Title: “Creative individuals or creative situations?”

Abstract: Computers can be used as a key research tool because they allow us to do things that have been difficult or unfeasible in the past. This potential could facilitate discussion of ideas in new ways. This paper presents preliminary findings of a computational model that may contribute to extend our –presently limited – understanding of creative phenomena in design. As part of an extensive modelling effort, it offers initial insights that may shift the current focus in individual creativity to a more extensive view where the situations within which designers operate play a key role in the occurrence and definition of creativity.

Título: “¿Individuos creativos o situaciones creativas?”

Resumen: Las herramientas computacionales pueden considerarse estratégicas para la investigación en tanto permiten hacer cosas que en el pasado eran difíciles o prácticamente imposibles. Esta posibilidad podría así facilitar la discusión de ideas desde nuevos puntos de vista. Este artículo ofrece resultados preliminares de un modelo computacional que podrían contribuir en la extensión de nuestro –actualmente limitado– entendimiento de los fenómenos creativos en las áreas del diseño. Inscrito en un esfuerzo teórico más amplio, se presentan aquí ideas iniciales que modificarían la atención que hoy en día se concentra en el estudio de la creatividad individual para sugerir una perspectiva más amplia en la que las situaciones dentro de las cuales los diseñadores operan cumplen un papel fundamental en la definición de la creatividad.

Ricardo Sosa and John S Gero
Key Centre of Design Computing and Cognition
University of Sydney, NSW 2006, Australia
{john, rsos7705}@arch.usyd.edu.au

Creative individuals or creative situations? A computational model of creativity based on social influence

"A wide range of important social phenomena can be made to emerge from the spatio-temporal interaction of autonomous agents operating on landscapes under simple local rules."
(Epstein and Axtell 1996)

"Even remarkably simple programs seem to capture the essential mechanisms responsible for all sorts of important phenomena that in the past have always seemed far too complex to allow any simple explanation."
(Wolfram 2002)

1. Introduction

This paper presents preliminary findings of a computational model of social influence and their possible implications in studies of creativity and design. The modelling approach as illustrated in the opening quotes focuses on the link between individual behaviours and the emergent collective structures that result from their interaction in an environment. A longstanding assumption of relevant studies is that "society is indispensable to the individual because it possesses at a given moment an accumulation of values, of plans and materials which the individual could never accumulate alone …but individuals are also indispensable to society because …they create all the material values, the whole fund of civilization" (Thomas 1923). In current social theory it is further observed that "any socio-cultural action, wherever it is situated historically, takes place in the context of innumerable interrelated theories, beliefs and ideas which had developed prior to it and exert a conditional influence on it." (Archer 1996) Such views refer to a notion of culture which may provide direction to the study of creativity when the latter is considered in the aggregation of simple individual behaviours based on local conditions from which group-level change phenomena arise. Some frameworks have included the social and cultural dimensions in creativity studies (Csikszentmihalyi 1997, Findlay and Lumsden 1988), diffusion of innovations (Rogers 1995), and in the link between micro and macroscopic phenomena (Boyd and Richerson 1985, Lumsden and Wilson 1981).

2. Computational studies of creativity and culture

Whilst both terms culture and creativity remain ambiguous in their definitions (Cropley 1999, Boyd and Richerson 1985), there exist various efforts to better understand the emergence and the role of shared values in a society as well as their transformation and replacement by new ideas generated by individuals characterised as change agents and ultimately either rejected or adopted by the rest of the members of a social group. Designers are assumed to play a key role in constantly defining the material culture (i.e., designed artefacts) of their society, and to do this through a process in which creativity is of particular importance – and only partly understood at present. Computational simulation models have special relevance to the study of these phenomena insofar as they enable experimentation with constructs and timeframes inaccessible to other research methodologies. In particular agent-based models of social processes are seen as artificial societies (Epstein and Axtell 1996) or laboratories where the researcher attempts to "grow" social structures in the computer - or in silico (Langton 1995) - the aim being to explore

hypotheses and discover key mechanisms that are sufficient to generate the macroscopic social structures and behaviours of interest.

The study of creativity as a complex adaptive system (Buckley 1998) assumes that a close relation exists between creative designers and their society and environment in the occurrence and definition of creativity. Such a notion is based on situatedness (Clancey 1997) and could be an appropriate way of shifting the inquiry focus from the personal characteristics of gifted individuals commonly addressed in creativity research (Runco and Pritzker 1999, Weisberg 1993) to the dialectic interaction between individuals that are believed to construct a personalised worldview within which they design (i.e., a situation) and the ensuing collective structures. The modelling of this joint relation is assumed to contribute to the explanation of the dynamics of creative phenomena.

3. Model of social influence

The model of social influence presented here is based on the well-researched cellular automata (CA) voter model (Liggett 1999) as applied by Axelrod (1997) to address one of the simplest notions of social influence, namely, "who we are affects whom we interact with, and whom we interact with shapes who we become". This is considered a mechanism of social interaction and culture convergence (where society is defined as a network of individuals in contact and culture as a set of shared values reached by the interaction of such individuals) that deals with how individuals become more similar as they interact taking into account the fundamental principle of human communication that the transfer of ideas tends to occur most frequently between people who are similar in certain attributes such as beliefs, education, social status, and the like.

This model describes a population of computational agents in a two-dimensional grid of sites with individual values defined by a list of features, each with a set of possible traits. Two individuals have compatible values if they share at least one trait of a common feature, and share the same culture if they have the same traits for each feature. Individuals have four adjacent neighbours each: east, west, north, and south sites. Although Axelrod (1997) presents a grid with boundaries where sites on the edge have three neighbours and sites in the corners only two, equivalent results are observed in a torus grid where sites on the edge interact with the neighbouring site in the opposite edge of the grid, so that all sites interact with four neighbours. A system run is based on a sequence of events where a site and one of its neighbours are randomly selected. Both sites have a probability of interacting that is proportional to their similarity, i.e., two entirely different sites have probability 0 of interacting, whilst two identical sites have probability 1 of interacting. Interaction in this model means the comparison and transfer of values from one individual to the other. A process description is:

1. pick a site and one of its neighbours at random
2. pick a common feature at random, if they share the same trait then
3. pick a feature where both sites differ, if any
4. copy the trait from the neighbour into the site

More formally:

1. Let culture c at a site change as
2. select a random site s, a random neighbour of that site n, and a random feature f
3. let $G(s,n)$ be the set of features g such that $c(s,g) \neq c(n,g)$
4. if $c(s,f) = c(n,f)$ and G is not empty, then select a random feature g and set $c(s,g)$ to $c(n,g)$.

The results presented by Axelrod (1997) are confirmed in our replication of this model of simple social convergence. In essence, at all times the population converges presenting regions or contiguous sites with identical values after around 80,000 iterations. At times the final configuration shows a single dominant region, whereas often two or more incompatible regions become stable since neighbouring sites have no common features and hence are unable to interact.

In exploring the potential implications of this convergence structure in the study of creativity, a feasible extension is that faced with perceived uniformity, at least a few individuals would try to dissent by

introducing a new value into the system. Such a model assists in considering how designers could induce a social change and the necessary change rate for a population of agents to be able to give rise to a culture. Presumably, different rates of innovation would either prevent culture convergence or would not have the sufficient impact on the population to contest group convergence and permit collective transformations. The former social influence algorithm is thus complemented with the following procedure: given a global novelty probability any individual is able to generate a random trait in a random feature. One way of probing such probability is inspired by the ratio of designers to the rest of society. Consider the U.S. Census Bureau data of the Decennial Census 2000 where the Standard Occupational Classification shows that 0.177% of the population works in the creative design professions (SOC codes 27-1021 to 27-1027). The model is set with a stochastic condition that enables the trigger of a random change equivalent to a 0.177% rate.

A typical run shows that such a marginal innovation rate in fact supports culture convergence and at the same time generates cycles of culture change in a population of agents, which could be counter-intuitive. Since a probabilistic analysis of the social influence model suggests that a value shared by a majority of the population would inevitably take over marginal compatible cultures, this is offered as an explanation for the development of what is defined as a region and the fact that often only one culture dominates (Axelrod 1997). The response to this contradiction may represent a key insight for a situated approach to creativity (Gero and Sosa 2002) by suggesting that individual change agency has an entirely different group impact according to the particular global structures at the time of action triggering. Consider the two episodes within a system run shown in Figures 1 and 2 where the dominant collective value faces the increasing spread of one or more alternative cultures, in the former case being replaced by the new culture and in the latter reverting to dominance. These examples show group structure as an emergent result of the sum of every interaction among individuals at particular time steps and illustrate how any given individual perturbation may carry entirely different global effects on the development of shared values depending on the collective structures present.

Moreover, within this model of global convergence, local divergent behaviour is observed in a kind of crossover process, which further emphasises that change agency is eminently situated inasmuch as the effect of any individual local action is bounded by the ensuing global conditions. To better appreciate this, consider the execution of an identical individual change action (i.e., the introduction of a random value) at different time steps of a control case. Although the action is the same in all test runs, the global impact is observed to largely depend on the social structure at the time of execution (Sosa and Gero 2002). Likewise, in a control case where two different individual change actions are executed at the same time step by an individual the result can be the same global effect in the dominant culture. This preliminary finding could be significant in that it illustrates how influencing society can be seen as a function not only of what action a change agent executes but to some extent more importantly of where and when it executes the action.

Figure 1 Episode that illustrates a dominant culture (continuous line) being replaced by a nascent value (dotted line) that is increasingly adopted by members of a population. The graph plots value adoption in a population of 100 sites against time steps.

Figure 2 Episode that illustrates a dominant culture (continuous line) challenged by a nascent value (dotted line) that is adopted by up to 90% of the population but that is ultimately discarded. The graph plots value adoption in a population of 100 sites against time steps.

Experimentation with illustrative extensions of this model of social influence offers a series of macro-structural explanations of social change phenomena that allude to the importance of supra-individual factors in the convergence and transformation of shared values (Sosa and Gero 2002). The results, although limited by the simplification of the modelling approach, offer preliminary - and in some cases counter-intuitive - insights into the dynamics of individual and collective behaviours that may take part in the occurrence of creative phenomena. In sum, at present such findings could point towards a situated view of creativity in which the weight is shifted from creative individuals to creative situations.

4. Creative Design Situations

The term situation derived from the Latin status refers to the perceived position or condition of a person or thing relative to that of others. Etymologically this term denotes a twofold notion, a) the state or condition of an individual and b) as interpreted against the state or condition of its environment, including other individuals. In the model of Creative Design Situations or CDS (Gero and Sosa 2002), designing is seen as a situated phenomenon (Clancey, 1997), which leads in formal terms to the idea that an individual interacting with its environment over a period of time constructs a space that stands for its reality. In other words, an individual inhabits its situation as the result of its interaction with its environment over time. From the individual's point of view the real world is determined by its current situation, if seen in phenomenological terms.

This view is relevant insofar as a design situation can be defined as the perceived set of social, temporal, and environmental factors that in conjunction with the individual's goals contribute to shape its process of designing (Gero and Fujii 2000). Under this view the conventional study of individual creativeness requires reassessment in order to advance beyond the many difficulties of creativity research including fundamental paradoxes that show that contradicting personal features and abilities seem to characterise different creative persons (Cropley 1999, Gardner 1993). This approach to the study of design situations promotes a new way to consider the following questions and their relevance to creativity in design:

- How may individuals influence each other in a social group? If a situation stands for an individualised construction of the world, a group in which members share some elements of their situations can be characterised as a social unity, arguably the foremost concept in Kuhnian theory defined as a community (Kuhn 1974), especially since paradigms and revolutions can only be

understood in relation to a defined community. Contact among designers and other members of a population could thus be modelled in terms of their interaction mediated by the designed artefacts, a process that may constantly redefine the shared elements of their situations (Taura et al. 2002). In a model that captures this influence, it becomes possible to explore the emergence of widespread solutions to joint problems and their transformation over time relative to particular individual and situated factors.

- How can culture emergence and culture change in design be explained through social interaction? Understanding culture as a set of shared values among the individual situations of members of a social group, design culture can be formally represented through the features of the designed artefacts of a society. A model of this kind provides the means to explore how individuals shape their culture and how the latter influences their design behaviour in return. In addition, if culture formation requires social convergence, how may culture drift combine convergent and divergent processes? This modelling approach enables experimentation on the relation between convergent and divergent structures in the group level and their roles in the emergence of culture and its continuous transformation. In this way simulation scenarios can be run from various initial conditions and assessed by the resulting designed artefacts adopted by a population within a time frame.

- How may a single individual - or a minority of individuals - be able to influence the society at large? By controlling relevant individual conditions associated with the awareness of their situation, this framework enables experimentation on the role and impact of change agents in a society in terms of their individual design actions coupled with social settings. Rather than accounting only for the individual's characteristics, the conditions within which an individual may trigger a change action and the impact of such action in relation to collective structures become relevant. Hence, if creativity is said to require contradictory personality characteristics (Cropley 1999), this approach may provide an alternative to the search for universal characteristics of creativity by suggesting that creative outcomes may be better understood if seen as bounded by situated factors.

5. Discussion

Conventionally, prominent persons have been the object of study of creativity with the aim of identifying habits and skills that presumably conceal the key to creative behaviour and which are thus taught to people in order to improve their creativity. This paper has presented a view that adds a further dimension and proposes that creativity can be better understood if seen as being strongly associated to the coupling of individual and situated factors. The current model calls for more detailed micro-level specifications to better account for this coupling (Harper 1993), which is the nature of ongoing research in order to include agency mechanisms of awareness and manipulation of a design situation. In sum, in understanding creativity in design, the commonplace research approach of defining creative subjects a priori could be complemented by the study of the dynamics through which an otherwise ordinary designer becomes influential by the social recognition of its behaviour and the coupling of individual and situated factors that serves as the source for what is considered as creative production by its social group. In addition, the study of culture as the set of collectively agreed shared values presumably requires attention to its role in determining common design behaviour in a social group.

References

Axelrod, R: 1997, *The Complexity of Cooperation, Agent-based Models of Competition and Collaboration*, Princeton University Press, New York.

Boyd, R and Richerson, P: 1985, *Culture and the Evolutionary Process*, University of Chicago Press, Chicago.

Buckley, W: 1998, *Society –A Complex Adaptive System, Essays in Social Theory*, Gordon and Breach, Amsterdam.

Clancey, W: 1997, *Situated Cognition, on Human Knowledge and Computer Representations,* Cambridge University Press, Cambridge.

Cropley, A: 1999, Definitions of creativity, *in* Runco, M. and Pritzker, S. (eds), *Encyclopedia of Creativity*, Academic Press, San Diego, pp. 511 –524

Csikszentmihalyi, M: 1997, *Creativity, Flow and the Psychology of Discovery and Invention*, HarperCollins, New York.

Epstein, JM and Axtell, R: 1996, *Growing Artificial Societies, Social Science from the Bottom Up*, The MIT Press, Cambridge.

Findlay, CS and Lumsden, CJ: 1988, *The Creative Mind*, Academic Press, Orlando.

Gardner, H: 1993, *Creating Minds*, *an Anatomy of Creativity Seen Through the Lives of Freud, Einstein, Picasso, Stravinsky, Eliot, Graham and Gandhi*, Basic Books, New York.

Gero, JS and Fujii, H: 2000, A computational framework for concept formation in a situated design agent, *Knowledge-Based Systems* 13(6), 361-368.

Gero, JS and Sosa, R.: 2002, Creative design situations, *in* Eshaq, A, Khong, C, Neo, K, Neo, M and Ahmad, S l. (eds), *CAADRIA 2002,* Prentice Hall, New York, pp. 191-198.

Harper, CL: 1993, *Exploring Social Change*, Prentice-Hall, New Jersey.

Kuhn, T: 1974, Second thoughts on paradigms, *in* Suppe F. (ed), *The Structure of Scientific Theories*, University of Chicago Press, Chicago, 459 –482

Langton, CG: 1995, *Artificial Life, an Overview*, The MIT Press, Cambridge.

Liggett, TM: 1999, *Stochastic Interacting Systems: Contact, Voter, and Exclusion Processes*, Springer-Verlag, Berlin.

Lumsden, CJ and Wilson, EO: 1981, *Genes, Mind and Culture: The Coevolutionary Process*, Cambridge: Harvard University Press.

Rogers, EM: 1995, *Diffusion of Innovations*, The Free Press, New York.

Runco, M and Pritzker, S (eds): 1999, *Encyclopedia of Creativity*, Academic Press, San Diego.

Taura,T, Yoshimi, T and Ikai, T: 2002, Study of gazing points in design situation, *Design Studies*, 23(**2**), 165-185.

Thomas, WI: 1923, The measurement of social influence, *in* Thomas, W. I., *The Unadjusted Girl: with Cases and Standpoint for Behaviour Analysis*, Little Brown, Boston, pp. 222-257.

Sosa, R and Gero, JS: 2002, Computational models of creative design situations, *in* JS Gero and F Brazier (eds), *Agents in Design 2002,* Key Centre of Design Computing and Cognition, University of Sydney, Australia, pp. 165-180

Weisberg, R: 1993, *Creativity, Beyond the Myth of Genius*, W.H. Freeman and Company, New York.

Wolfram, S: 2002, *A New Kind of Science*, Wolfram Media, Champaign.