CAN A VIRTUAL DESIGN ENVIRONMENT ENHANCE GROUP CREATIVITY AND THE USE OF STIMULI?

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It is a common perception that creativity for design is best performed in a collaborative, group environment. Group idea generation and brainstorm sessions are of widespread practice across industries. This technique remains popular despite numerous studies highlighting the inefficiencies of generating idea in such a fashion. This paper puts together three ways of improving the group brainstorming session; working in nominal groups, using stimuli and working in a virtual team. The final sections sets out recommendations for a future virtual design environment capable of supporting group brainstorming.

Keywords: Group creativity, Virtual design teams, Creative stimuli.

1. INTRODUCTION

It is a common perception that creativity is a topic whose importance is accentuated in a collaborative, group environment. Group idea generation and brainstorm sessions are of widespread practice in all industries. The most common technique used is a type of free thinking brainstorming, though Osborn's original rules are rarely recited or adhered to. This popularity remains despite the numerous studies highlighting the inefficiencies of generating idea in such a fashion. The characteristics and inefficiencies of such sessions are discussed in Sec. 2. One method proposed to counteract the above mentioned inefficiencies of brainstorm sessions is to work in a virtual environment, Sec. 3. Another important area or research in the enhancement of creativity is the use of various types of creative stimuli which is summarised in Sec. 4.

Distilled from this study are a number of observations regarding the positive and negative affects of the use of creative stimuli on a group's output. Section 5 then summarises the findings of Secs. 2, 3 and 4, into a table of advantages and drawbacks. This paper is deliberately speculative, aiming to stimulate discussion and further research, exploring whether the advantages of working in a virtual environment, can be used to improve brainstorm sessions and ends with some recommendations for such a virtual computer supported creativity system that may go some way to achieve this.

2. GROUP CREATIVITY

Perhaps the biggest debate on the topic of creativity is in the role and effectiveness of groups in the process. Many studies have been conducted in this area with conflicting results and explanations. Over the last decade as a result of numerous empirical studies it has been shown, to the surprise of many, that nominal groups (individuals working separately) outperform real groups in terms of the collective creative performance per group member. This section will explore this from a theoretical perspective,

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first introducing the creative cognition operations of individuals and group members, Sec. 2.1, before the theoretical underpinnings of group creativity, Sec. 2.2.

2.1. Creative cognition

While the group and the environment may have a large affect on the creative outputs of a group, it is ultimately the individuals within a group that are responsible for the creative outputs or ideas. It is for this reason that creative cognition at the individual designer's level should be central to any research in this area [1].

Creative operations, such as associations, analogy, application and combination have been suggested by numerous authors. In a comprehensive review, Welling [2] suggests that there are but four mental operations in creative cognition: application of existing knowledge, analogy detection, combination generation and abstraction discovery.

The application of existing knowledge is described as the use of existing knowledge in its habitual context. It is suggested that creativity is required in fitting reality into a pre-existing framework. This would include the use of mathematics, modelling languages, parametric manipulations, and various forms of analysis helping to activate further knowledge. However, this is considered by many authors to be a routine activity and thus non-creative.

Analogy detection is the recognition that an old situation is in some way similar and applicable to a new situation. This is important for both creativity in engineering design where a solution principle may be used for a new technology, and for the arts where an analogy or metaphor can be used to enhance a description.

Combination generation is where two concepts, functions, or ideas are combined or merged together to form an enhanced version. A modern example would be in the combination of the mp3 player, phone and camera, or a hybrid car.

Lastly, abstraction discovery is a level of insight an understanding of how things work or relate to each other. It is of large importance to defining a problem or understanding a task, which is essential to both the creative process and the design process more generally [1]. This operation is thought by Welling to be both, overlooked by traditional literature and of great importance to creativity.

2.2. Theoretical underpinning of group creativity

This section will describe the creative potential of group creativity by using a model of idea spaces. In this paper the idea space of an individual represents the set of ideas that an individual is theoretically able to produce with his / her existing knowledge. If we consider Figure 1, person A has an idea space of A, within a potentially infinite total idea space. If person B and C join to form a group the idea space will merge giving an enlarged idea space, but with some overlap and repetition of ideas, as shown by the intersections.

Figure 1 implies that a greater number of individuals are of benefit, where each additional member enlarges the potential idea space. However, it is not clear whether group members should work together as a real group or separately as individuals, in a nominal group, and then pool their ideas at the end.

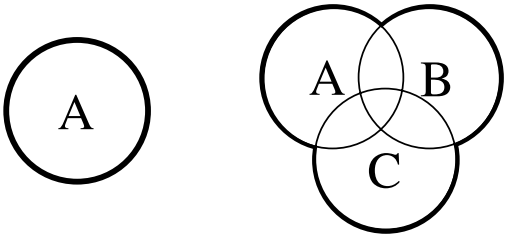

Figure 1. The idea space for groups and individuals.

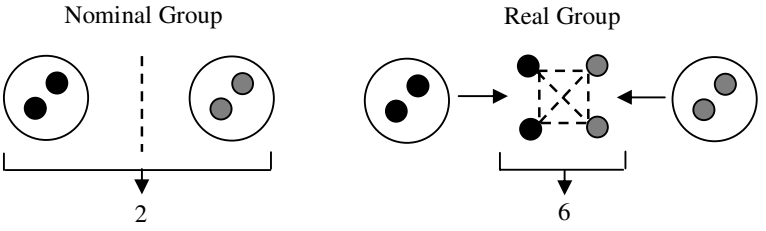

Figure 2. Idea combinations for nominal and real groups [3].

Working as a collective, or real group, has some benefits, when relating to the Welling's four mental operations in creative cognition. Primarily, the work of one member, whether that is the application of existing knowledge, drawing analogies or discovering abstractions, is witnessed by all other members and so can act as a stimulus for them to work from, prompting new directions of thought and ideas for all members. But it is in combination generation that a group can make a large theoretical difference.

Warr [3] suggests that an increased number of ideas may be had by combining 'matrices of thought'. By the simple combination or union of suggested ideas, groups should in theory have huge advantage over individuals. Essentially what Warr is suggesting is that individuals create ideas by combining different 'thoughts' together into a finished article. These thoughts can be combined with any other thoughts, so the more produced, the more combinations of finished ideas are possible, Figure 2.

In Figure 2, the situation on the left represents two people working in a nominal pair, each has two different ideas in their idea space, these then combine into two different design concepts. On the right is the same situation except the two people work as a real pair and by combining matrices of thought they are able to produce six final design concepts.

2.3. Why real groups underperform

Considering the theoretical potential of real, collective groups over individuals, it seems strange that they exhibit relatively poor performance. This has been put down to a number of factors such as production blocking, evaluation apprehension, free riding and fixation.

Production blocking is attributed to real groups as members have to wait in turn to voice their ideas. Although it can be argued that these ideas have to be voiced at some point during the process in order to evaluate them, it would be better if it did not disrupt the creative flow of individuals.

Evaluation apprehension is a serious problem. Traditional brainstorming tries to gloss over this problem simply by stating no idea is a bad idea and members must defer judgment. However, in reality this is not enough as members can be silenced due to the fear of ridicule and judgment.

Free riding is a motivational issue. In groups of a certain size some members are unmotivated to contribute while the rest of the group is maintaining and adequate quality and frequency of ideas. These results in some member partaking in 'social loafing' letting other do the work.

The final recognised drawback of working in real groups is fixation in the form of group think. Although working in teams is often seen as a good way to avoid individual fixation, working in real groups can see a tendency to revert back to favoured concepts, shared levels of abstraction and linear rather than lateral thinking.

3. THE CREATIVITY OF VIRTUAL DESIGN TEAMS

A virtual design team is one in which the participants are physically separated from each other, perhaps even working in different countries and time zones, who collaborate together on design activities, typically using modern computing and communications technology to facilitate and support these actions. Although virtual teams have received substantial attention by researchers and practitioners over the last years, some of the issues that affect their effectiveness and performance have been scarcely investigated; and creativity constitutes one of these currently under-researched issues. Similarly,

although virtual teams are viewed as offering the opportunity for innovative solutions to problems, little is known about how to best utilise diverse expertise in virtual teams and this constitutes an important gap in knowledge.

Virtual teams are emerging as a response to the need for global collaboration and technological advances have played a central role in enabling this. In the beginning, virtual teams relied exclusively on asynchronous computer mediated communication, predominantly the use of email, although technology developments, such as video conferencing, now allow for synchronous real-time interaction and collaboration [4]. These technologies may compensate for some of the communication difficulties and negative effects associated with physical separation. Virtual teams are also known as computer-mediated, dispersed or distributed teams in the extant literature. In order to discuss the benefits of virtual teams in this paper, a common definition must be given:

"Groups of geographically and organizationally dispersed co-workers that are assembled using a combination of telecommunications and information technologies to accomplish an organizational task" [5].

3.1. Benefits of Virtual Teams

Virtual working and by association virtual teams have a number of important recognised benefits, both to employees and to the employer in terms of flexibility of working hours and an employee's ability to work on a number of different projects concurrently [6]. Rice et al. [4] point out a number of benefits of virtual teams, including: increased productivity, better outcomes and reduced relocation costs. By working virtually, a team can more easily involve members from across company departments, suppliers and contractors, potentially spread around the world, receiving immediate feedback from distant locations and operations. This gives companies the opportunity to access the best-qualified individuals worldwide and thus capitalise on the expertise of human capital based in different locations whilst also increasing team diversity by involving people previously unattainable [7]. It is theorised that increasing the diversity of the people involved, in terms of background, culture and expertise should expand the group's idea space and reduce idea overlap, as shown in Figure 3.

However, the emergence of virtual teams in the workplace raises challenges for the participants and their managers. For example, a major obstacle with virtual teams is whether trust can develop among members who although work together, might not know each other or never meet physically [8]. The following section discusses some of the main challenges encountered in virtual teams, from management, information systems, and organisational literature.

3.2. Drawbacks of Virtual Teams

Some of the major challenges facing virtual teams are as follows: reduced member awareness, isolation, reduced richness of information, miscommunication, new trust dynamics, greater conflict, and cultural differences [4, 9].

Bell and Kozlowski [7], on the other hand, highlight the complex nature and structure of different types of virtual teams and suggest different types of leadership, such as shared or distributed leadership

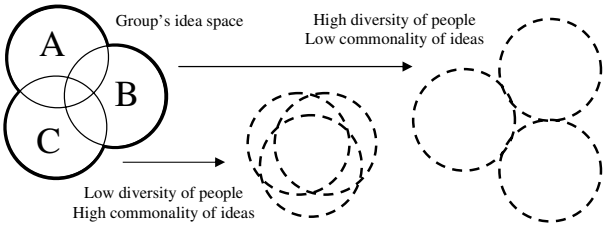

Figure 3. A visual representations of the advantages of having a high diversity of people.

as being more effective. Another issue which can complicate leadership and power structures within the virtual team is that of the emergence of subgroups, namely groups of individuals who might be physically collocated within the wider virtual group and can therefore exert a stronger voice within the whole team [10]. Lastly, media richness theory, which describes communication technologies as having different degrees of richness, with regard to the personalisation, cues, and feedback they can afford. The richness of the media used is linked to the quality of critical thinking in virtual teams [11].

To counter many of these drawbacks, research and industrial practice has begun to look at teams that operate in part virtually and in part face-to-face, thus forming hybrid teams. To this end, when conducting the face-to-face phase at the beginning, co-workers may establish high level of trust and overcome one of the biggest limitations of working in virtual teams.

4. THE USE OF CREATIVE STIMULI

A considerable amount of research has been carried out into what makes creative people creative, from the effects of incubation periods, where the subconscious mind is given time to 'think' over a problem, through to the use of "loafing about" and "humour" [12]. In general, research has shown that the process of generating ideas is enhanced by providing three main elements; nurture, freedom and time [13].

However engineers and designers are often placed in situations that, due to industrial constraints, require them to generate ideas and concepts more quickly, with the quality of these ideas being compromised by the shortness of time in which they are to be produced [13]. It has been demonstrated empirically that exposure to visual stimuli at the conceptual design phase, with or without instructions to make use of such stimuli, has a positive effect on idea generation [14], Figure 4. As a result the use of creative stimuli and tools has propagated throughout industrial design practice as a way of improving idea quantity and quality in limited time frames, with the preferred creativity tool being the traditional brainstorm.

It has been said that creative ideas are new and unexpected combinations of existing knowledge 'items' in memory and new information 'superimposed' on them [14]. Anecdotal evidence suggests that designer's store, physically or in their memory, visual images and artefacts that they consider may potentially be helpful as sources for future design ideas. Several design consultancies have embraced this idea and over many years built up an extensive collection of different materials, mechanisms, toys and gadgets that they have formed into a single reference library and inspiration source. One consultancies collection has in fact gotten so large that they now even employ a full time member of staff just to maintain and archive it, making it accessible to all employees to use.

Goldschmidt neatly demonstrates this phenomenon of collecting potential stimuli with a quoted description of Le Corbusier's Design process:

"His mind was well stocked with ideas, devices, configurations and images gleaned from tradition, from painting, from observation, and of course his own earlier works... at the right moment images would flow to the surface where they would be caught, condensed and exteriorized as sketches."

Despite considerable research into the creative process, there has been limited exploration of what format stimuli should take, with the assumption being that visual stimuli, whether it's video, images or

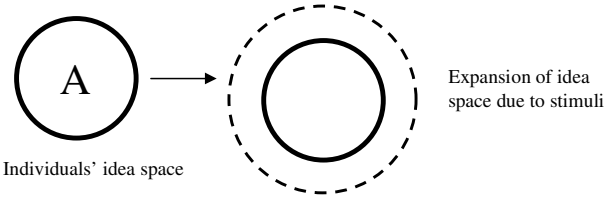

Figure 4. A visual representation of the advantage of using stimuli.

physical artefacts, are best since designers tend to work in a visual environment. This does not have to be the case, written texts and descriptions can also be effective methods of inspiration, communicating ideas that may be impossible to express through visual images and reducing potential stimuli drawbacks such as 'fixation' [14]. As part of the process of rooting through and searching for new stimuli, either physically or mentally, designers can often become attached to ideas, which they develop further at the expense of searching for better ones [15]. This attachment to an idea is known as fixation and can greatly reduce the level of idea generation and creativity of a designer's performance.

The use of video stimuli is commonly collected as part of a pseudo-ethnographic 'quick and dirty' study [16], where a researcher videos and records the actions of users in different situations, perhaps asking them to describe their experiences as they use a particular product or service. These studies are often either done by trained ethnographers who then report the findings to the design team or by a team of ethnographers and designers together, which greatly helps to focus the study on the design requirements. The simple act of immersing the designer in the data collection process can act as a strong creative stimulus, but the amount of time required to do this can make the process expensive and impractical.

In order to gain some insight into the use of video and text based stimuli and how information could be best introduced into a creative process, a design experiment was undertaken that looked at the effects of introducing information in different formats to a design team. A comprehensive description of this experiment is available in Elias *et al*. 2010 [17], but in summary it involved 15 engineering designers, arranged into five teams with three designers in each and starting with a similar base level of knowledge and training. The teams were given identical design briefs and a single hour to generate as many ideas as they could, using any design technique they were familiar with. After 20 minutes, four of the five teams were given additional information, in different formats, to help them focus their ideas on the design brief, one of these teams however received "placebo" information of no value to the exercise and the fifth team was left as a "control" group.

The results from this experiment ran contrary to the established benefits of using stimuli in creativity. The control group, with no information, produced many more ideas than the other teams. The five teams collectively generated 207 ideas in a single hour, the equivalent of 3.45 ideas every minute. The best team generated 62 ideas and the average for all five teams was 41 ideas in the hour. An explanation for this is that the implementation of a stimulus needs to be carefully managed and facilitated, in order to avoid fixation or act as a distraction or interruption. The team with no additional information effectively worked without interruption for the whole hour whereas the other teams all had to stop and process new information, which in some cases took up to 15 minutes of their time to do so. In terms of idea quality, the control and placebo teams performed equally badly with the three remaining teams scoring higher.

5. REQUIREMENTS OF A NEW VIRTUAL ENVIRONMENT

In this section the findings of the previous discussions are summarised into a table of advantages and disadvantages in comparison to a standard traditional group brainstorm creativity session. The aim being to develop a set of requirements for a new virtual design environment that can build on the advantages of each approach and negate many of the disadvantages.

What is desired is a design environment that encompasses all the advantages of traditional brainstorming, with those of using nominal groups, stimuli and set in a virtual environment with the ultimate aim of benefiting the creativity of design teams in international organisations.

Traditional Brainstorming (real, co-located groups)

Advantages	Disadvantages
– Simple to organise	– Can cause group think
– Good number of ideas generated	– Often involves only a single level of abstraction
– Quick result	– Members can 'free ride'
	– Production blocking

	– Can cause critical evaluation – Not as effective as it should be
Brainstorming with Nominal Groups	
Advantages	Disadvantages
– More effective than traditional brainstorming – Individuals work in a focused way – Can cover a wider idea space	– No real time 'matrices of thought' or combinations of ideas between people – No real time sharing of ideas for evaluation
Virtual Design Teams	
Advantages	Disadvantages
– Can include a high diversity of people – Can include international participants – Can include different global departments – Offers access to the best people – Cost effective to organise and run – May operate synchronously or asynchronously	– Language & cultural barriers are harder to overcome – Unfamiliar atmosphere, process and power structure – People can be ignored – Does not support socialisation – Lack of trust and identity – Media choice limitations
Brainstorming with Stimuli	
Advantages	Disadvantages
– Memory prompting – Can remove fixation – Analogy prompting – Can create new trains of thought, widening the idea space	– Can create fixation – Can cause group think – Can be an interruption – Can be a distraction – Can take a long time to prepare

6. RECOMMENDATION FOR A POSSIBLE FUTURE VIRTUAL DESIGN ENVIRONMENT

For this section, some assumptions about the level of technology available to the participants must be made; each participant should have access to an internet enabled computer, web cam, microphone and a computer linked sketch pad or similar, that can record and translate all sketches and notes into a computer image or text that can be viewed and edited by other participants.

With this base level of technology available to each member of the virtual environment, it is now possible to make recommendations for a computer system that could support brainstorming and design creativity in a virtual environment. Due to space constraints in this paper, it is not possible to go into detail but it is the intention that this deliberately limited list of recommendations be a point of discussion and stimulus for further research and development in this field:

Session Control and Facilitation Support

The leadership or facilitation of any brainstorming session is an important but difficult task, becoming harder still when done virtually. The facilitator or leader is responsible for steering the process, bringing clarity and order to discussions, giving people equal time to voice their thoughts and often creating a summary of the outputs. In this context, a computer system could:

– Provide a live translation system if language barriers become an obstacle
– Automatically record all ideas generated, producing a summary of ideas generated
– Allow participants to flag their opinion on an idea, editing and developing each other's ideas

– Provide an idea time line and 'development tree' showing how an idea or concept evolved throughout the session.
– Notify the facilitator when a person was 'free riding' and not contributing to the session.
– Give people the opportunity to virtually 'raise their arm', alerting the facilitator that they would like to speak or contribute.

Idea Generation and Creativity Support

– Automatically detect when the rate of ideas has stagnated and provide stimuli
– Encourage matrices of thought by making the ideas of one participant available to all others.
– Automatically detect when the group is suffering from 'group think' and fixation and cut communication channels, moving the group into a nominal group for a time period.

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