Understanding Design as a Social Creative Process

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ABSTRACT
The Human-Computer Interaction community has long been concerned with design. Terms such as 'creativity' and 'innovation' are frequently used when referring to the design process and in this paper we examine what creativity is with respect to design. Design is often a collaborative and, therefore, a social activity. We review the evolution of definitions of creativity, leading to our proposal of a unified definition, we present a theoretical account of why social creativity should in principle be more productive than individual creativity. We explain findings to the contrary in terms of three social influences on creativity and suggest that research in supporting design should focus on mitigating the effects of these social influences on the creativity of design teams.

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Keywords: Creativity, Social Creativity, Creative Process Models, Creative Problem Solving.

INTRODUCTION
The Human Computer Interaction (HCI) community has long been concerned with the design of usable software applications and computer systems. In recent years, a consensus has developed that involving users directly in the software development process can lead to more useful and usable systems. This has found its clearest expression in the Participatory Design (PD) movement. PD initially grew out of Scandinavian concerns to bring democracy into the work place [16], by involving users in the design stage of the software development process. Since the 1970s, the focus of PD has shifted from introducing democracy into the work place to a belief that 'active user involvement in the software development process leads to more useful and usable software products' [33]. PD epitomizes the collaborative nature of design, bringing together stakeholders from diverse backgrounds to work together in both the analytical and creative practices of systems development. Design in PD is a social rather than an individual activity. Even in design processes that do not encourage user participation, an individual designer rarely works in isolation and, therefore, an understanding of social creativity has more general applicability.

The collaborative processes of generating design requirements and envisioned system designs remain something of a 'magic art', within both PD and other systems development approaches. In the PD literature, this 'magic art' is frequently referred to using terms such as *creativity* and *innovation* [e.g. 1, 4, 7, 25, 33, 44, 45]. However, while participatory design may be viewed as a collaborative or social creative process and PD researchers and practitioners use the term 'creativity' when referring to the design process, they provide little definition of what this term means and what is actually involved in this process of social creativity.

So why is creativity important to design? Taylor *et al* [46] argue that the larger the number of ideas produced, the greater the probability of achieving an effective solution. Thus, the more creative we are in design, the greater the probability of designing useful and usable software applications and computer systems.

In this paper, we provide an overview of previous definitions of creativity; compare creative process models; develop a definition of creativity that unifies previous definitions; make a theoretical claim that social creativity should be more productive than individual creativity and explain findings to the contrary in terms of three social influences on creativity; and suggest future directions for research in understanding the social creative activity of design and means of supporting and improving design as a social creative process.

WHAT IS CREATIVITY?

Definitions of creativity have been developed and evolved over several decades. There have been three main concepts by which creativity has been defined: the creative process [e.g. 3, 24], the creative person [e.g. 19, 20] and the creative product [e.g. 2]. In this section, we look at each of these concepts in turn to see how definitions of creativity have evolved.

The Creative Process

Early definitions of creativity defined it in terms of the *creative process*, that is a process essentially internal to an individual by which ideas are generated. Boden [3] described the creative process as a person's exploration and transformation of conceptual spaces. Gabora [17] likens the human mind to a map where memory locations are represented in neurons. The exploration of conceptual spaces relates to recalling these memory locations, while transforming conceptual spaces relates to forming new associations between neurons to produce new ideas.

Koestler [24] proposed that creativity involves a 'bi-sociative process' whereby an individual deliberately connects previously unrelated 'matrices of thought' to produce a creative idea. When Koestler uses the term 'matrix of thought', he is referring to an idea or concept in an individual's mind. However, when we view creativity as a collaborative or social process, the matrices of thought that are to be combined in the generation of creative ideas are not necessarily in the mind of a single individual but may come from more than one person in the group.

In addition, these combinations of matrices of thought are not necessarily just in the minds of the participants. Some theoretical perspectives, such as Distributed Cognition [21, 22], move away from the individual mind and focus on the inclusion of significant features in the environment that support cognition. In our previous work on PD, we have explored the use of external shared representations to support the development of shared design ideas and understandings [33, 34]. From this perspective, we may consider the creative process as combining matrices of thought in our mind and our environment.

Furthermore, although Koestler refers to creativity as a 'bi-sociative process of unrelated matrices of thought', it should be considered as more of a multi-sociative process of related or unrelated matrices of thought as there may be occasions when the creative process involves the combination of more than two matrices of thought which are either related or unrelated.

Whilst these definitions provide a possible explanation as to how creativity comes about in the mind of the individual, they do not give us a complete understanding of creativity and provide no way of measuring when creativity has occurred or to what degree.

The Creative Person

A dominant approach in the 1950s was that of defining creativity in terms of the *creative person* [e.g. 20]. 'Creative personality is then a matter of those patterns of traits that are characteristic of creative persons' [20]. It may be the case that these traits assist in the creative process, allowing the individual to explore and transform conceptual spaces in their mind more easily than a less creative person. However, while this apparently circular definition tells us that traits are what make a person creative, it fails to say what these traits of a creative person actually are.

Various creativity tests have been devised to assess the traits of creative individuals: personality inventories, biographical inventories and behaviour tests. These tests were developed based on studies using very large numbers of subjects in which the creativity of the subjects was assessed by 'experts' – an assessment that was itself subjective. Gough [19] introduced a Creativity Personality Scale using an Adjective Check List where 18 adjectives positively relate to creativity and 12 adjectives negatively relate to creativity. In this test, individuals use the adjectives to describe themselves. The test adds a unit point for the use of a positive adjective and subtracts a unit point for the use of a negative adjective. Creative individuals tend to use the adjectives positively related to creativity rather than the negatively related adjectives and therefore score higher than less creative individuals.

However, Ward [49] argues that test scores should not be considered a measure of creativity. While these 'abilities' are important to creativity, Amabile [2] argues that it is inappropriate to label the results of these test scores as some direct indication of some global quality known as creativity. Although such tests may not be suitable for assessing creativity, they could be used to identify some of the attributes of creativity, as in studies by Elam and Mead [14] and Marakas and Elam [30], to compare the *potential* for creativity of different people.

The Creative Product

Definitions of the *creative product* refer to the product's reflecting some distinguishing signs of creativity – such as aesthetic responses brought about in the observers. Theorists who define creativity in terms of the creative product tend to include characteristics of 'novelty' and 'appropriateness' [e.g. 2, 6, 23].

How do we know then when an idea is *novel*? We consider a novel idea to mean the combination of two or more matrices of thought that are considered new or unusual. However, what may be considered novel to one person may not to another. Boden [3] views novelty as belonging to one of two categories: Psychological Novelty (P-Novel) and Historical Novelty (H-Novel). P-Novel is an idea which is new to the mind in which it arose, though it may have been thought of by others before. H-Novel is an idea which is P-Novel and has never been thought of by anyone

else before. To assess if an idea is P-Novel, one could simply ask the individual who thought of the idea using a retrospective protocol, but assessing an idea to be H-Novel is improbable as one would have to cross cultures and time to see if the idea had occurred before. Due to the more objective measure of P-Novelty, in our research we consider as novel an idea that is new or unusual to the mind in which it arose. This view has also been adopted by other creativity researchers [44].

Novelty is a necessary but not sufficient feature of creativity. It is *appropriateness* that differentiates novelty from creativity. So, how do we assess a novel idea to be appropriate – and appropriate to what? Many creative process models [e.g. 2, 36, 44, 48] have a stage of problem definition and preparation. When we are creative we generally start with a problem, whether it is producing a painting or identifying a solution to a design problem. During the problem definition and preparation stage of the process, the problem is explored, allowing characteristics of potential solutions to be determined. A solution is considered appropriate if it conforms to these characteristics. The characteristics that determine appropriateness are likely to vary from domain to domain. Relating value to our concept of appropriateness, Brannigan [5] comments that 'value judgments are to some extent culture-related, since what is valued by one person or social group may or may not be valued by another'. Thus, the appropriateness of a product should be assessed in relation to the setting for which the product was intended.

Boden [3] argues that if we can identify the creative ideas generated through a creative process, we could develop some way of 'counting' them in order to measure the creativity of an individual or group. If we consider these ideas to be the 'creative product', such a measurement could identify when creativity has occurred and give some objective measure of its extent. However, Amabile argues that 'assessment of creativity cannot be achieved by objective analysis alone. Some type of subjective analysis is required' [2]. Amabile proposes the subjective analysis of experts to determine the degree of creativity of a product. Such a measurement has been used as a reliable measure for the degree of creativity associated with a product [14], although Marakas and Elam [30] notes that research is needed on this issue of measurement.

Creative Process Models

The concept of 'creative process' described above views creativity as essentially the individual exploration and transformation of conceptual spaces [3] to generate ideas. There is in addition a long history of research [e.g. 2, 36, 44, 48] that uses creative process models to describe various phases that occur in the process of being creative, including but not limited to idea generation (Figure 1).

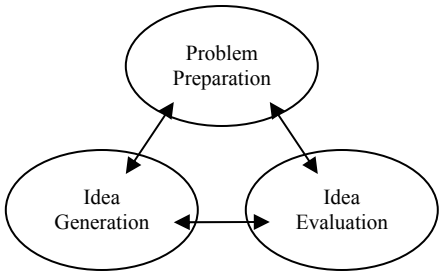

Figure 1 – Generic Creative Process Model

One of the first models of the process of being creative was proposed by Wallas [48], who described creativity as involving four phases: Preparation; Incubation; Illumination; and Verification. *Preparation* is a stage in which one clarifies the problem and develops an understanding of it, so that one is prepared for what may be needed in potential solutions to the problem. This stage may involve gathering relevant data about a problem and reviewing it. *Incubation* is when one no longer consciously considers the problem. However, although conscious thought is suspended, the problem remains as an ambient thought awaiting some creative insight (i.e. a 'eureka' moment). The *Illumination* stage is when this creative insight occurs. Nemiro [32] describes this as 'when there is a sudden change in perception, a new idea combination, or a transformation that produces an acceptable solution to the problem at hand'. This reflects both Koestler's [24] combination of matrices of thought and Boden's [3] transformation of conceptual spaces. The final stage, *Verification* involves making sure that one's creative insight or novel idea is in fact an appropriate solution to one's problem. This reflects the characteristics of novelty and appropriateness used to define a creative product [e.g. 2, 6, 23].

Later models moved away from proposing unconscious stages of incubation and illumination, towards a more conscious process of deliberately coming up with ideas. Osborn [36] described the creative process as comprising two main stages: Idea Generation and Idea Evaluation. *Idea Generation* is made up of a further two sub-stages: *Fact-finding* – the process of problem definition and preparation – and *Idea-finding* – the process of producing novel ideas through the combination of old, existing ideas. During the *Idea Evaluation* stage, these novel ideas are assessed for their 'appropriateness', allowing creative solutions to be identified.

Amabile [2] provided a componential framework, showing how domain-relevant skills, creative-relevant skills and task motivation might contribute to the creative process. *Domain-relevant skills* are attributes such as factual knowledge and skills – attributes that will affect an individual's performance in a given domain. *Creative-relevant skills* include a person's cognitive style – this will influence the way the individual explores and transforms

<table>
<tr><th>Models</th><th colspan="2">Analysis of Problem</th><th colspan="2">Generating Ideas</th><th>Evaluating Ideas</th><th>Donating</th></tr>
<tr><td>Wallas [48]</td><td colspan="2">Preparation</td><td>Incubation</td><td>Illumination</td><td>Verification</td><td>X</td></tr>
<tr><td rowspan="2">Osborn [36]</td><td colspan="4">Idea Generation</td><td rowspan="2">Idea Evaluation</td><td rowspan="2">X</td></tr>
<tr><td colspan="2">Fact-finding</td><td colspan="2">Idea-finding</td></tr>
<tr><td>Amabile [2]</td><td>Problem or task presentation</td><td>Preparation</td><td colspan="2">Response generation</td><td>Response Validation</td><td>X</td></tr>
<tr><td rowspan="2">Shneiderman [44]</td><td colspan="3">Collect</td><td colspan="2">Create</td><td>Donate</td></tr>
<tr><td colspan="6">Relate</td></tr>
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Table 1 – Comparison of Creative Process Models

conceptual spaces. *Task motivation* determines how an individual approaches a task – an individual's enthusiasm for a task.

In Amabile's [2] creative process model there are five stages: problem and task presentation; preparation; response generation; response validation; and outcome. In *problem and task presentation* the individual is presented with the problem and what is involved. During this stage of the process, task motivation has to be high, so the individual has sufficient interest to pursue solving the problem. While Amabile [2] does not acknowledge this, domain knowledge – does the individual understand the problem and what is involved – may also be important in this stage, having an influence on task motivation.

Preparation involves the individual building up knowledge about the problem and researching what a potential solution may necessitate. Domain-relevant skills are particular important at this stage, as domain knowledge will play an important part in generating an acceptable solution.

Response generation is heavily dependent on creative-relevant skills and task motivation. Creative-relevant skills could influence the quality of the ideas produced, as the better the individual is at exploring conceptual spaces, the more novel the solutions are likely to be. Task motivation could also have an influence on the quantity of ideas produced. Osborn [36] argues that 'quantity breeds quality' therefore a high task motivation is required so that more ideas are produced, as the more interested an individual is in a problem the more time and effort she is likely to spend generating ideas to solve it.

Validation of the responses and solutions generated is heavily reliant on domain-relevant skills, as the individual must have knowledge by which to assess the appropriateness of the generated ideas.

Finally, one of three possible *outcomes* is achieved: a solution is obtained and the process has been a success; all ideas for a solution are rejected and therefore the process has failed; the ideas generated have made a contribution to the problem, but it is not yet solved, in which case we return back to the first stage of the creative process and reassess the problem.

Shneiderman [44] uses a four stage model to describe the creative process: Collect; Relate; Create; and Donate. *Collect* is the initial stage of collecting information about the problem from information resources such as digital libraries and the Web. The *Relate* stage in the model is when one consults with peers and mentors. This stage should be performed throughout the model as an iterative cycle, interleaved with the other stages. *Create* is the stage in which one explores, composes and evaluates possible solutions. *Donate* is the dissemination of the results to information resources. This stage may cause new needs to be identified or cause new ideas to be generated by the community who view the solutions, resulting in returning to previous stages in the model.

A Comparison of Creative Process Models

Creative process models have been evolving since at least 1926 when Wallas [48] introduced one of the first. Since then, researchers in the area of creativity have been refining these models more accurately to reflect the process involved in generating creative solutions and to assist in making individuals and groups more creative. It should be noted that such models are not intended to be step-wise linear models, but rather models which show various phases of the intertwined and iterative nature of creativity (Figure 1) – descriptive rather than prescriptive. We now consider the similarities and differences between these different models. Table 1 presents an overview of creative process models.

A common theme with all the models is the analytical stage of preparation. Before the generation of ideas to solve our problem, the individual views relevant information associated with the problem to develop an understanding of what is required in order to generate an acceptable solution. Amabile [2] refers to this as the building up of one's domain knowledge.

Once the individual understands the problem and has built up the relevant domain knowledge, the more specifically creative phase of the creative process model occurs – Idea Generation. Some models [e.g. 48] view this phase as a subconscious activity with stages of incubation and illumination, while others [e.g. 2, 36, 44] believe it to be a conscious activity where the individual deliberately generates new ideas through combining old, existing ideas.

An argument against the subconscious view is offered by Perkins [41] who argues that subconscious mental processes are behind all forms of thinking, and are therefore not specifically related to creativity. Plsek [42] argues that just because we cannot fully describe our subconscious thought process does not mean we are not in control of it.

All the creative process models have an Idea Evaluation stage. Such a stage is an important part of the creative process, as it is through the evaluation of the novel ideas produced during the Idea Generation stage that we judge their appropriateness, and so whether or not they are considered creative.

Shneiderman's [44] creative process model combines the stages of Idea Generation and Idea Evaluation into a Create stage. The combination of these two stages is unusual as all the other models separate Idea Generation and Idea Evaluation. Osborn [36] says that the most important principle of Idea Generation is *deferment of judgment*. Amabile [2] has shown in her studies how evaluation can decrease creativity and therefore the number of ideas which are generated. A decrease in the number of ideas produced will also violate another of Osborn's [36] principles: *quantity is wanted*. Hence, a refinement to Shneiderman's creative process model would be to replace the create stage of his model with two stages which consider Idea Generation and Idea Evaluation separately.

Many of the models [e.g. 2, 36, 48] consider the creative process from the perspective of the individual. Shneiderman [44] describes these as inspirationalist and structuralist views of creativity. *Inspirationalists* focus on the individual coming up with ideas, in a fashion such as the 'eureka' moment – a sudden change in perception giving rise to an idea from the subconscious [32, 48]. *Structuralists* apply more systematic approaches to exploring and transforming conceptual spaces, as described by the creative process models of Amabile [2] and Osborn [36]. Influenced by researchers such a Csikszentmihalyi [9], who emphasises the importance of the social nature of creativity, Shneiderman [44] brings a social influence to the creative process model. The latter *situationalist* view of creativity moves away from the individual perspective on creativity and views creativity as more of a social process, placing more importance on interaction and collaboration with other individuals and the world around us.

Towards a Unified Definition of Creativity

'In our study of creativity in design then we need to examine not only products but also processes and persons' [27]. While the focus of definitions of creativity has evolved over time, from process to person to product, these are all essentially important components of creativity (Figure 2). Each individual, or member of a group, has certain creative abilities; she may explore and transform conceptual spaces, combine matrices of thought to generate new ideas; and these ideas may consist in or lead to the development of a creative product. Previous research has tended to focus on the embodiment of such ideas in other subsequent products, viewing the latter as the 'creative product'. In this research, we focus on creativity as the production of the ideas themselves. In line with Boden [3], we argue that considering the generated ideas as the creative product can help provide a basis for measuring or assessing the nature and extent of the creativity that has occurred.

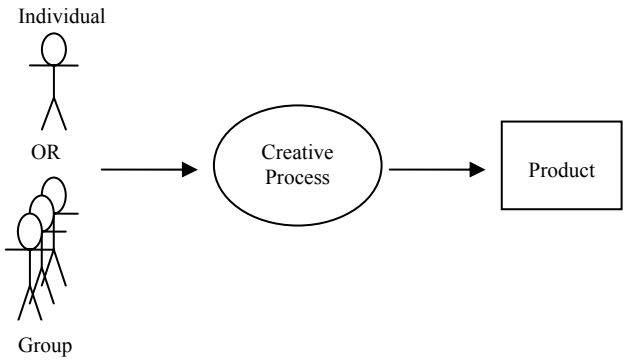

Figure 2 – The components of creativity

Drawing together the strands of previous research, we propose a unified definition of creativity:

'Creativity is the generation of ideas, which are a combination of two or more matrices of thought, which are considered unusual or new to the mind in which the ideas arose and are appropriate to the characteristics of a desired solution defined during the problem definition and preparation stage of the creative process'.

We can make this definition of creativity more specific to a particular domain, such as PD, by forming an instance of this generic definition. To do this, we specify what our novel product is and specify what makes our novel product appropriate and therefore creative. For example, an instantiation of our definition of creativity for a PD software prototyping activity is:

'Creativity in participatory software prototyping is the generation of software design ideas, which are a combination of two or more matrices of thought, which are considered unusual or new to the mind in which the ideas arose and conform to the user requirements defined during the software development process'.

Here, our products from the creative process are the design ideas generated to solve the design problem at hand. A design idea is deemed creative if it is new or unusual to the mind in which it arose (novelty) and conforms to the requirements of the design problem (appropriateness).

ARE MORE HEADS BETTER THAN ONE?

Gennari and Reddy [18] describes the design process as, 'human activity, involving communication and creative thought among a group of participants'. With respect to PD, this creative activity involves stakeholders working

together to generate design ideas that may be implemented to develop a system. Much of the work on creativity to date has focused on the individual [e.g. 2, 36, 48]. However, there is a recent emergence of researchers considering the social aspects of creativity [e.g. 9, 13, 15, 29, 44, 50]. A fundamental question about activities that involve a social component is: what effect does the social nature of this activity have on creativity? For instance, what effect does the collaboration of stakeholders working together have on their creative generation of design ideas?

Osborn [35] suggested that groups following his brainstorming rules as a method of problem solving would generate more ideas in terms of quantity and better ideas in terms of quality. In fact, Osborn claimed that, 'the average person can think up twice as many ideas when working with a group than when working alone' [35].

Taylor *et al* [46] empirically tested Osborn's claim in a study which compared real groups (i.e. face-to-face interacting groups) with nominal groups (individuals working on their own and then collating their outputs to form a cumulative output). Taylor *et al* found that nominal groups produced nearly twice as many non-replicated ideas as real groups – refuting Osborn's claim.

Although Taylor *et al* [46] were the first to contradict Osborn's claim, many in the psychology community have investigated why real group creativity is not as effective as nominal group creativity. Demhis and Valacich [10] stated that over the previous 4 decades, more than 50 studies had shown nominal groups outperforming real groups.

However, why should it be the case that real group creativity is not as effective as nominal group creativity? Paulus and Yang [40] argue that 'the idea exchange process in groups may be an important means for enhancing creativity and innovation'. This is similar to what Osborn [36] emphasizes in one of his four brainstorming rules: 'improving and combining ideas'. McGlynn *et al* [31] acknowledges the *potential* for groups to generate more and better ideas, so why is it that the majority of the empirical investigations performed over the last half century suggest that this potential is not realized?

The Theoretical Potential of Social Creativity

Building on our unified definition of creativity and our previous work investigating the social creative process of PD [33, 34, 50], we have developed a theory that explains the potential of social creativity to support greater idea generation than individual creativity and suggests means by which we may encourage that potential to be realized.

One of the major advantages that real groups have over nominal groups is their shared resources. Fischer [15] argues that 'the unaided individual mind is highly overrated … much of our intelligence and creativity results from interaction and collaboration with other individuals'. Each individual has a domain of knowledge and within this domain of knowledge has a collection of matrices of thought. An individual has only the matrices of thought available in her own domain of knowledge, but real groups can interact with each other, externalizing their matrices of thought and making them available to others [33, 34].

Our theory shows how real groups have the potential to generate more creative ideas than nominal groups by taking advantage of these shared domains of knowledge. By externalizing matrices of thought, more combinations of matrices of thought can be derived, producing more creative ideas. In the following examples we only use two individuals in our groups for simplicity; however the argument holds for larger groups also.

Nominal Group

In our simplest case scenario for the nominal group we have two individuals working independently on a creative problem solving task. Each individual has a domain of knowledge which each contains two matrices of thought (see Figure 3).

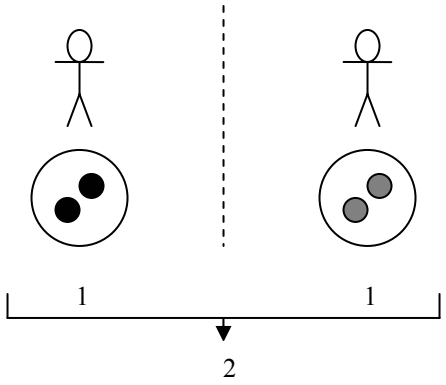

Figure 3 – Creative ideas produced by a nominal group

According to our definition of creativity, each of the individuals can combine her own internal matrices of thought to produce a creative idea. We assume for this simplest case scenario that the combination of these matrices of thought will produce an idea which is both novel and appropriate and therefore considered creative according to our unified definition of creativity. Hence, in this scenario our nominal group generates a total of two creative ideas, one from each participant.

Real Group

In our simplest case scenario for the real group we have two individuals working together (i.e. interacting face-to-face) on a creative problem solving task. As with the nominal group, each individual has her own domain of knowledge each of which contains two matrices of thought (see Figure 4).

The members of the group in this scenario are able to interact with each other and have the ability to externalize their matrices of thought to other members of the group, effectively forming an external shared representation of their matrices of thought [33, 34]. Therefore, within this

external shared representation we have four matrices of thought which can be combined to produce creative ideas. For our simplest case scenario we assume that we can combine each pair of matrices of thought to produce an idea that is both novel and appropriate and, therefore, is deemed creative in accordance with our unified definition of creativity. Hence, as shown in Figure 4, our real group generates a total of six creative ideas.

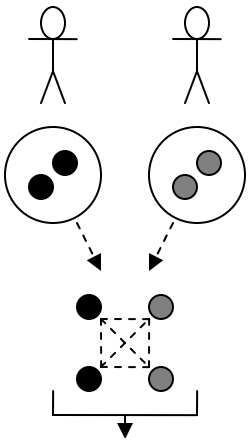

Figure 4 – Creative ideas produced by a real group

Nominal Groups vs. Real Groups

As we can see from our simplest case scenario, real groups have the theoretical potential to outperform nominal groups. The ability for real groups to interact with each other in order to externalize matrices of thought increases the resources available to the group, giving them the opportunity to form new combinations of their matrices of thought and so produce creative ideas. Although some combinations of matrices of thought may not be possible, this is true for both nominal and real groups, making the possible combinations for real groups significantly higher. For this theoretical potential to be realized there need to be effective and efficient methods available for externalizing the matrices of thought and making them available to the members of the group.

Having shown that real groups can theoretically outperform nominal groups, we have to ask why the last 50 years of empirical studies overwhelmingly suggest that real group creativity is not as effective as nominal group creativity. These studies have uncovered three significant social influences that impede social creativity.

SOCIAL INFLUENCES ON CREATIVITY

Many researchers [e.g. 11] have attempted to explain the mass of evidence contradicting Osborn's [35] claim that real group creativity is more effective than nominal group creativity. The three major explanations that have been explored thoroughly by the creativity community are the social influences of production blocking, evaluation apprehension and free riding.

In this section, we describe these interpretations of why nominal groups are more creative than real groups, and briefly discuss what researchers have found about these phenomena. With an understanding of the effect of these social influences on creativity, we can move towards proposing how best to support social creativity to realize its full potential.

Production Blocking

Production blocking is common when ideas are expressed verbally within a group. Verbally expressing ideas is a form of asynchronous interaction, i.e. only one person in a group can express her ideas at one time. The problem with asynchronous forms of interaction with respect to group creativity is that if one member of the group is expressing her ideas, other members of the group are simultaneously prohibited from expressing their ideas. They may subsequently forget their ideas or suppress them because they may feel their ideas are less relevant as time passes. Another problem is that they may rehearse their ideas internally, preventing them from concentrating on what other members say. This renders ineffective the sharing of matrices of thought, the very feature that makes real groups potentially more creative than nominal groups. Finally, if group members are prevented from expressing their ideas as they occur, they may be discouraged from producing further ideas.

Thus, production blocking can have a major negative impact on social creativity. Lamm and Trommsdorff [26] argued that production blocking was the most important cause of nominal groups outperforming real groups. This has been confirmed by Diehl and Stroebe [11] who observed the effects on creativity between nominal and real groups while manipulating production blocking, evaluation apprehension and free riding. The major effect of production blocking on creativity was observed also in further studies by Diehl and Stroebe [12]. However, there are questions about the ecological validity of focusing on verbal interaction, as in many of these studies. In practice, it is very rare for a group to concentrate solely on verbally expressing their ideas and then transcribe them at a later date. It is more common for individuals within a group to note ideas down using notepads or flipcharts as an external shared medium, interleaving such representations dynamically with verbal contributions.

To mitigate the effects of production blocking, researchers have moved towards using synchronous interaction techniques for expressing ideas, such as writing ideas and distributing them around the members of the group. This has been done by writing ideas down on cards [e.g. 40] or by using electronic brainstorming systems [e.g. 10]. However, by altering the method of externalizing ideas the effect of production blocking changes, but the confounding variable of evaluation apprehension is also altered. Writing

ideas down instead of saying them can anonymize the ideas [40], potentially lessening the effect of evaluation apprehension. Paulus *et al* [39] proposes a combination of speaking and typing ideas, since verbalizations lead to more positive feelings about performance [39] and may allow for cognitive stimulation by others' ideas. This raises the interesting issue of what effects the number and type of available communication channels have on creativity.

Evaluation Apprehension

Although one of Osborn's brainstorming rules is 'the deferment of judgment', members of a group may still fear criticism from other group members, preventing them from expressing ideas and externalizing their matrices of thought. The negative effects of evaluation apprehension reduce the quantity of ideas produced in groups and in turn have a detrimental effect on creativity.

Researchers [e.g. 8, 11] have performed studies observing the effects of evaluation apprehension by manipulating the perceived expertise of group members. In a study by Diehl and Stroebe [11], evaluation apprehension was manipulated by comparing groups who had judges assessing their work, or where members were informed that others within the group had expert knowledge in the field of the problem they were given – *the high evaluation condition*. Within *the low evaluation condition*, the group's work was not assessed and all members of the group where perceived as equals. The results of this research showed that groups under the high evaluation condition produced significantly fewer ideas than groups in the low evaluation condition.

However, contradicting these findings was a study by Maginn and Harris [28] who manipulated evaluation apprehension on individuals working on brainstorming tasks and found no effect on the productivity of ideas. Maginn and Harris [28] argued that their judges did not produce significant evaluation apprehension because they were not in the same room as the subjects. So perhaps evaluation apprehension is actually induced by physically present peers rather than remote judges. Diehl and Stroebe [11] looked at the difference between judges and peers in their evaluation apprehension condition but failed to find any significant differences. However, there was a tendency for peers to induce higher evaluation apprehension for controversial problems, whilst judges caused higher evaluation apprehension for uncontroversial problems.

To overcome the effects of evaluation apprehension, it has been suggested by some researchers [e.g. 40] that anonymous means of expressing ideas remove an individual's identification with an idea and therefore help encourage people to express their ideas as the fear of criticism is removed. This anonymous communication has been a key feature of electronic brainstorming systems [e.g. 10, 47] which allow ideas to be pooled without identification of the originator. This raises interesting issues of the effects of public, social and private interaction on creativity.

Free Riding

Free riding, otherwise known as social loafing, is the result of group members' becoming lazy, relying on other members in the group and not contributing as many ideas as they could. Diehl and Stroebe [11] argued that free riding was a result of pooled assessment in groups compared to individual assessment when working alone. Some group members expect their ideas to be pooled and therefore assessed as a group. Subjects working alone expect their individual effort to be monitored and are thus unable to avoid their poor performance being detected.

In a study performed by Diehl and Stroebe [11] to identify the effects of free riding in real and nominal groups, groups who were under the condition of personal assessment (each individual being assessed individually) produced more ideas than groups who were being assessed collectively (the group being assessed as a whole).

How then can the effects of free riding be reduced? Diehl and Stroebe [11] highlight identifiability in groups – the larger the group, the higher the temptation to free ride. If subjects were identifiable with their ideas, they would be less likely to free ride as their lower performance would be apparent to other group members. However, as noted above, it is desirable to remove identification from ideas in order to mitigate evaluation apprehension. Hence, there is a trade off between free riding and evaluation apprehension. This trade off can been seen in a study by Paulus and Yang [40] who claimed that writing ideas provided anonymity, but made subjects use coloured pens to identify them with ideas in order to reduce social loafing. It is an open question whether evaluation apprehension or free riding is more detrimental to creativity.

Paulus [37] refers to social stimulation – encouraging a high motivation level in groups by increasing accountability for individual performance. Various studies [e.g. 38] have shown that providing groups with a comparison standard increases their performance and providing explicit feedback about individual performance also increases performance of group members. It is unclear what is the best way to provide such explicit feedback, and so increase individual and group performance by reducing free riding, while not causing a negative effect on creativity by increasing evaluation apprehension.

CONCLUSIONS AND FUTURE WORK

In this paper we have built upon work from various research communities to explore the nature of creativity with respect to design. We have reviewed changing definitions of creativity over the past several decades and consolidated this work in a new unified definition of creativity that incorporates the essential components of the creative individual, the creative process and the creative product.

Design is in general a collaborative and social process, with few designers working entirely in isolation. Hence, in treating design as a creative process, we must understand it as a *social* creative process. We argue that theoretically social creativity should be more productive than individual creativity, and so design teams should be more creative than individual designers working alone.

However, there is a considerable body of experimental evidence that suggests that real groups are less creative than nominal groups. This dampening effect on social creativity is primarily the result of three interacting social influences: production blocking, evaluation apprehension and free riding.

Our current work is investigating how we can mitigate the main effects and interaction effects of production blocking, evaluation apprehension and free riding in order to allow social creativity to realize its theoretical potential. We are currently conducting experiments to investigate how this may be achieved. Further research will follow on from this to incorporate our findings in guidelines for collaborative design practice.

In our ongoing work, we are tackling several questions, including: what effect does the number and type of available communication channels have on social creativity?; what are the effects of public, social and private interaction on creativity?; what are the optimal means to increase individual performance by reducing the effects of free riding while not inhibiting creativity by increasing evaluation apprehension? With answers to these questions we can look towards supporting social creativity and improving the practice of design, in particular participatory design, leading ultimately to more usable and useful products.

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