Stimulating Stakeholders' Imagination: New Creativity Triggers for Eliciting Novel Requirements

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***Abstract*—Requirements engineering is a creative process in which stakeholders and engineers work together to create ideas for new products, services and systems. Several techniques have proved to be effective for eliciting creative requirements. Yet, most of these techniques are heavy to implement and require long periods of time to be applied correctly. Few lightweight creativity techniques have been developed for use in requirements engineering. One such lightweight technique is the creativity trigger, which provides simple guidance to stakeholders and engineers to help produce creative requirements. While easy to apply, creativity triggers were derived informally from experience of practitioners and have not been validated in a systematic way. This paper reports design and preliminary validation research, that sought to provide empirical foundations for a more complete set of lightweight creativity triggers, to be used by stakeholders and engineers to quickly and simply generate new and useful requirements on products, services and systems.**

I. Introduction

Requirements engineering is now recognised to be, at least in part, a creative process in which stakeholders and engineers work together to create ideas, eventually expressed as new requirements for new products, services and systems in order to gain a competitive advantage. Different creativity processes [1], [2], techniques [3], [4] and software tools [5], [6] have been developed for use in requirements projects, and evaluations of each have demonstrated their roles in and benefits for such projects [4]. However, one outstanding limitation of these processes, techniques and tools is the resources and time needed to use them – most require larger number of stakeholders over longer periods of time to be effective. And, although there have been attempts to adapt simpler, quicker-to-use creativity techniques such as hall of fame and constraint removal for requirements work [7], the number of these lightweight creative techniques is still small.

One of these lightweight creativity techniques developed for use in requirements engineering work are creativity triggers. Creativity triggers provide simple guidance to stakeholders and engineers to discover new requirements associated with a particular quality of a new product, service or system – a quality that is believed to be associated with more innovative solutions. One example of a creativity trigger is Convenience, which guides the stakeholder to make the product, service or system easier to use by discovering ideas to, for example, remove one or more actions that the users undertake, or automate these user actions. Familiar examples of products and services considered innovative through greater convenience include checkouts at Apple Stores (by removing the actions of finding and queuing at checkout desks) and automated credit top-ups of digital travel cards in London (by removing the need to top-up online or at the station). Other such triggers include Service and Information Choice, and each trigger's guidance is often composed of no more than 3-4 statements and images. This current trigger set was derived informally from the experiences of two seasoned requirements analysts – Suzanne and James Robertson. Although no reference exists on creativity triggers, the triggers have been delivered to many clients – through workshops and brainstorming sessions – and have proved to be valuable creativity-supporting tools. In addition, the creativity triggers have also been used as a tool in previous requirements engineering research [8]. However, there has been no systematic attempt to validate the correctness and completeness of the set of possible creativity triggers.

Therefore, in this paper, we report design research that seeks, for the first time, to provide empirical foundations for a more complete set of lightweight creativity triggers that stakeholders and engineers can use quickly and simply to generate new and useful requirements on products, services and systems. We also report a first lightweight empirical evaluation of the triggers. In Section 2, we present related work and position creativity triggers in the broader requirements engineering body of knowledge. We report the motivation for our research in Section 3, describe our design research in Section 4, and present a first lightweight evaluation of our results in Section 5. We emphasize the limitation of our work in Section 6, further discuss our results and future work in Section 7, and summarize the paper in Section 8.

II. Related Work

This research adopts Sternberg's definition of creativity – the ability to produce work that is novel and appropriate to the task [9] – as prototypical of reported definitions of creativity. Therefore, in simple terms, the research defined creative requirements work as the production of requirements that are both useful and new to project stakeholders. There is no shortage of techniques to elicit and acquire existing, and hence not new requirements and requirements-related knowledge from stakeholders, as the classifications reported in [10], [11] reveal. Some of these techniques have characteristics

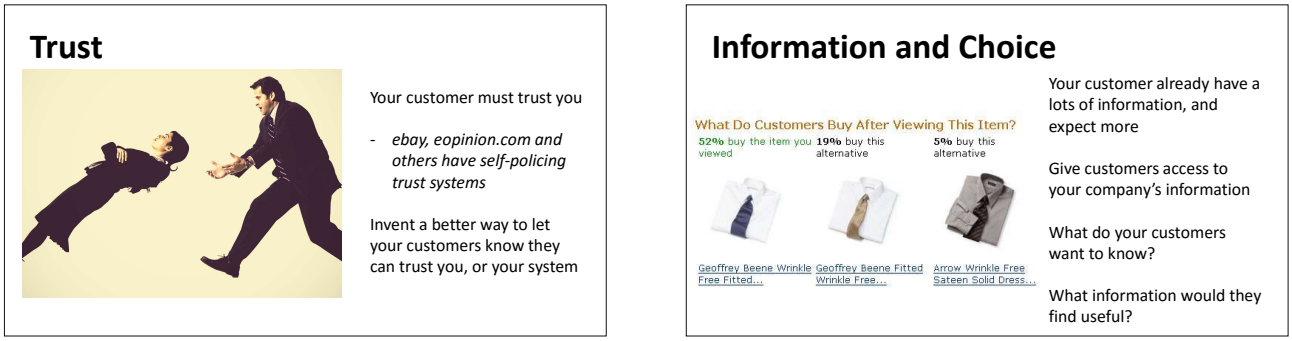

Fig. 1. Examples of a Creativity Trigger by Robertson & Robertson

that encourage creative thinking about the requirements of a future system – both scenarios [12], [13] and prototypes [14], [15] direct stakeholders to explore and discover future system behaviours and qualities, some of which might be novel and hence creative – while brainstorming seeks to exploit group dynamics to generate more requirements, some of which might be novel and hence creative. However, the discovery of requirements that are novel is not the primary intended functions of these techniques. To fill this gap, Maiden and his colleagues introduced and experimented at length with creativity techniques adapted to requirements projects in large-scale workshops [16]. These techniques included, analogical reasoning, rule-based idea combination and rich storyboarding [17], [18], [16], and were demonstrated to be effective for generating novel requirements for new systems, albeit in multi-day workshops with larger numbers of stakeholders.

More recent research has sought to adapt creativity techniques for use in agile projects by single or small numbers of stakeholders – techniques such as constraint removal, hall of fame, sketching and storytelling [7]. Creativity triggers were included as part of this work, and applied in an agile context. Each creativity trigger describes a quality associated with innovative products, services and systems, and one or more simple guidelines that direct users to discover requirements leading to this quality. The current set of 7 triggers, and hence qualities, reported by Robertson and Robertson are Service, Information Choices, Participation, Connections, Trust, Convenience and Green. An example is reported in Figure 1. However, the triggers have not been published, and the completeness or correctness of these 7 triggers has not been evaluated systematically.

The concept of triggers to direct engineers and designers to qualities associated with creative outcomes is not new. For example, TRIZ is an earlier problem solving methodology that draws on the past knowledge and ingenuity of thousands of engineers to accelerate the project team's ability to solve problems creatively [19]. The method was developed in a pre-digital world and is composed of reusable solutions to complex problems, for example to resolve the problem of a long object in a moving one, use the Nested doll pattern to place one object inside a cavity within the other object. Adopting the same approach, various sets of creative deck cards – like the "75 Tools for Creative Thinking", "IDEO cards", "ThinkPak" or "MethodKit" – have been commercialized to support businesses solving their problem in innovative ways, yet lack a systematic/scientific baseline.

Previous references clearly suggest that creativity triggers can be useful as lightweight tools to support the elicitation of creativity requirements. Yet, there has been no systematic research on the meaning of creativity triggers and the reason why they work as creative prompts. Previous work implies that there is currently no scientific underpinnings to construct a more complete set of creativity triggers. As a consequence, our research objective in this paper is to gain better insight into the concept of creativity triggers, and to identify in a more systematic way the different triggers that may exist. We do so based on empirical work that we describe in this paper.

III. Baseline: Exploration of the Concept of Creativity Triggers

In this section, we present the work undertaken to understand the nature of creativity triggers, and answer: "what makes a trigger creative, likely to generate new ideas, or less creative, less likely to generate ideas?". This question was answered by conducting the interviews and focus groups described below, the results of which informed subsequent studies.

A. Discussion with Practitioners and Experts

We ran two focus groups. Both of them took place at City University London. The focus groups lasted from 30 to 45 minutes, and involved from 3 to 4 subjects. Subjects were under-graduate and graduate students from the City University London. They all had some professional experience and knowledge background related to design and/or creativity. During the sessions, subjects were asked to brainstorm about what creativity triggers might be, to do some sorting tasks on concepts associated with creativity, and to discuss openly about their own perception of some fictitious creativity triggers. Prior to these sessions, we ran a pre-study focus-group, to ensure the clarity and relevance of our questions and exercises.

In parallel with the focus groups, we conducted 3 interviews with creativity or design practitioners. All of them had some experience in using creativity triggers. Interviews consisted of a series of open questions about the nature of creativity triggers. Some examples of questions we submitted are[1]:

- What is your vision of creativity triggers?
- What are the creativity triggers supposed to be?
- How would you use creativity triggers?
- Do you see other ways of using triggers?

In addition to the questions above, we invited – even encouraged – subjects to share any additional feedback about their own experiences, opinions or views on creativity triggers.

B. Main Observations

During interviews and focus groups, we made several observations about the nature of creativity triggers. Based on these observations, we were able to identify a series of guidelines that we used for designing and identifying new creativity triggers (see next Section). The main observations we made about the nature of triggers are summarized below, with subject quotes selected as indicative of subject responses.

1) "*Creativity triggers can be seen as disruptors during acquisition of information; they force the business to think differently about how they could solve some of their problems*": Triggers point to uncommon qualities of products or services, as a way to break defaults. They are expected to provoke reaction from the stakeholders;
2) "*Triggers are positive qualities, things or subjective constraints that future designs should do or respect*": Triggers are non-functional, they have no clear cut satisfaction criteria, and are somehow subjective;
3) "*[A trigger] has to be open to interpretation; people must be able to interpret the trigger in a way that makes sense in their own context. The wider the interpretation, the better*": triggers should not be too specific, and open to interpretation;
4) "*I think triggers could be seen as categories of focus, like some sort of pointers to topics which are not obvious to stakeholders, so that they are more likely to generate creative ideas*": triggers should be sufficiently ambiguous but still understandable by stakeholders to help them produce creative ideas.

We also explored with subjects about how creativity triggers should be applied, and elicited some interesting observations, the most important of which are reported below.

1) "*I wouldn't use three or more triggers at the same time. I don't want to overwhelm my customers with too many cards, that wouldn't help at all*": using a combination of two triggers ensures that stakeholders are not overwhelmed, and still produce creative requirements;
2) "*There are triggers which work better than others, but it actually depends on what you are looking for. It depends on your objectives, and on the project in which you apply the triggers*": triggers' effectiveness depends on the engineer's objectives and on audience. There are no universally good triggers;
3) "*I think the best way to go [using the creativity triggers] is to simply talk about it, during interviews or meetings.*": triggers should be used and discussed during interviews, work-groups or brainstorming sessions.

Altogether, previous observations provide the groundwork for a more systematic study of creativity triggers. They give good indications of what creativity triggers are, of how they work, and the conditions they have to satisfy in order to actually be creative. Our observations also confirm the need for a more complete – systematic – study of creativity triggers; discussions with subjects enabled to point out some potentially relevant creativity triggers, but these tentative triggers are still informal, and lack of validity. This calls for clearer and more compelling evidence of what creativity triggers actually are, and of whether and how they actually help requirements engineers in the acquisition of more creative requirements. Starting from these premises, the next Section reports a systematic and rigorous study in order to discover candidate creativity triggers; it does so by collecting a large amount of data, used to identify a set of candidate creativity triggers.

IV. Study: Identification and Definition of New Creativity Triggers

Based on the observations made during our preliminary discussions with practitioners and experts, we were able to design a survey, the purpose of which was to gather data about creativity triggers. The result of this survey was a list of candidate creativity triggers, some of which are further investigated in the remainder of this paper.

A. Methodology

To collect data about creativity triggers, we designed an online survey. The survey design made it possible to collect a large quantity of data, which proved to be useful to define a list of candidate creativity triggers. As discussed in previous Section, creativity triggers are qualities – non-functional requirements – that people associate with innovative solutions. As a consequence, our survey sought to elicit many such qualities. Collecting innovative qualities alone is difficult; it is not feasible to ask people list all the qualities they think of, without providing a reasonable context. As a consequence, we designed our survey to collect two types of information:

- **Innovative Solutions**: products or services that people considered to be creative at the moment they were released on the market;
- **Innovative Qualities**: non-functional properties that people associated with the solutions at the moment it was released on the market.

Note that we clarified the concept of creativity as much as feasible in the survey; subjects were told that "by creative, we mean novel compared to other products and services available at the same time". We believe this mitigated the risk of subjective interpretation of what solution is creative

[1]The study material is available at *www.creativitytrigger.com/design*

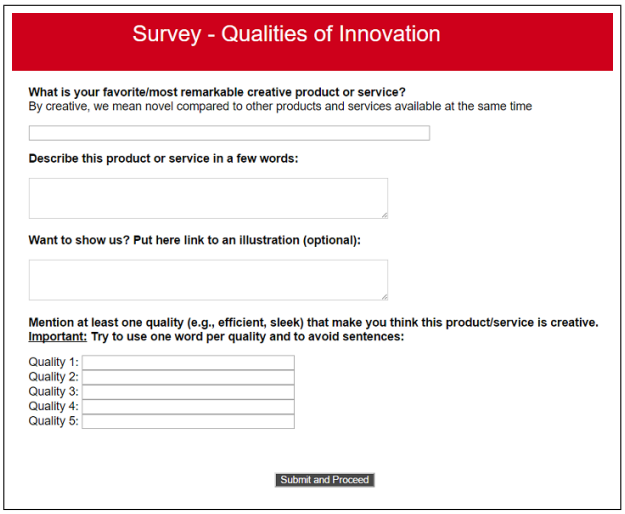

Fig. 2. A Screen-shot of our Online Survey's Main Page

or not. The design of the survey was simple, in order to avoid any confusion, and a screen-shot of its main page is shown in Figure 2. The survey is still available on-line and unchanged since its presentation to subjects [2]. Our objective in collecting such data was to understand better what qualities people associate with innovative products or services, i.e., why people consider something is creative, as opposed to being more conventional. Starting from such qualities, we believed that it was feasible to identify dimensions along which a solution should be improved, in order to ensure it is sufficiently novel to its stakeholders, i.e., the creativity triggers.

We crowd-sourced as a way to collect data. We gathered answers from 335 subjects, mainly from Belgium, Canada and the United Kingdom. We did not target one specific subject profile; any person who had the URL of the survey could answer to it, and share it with other people. We do not consider this to be a problem, as the questions in the survey are simple, open-ended, and referring to common-sense concepts. Subjects were not compensated for completing the survey, but were offered access to a summary of our results. Such data, combined with observations and conclusions collected in phase 1, helped in the prototyping of creativity triggers (phase 3).

B. Data Manipulation

Our survey collected 861 combinations of creative qualities and products/services. From the 861 answers, we identified 234 different qualities that people associate with innovative solutions. The top 5 innovative solutions and qualities are listed in Table I.

We reduced the number of qualities to 188 by running a stemming algorithm to group the qualities that share the same stem; for example, the qualities "joy" and "joyful" share the same root "joy" and were grouped together. Most of the 188 remaining qualities overlapped with other qualities, making it useful to try to group the qualities that were semantically

[2] *http://semvm02.city.ac.uk/becreative/triggers/survey.php*

TABLE I
SURVEY'S TOP ANSWERS

Quality	Count	Solution	Count
Convenient	87	Smartphone	23
Effective	58	Social Networks	17
Useful	49	Nest Thermostat	6
Fast	41	Gopro	5
Amusing	37	Airbnb	3

close into different clusters, i.e., the qualities dealing with the same properties of a solution. For example, "joy" and "fun" are two qualities dealing essentially with the same properties of a solution, so they can be grouped into one single cluster of similar qualities.

To ensure an objective classification of the qualities – not relying on subjective understanding of the qualities –, we used a clustering algorithm, more specifically the Ward's Hierarchical Clustering Method. The latter represents the clusters under the form of a dendrogram and manages varying granularity levels in the data. The algorithm takes as input a list of rows (observations) that have to be clustered. To actually group observations, the algorithm uses a set of columns (variables) that are used to compute distance between different observations.

Some data preparation was necessary to run the algorithm on our data. The observations to be clustered were the qualities we collected from our survey. To group the qualities, we needed several variables. These variables were the synonyms of our survey qualities, that we used as a way to estimate how semantically close the qualities were; our assumption is that qualities sharing many synonyms are closer to each other than qualities sharing no synonyms. As a consequence, the synonyms were only used to group qualities, but are not reported as part of our final set of clustered qualities. The procedure for collecting synonyms and preparing data was as follows:

- Find all the synonyms of each quality (via Thesaurus)
- In a spreadsheet, insert one line per quality
- In a spreadsheet, insert one column per synonym
- Write 1 each time a word is a synonym of a quality
- Write 0 each time a word is not a synonym of a quality

The procedure above produced a table of 188 (qualities) * 2492 words (synonyms), with binary values (0 or 1) in it. Some (45) lines in this table only have 0 in it; these are the qualities which have no known synonyms in the Thesaurus. Most of the time, this is due to subjects who encoded a set of words instead of one single quality in our survey (e.g. "It activates only when needed"). For simplicity, such data was rejected. Similarly, some columns in the table only have one 1 in it; it means there is only one quality that has the word as a synonym. We reject those synonyms, as they do not help in the measurement of a distance between two qualities.

C. Results

The complete dendrogram with the 143 remaining qualities is reported in Figures 3 and 4. It reads as follow: the longer

the horizontal line between two qualities, the more distant they are. If that line is small, we can consider the qualities to be semantically close. As an example, consider at the bottom of Figure 4 the qualities “Unusual”, “Amusing”, “Humerous” and “Witty” which are clearly different from the other surrounding qualities yet close to each other, so that we group them in one single cluster. Based on such a reading of the dendrogram, it is possible to identify 40 clusters of innovative qualities, listed in Table II. As discussed above, we see these clusters as candidate creativity triggers, some of which are further investigated further. It is important to bear in mind that the hierarchical clustering reported in Figures 3 and 4 is the result of some quantitative treatment of the data, and, as a result, some of the suggested clusters may not be sensible (Discreet, Required & Straightforward, Silent, Relaxing, etc.) or may be too obvious (Needed & Necessary, Helpful, Practical, Functional, Useful) in the context of requirements elicitation. This implies that each quality will not systematically lead to a trigger; as a consequence, our design research uses the guidelines identified in Section III to select most relevant clusters.

Starting from our list of clusters, and bearing in mind the guidelines about creativity triggers we collected during our preliminary exploratory study (see Section III), we designed

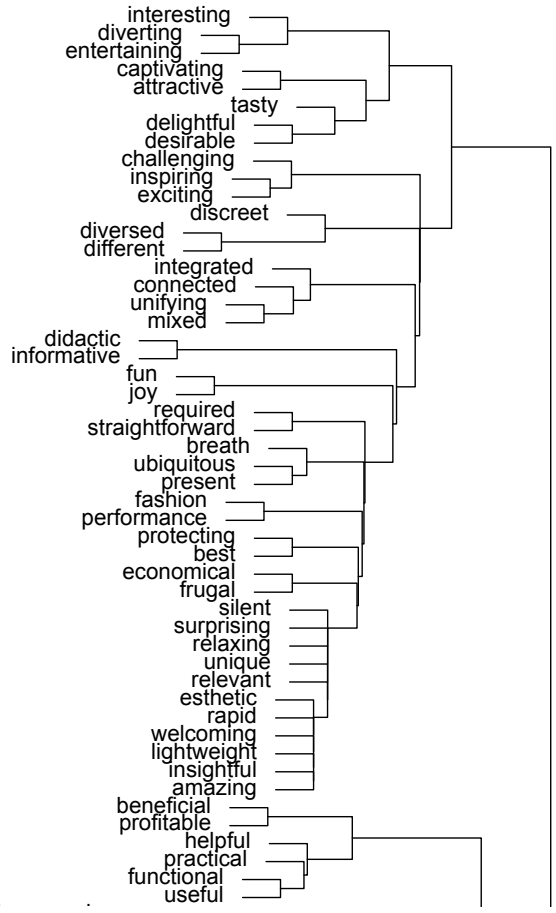

Fig. 3. Ward’s Hierarchical Clustering Output on Survey Data - Part 1

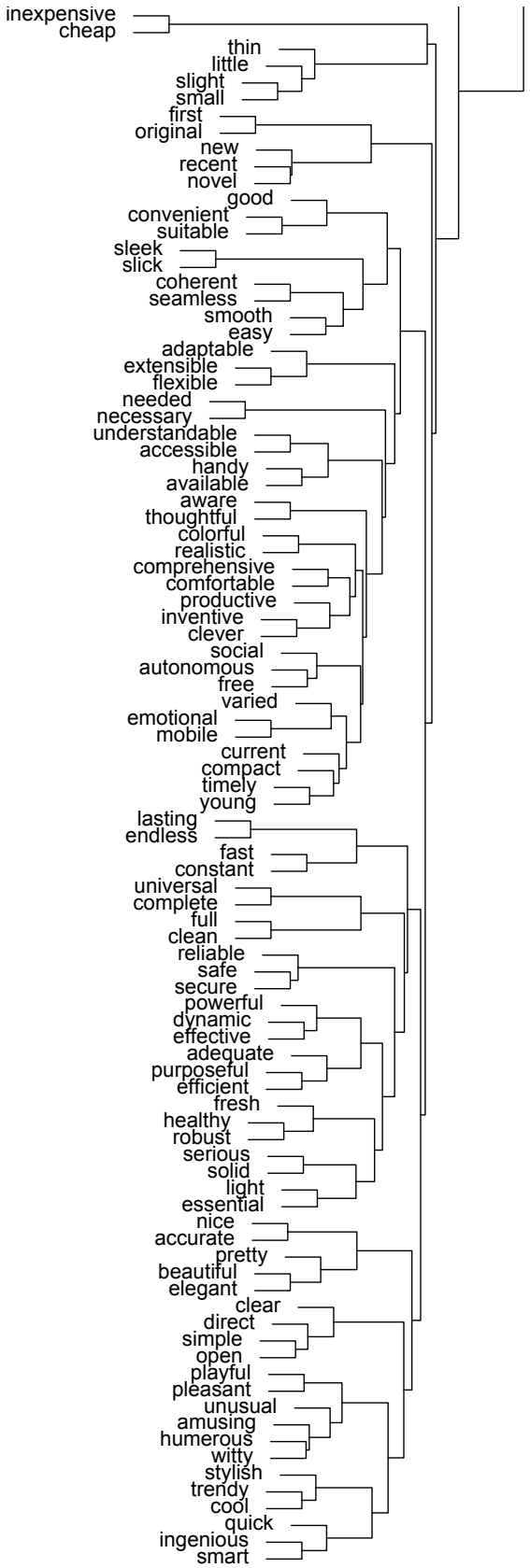

Fig. 4. Ward’s Hierarchical Clustering Output on Survey Data - Part 2

TABLE II
40 CLUSTER OF CREATIVE QUALITIES

Interesting, Diverting, Entertaining *	First, Original, New, Recent, Novel	Reliable, Safe, Secure
Captivating, Attractive	Good, convenient, suitable	Powerful, Dynamic, Effective
Tasty, Delightful, Desirable	Sleek, Slick	Adequate, Purposeful, Efficient
Challenging, Inspiring, Exciting	Coherent, Seemless, Smooth, Easy	Fresh, Healthy, Robust
Diverse, Different	Adaptable, Extensible, Flexible *	Solid, Light, Essential
Integrated, Connected, Unifying, Mixed	Understandable, Accessible, Handy, Available	Nice, Accurate
Didactic, Informative	Aware, Thoughtful	Pretty, Beautiful, Elegant
Fun, Joy *	Colorful, Realistic	Clear, Direct, Simple, Open
Breath, Ubiquitous, Present	Productive, Inventive, Clever	Playful, Pleasant
Fashion, Performance	Social, Autonomous, Free	Unusual, Amusing, Humorous, Witty *
Economical, Frugal *	Current, Compact, Timely, Young	Stylish, Trendy, Cool
Beneficial, Profitable	Lasting, Endless *	Quick, Ingenious, Smart
Inexpensive, Cheap	Fast, Constant	
Thin, Little, Slight, Small *	Universal, Complete, Full, Clean	

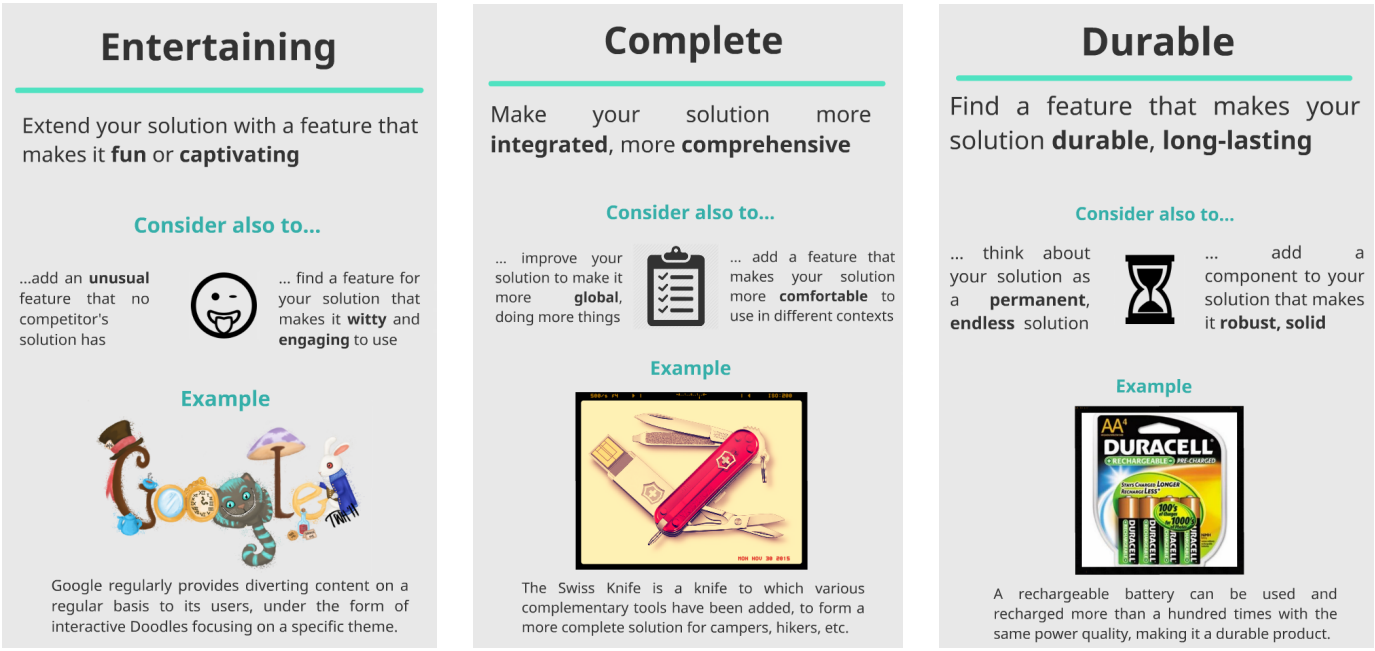

Fig. 5. Examples of Visuals for the Creativity Triggers

6 new creativity triggers. Note that it is possible to identify more triggers from our data; however we decided to initiate our work on creativity triggers by focusing on a limited number of triggers. We selected the clusters of qualities that were more frequently mentioned in our survey, and which were not redundant with those suggested by Robertson and Robertson. The clusters we used are marked in a * symbol in Table II.

Each trigger takes the form of a small card, to ensure the triggers are easy to use during elicitation. There is one single template for each card. On the top of the card, the *title* of the trigger is reported, in large and bold font to ensure high visibility. For each cluster, we used the quality with the highest frequency as the title of the trigger. A *short description* of the trigger is reported below the title, to clarify it. This description makes use of the other qualities available in the cluster. Two additional *guidelines* are reported on the card; these are directive sentences using additional keywords – synonyms of qualities included in the cluster – intended to help the engineers exploiting the creativity trigger. These guidelines are directly inspired by the sentences included in original creativity triggers by Robertson and Robertson shown in Figure 1. In addition, an *example* of a product or solution that satisfies the qualities related to the creativity triggers is reported. This example intends to make the card clearer, more solid. Finally, *visuals* are included; a symbol (in the center of the card) is used, that intends to reflect the title of the card, and an image/picture is included to support the example.

We submitted our prototype cards to the subjects we interviewed during the preliminary phase of this study, as a first informal evaluation of the clusters and related creativity triggers. This step gave us the opportunity to check if our design of the creativity triggers fitted with the perception of triggers by creativity and design experts. Most subjects agreed with our design of the triggers:

TABLE III
SIX NEW CREATIVITY TRIGGERS FOR ELICITING CREATIVE REQUIREMENTS

Name	Description	Guideline 1	Guideline 2	Example
Entertaining	Extend your solution with a feature that makes it **fun** or **captivating**	...add an **unusual** feature that no competitor's solution has	... find a feature for your solution that makes it **witty** and **engaging** to use	Google regularly provides diverting content on a regular basis to its users, under the form of interactive Doodles focusing on a specific theme.
Light	Try to simplify your solution, to make its structure **slighter**, more **lightweight**	... remove parts of the solution to make it more less busy, time consuming	... revise your solution to make it looks **thinner** or **smaller**	Apple initiated the trend of ultra-light portables by reducing the size and weight of its MacBook Air's structure, to make an extra-flat laptop.
Adaptable	Can you replace multiple products with one **adaptable** product?	... add a new feature to your solution to make it able to **change**	... try to make your solution more **malleable**, more **flexible** for the user	Microsoft's Surface is a tablet that turns easily into a fully functional laptop. It can adapt to multiple contexts of use, and satisfy with various user needs.
Economical	Try to update your solution so that it consumes less resource?	... imagine how your solution could become more **frugal**, less demanding	... include a feature that enables to **save**, **spare** some resources	IKEA uses its warehouses as sell-points, as a way to consume less resources (space, logistic, employees, maintenance, etc)
Complete	Make your solution more **integrated**, more **comprehensive**	... improve your solution to make it more **global**, doing more things	... add a feature that makes your solution more **comfortable** to use in different contexts	The Swiss Knife is a knife to which various complementary tools have been added, to form a more complete solution for campers, hikers, etc.
Durable	Find a feature that makes your solution **durable**, **long-lasting**	... think about your solution as a **permanent**, **endless**, solution	... add a component to your solution that makes it **robust**, **solid**	A rechargeable battery can be used and recharged more than a hundred times with the same power quality, making it a durable product.

- "*All very interesting, and of course they make you think!*"
- "*The card format should allow the workshop participant to feel much more a part of the process, and somewhat in control of his/her deck*"
- "*The guidance for the designer is much better, the facilitator will have less to do*"

In addition to some other comments related to the display of our creativity trigger cards, a recurring comment made by the experts was that two of our prototype creativity triggers – namely "Funny" and "Entertaining" – were too similar, and very likely to generate the same kind of ideas. We therefore decided to group these two and introduce a new creativity trigger (the "Light" trigger). The final result is the list of 6 creativity triggers described in Table III. For each trigger, we document a name, a description, two guidelines that aim to support stakeholders in applying the triggers, and an example of a solution (product or service) that satisfies the qualities related to the creativity trigger. Each of these trigger's components makes use of one or more qualities from the original cluster inspiring the trigger. The cards reported in Figure 5 are illustrations of our final prototypes.

V. EVALUATION: TESTING THE EFFECTIVENESS OF NEW CREATIVITY TRIGGERS

Previous sections focused on the design and systematic identification of new creativity triggers. This Section intends to evaluate the usefulness of new creativity triggers in the context of requirements engineering, and more specifically in the context of requirements elicitation. Our objective is to show that using creativity triggers helps stimulating stakeholders' imagination. We do so by asking several subjects to produce ideas before and after some triggers are presented to them, and comparing the results.

A. Methodology

We conducted a lightweight empirical study to evaluate the effectiveness of our proposed triggers. To estimate the relevance and relative effectiveness of creativity triggers, we compared the production by subjects of ideas with and without the creativity triggers. Subjects were students in Human-Centred Systems from City University London. They had profiles similar to the subjects we involved in the preliminary phase of our research, i.e., students with some professional background, and a high interest in topics related to creativity. We involved 8 students. The evaluation took place at City University London. It took the form of 4 work-groups, in which subjects were working in pairs. Subjects could use material such as post-its, sketches, and could access the Internet. The evaluation consisted of three steps.

1) Design Task Without Creativity Triggers: Subjects were introduced to a simple design problem, and had to propose early requirements to solve that problem. We used a design problem related to a cinema context. We choose this application context because it deals with an appealing topic, and requires/utilises a lot of common domain knowledge. Moreover, it is an open – yet clearly delimited – problem for which numerous improvements can be suggested. More specifically, subjects were asked to consider the following problem statement: "How would you deal with the Cinema auditorium being empty and usually unattractive, and with the Cinema food services being too similar to what you would have at home, in front of your own screen?". Afterwards, subjects were asked to suggest solutions to this aforementioned problems. This step lasted between 20 and 25 minutes.

2) Design Task With Creativity Triggers: Two of the creativity triggers listed in Table III were presented to subjects (under the form of cards, as shown in Figure 5). Subjects were then asked to pursue the design task initiated in Step 1, using

those triggers. Other conditions remained unchanged. Bearing in minds our observations about the use of triggers (in Section III), we selected two triggers for the subjects: Entertaining and Complete. We picked these triggers because they fit well with the context of cinema, and appear to be complementary. This step lasted between 20 and 25 minutes.

3) Debriefing about Creativity Triggers: Subjects were questioned after the design task, in order to collect feedback about the creativity triggers. This part of the study took the form of a semi-guided interviews, and lasted no more than 10 minutes. Step 3 of each session was audio recorded. The questions we raised are as follows:

1) Which of the two triggers did you prefer? Why?
2) Which aspect of the trigger did you appreciate most?
3) Is the name of the trigger self-explanatory?
4) Is the creativity trigger card sufficiently clear?
5) Did you find the guidelines in the triggers helpful?
6) Did the images/icons influence your design task?
7) How did the example support your design task?

B. Results

While we have no clear quantification of their effects on elicitation, we have reasonable indications that creativity triggers are helpful during elicitation. In most cases, it turns out that the triggers came as a second wind for the production of new requirements; subjects who ran out of steam in step 1 of the evaluation started to produce new ideas in step 2, and subjects acknowledged several times that they would not have produced as many requirements without the creativity triggers. For instance, one participant said: *"I'm surprised actually of what we got to, we've got a lot more ideas than I expected*". It suggests triggers have proved to be valuable in the production of additional ideas.

Results also suggested that creativity triggers have clear if indirect positive influence on the production of requirements, which is an interesting effect that could be leveraged during elicitation. One subject explained: *I think this trigger [subject points to Entertaining Card] really brought more idea than the other, maybe because of the task. The entertaining trigger was something we would not have considered otherwise*". Such feedback led us to the conclusion that triggers helped to deliver some uncommon qualities of solutions, and hence help breaking default conceptions of stakeholders about how a problem could be solved.

Last but not least, subjects acknowledged explicitly that creativity triggers helped them in the process, and are relevant creativity tools to be used during design activities. For instance, one group mentioned that "*If you have a specific and clear goal that the trigger would set, then you can come up with many more things. Maybe not all will be useful, but at least you think about it*". This can be interpreted as the fact that triggers define a reasoning target, something that stakeholders should reflect upon. Triggers narrow the scope of the design task to one specific creativity dimension, which makes it easier to produce new requirements.

Overall, we interpret these observations as clear indications that creativity triggers were actually used in the design task and that they actually lead to the production of additional novel requirements for the cinema design-task solution. In addition, the evaluation also enabled us to gain further insight into the concept of creativity triggers. We collected feedback during the debriefing step of our methodology, that we summarize in Table IV. We list the most significant conclusions from this feedback below.

1) There is no best trigger, there are preferred triggers: Overall, subjects preferred to use the "Entertaining" creativity trigger. It turned out that the latter was easier to understand in the context of the cinema design task. Two groups mentioned that they already covered the "Complete" trigger before step 2 of the study. Yet another group mentioned that "*[...] the Complete trigger was definitely useful, [because] we got the headset idea from it*", thereby emphasizing the relevance of the second trigger. From these observations, we learned that (i) the effectiveness of a trigger likely depends on its context of use and (ii) there are no clear-cut indications of which trigger is best. This might suggest a trigger's effectiveness is somehow dependant on the person who uses it.

2) Keywords are essential to comprehend the trigger quickly: The most appreciated element of the triggers was the keywords. These are the main qualities (synonyms, bold text) that we associate with a creativity trigger (see Table III). It is interesting to note that none of the groups referred to these as the "guidelines"; they only looked at the keywords, without reading (or actually paying attention to) the sentences in which they were presented. Subjects agreed that the combination of several keywords related to the creativity trigger was a good prompt; "*the keywords were great, they helped us think outside the box, and they are easy to read, they make it quick*". The keywords make the creativity cards more immersive, and act as facilitators.

3) Interpreting the trigger is subjective: The groups nearly all disagreed with the name of at least one trigger. When explaining their views, subjects systematically emphasized the fact that "*there might another, better, interpretations of the trigger*" based on the name. As describe earlier , the trigger cards were designed to be open to interpretation, and to be understood differently by different people (see Section III).

4) Visuals are significant, and make the triggers tangible: The icons and pictures in the cards were helpful to subjects, because they make the trigger cards more tangible, visible, and easy to read. That is, the visuals reduce the time it takes to put the trigger into practice. A group mentioned, for example, that "The Swiss Army Knife picture was perfect. I mean, it really makes the card striking, like very clear". More importantly, the icons and pictures helped subjects interpreting the triggers, as discussed above. One group for example explained that "*the Google doodle visual suggests the card is about making stuff diverting, but not necessarily funny, like for example a thriller. But the smiley face, it makes me think of the card as suggesting some sort of witty and funny entertainment. So we used the witty interpretation, it was more inspiring to us*". It was clear

TABLE IV
SUMMARY OF ANSWERS TO THE FEEDBACK QUESTIONS - STEP 3

Question	Summary of Answers
1. Which trigger did you prefer?	One group preferred the "Complete" trigger, which they say was less obvious in the cinema context than the "Entertaining" trigger. The three other groups preferred the "Entertaining" trigger. Two of these groups mentioned they already partially covered the "Complete" trigger in part 1 of the exercise.
2. What aspect is preferred?	One group emphasized the importance of examples, which they said helped them in better understand the trigger. Three groups explained they preferred the keywords, because they enable to understand quickly the trigger card, and help think outside the box.
3. Is the name of the trigger self-explanatory?	One group agreed with the names of the triggers, explaining it was clear and simple. Out of the three other groups, two did not like the title of the "Entertaining" card, explaining it was too large, and that there were potentially many different interpretations. Two group did not like the title of the "Complete" card, and suggested replacing it with the quality "Comprehensive" or "Integrated".
4.Is the card sufficiently clear?	Two groups agreed that the cards as a whole were perfectly clear. Two other groups stressed the fact that some keywords were harder to interpret than others, e.g., the keyword "Global", but that it was always possible to understand part of the trigger.
5. Did you find the guidelines helpful?	One group did agree with the guidelines proposed in the two triggers. Three groups stressed the fact that they did not use the guideline and focused on the keywords in these guidelines. Two groups agreed on the fact that guidelines should be used as support to apply the trigger card, in case it is not clear enough.
6. Did the visuals influence your design?	Three groups liked the icons, which they said were clear and simple to understand. Overall, these groups agreed the icons was the point of entry of the card, the first aspect of the trigger they looked at. Three groups also emphasized that the pictures were useful supports to illustrate the example, to make it more concrete, and to better understand the way the trigger should be used.
7. How did the example support your design task?	One group did agree with the examples in the cards, and that it was helpful. Two groups emphasized that they particularly appreciated the Swiss Army Knife example. They explained it was a clear example, which provide additional guidance about how the trigger should be interpreted. The Google Doodle example was also appreciated by two groups, for the same reasons.

TABLE V
ASSOCIATIONS BETWEEN EARLY REQUIREMENTS AND TRIGGERS

	Idea	**Trigger**
1	The cinema sunglasses with custom headset	Complete
2	The cinema nursery with various childcare activities	Entertaining
3	The secret cinema booth	Entertaining
4	The interactive fiction with quiz and trivia	Entertaining

to the card user how to decide which interpretation/direction he/she preferred to follow.

C. Concluding Remarks

We collected clear evidence that the use of creativity triggers helps in the identification of early requirements when realizing a design task, and might therefore help in the production of creative early requirements during elicitation. Comparing sketches and posts-it produced during the first two steps of the evaluation, taking into account the various notes experimenters took during the design tasks, and gathering the feedback produced by subjects after the evaluation study, we concluded that creativity triggers did influence subjects in the resolution of their problem. Although the link between triggers and early requirements may sometimes appear to be indirect, subjects emphasized several times the link between a trigger and a requirement they came up with. Associations explicitly made by subjects are summarized in Table V.

VI. THREATS TO VALIDITY AND FUTURE WORK

Various threats to the validity of the results were identified. Most were threats to *conclusion validity*; we involved a large number of subjects from multiple countries in our survey to ensure high statistical power and heterogeneity of subjects. We also designed a procedure to control the experimental settings and avoid irrelevancies. A threat to *internal validity* was the maturation of subjects in our evaluation step, since the same subjects were questioned before and after being introduced to the triggers. We acknowledge that limitation, and emphasize the early nature of this part of the research; our goal was not to conduct a sound empirical validation of creativity triggers, but simply to demonstrate their relevance, and motivate additional validation effort. The *construct validity* was threatened by the use of students in several steps of our research; we relied, however, on research suggesting that studies conducted with students are no more or less biased than other subject groups [20]. Finally, interaction of setting/selection and treatment threatened the *external validity* of our research; the simple nature of the design task and the selection of subjects may not generalize to other settings. Again, we justified this limitation by the fact that we only propose a first lightweight evaluation of the triggers rather than an actual validation.

Overall, therefore, cautiousness is required when applying our results in different settings. As a consequence, our plans for future work that aim to deal with these limitations. We plan to continue working on the list of qualities we collected. Our objective is to identify additional creativity triggers, and to test them in more representative elicitation settings. In addition, we plan to design a platform – most likely online – to share our results with RE practitioners, share our own experiences of the triggers and collect more feedback from RE community.

VII. DISCUSSION

Our objective in this paper was to study in a more systematic and rigorous way, the concept of creativity triggers that were initially suggested by Robertson and Robertson, and to evaluate the effectiveness of such triggers in the elicitation of creative requirements. In this paper, we designed 6 new triggers[3], and were able to partially validate the 7 initial triggers reported by Robertson and Robertson (each appears in our list of creative quality clusters).

It is interesting to note that creativity triggers are prompts, similar to Procedural Prompts [21] or more generally to any

[3]The final list of triggers can be accessed via *www.creativitytrigger.com*

prompting technique that can be used during design process [22], [23], [24]. Beside their innovative properties, creativity triggers have – as any prompt – a series of advantages, including the facts that:

- It sets a structure and focus for the elicitation;
- It applies to any development approaches (e.g., it can integrate in Agile or Waterfall methodologies.);
- It can be integrated into existing elicitation methodologies to improve their effectiveness.

The former suggests creativity triggers do not come with any methodological recommendations on how they should be used; we set no specific constraints on the way our creativity triggers can be applied during elicitation of requirements. In our view, creativity triggers can be used during classical elicitation activities such as interviews, work-groups, brainstorming, etc. [10], or can also integrate in specific creativity methods such as RESCUE and its creativity workshops [25]. Either way, creativity triggers simply need to be presented to stakeholders, and to be discussed together with the engineers. Triggers have been designed to be self-explanatory, so that they do not require specific experience to be applied.

In parallel work, the original Robinson & Robinson creativity triggers have been incorporated into an online tool supporting creative goal modeling[4]. Future work will add the new triggers created as part of the current work.

It is important to note that the creativity triggers can be relevant to use in virtually any application area, but that some triggers appear to be easier to use than others, depending on the context in which they are applied. Consider our evaluation study as an example; it turned out that the *Entertaining* trigger was fairly simple to apply to a cinema for most subjects, and subjects did not have difficulties in using it to solve their design task. Things were more nuanced for the Complete trigger; some subjects did not understand easily how the triggers could be useful for the design task. This does not suggest the quality and quantity of requirements produced through the second triggers were lower; it simply means that the ease-of-use of a trigger likely depends on the topic being discussed and on the people using it. It is up to the engineers to pick a (set of) trigger(s) that best fits with the problems to be discussed and the people being involved.

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