DIFFUSION OF DESIGN IDEAS: GATEKEEPING EFFECTS

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1. Introduction

Designers and design managers are interested in gaining a deeper understanding of the complexities of creativity and innovation (Langdon and Rothwell 1985). These two phenomena can be seen as complementary dimensions of a differentiation cycle where design plays a key value-adding role that gradually reduces through commoditisation. However, there is a lack of relevant evidence to explain the link between creativity and innovation. Creativity is increasingly considered as occurring in the interaction between the individual generator of an idea and a group of evaluators (Sawyer et al 2003). However, most studies have regarded the generation of a solution -and not its social impact- as the outcome of the creative process (Runco and Pritzker 1999). Accordingly, computational modelling of creativity has been mainly conducted in a social void (Boden 1999).

This paper presents a computational framework of design as a social activity where the final outcome is the impact that generated artefacts have in a social group. The research aim is to gain understanding of the role of designers as change agents of their societies (Gero 1996). The link between individual action and social change is not easy to investigate. Conventional methods of inquiry focus either on personal or collective units of analysis but little evidence exists on their co-determination (Conte et al 2001).

Csikszentmihalyi (1988) suggests a broader view for the study of creativity where different stakeholders are taken into consideration. The DIFI framework (Domain-Individual-Field Interaction) addresses the role that the individual, the field and the domain play in the definition of creativity. Emphasis is on the interaction between agent, social, and epistemological levels of analysis respectively (Feldman et al 1994).

In proposing a social psychology of creativity Amabile (1996) focuses on sources of motivation. She suggests that whilst intrinsic motivation tends to promote creativity, extrinsic motivation may have the opposite effect to an extent. Extrinsic motivation refers to rewards or other motivational conditions presented to or perceived by the individual generator. Such findings have started to illustrate possible ways in which creativity is partially determined by factors other than those pertaining to the individual generator of solutions.

In the literature, gatekeepers are characterised as individuals that hold a position of authority to determine the inclusion of new ideas into the body of knowledge shared by a social group (Gardner 1994). Csikszentmihalyi (1988) and Liu (2000) refer to the evaluative role of gatekeepers. However, little is known about the nature and impact of this role (Rogers 1995).

By studying patterns of creative people such as Pablo Picasso and Sigmund Freud, Gardner (1994) suggests that the hierarchical structure of a field has an effect on the ascription of prominence and creativity. The evidence suggests that in more hierarchical fields (i.e. "where a few powerful critics render influential judgments about the quality of work") it is easier for a small number of creators to be recognised and gain influence (Gardner 1994).

This paper presents computational experiments with a multi-agent framework to explore the idea that gatekeeping structures can determine how a design solution is spread and recognised in a society.

2. Artificial Societies

The agent-environment divide that dominates the computational modelling of behaviour has been a convenient approach to the study of insect colonies and other forms of collective intelligence such as robots. This individualistic view of causation of behaviour has been extended to some extent to model human collective behaviour (Gilbert and Doran 1994). However, evidence from experimental studies has suggested that human behaviour is a function of the combination of individual and social processes (Argyle et al 1981; Ross and Nisbett 1991).

The modelling of social interaction is yet to account for explicit representation of circular emergence (Conte et al 2001). In ant colonies a form of collective intelligence is said to emerge bottom-up, i.e. as an aggregate effect of simple rules of reactive behaviour. However, the behaviour of more complex organisms such as humans is not expected to be guided exclusively by fixed reactions to physical stimuli. Instead, individuals seem to rely on shared structures collectively developed and evaluated by other members of their social group. Such structures feed back into individuals and may generate normalised or conforming behaviour particularly when faced with new ideas (Argyle et al 1981).

In this paper, a socio-cognitive architecture is presented that addresses the combination of individual and situational factors. Individual factors are those that differentiate individuals such as thresholds of intelligence, abilities and preferences. Situational factors are those that characterise the interpretation of external factors such as channels of interaction and group pressure. A well-known experiment in social psychology is used to illustrate our architecture.

2.1 DECISIONS UNDER GROUP PRESSURE

A computational implementation of the Asch compliance paradigm (1951) is used to illustrate socio-cognitive causation of behaviour. In this widely replicated experiment test subjects comply with judgements expressed by associates of the experimenter when placed within certain group settings. The task consists of matching the length of a test line with three options as shown in Figure 1. Although test subjects provide correct estimations when tested in isolation, they tend to comply with group judgements even when these are visibly wrong.

In this multi-agent replication a control variable is added to determine the level of difficulty of the task. Task difficulty $\boldsymbol{t}$ is a value between 0.0 and 1.0 that represents the distance between test and control lines. When $\boldsymbol{t} \approx 0.0$, lines are close and easy to compare and agents tend to individually produce correct estimations. When $\boldsymbol{t} \approx 1.0$ line lengths are distant and hard to match and agents tend to produce wrong estimations. An individual estimation $\boldsymbol{e}$ is generated as a function of individual ability and task difficulty. Ability $\boldsymbol{a}$ is implemented as a probability between 0.0 and 1.0 to reach a correct estimation. Abilities are randomly assigned through the group from a Gaussian distribution. A correct estimation $\boldsymbol{e_c}$ is reached when the combination of abilities and task is greater than an arbitrary threshold of 0.5:

$$\boldsymbol{e_c} = \{ \boldsymbol{a} + (1 - \boldsymbol{t}) > 0.5 \} \qquad (1)$$

Agents engage in social interaction consisting of a sequential order to express their opinions. To this end they are assigned an extroversion threshold $\boldsymbol{v}$ (Eysenck 1991) from a Gaussian distribution and an order to state their response $\boldsymbol{o}$. If agents consecutively agree on a response, group pressure builds up towards that response. In the original experiment the test subject is instructed to respond only after all other group members have expressed theirs, i.e. $\boldsymbol{o} = N$ where N is group size (Asch 1951).

Figure 1 shows a typical case of compliance. Individual estimations $\boldsymbol{e}$ are shown for every agent in the table. The graph plots agent group ($N = 8$) by response order $\boldsymbol{o}$ in the horizontal axis and extroversion thresholds $\boldsymbol{v}$ in the vertical axis. Notice that *agent7* is the only agent to reach a correct estimation. However, its turn to provide a response in the group is at a time where all previous agents have collectively formed an opposing unanimity. At such point group pressure (slope line in graph) is greater than *agent7*'s ***v*** and therefore it complies with an incorrect group judgement.

Asch (1951) found that unanimity is the strongest situational determinant for compliance. In our model, unanimity occurs more frequently around the extremes of task difficulty causing most agents to conform to high group pressures.

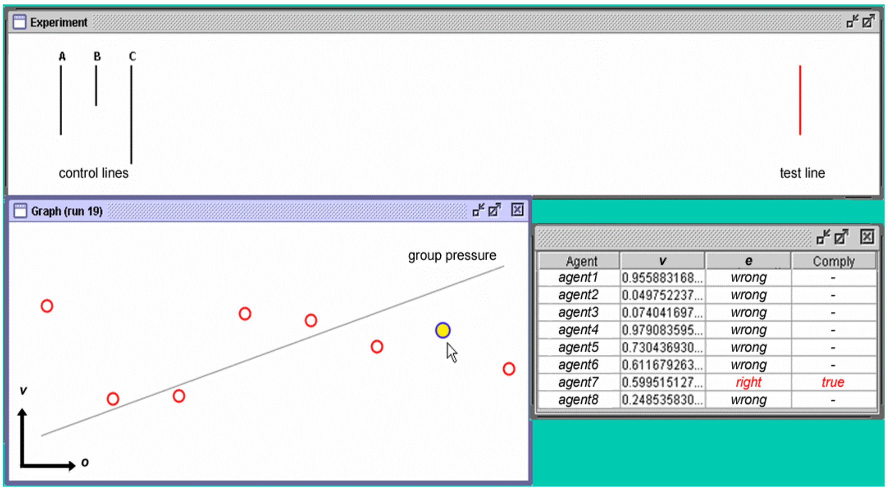

*Figure 1. An agent implementation of Asch's experiment (1951) where an agent complies with an erroneous majority despite reaching a correct estimation (**e**).*

Within this model of compliance personal factors play a role in determining behaviour. If *agent7* in Figure 1 had an extroversion value ***v*** higher than emergent group pressure, it would avoid compliance by providing a right response. Likewise, situational factors matter. If *agent7* was allowed to respond at an earlier time or if a previous agent had differed, *agent7* may have faced a lower group pressure and avoided compliance. Therefore, resulting behaviour can only be explained by a combination of individual and emergent group conditions. In this case, the aggregate effect of group pressure combined with an individual threshold of extroversion.

Different insights were extracted from the verbal account of yielding subjects from the original experiment after conditions were revealed (Asch 1951). Influence effects fell into three categories: distorted perception, distorted judgement, and distorted action. The first two resemble informative influence whilst the third is a type of normative influence. These sources of behaviour can be mapped onto behaviour components $m_{i\text{-}n}$ of compliers as a function **M** of their appraisal of the situation:

$$\mathbf{M} = \sum \{ \quad \begin{array}{l} A : perception_i[\mathbf{S}(\mathbf{E'}_i)] \\ B : judgement_i[\mathbf{S}(\mathbf{E'}_i)] \\ C : action_i[\mathbf{S}(\mathbf{E'}_i)] \quad \} \end{array} \tag{2}$$

where $\mathbf{E'}_i$ represents a perceived unanimity state and $\mathbf{S}$ the complier's appraisal of a situation within which sufficient conditions exist for a type of distortion. Individuals from group A have their perceptions distorted and their behaviour **M** is subsumed by group influence. Judgements and actions are distorted in groups B and C respectively.

Figure 2 shows a diagram of our multi-agent system where components $m_{n,i}$ become part of the group structure. As agents interact group structures emerge and mediate their interaction with the environment. These structures are shared by agents at different times causing them to exhibit different degrees of normalised behaviour. For instance, perceptions may become collectively biased, preferences may be emphasised by groups at different times, and socially permissible actions may be established.

Unlike the arguably artifactual conditions of the experiment discussed above (Asch 1951), in less structured forms of social interaction the formation of group effects need not be sequential. Agent interaction may then be assumed to take place in social networks (Wasserman and Faust 1994).

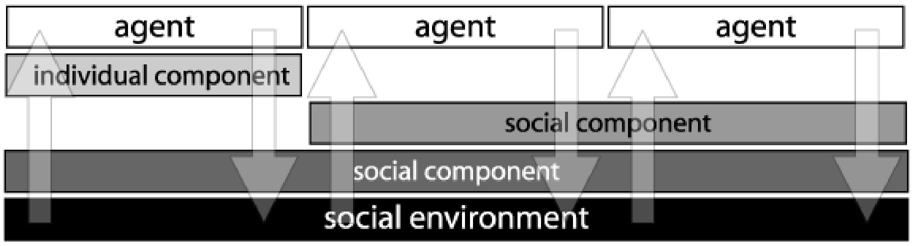

Figure 2 Socio-cognitive architecture where behaviour components become part of the group structure.

The collective state of a society B can thus be defined as:

$$B = \{ \mathbf{M}_{i\text{-}n}[\mathbf{S}_{i\text{-}n}] \} \tag{3}$$

where state B is a function of agents' behaviour $\mathbf{M}_{i\text{-}n}$ codetermined by internal states and their situation $\mathbf{S}_{i\text{-}n}$. A situation can be defined at the individual level and it can also be shared by a group (Ross and Nisbett 1991). A shared situation is perceived by a group of agents as a result of the combination of internal states and perceived external state. Extending the previous example, at the individual level a situation may be one of compliance whilst at the group level it may be a one of unanimity. These are corresponding characterisations of one common collective structure, i.e., group pressure. This architecture supports equivalent agents acting differently within different situations, and different agents behaving similarly within similar situations.

3. Adopters, Opinion Leaders and Designers

A multi-agent system of design is implemented based on this framework. Members of an adopter population evaluate available design solutions and take an adoption decision. In this choice individual thresholds of perception and preference are complemented by social interaction where opinions are exchanged amongst adopters. One of the effects of this type of social behaviour is the emergent formation of opinion leaders, i.e. adopter agents that exert influence over the adoption decisions of others. Structures of dominance emerge where the most influential adopters acquire the role of gatekeepers. Gatekeepers in this model are responsible for considering available solutions for their inclusion into the repository of their societies (Feldman et al 1994).

Designers are agents that create and transform solutions that are adopted by the population and that are considered by gatekeepers for their inclusion in the repository. Some of the resulting phenomena of interest are the size of adopter groups (a measure of popularity) and the number of entries to the repository (a measure of critics' endorsement). The design process consists of generating alternative solutions by learning (a measure of knowledge) or by imitating other designers (a measure of peer-recognition). Lastly, adopter groups manifest their satisfaction with their adoption choices (a measure of quality). In the literature *creativity* is defined by such components as aesthetic appeal, novelty, quality, unexpectedness, peer-recognition, influence, intelligence, learning, and popularity (Runco and Pritzker 1999). In this framework, creativity is defined by a set of complementary processes including adoption of a solution by a population, nomination by specialists and colleague recognition.

A designer is considered creative by its social group when it reaches large adopter groups, its artefacts are entered into the repository, other designers imitate its artefacts, it transforms the design space by formulating knowledge, and its adopters have high satisfaction levels. Experimentation in this framework consists of exploring the effects that both individual and situational factors have on determining the creativity of designers.

3.1 SOCIAL INTERACTION

During a system run adopters rely on social interaction to validate their perceptions, spread preferences and in general to conduct their adoption decisions. To this end different social spaces are defined where adopters interact. At initial time adopter agents are randomly assigned a location on each space. These social spaces have different rules of interaction and development. Two aspects addressed in this paper are social tie strength (**T**) and neighbourhood size (**H**).

Ties are interaction links between nodes in a social network where nodes represent the relationship between adopter agents in that particular social space (Wasserman and Faust 1994). **T** is determined by the probability that associated nodes may interact over a period of time (Granovetter 1973). Strong social ties exist between nodes in a kinship network, whilst weak ties exist in networks where casual encounters occur between strangers or acquaintances. **H** is determined by the number of links from a node, also called ego-centred networks (Wasserman and Faust 1994). In our framework we implement a basic notion of tie strength as a probability $0.0 \leq \mathbf{T} \leq 1.0$ that the link between a possible pair of adopter agents will remain at the next time step (Marsden and Campbell, 1984). $\mathbf{T} \approx 0.0$ brings higher social mobility, i.e. adopter agents are shuffled more often and get to interact with different adopters over a period of time. In contrast, $\mathbf{T} \approx 1.0$ bonds adopter together causing a decrease in social mobility, i.e. adopter agents interact within the same groups for longer periods of time.

3.2 INFLUENCE DOMINANCE

A social space $\mathbf{L_1}$ in this framework is set where adopters exchange preferences **F**. Within a second social space $\mathbf{L_2}$ percepts **G** are traded. A third space $\mathbf{L_3}$ is set where agents exchange adoption decisions $\mathbf{G}_{max}$. In all spaces **H** has an initial value of 2 that varies during a system run according to the influence that an adopter exerts on others. More influential adopters have larger neighbourhoods.

The distribution of influence dominance **D** in an adopter population is measured by the Gini coefficient γ, a summary statistic of inequality. When $\gamma \approx 1.0$ influence is concentrated by a few adopters and more stable dominance hierarchies exist. In contrast, when $\gamma \approx 0.0$, influence is more distributed among adopters. More formally,

$$\gamma = \{ \sum [(|d_i - d_{i+1}|) / \mathbf{D}_{mean}] / (2\, \mathbf{D}^2) \} \tag{4}$$

where the difference of every possible pair of dominance values ($d_i - d_{i+1}$) is divided by the mean of the entire dominance set of the population ($\mathbf{D}_{mean}$). The relative mean difference (γ) is obtained by dividing pair differences by the square of the size of the dominance set ($\mathbf{D}^2$) (Dorfman 1979).

At initial time agents are randomly assigned extroversion thresholds **X** in every social space (Eysenck 1991). An adopter agent is assigned different **X** in different social spaces. Extroversion values are not fixed during a system run but change as a result of exerting influence over other agents.

Exchange between any pair of adopters starts by a comparison of their extroversion thresholds. In the social space where preferences are exchanged, the adopter agent with the highest extroversion of the pair influences the less extrovert adopter on the criterion with highest preference. A negotiation process occurs by which the influenced adopter increases its preference by half the difference between their preferences. However, if the chosen artefact of both adopters is the same and their preferences too similar, the more extrovert changes its focus of attention by shifting its preference to another criterion. This is a way to implement uniformity-avoidance and novelty-seeking behaviour, i.e. "p_i is an adopter's top preference until it perceives that p_i is commonplace". Within other social spaces different content is exchanged following a similar approach. More formally influence **I** between adopters *i* and *j* is of the form:

$$\mathbf{I}_{i\text{-}j} = |\mathbf{X}_i - \mathbf{X}_j| \ \{ \ \mathbf{F}_j \mathrel{+}= [(\mathbf{F}_i - \mathbf{F}_j)\ (0.5)] \ \} \qquad (5)$$

where the more extrovert adopter *i* influences the less extrovert *j*. Negotiation occurs as the target preference **F** of agent *j* approaches agent *i* by a ratio of their difference. The exchange of percepts and adoption choices in their corresponding social spaces takes place in the same form.

In this way adopter agents exchange components of their individualised adoption process. However, even if an influential adopter is successful in spreading its preferences and percepts, adoption decisions in a group need not converge. Adopters with equal top preferences may still perceive artefacts differently and therefore reach different adoption decisions.

3.3 OPINION LEADERSHIP AND GATEKEEPING

Promoters are opinion leaders that adopter populations collectively designate as a result of their aggregate interaction. At initial time the set of promoters **R** is empty. As a result of social interaction over time, adopter populations form social structures. These structures can be determined by various exchange processes. This paper focuses on influence hierarchies between adopters. Adopters that gain a dominance level of one standard deviation above the mean are nominated as promoters **R**. An adopter population may have characteristics that enable many agents to gain opinion leadership temporarily or may have characteristics that generate only a limited number of stable opinion leaders. Whilst in the former $\gamma \approx 0.0$ supports social mobility, the latter exhibits social stability and $\gamma \approx 1.0$. Formally,

$$\mathbf{R} = \{ \ d_i > (\mathbf{D}_{mean} + \mathbf{D}_{stdev}) \ \} \qquad (6)$$

where a promoter **R** is every adopter whose dominance is greater than one standard deviation above the mean of group dominance **D**. The role of promoters in this framework forms a two-way bridge between adopters and designers. Firstly, they serve as adoption models providing designers with positive feedback for reinforcement learning. Secondly, promoters become gatekeepers of the field given their ability to nominate artefacts for entry into the artefact repository **Y**, i.e. a collection of artefacts that defines the material culture of a population (Feldman et al 1994).

Since the number of promoters is by definition a small ratio of the adopter population, they are more likely to spend more real and computational resources in analysing available artefacts. With an adopter background, promoters follow the standard adoption decision process described above but also gain access to more detailed evaluation criteria.

The repository of artefacts **Y** is initialised with an entry threshold $\varepsilon = 0$. During a system run ε is increased supporting a notion of group progress by which the entry bar is raised with every entry. Two possible entry modes are addressed in this paper. Promoters can nominate artefacts that either increase the population's threshold of entry ε or perform well in different criteria than existing entries. Promoters evaluate artefacts using geometric descriptions like orthogonal rotation, uniform scale, and reflective symmetry. The nomination of artefacts by promoters occurs at a control rate specified by the experimenter. Entry threshold ε to repositories has a decay mechanism **A** of the form:

$$\mathbf{A} = \{\ \varepsilon \mathrel{-}= (0.05\varepsilon)\ \} \tag{7}$$

where ε decays marginally over time. **A** is executed when promoters fail to nominate qualified entries above ε.

Adopters and promoters provide the first elements of our definition of creativity. A creative design must be recognised and adopted by a population. Cumulative adoption of artefacts addresses a notion of popularity (Simonton 2000). It must also be selected by gate-keepers, i.e. experts collectively nominated and representative of their social group. This selection is based on rules of entry that evolve as artefacts and societies change. Critics' choice addresses the idea that creativity is judged by relevant arbiters (Gardner 1993; Feldman et al 1994). Lastly, adopter categories enable classification on the basis of when they choose an artefact (Rogers 1995).

4. Gatekeeping Effects

The following experiments address the role of social ties in the formation of influence structures in a population and the associated effects on creativity and innovation. A series of simulations are run where the initial configuration of adopters and designers is kept constant (i.e. control random seeds) and **T** is the independent variable. MonteCarlo runs are conducted to explore the range **T** = 0.0 to 1.0 over 7500 iterations in populations of 10 agents, i.e. where agents remain in their social location at all times and where agents change social locations at all times, respectively. Preliminary runs showed that dependent variables stabilise between 2500 and 5000 iterations. The resulting dataset is then filtered in order to exclude outliers, i.e. values 1.5 standard deviations from the mean. All the following results represent means of 10 simulation runs.

Each simulation run is initialised in a converged state to avoid biases in the form random initial artefact configurations. Therefore at iteration step 0, adopters perceive no differentiation between artefacts and all abstain from adopting. It is only after a designer first modifies an artefact when adoption commences.

4.1. DOMINANCE HIERARCHIES

As **T** increases, social mobility decreases causing agents to interact more often with a stable group of neighbours. As a result, influence is more concentrated ($\gamma \approx 1.0$), i.e. a few adopters exert dominance over others. In contrast, as **T** decreases, social mobility increases and agents have contact within a varying neighbourhood. In such conditions, influence structures of dominance are more distributed ($\gamma \approx 0.0$), i.e. hierarchies are more flat. Figure 3 shows a scatter plot and power-law relation of tie strength **T** and Gini coefficient γ.

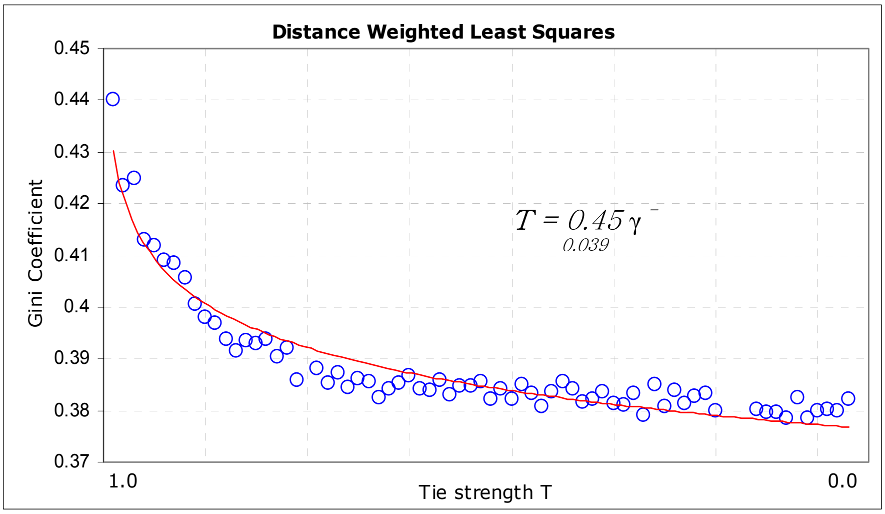

*Figure 3. A power law function is empirically demonstrated for tie strength and Gini coefficient (**T** = 0.45 $\gamma^{-0.039}$).*

4.2. GATEKEEPING EFFECTS

The formation of dominance structures shows unexpected effects in adoption and design behaviour. On the one hand an inverse correlation is shown between tie strength **T** and number of entries to the repository **Y**. Lower values of **T** are correlated with larger repositories as shown in Figure 4, Pearson = 0.6706 $N = 30$ p = 0.001.

This phenomenon may be due to the nature of the promoter role and is particularly insightful in regards to gatekeeping (Feldman et al 1994). In societies with rigid influence hierarchies (**T** ≈ 1.0) there is less variation in adopters that play the promoter role. Therefore interpretations that serve to evaluate artefacts for entry remain constant over time. In contrast, in societies with lower **T** and therefore where influence is distributed rather than concentrated there is a higher change rate of gatekeepers. Consequently, more diverse evaluations of artefacts mean more artefacts are submitted to the repository. As an effect, designers in general tend to receive more recognition for their work.

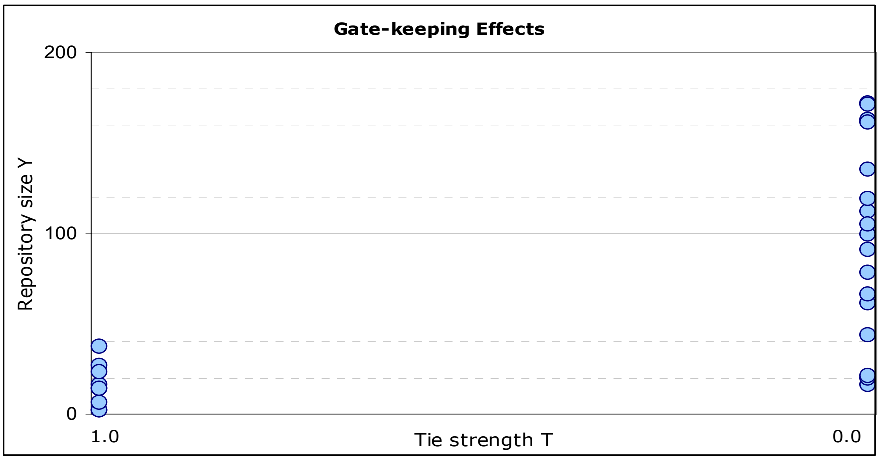

Figure 4. Social spaces with high tie strengths tend to produce smaller repositories.

The mean score of repository entries is also correlated with variations in tie strength **T**, Pearson = 0.5657 $N = 30$ p = 0.002. This demonstrates that large repositories contain artefacts ascribed with higher quality. It is of special interest that the size of the design space defined by designer agents increases by manipulating a situational factor such as **T**. The connection between high mean scores and large repository sizes is better illustrated by the decay mechanism of the repository in eq. 10. In simulation runs where artefacts are submitted more often to **Y**, these are required to exceed the entry threshold ε and must have, by definition, higher scores assigned by promoters.

4.3. DIFFERENTIATION EFFECTS

The differentiation of design artefacts is measured through the Strategic Differentiation Index (SDI) (Nattermann 2000). These experiments show that SDI decreases with higher **T** and has the opposite effect as **T** decreases. In other words, designers operating on tight social spaces where influence structures are rigid tend to generate more similar artefacts whilst the same designers operating on wider distributed influence social spaces have a tendency towards higher differentiation, Pearson = 0.5755 $N = 30$ p = 0.004.

4.4. PROMINENCE EFFECTS

Lastly, effects on the size and nature of adopter groups are addressed. Monte Carlo runs where tie strength **T** is the independent variable consistently show that **T** is positively correlated to adopter group size, Pearson = 0.608 $N = 26$ p = 0.001. This illustrates that low tie strengths increase abstention. On the other hand, **T** is also correlated to distribution of adoption defined as the ratio between the smallest and the largest adopter groups as shown in Figure 5, Pearson = 0.6796 $N = 26$ p = 0.001. Namely, in social spaces where **T** ≈ 0.0 and influence is more distributed, adopters tend to abstain more and their choice tends to be more closely distributed across designers. In contrast, **T** ≈ 1.0 increases total adoption and concentration of choices. In other words, the competitiveness between designers and their prominence can be determined by the way in which their evaluating groups organise.

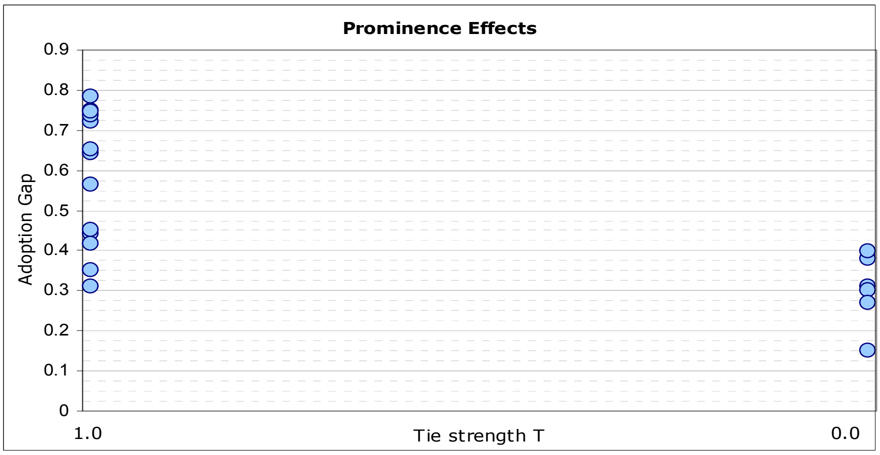

*Figure 5. Social spaces with high tie strengths (**T** ≈ 1.0) tend to produce higher variation between adopter groups' sizes.*

4.5. SUMMARY

These experiments illustrate a fundamental idea about the nature of creativity and innovation, i.e. that a situational factor that regulates the way in which adopters interact may have a significant effect on how both designers and adopter groups operate. The implications are that by observing the performance of any particular designer it is not possible to put forward conclusions about their individual characteristics alone. Instead, the causal of behaviour could be a situational factor that defines not the designer's characteristics but those of the evaluators.

5. Discussion

The experiments presented in this paper support the idea that creativity transcends the individual domain. Patterns of creative figures show that characteristics external to the individual may determine who and how is considered creative in a society. Graham, Einstein, Picasso and Freud have been characterised as extraordinary creators. Whilst their personality traits and abilities have little in common (Gardner 1993), similarities exist between the structures of the fields within which they operated. Namely, a few powerful critics rendered influential judgements about their quality of work (Gardner 1994).

Our experiments confirm this observation. When the tie strength between members of a population is high $\mathbf{T} \approx 1.0$ it is more likely that adoption concentrates on one designer. That is, keeping designers and adopters constant and varying only the way in which adopter groups interact causes one designer to become more prominent than the rest.

A measure of differentiation further shows that although prominence is more concentrated, the actions of others may rapidly become similar. This *herding* effect may be the basis on which prominence becomes less stable in more hierarchical fields (Gardner 1994).

However, our experiments have shown that in societies where ties between agents are stronger, repositories tend to contain fewer entries and they tend to have lower ascribed values. Accordingly, a generalisation can be formulated as follows: In more hierarchical fields prominence tends to concentrate on a few creators. Under such conditions, imitation of valued solutions increases whilst differentiation between available solutions decreases. In such fields the resulting domain tends to be smaller and to consist of solutions that have lower perceived value. These findings need to be further compared to evidence from empirical observations.

An open question that deserves attention is the way in which critics' endorsement may shape adoption. In our experiments these processes remain independent but a number of assumptions can be explored. Firstly, adopters may exhibit bias in their adoption decisions towards critics' choices. Secondly, polarisation and segmentation effects can be addressed where sub-groups of adopters form around differing critics.

Hierarchy differences and their possible effects on creativity and innovation may occur between different fields. However, such differences and observed effects seem more likely to vary within a field at different stages of development. In early stages of field formation, when influence is more distributed, it may be harder for a single designer to be recognised as creative. As the field advances and gatekeeping hierarchies develop, the distribution of prominence may become more concentrated. With the arrival of a new paradigm, hierarchies in the field may collapse reinitiating the cycle of effects on prominence (Kuhn 1974).

A corollary of these experiments is that in studying prominent designers, it seems necessary to consider the properties of the field within which they operate.

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