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STIMULATING CREATIVITY: A MORE PRACTICAL ALTERNATIVE TO TRIZ

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ABSTRACT
Being able to stimulate creative ideas on demand is a desire for engineers, scientists and artists alike. Creative stimuli in the form of the TRIZ inventive principles have shown much potential, however the industrial uptake of such stimuli is limited due to the practicalities of using this TRIZ approach. The following paper proposes a practical alternative to producing creative stimuli termed Sweeper and tests both approaches during industrial brainstorm sessions. The results showed that all creative stimuli tools were of benefit. The Sweeper tool performed best in terms of the rate of idea production and levelled the TRIZ tool in terms of the quality of ideas.

Keywords: Design, Creativity, Stimuli, Information management

1 INTRODUCTION
It has become widely accepted that business survival and prosperity is strongly attributed to the ability to innovate [1-4]. In order to harness this ability, many engineering companies have specific innovation and R&D departments, developing new products through strategically constructed innovation processes. However, ultimately, "innovation depends on the generation of creative, new ideas" [5].
This paper describes research using several industrial case studies which are analysed to compare the performance of 4 approaches of providing engineers with creative stimuli. The research took place within the Innovation Hub at a large multi-national packaging company that design mostly metal packaging (tins, cans, pouches, some bottling: mostly for the food and beverage industries) and the design of associated machines and manufacturing processes. The following section will provide the reader with some background into the area of creativity in engineering design.

1.1. The nature of creativity in industry
The process of generating creative ideas is enhanced by providing creative individuals three main elements; nurture, freedom [6] and time [7, 8]. However, such is the nature of industry that time pressures often dominate, requiring rapid idea and concept generation from engineering designers. The need for increased quality of ideas is compromised by the time in which they are to be produced. Thus creativity tools are required to aid the designer to produce more 'creative' ideas in shorter periods of time.
It could be argued that a creativity support tool should aid a designer during any phase of the creative process, either; as a task framing tool during the analysis phase; as an idea generation tool during the generation phase; or as a selection or evaluation tool in the evaluation phase [9, 10]. The focus of this research is on the generation phase. Though there are many techniques and tools for generating creative ideas, brainstorming is undoubtedly one of the most popular creative techniques used by organisations [11]. However, this technique does not come without its limitations [12].
In recent research of several industrial case studies, it was shown that the rate of idea generation during brainstorming decreases slowly and steadily after 30 minutes, with a dramatic decrease in idea quality after just 20 minutes [13]. It was later shown that the introduction of stimuli into the brainstorm sessions was beneficial and helped to maintain idea frequency and quality [14]. This paper will concentrate on what can be thought of as "generation tools" and in particular those which propose information to the designer in the form of creative stimuli. One existing method that provides such stimuli is the contradiction matrix and the creative principles from TRIZ [15].

1.2. The rise of TRIZ

Of recent years, headlines into the research of creativity in engineering design have been dominated by the introduction of TRIZ, the theory of inventive problem solving [15]. This theory is endorsed by a large quantity of dedicated, enthusiastic researchers and practitioners in the field. These so called 'Trizniks' [16] also treat the theory as a 'philosophy' [17] and even a 'quasi-religion' [18]. TRIZ consists of a large number of tools which focus on the clarification of task and conceptual design stages of design. The application of these tools are characterised by 'TRIZ like thinking' suggesting an unconstrained and idealistic approach and 'TRIZ like solutions' hitting at the route of problems at minimal cost by using the readily available resources.

It is believed by the authors that while many of the tools contained within this theory are created by the re-branding of age old creativity tools and techniques, the contradiction matrix and inventive principles at the centre of TRIZ are truly ground breaking and worthy of the hype. The matrix works by abstracting the problem to a generic problem, then selecting a generic solution from the results of an extensive patent review. This generic solution is in the form of an inventive principle acting as stimulus to the engineer, inspiring a potential solution to the specific problem at hand.

This method of problem abstraction and generic solution finding is well accepted and grounded in the cognitive psychology of creativity. However, the practical use of the contradiction matrix has its limitations. The method is often seen as time consuming and restrictive to the more creative engineers. Finding the generic problem can be very difficult and the inventive principles are often irrelevant or too specialised. The authors also believe the matrix to be more of a problem solving tool rather than a product design tool.

1.3. Contents of paper

In Section 2 the authors will state the important theoretical work surrounding this study and in particular the stimuli tools under comparison, the success criteria and the research hypotheses. In Section 3 the Sweeper tool is introduced followed by the experimental method (Section 4), the results (Section 5) and the discussion of results (Section 6)

2. THEORY

During this section the different creative stimuli tools are categorised within a matrix (Section 2.1) before each tool is explained in Section 2.2. The creative performance criteria by which to evaluate the tools are then described in Section 2.3, before the research hypothesis in Section 2.4.

2.1. Creative stimuli tool matrix

There are few categorisation schemes within the literature for the different types of creative stimuli. Previously, related schemes have described the types of stimuli in terms of function, behaviour, form and knowledge entities [19]. Others have categorised the stimuli as heterogeneous or homogeneous [20] with respect to the previous idea produced. However, none of the research from the literature, nor any of the commercial creativity tools reviewed have considered the potential of stimuli generated internal to the industrial domain [21-23] which should be linked to the distance of abstraction of the stimulus from the problem. This paper will thus analyse the potential of stimuli generated from information sources internal to the industrial domain in which the design task was set.

The categorisation of stimuli tools used in this paper is described by a 2x2 matrix (Table 1) constructed from the following two categories:

Source: where the Stimuli are drawn from. This can either be internal or external to the industrial domain in which the task is set.

Retrieval: how specific the retrieval mechanism is to the task. The Stimuli can either be retrieved by random, or, guided by an abstracted framework making it more affective (theoretically) to the task at hand.

Table 1. Matrix of creative stimuli tools

		Retrieval	
		Random	**Guided**
Source	**External**	A	B
	Internal	C	D

The potential of internally generated stimuli will be validated through the performance of creative stimuli tools in matrix positions C and D (Table 1) relative to the externally generated creative stimuli tools in positions A and B (Table 1). In particular, the guided Sweeper approach (section 3) in matrix position D will be compared against the other stimuli tools. Each of these tools is further detailed in Section 2.2.

2.2. Creativity tools within the matrix

The four different categories (see Table 1) of creative stimuli tool will now be detailed along with example of the stimuli retrieved (Table 2). Table 2 shows how each type of stimulus slide was constructed to display similar amounts of pictorial information, usually with some supporting text.

Type A

This tool draws random stimuli from sources external to the industrial domain in which the problem is set. From the Zusman et al. [24] matrix, typical Type A tools would include 'serendipity', 'forced analogy', 'relational words' and most representative 'random input'. To simulate a Type A creative stimuli tool for purposes of experiment, images were taken randomly from a popular online image bank and displayed singularly on electronic slides (see Table 2).

Type B

This tool intelligently guides the user to stimuli from sources external to the industrial domain in which the problem is set. This type of tool was made popular by TRIZ contradiction matrix [15] (see Section 1.2). However, there are several other creative stimuli tools that use guided stimulus retrieval such as FuncSION [25] and Animal Crackers [26]. To simulate a Type B creative stimuli tool the TRIZ contradiction matrix will be used and stimuli in the form of inventive principles will be retrieved (see Table 2 for an example).

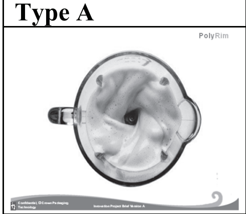
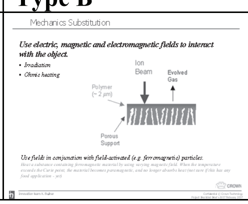
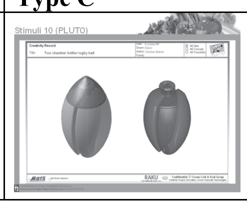
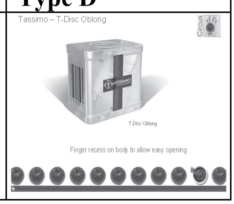
Type C

The theoretical Type C tool draws random stimuli internal to the industrial domain in which the task was set. Currently no official Type C tools exist, though they are commonly simulated naturally through designer's behaviour. It is common to look at previous designs, particularly through catalogues and prototypes from within the domain. In order to represent this type of tool, random concepts were selected from within the huge repository of previous design projects stored by the case company and used as stimuli (see Table 2).

Type D

The theoretical Type D tool is intelligently guided to stimuli internal to the industrial domain in which the task was set. To simulate a Type D tool the Sweeper tool was used (see Section 3 for details). An example of the retrieved stimuli can be found in Table 2.

Table 2. Examples of Stimuli retrieved by each tool type

Type A	Type B	Type C	Type D
			

2.3. Creative performance criteria

The creative performance of a group is often measured using two dependant variables of; number of ideas [20, 27], and, idea quality [28]. From an analysis of large quantities of literature, it would appear that the creative quality of an idea is generally defined by the criteria - 'originality' and 'appropriateness' to a task [29]. In earlier research the author(s) proposed the addition of a third criterion: unobviousness of an idea in relation to the task [30]. The performance criteria will enable the authors to determine the performance of each stimuli tool in terms of creative idea generation. In order to measure these success criteria several objective measures were used (see Table 3) which were observable from the industrial based case studies detailed in Section 4. However, as this paper regards the practical implications of the tools, the analysis will focus on the appropriateness of the ideas. In this study, the 'appropriateness' was measured by linking the ideas that came out of brainstorming session (*alpha*- and *beta*-ideas, figure 6), to the ideas that were subsequently presented at the company's first stage-gate (gate-ideas, figure 6). The study does not trace the gate-ideas through to final implementation.

Table 3. Dependant Variables (Success Criteria)

Variable	Definition
Frequency	How quickly ideas are being produced, or how may ideas are produced in a given time.
Originality	Whether the idea is related to a completely new concept (original) or not (routine).
Appropriateness	Whether the idea is disregarded (inappropriate) or is selected for further exploration.
Unobviousness	Whether the idea was generated quickly (obvious) or after a longer period.

2.4. Research hypothesis

In previous work [10] it was shown that creative design outputs are dependent on creative ideas at differing points of the design process. It was also proposed [30] that an idea must be deemed unobvious (as well as original and appropriate) if the goal is to be 'innovative' or to establish intellectual property. Therefore, the information used to create the idea must be both unapparent and relevant. This proposition linking unapparentness to creative idea-generation poses a contradiction. The closer (in terms of levels of abstraction) the stimulus is to the domain and task, the more apparent it will become, thus the appropriateness of the ideas should increase but the unobviousness should decrease. If, on the other hand, the goal is to produce the best possible solution, then 'unobviousness' does not matter. So why would stimuli generated internally to the industrial domain be useful for creative stimulation?

This question can be simply answered in term of stimuli relevance to each particular project goal. It is proposed that the external stimuli tools from categories A and B (Table 1) will produce ideas that are more unobvious than tools C and D, respectively. However, it is also proposed that tools C and D will produced a higher number of appropriate ideas due to the stimuli being relevant more often. Also, from a practical standpoint, how unobvious the idea is has no bearing on how good the idea is. It is therefore important that stimuli be only unapparent enough in order to prompt an idea that it is sufficiently unobvious that it would not have otherwise been thought of.

It is also hypothesised that the guided approach to retrieval as apposed to random retrieval of the stimuli will prove to be beneficial from either source. However, it is also hypothesised that the source of the stimuli will be more important than the method of retrieval.

3. THE SWEEPER CREATIVE STIMULI TOOL

The Sweeper tool was the name given to the tool being implemented by the case company. This was originally called Information Management for Creative Stimuli (IMCS) tool in a previous publication [14]. It comprises of three major dimensions, a search dimension, a return dimension and a store dimension (see Figure 1).

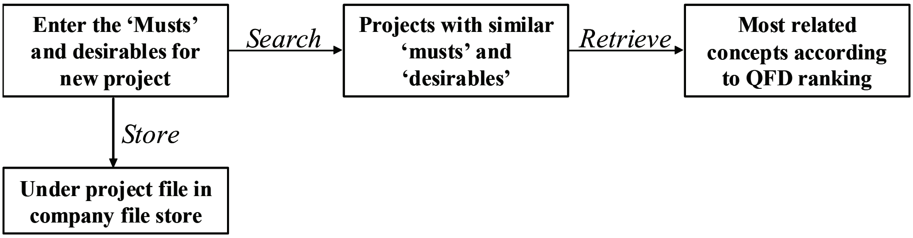


Figure 1. Customised Search, Retrieve and Store approach of Sweeper tool

Though the tool was manually simulated using the principles behind the search, store and retrieve dimensions for the purpose of this study, an automated version is foreseeable. The automated version is currently being prototyped and is described in the following sections (3.1-3.4). The Sweeper approach creates a link between the current problem to previous problems by comparing 'musts' and ‘desirables’ from the design specifications at the host company. This is comparable with the TRIZ contradiction matrix, which uses abstracted design contradictions to link the current problem to previous problems. Though there may be several methods by which to recall stimuli in an intelligent, guided manner, the method detailed below is one example providing a repeatable simulation of a Type D tool.

3.1. The search dimension

New project brief documents (Figure 3) are constructed from standard brief templates (Figure 2). On the construction of a new brief, musts and desirables are entered and linked to pre defined categories. To execute the Sweeper approach a search would be undertaken through the project files to find other project briefs containing the most accurately matched musts and desirables. For initial experimentation purposes this was undertaken by key word searching through the project briefs (Figure 4).

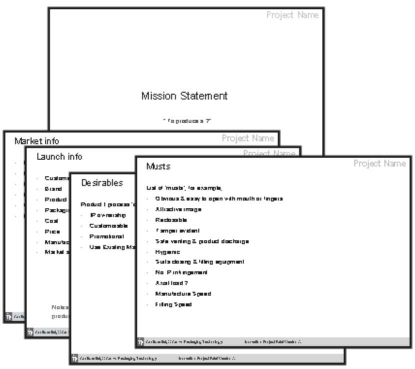


Figure 2. Brief templates

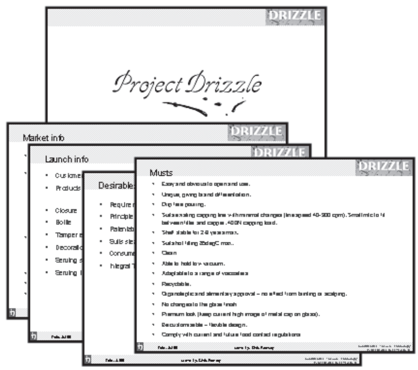


Figure 3. New briefs

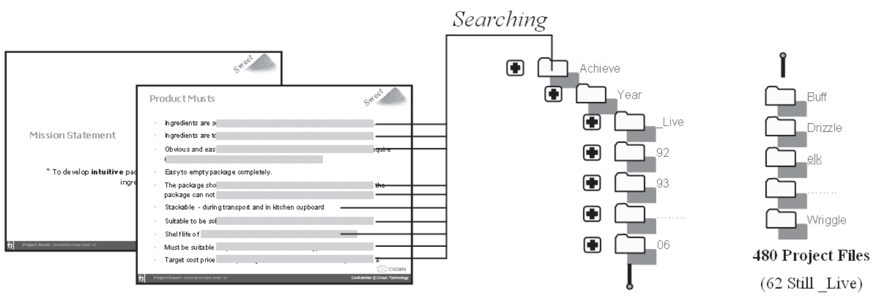


Figure 4. Searching for related project briefs

3.2. The retrieve dimension

Once the projects are identified from the search they are ranked as to how many musts and desirables were matched. As a secondary ranking, relatively rare requirements (for example ‘must enable one hand opening’) are ranked more highly than those which are more common (such as ‘must be hygienic’). Once the most relevant projects are identified the concepts are obtained from within the project files. The selected concepts from each project can be selected randomly, or linked to the QFD [31] files ranking how well each concept performed against the musts and desirables. This was used whenever a QFD file was present within the project folder. Concepts were returned in the form of a single slide, an example can be seen in the forth column of Table 2.

3.3. The store dimension

In order to make the Sweeper approach self-populating and expanding, the new project briefs and concepts must be stored into a system ready for retrieval at a later date. The brief must therefore be added to its project file and its musts and desirables categorised by the higher level structure. In order to do this, the musts and desirables are entered by free description and then in a computer implementation, linked via drop-down menus to the higher level heading (Figure 5) which would also be used for the search function. The concepts designed for each new project need to be saved under a consistent file name and stored within the project file along with any QFD analysis files.

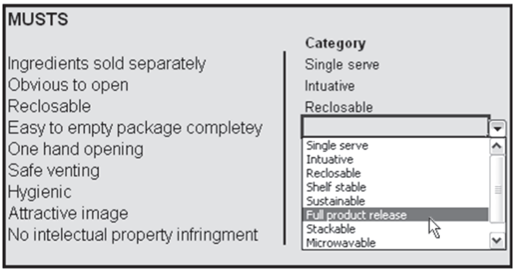


Figure 5. Linking musts to a higher level category

3.4. Implementing the Sweeper approach

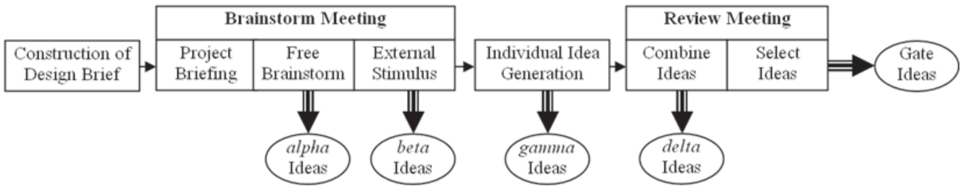
The Sweeper approach relies on several conditions, all of which were fulfilled by the case company. Firstly, the company must have a consistent and standard design process. Secondly, the documents containing the project brief, the designed ideas and concepts and must be consistently and appropriately named and must be stored electronically and logically.
Using a very simple ontology constructed by the company, umbrella terms can be used to classify the key terms from each requirement. This approach could be optimised by using some simple faceted classification techniques [32] enabling concepts and ideas to be linked to other supporting information regarding markets, business sector, date conception etc. rather than just the musts and desirables.

4. EXPERIMENTAL METHOD

The method used to compare and evaluate the performance of the creative stimuli tools was constructed to take advantage of a unique opportunity within an industrial innovation hub. The research methodology chosen uses and ‘insider’ or ‘participation’ action research approach [33], here the emphasis is firmly on what designers do rather than what they say they do [34]. In order to notate and capture date, protocol analysis was used, as used successfully in similar studies [19, 35]. Though, sample sizes were small and some variables were left uncontrolled, this gave the possibility to participate and capture real design activities with professional engineers.
The research method constructed for this study was built around the case company’s practices. The company’s standard innovation process was followed, as for all regular new projects. It was the decision of the author to concentrate the study in the ideas stage up to the first stage gate (Figure 6) where it is thought this research on stimulation for conceptual design will have most effect. It is worth noting that the case company is particularly good at consistently adhering to their innovation process. When setting up this study the researchers were aware that innovation within the packaging industry often focuses on design details that result in significant benefits to the company (high-volume, low-cost products). The stimuli tools developed in research have been tested within this context.

4.1. Ideas stage of innovation process

In each of the case projects under study, the following process was followed consisting of components, the brief, the brainstorm meeting, the individual idea generation, the review meeting and finishing at the stage gate. The outputs are ideas, categorised by the component or sub component in which they where produced.



KEY

alpha ideas:	Idea generated by during the free thinking brainstorm session.
beta ideas:	Idea generated after group is exposed to prepared stimuli.
gamma idea:	Idea generated individually after the brainstorm session.
delta idea:	Idea generated by combining ideas during the review meeting.
Gate idea:	An appropriate idea put forward for presentation at the gate meeting.

Figure 6. Case company innovation process (up to the first stage gate)

Construction of brief

Each design project studied began during the construction of the project brief. During this stage, the mission statement for the project is set, along with the various 'musts' and 'desirables' required for the design solution. The project manager is allocated and a team of approximately seven is assembled for a brainstorming session to generate solution ideas for the brief.

Brainstorm meeting

Within this session, roughly the first 30 minutes would consist of communicating the project brief to the team member's whilst trying to frame the problem at hand. This is commonly followed by a free thinking brainstorm lasting roughly 70 minutes during which alpha-ideas will be generated. Of the chosen case projects numbers 1-5 (see Table 3) presented in section 4.1, four used prepared creative stimuli. The stimuli were presented in turn after roughly 40 minutes to aid the session; the ideas produced during this period were termed beta-ideas.

Figure 7. Screen capture of typical brainstorm meeting

Individual idea generation

During this phase each team member is given roughly 1 week to produce 6 ideas (these ideas are to be in concept form, complete with function, behaviour and structure). These gamma-ideas can be constructed from ideas that they particularly like from the brainstorming session or as a result of a totally new idea generated. Each concept is named and drawn on an individual sheet.

Review meeting

During this review meeting team members exhibit each of their individual gamma-ideas and are encouraged to group idea by similarities and to make new and useful combinations of the ideas, noted as delta-ideas. After all ideas have been shared the groups of ideas are refined. At this stage several of the ideas are rejected due to them being inappropriate. The project manager will then draw up the selected ideas in the form of several gate concepts for the 1st stage gate report. The stage gate concepts resulting from the review meeting will inevitably be a mixture of the chosen alpha-, beta-, gamma- and delta-ideas.

4.2. Case project details

In total, the researcher attended over 15 brainstorm and review sessions and captured roughly 40 hours of footage. However, only 5 projects were chosen for extensive analysis. The projects were carefully chosen to ensure that it would be possible to make comparisons. It was deemed extremely important to ensure that the project managers of each project were experienced designers, as it was observed that projects managed by trainee or student designers could not be relied upon to follow standard procedure. Projects 1-4 of the chosen projects used creative stimuli; project 5 was provided with no creative stimuli and was used as a control group.

4.3. Idea capture

As part of the agreement with the case company the session was video and audio captured with synchronised capture of both PowerPoint slides and 'pen and ink' illustrations. The analysis software used to synchronise and code the data was Quindi© (www.quindi.com) meeting companion which made the analysis and transcription more efficient. During this session the author participated as a designer, with no thought of evaluation of the session. Participation enabled the author to gain better understanding of the process and made retrospective analysis of the content of session easier.
When analysing the brainstorm sessions of each statement and in many instances the attached illustrations were tagged as one of the three stages of the creative process, either 'analysis', 'generation' or evaluation' derived from previous work [10]. It was later decided that the generation statements were to be the focus and were broken down further in terms of, whether the statements refer to the function, behaviour or structure helping to define the novelty o an idea (see Section 2.3). These sometimes existed together, where group members may propose entire concepts. All ideas tagged were annotated chronologically along the meeting timeline (see Figure 8).

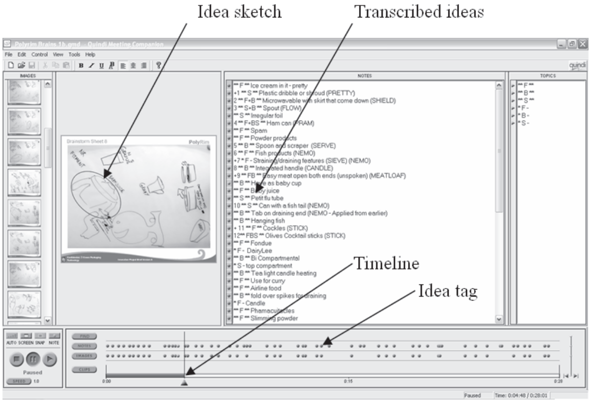


Figure 8. Screen shot of capture software

4.5. Notations validation

To validate this notation of ideas scheme an inter-observer reliability check was conducted. Three independent researchers were asked to mark up 10 minutes of video and audio footage each. Each was given the classification scheme and asked to place a note where an idea had occurred along with a description of the idea. On comparison of the results, it was shown to be a good validation where the independent researchers missed only 14% of the ideas, identifying the rest correctly. It is likely that this 14% can be put down to audio qualities and hearing each member of the group clearly. It is also thought that the author was better placed to make judgment on each statement/ideas due to having first hand experience of the brainstorm session and hour more practice using the mark-up scheme.
To validate the mark-up regarding how each appropriate idea relates to each concept, thus assessing it's originality, an independent researcher was used for 1 of the case projects. The researcher was given the definitions for function, behaviour and structure and was then asked to mark the connections between the appropriate alpha- and beta-ideas and the functions, behaviours and structures of the concepts. The researcher was also given an example of this mark-up from another project to work with. After comparison the researcher annotated each idea in terms of function, behaviour and structure of which 92% of the author's notation was correctly identified.

5. RESULTS

This section compares the creative performance of the four different stimuli tools. Each is analysed in terms of the rate of idea generation (Section 5.1), the appropriateness (Section 5.2), originality (Section 5.3) and the unobviousness (Section 5.4) of the ideas produced, along with the qualitative analysis throughout.

5.1. Rate of idea generation

Figure 9 shows the timelines of the 5 fully analysed brainstorm meetings. The first continuous line represents free thinking brainstorming above which each dot represents the occurrence of an alpha-idea. This is followed by the introduction of the various stimuli represented by the alternating dark and light grey lines above which each dot donates the occurrence of a beta-idea. The final shorter dark line represents the closing discussion. The numbers at points of each project line represents the total number of ideas to that point. The number above the dots represents the rate of idea generation (ideas/minute) up until that point. The figure underlined at the end of the stimuli section represents the rate of idea production of the beta-ideas only.

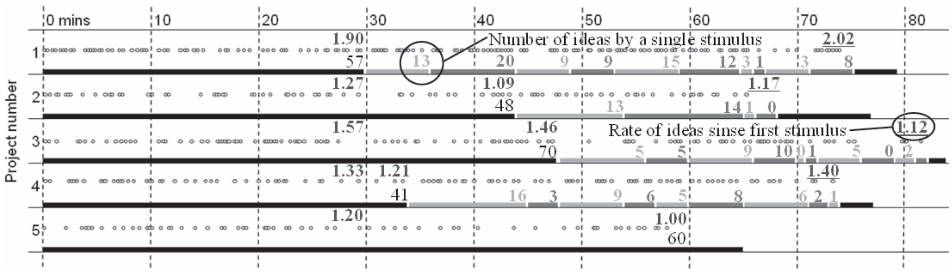


Figure 9. Rate of idea generation during brainstorm meetings.

Table 6 was constructed from the data in Figure 9. It showed that tool A produced the most ideas from a single stimulus, at 20 ideas. However, this figure is not very representative of performances as the particular task and designers in project 1 were more conducive to idea generation, producing more ideas per unit time than in the other projects. The random retrieval tools, A and C produced the best performing stimuli in terms of rate of idea generation at 2.5 ideas per second. However, as expected, this was contrasted by the higher number of stimuli which produced no ideas.

The most interesting and telling statistic details the rate of beta-idea generation to be higher than the rate of alpha-idea production in project 1, 2 and 4 with only tool C producing less ideas. The highest (relatively) performing was the Type D stimuli tool increasing the rate of idea production by 16%. It also was observed that Type C and D tools produced a higher quantity of ideas, which were directly associated with the stimuli.

Table 6. Comparison of rates of idea generation of stimuli tools

	Tool A *Ext. Rand.* **(project 1)**	**Tool B** *Ext. Guid.* **(project 2)**	**Tool C** *Int. Rand.* **(project 3)**	**Tool D** *Int. Guid.* **(project 4)**
Most ideas from single stimulus	20	14	10	16
Highest idea rate of stimulus (Ideas/min)	2.5	1.3	2.5	2.0
Longest time of stimulus (min)	8	11	8	11
Total time using stimuli (min)	46	24	34	40
Number of stimuli producing ≤3 ideas	5	2	5	3
Rate of *beta*-idea generation (Ideas/min)	2.02	1.17	1.12	1.40
Rate of generation of *beta*-ideas/*alpha*-ideas	1.06	1.07	0.77	1.16

5.2. Appropriateness of ideas

Figure 10 shows the appropriate ideas produced during each brainstorm session, signified by the numbered circles along each timeline. The light and dark dashes represent the introduction of the various stimuli.

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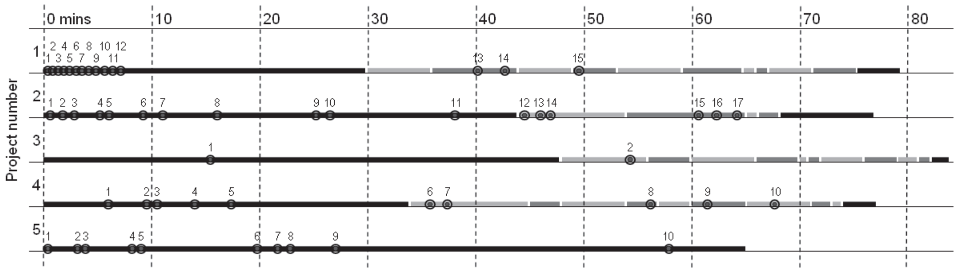

Figure 10. Appropriate ideas generated during brainstorm meetings.

From the comparison made in Table 7, it can be seen that the type B stimuli tool proposed 2 stimuli each with 3 beta-ideas, more than any other tool. Both guided stimuli tools produced more ideas than the random stimuli tools. However, both internal stimuli tools produced a higher quantity of beta-gate ideas relative to the total number of gate ideas, providing compelling evidence for the potential behind internal generated stimuli. From the protocol analysis it was shown that the guided tools (B and D) produced more ideas both directly and abstractly inspired by the stimuli. Also, more of the stimuli proposed from the type D tool produced beta-gate ideas.

Table 7. Comparison of Appropriate ideas produced of stimuli tools

	Tool A *Ext. Rand.* **(project 1)**	**Tool B** *Ext. Guid.* **(project 2)**	**Tool C** *Int. Rand.* **(project 3)**	**Tool D** *Int. Guid.* **(project 4)**
Most gate ideas from stimulus	2	3	1	2
Number of *beta*-gate ideas	3	6	1	5
Number of directly inspired ideas	1	3	0	1
Number of abstractly inspired ideas	0	3	1	3
Number of *beta*-gate ideas/total gate ideas	0.2	0.35	0.5	0.5
Number of stimuli producing a gate idea	2	2	1	4

5.3. Originality of ideas

Stimuli tool type D produced the most original ideas. Both directed tools produced a higher quantity of original ideas relative to the appropriate ideas. This was the opposite of what was expected. One reason for this may have been in the definition of originality being relative to a new concept rather than an original entity within the concept.

5.4. Un-obviousness of ideas

As previously stated (Section 2.3), un-obviousness is quite controlled over the course of this study and is more suited for the comparison of individual ideas. All beta-ideas produced are relatively unobvious due to the delay before the stimulus is prescribed.

6. CONCLUSION

Throughout this action research based study the following conclusions were drawn from both the quantitative and qualitative data captured before, during and after the industrial brainstorms sessions. Firstly, all stimuli tools proved to be useful. From the protocol analysis, the evidence suggested that the stimuli both helped to remove production blocks and inspired new ideas either directly or by initiating a train of thought leading to a new idea.

The random externally sourced stimuli tool (Type A) seemed to work well at removing blocks as all participants could relate to the stimuli in one way or another. However, it was the guided tools (Types B and D) that proved to perform better. In terms of the rate of idea generation the Sweeper (Type D) performed the best, outperforming the TRIZ tool (Type B). This was due to the lack of meaning or

understanding attributed to the TRIZ stimuli, with half of the stimuli producing less than 3 ideas. In this study, the design team were only exposed to the inventive principles from TRIZ and did not benefit from the 'contradiction finding' part of TRIZ, which was prepared in advance of the brainstorming session. It is worth noting that this may well have affected the results from this tool. In terms of idea quality (originality, appropriateness and unobviousness) the guided tools (Types B and D) performed roughly equally, outperforming the randomly generated retrieval approaches.
Given the above performance of the tools, the practical aspects such and implementation and ease of use must be considered. Both random retrieval stimuli tools outperformed the nominal group and are extremely easy to implement by simply selecting random concepts and images, making this approach worthwhile to industry. The Sweeper tool will take some time for implementing, likewise the TRIZ contradiction matrix for learning and mastering. However, once implemented the Sweeper tool can provide quick access to guided stimuli in comparison with the contradiction matrix which is labour intensive. This 'easy-access' factor proved very important to the case company now implementing the Sweeper tool. In the case company, the idea repository that the Sweeper tool can draw from is large; containing approximately (?) completed projects from 199?-2009 which each typically contain (.. number?) of ideas that could be used as stimuli. For smaller or newer companies without large idea repositories, the guided (TRIZ tool) and un-guided (type A) tool, both providing stimuli from external sources, will benefit brainstorming sessions.

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