to solve problems, which also vary in difficulty.
2. Panzarasa: The effects of group structure on innovation. Social network structure (the totally connected network, the chain, the ring and the star) has been reported to affect innovation (Bavelas, 1951). The DiET platform will be used to obtain different interaction topologies (Opsahl et al., 2008) that, in turn, reflect the degree to which individual actors belong to socially cohesive clusters or occupy brokerage positions between otherwise disconnected others (Burt, 2004). We will examine the degree to which network centralization, brokerage, and cohesion combine with task complexity to affect group innovation.
3. Healey: Effects of communication processes on innovation. A key part of joint problem solving is the process of collaboratively articulating the problem (Schwarz, 1995). We will use the DiET platform to test this process by selectively manipulating people's turns during collaborative problem solving (e.g. adding signals of certainty "right"/"okay" and uncertainty "um"/"err") and assessing the effects on innovation.

Data will be analysed to characterise the influence of group size, structure, and problem articulation on the processes controlling trajectories of innovation (Hills et al., 2012), and especially the socio-cognitive interactions through which the solutions provided by one participant influence the semantic (i.e., conceptual) trajectories provided by others (Panzarasa et al., 2001).

Project Roles and Responsibilities. Hills will provide expertise on the computational methodologies for characterizing human search behaviour in complex tasks in cognitive psychology, will manage RA1 (pre-doc), and will run study 1. **Panzarasa** will provide expertise on organizational behaviour and innovation networks, will jointly manage RA2 (post-doc), and will be responsible for conducting, analyzing, and reporting study 2. **Healey** will provide expertise on human interaction, will jointly manage RA2 (with Panzarasa), will be responsible for the reconfiguration and testing of the DiET platform, and conduct, analyse and report study 3.

Timeline. The overall project will take 9 months. Task specification and piloting will begin in November feeding into re-configuration of DiET, fine-tuning and installation at Warwick and QMUL in Nov-Feb (months 1-4). Data collection will be finished by the end of May (month 7). March-July (Months 4-9) will be devoted to integration, analysis and interpretation of the results (targeted as conference and journal papers) and developing new grant proposals to EPSRC and ESRC and the diffusion of results.

Breakdown and Justification for Requested Project Costs Funding is requested for *shared facility development* (DiET platform reconfigured and installed at both sites) and *pump-priming* of new experimental work leading to new proposals. We request two research assistants to programme distribute and maintain the DiET platform and to collect and analyse data. One post-doc RA with programming and experimental skills is requested for 6 months at QMUL: £22,219. One pre-doc RA is requested to run experiments at Warwick £3394 (equivalent to 190 hours). Subject payments are needed to runs the 3 main experiments (QMUL: £1,267, Warwick: £633, 380 participants at £5 per participant). Finally, funding is requested for: travel between Warwick and QMUL (QMUL £200, Warwick £200); and travel & subsistence to three conferences: £1500 (QMUL: £1000, Warwick £500). Total Costs for Funding from both awards = £29413.

Outcomes and Prospects for Future Collaboration and Intentions to Seek External Funding This project will provide a major contribution to our understanding of the processes driving group innovation and problem-solving by demonstrating how principles of computational modelling and large-scale data analyses, typically used for the study of individuals tasks, can also be applied to group tasks. This project is expected to lead to two publications on processes of group innovation, one focused on group size and the other on group structure. The project will also provide pilot data and proof-of-principle for a larger-scale proposal on group innovation that we will submit to a major funding body, such as EPSRC's Communities and Culture theme or ESRC's Innovation theme. The long-term objective will be to shed light on how knowledge sharing and information processing within groups are affected by problem complexity, number of actors, interaction and communication topology, and cognitive heterogeneity. Our future project will thus have a broad scope and a highly inter-disciplinary nature that will make it suitable to a number of funding bodies (see, e.g., the recent call by the Institute for New Economic Thinking) that have expressed interest in proposals that lie at the interface between disciplines and appeal to a wide scientific community.

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