Brainstorm, Chainstorm, Cheatstorm, Tweetstorm: New Ideation Strategies for Distributed HCI Design

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ABSTRACT
In this paper we describe the results of a design-driven study of collaborative ideation. Based on preliminary findings that identified a novel digital ideation paradigm we refer to as *chainstorming*, or online communication brainstorming, two exploratory studies were performed. First, we developed and tested a distributed method of ideation we call *cheatstorming*, in which previously generated brainstorm ideas are delivered to targeted local contexts in response to a prompt. We then performed a more rigorous case study to examine the cheatstorming method and consider its possible implementation in the context of a distributed online ideation tool. Based on observations from these studies, we conclude with the somewhat provocative suggestion that ideation need not require the generation of new ideas. Rather, we present a model of ideation suggesting that its value has less to do with the generation of novel ideas than the cultural influence exerted by unconventional ideas on the ideating team. Thus brainstorming is more than the pooling of "invented" ideas, it involves the sharing and interpretation of concepts in unintended and (ideally) unanticipated ways.

Author Keywords
Ideation; brainstorming; chainstorming; cheatstorming; tweetstormer;

ACM Classification Keywords
H.5.2. User Interfaces: Theory and Methods; H.5.3. Group and Organization Interfaces: Collaborative computing

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Design; Experimentation.

INTRODUCTION
The ability to generate new ideas as part of a creative design process is essential to research and practice in human-computer interaction. The question of how best to generate ideas is not entirely clear, however. Not only are countless design and research methodologies commonly employed by HCI teams, their ideation effectiveness depends on numerous interdependent and variable factors including the scope and objectives of the project in question, the expertise and variety of the people involved, the strength and familiarity of their social relationships—not to mention their degree of familiarity with previous ideation and research activities—and cultural and personal factors including a person's workplace norms and values, personal motivations and desires, confidence, degree of social collaboration, esteem, and so on. In this paper we describe the results of a design-driven study conducted with the aim of improving collaborative ideation on HCI projects using distributed software tools. Specifically we focused our research on how digital tools might be used to enhance the practice of group ideation among members of asynchronously distributed collaborative teams.

A range of different ideation techniques are used in design and HCI. In this paper, we begin with a discussion of the relative benefits and drawbacks of one such ideation method, specifically *brainstorming*, as described by Osborn [33] and evaluated by Isaksen [21], among others. We then describe a design research process that explored the creation of distributed brainstorming alternatives. Two exploratory studies were performed. First, we developed and tested an ideation method we refer to as *cheatstorming*. Using this technique, previously generated brainstorm ideas are delivered to targeted local contexts without the need for imaginative ideation. We then performed a second study of the cheatstorming method to better understand its implications and improve its efficiency. Based on observations from these studies, we conclude with the observation that ideation need not be limited to the generation of new ideas. From this perspective, the value of group ideation activities such as brainstorming has less to do with the creation of novel ideas than its cultural influence on the ideating team. Ideation, in short, is the radical re-distribution of ideas to "unconventionalize" a given context.

Brainstorming Effectiveness as an Ideation Technique
The term brainstorming is best identified today with Osborn's book on creativity titled *Applied Imagination*, first published in 1953 [33]. Osborn, who worked as an advertising executive in the 1940s and 50s, wrote a detailed examination of the creative problem solving process, and introduced brainstorming as one part of this process. Rich with current examples from that time, the book attempted to systematically define a method for deliberate creative group ideation from a very practical standpoint. Osborn divided the process into three main phases [33, p. 86]:

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(1) *Fact-finding:* Problem-definition and preparation; gathering and analyzing the relevant data.

(2) *Idea-finding:* Idea-production and idea-development; thinking of tentative ideas and possible leads and then selecting and combining them.

(3) *Solution finding:* Evaluation and adoption; verifying the offered solutions, and deciding on and implementing a final selected set.

In great detail, Osborn explains suggested practices for performing each of these stages, focusing in particular on the *Idea-finding* phase. He claimed that Idea-finding is "the part of problem-solving that is most likely to be neglected" by groups [33, p. 111], and offered four guidelines that should be carefully followed in order to conduct a brainstorming session effectively and yield the best results:

1. ***Criticism is ruled out:*** *Adverse judgment of ideas must be withheld until later.*
2. ***"Free-wheeling" is welcomed:*** *the wilder the idea the better; it is easier to tame down than to think up.*
3. ***Quantity is wanted:*** *The greater the number of ideas, the more the likelihood of useful ideas.*
4. ***Combination and improvement are sought:*** *In addition to contributing ideas of their own, participants should suggest how ideas of others can be turned into better ideas; or how two or more ideas can be joined into still another idea.* [33]

Since then, many have built on these rules as brainstorming has become an increasingly popular method for idea generation in business and academic contexts. For example, Osborn's rules have been adapted to be more playful and memorable for educational purposes (*e.g.* "Gleefully suspend judgment," "Leapfrog off the ideas of others" [14]), and additional rules such as "be visual," "stay focused on the topic," and "one conversation at a time" have been added to better guide brainstorming sessions in the context of corporate design consulting [23].

Despite its widespread adoption in collaborative innovation environments in industry, the effectiveness of brainstorming has been a hot topic of debate in the academic community since its first introduction. The first criticism was sparked by a 1958 paper published by a group from Yale University (Taylor, Berry and Block) that compared the performance of randomly assigned brainstorming groups with that of randomly assigned individuals whose work was later pooled [42]. Numerous subsequent studies (*e.g.* [2, 35, 8, 26]) have built on this work to critique the effectiveness of brainstorming in groups relative to individuals working independently, arguing—among other things—that fewer good ideas are generated for each hour of individual effort expended.

It is important to note, however, that the Taylor, Berry and Block study [42] did not actually test the effectiveness of the *rules* of brainstorming, since the same rules were applied to both experimental conditions (individual and group). To be fair, Osborn recognized the necessity and advantages of working in groups for many reasons beyond the sheer quantity of ideas produced, especially when solving problems [33, p. 139]. In fact, the guidelines he suggested were specifically targeted at addressing the common inhibitory factors of group ideation. Rules such as "defer judgment" and "go wild" aimed not at individual productivity but improved social dynamics and sharing of ideas between members of a team. He also made the point to address a common misconception, stating that "group brainstorming is recommended solely as a *supplement* to individual ideation." [33, pp. 141-142]. Still, studies critiquing the effectiveness of brainstorming on the grounds that it is inefficient were widespread through the late 1990s. More recently, the debate on productivity and collaboration has transferred to the domain of computer-mediated ideation (discussed below).

Limitations of Brainstorming

Three major explanations have been offered to account for lower purported productivity in brainstorming groups relative to ideating alone: *production blocking*, *evaluation apprehension* and *free riding* [8]. We discuss each briefly in turn.

Production blocking

Since only one person speaks at a time in a group setting, others are inhibited from expressing their ideas while another team-member is speaking, potentially slowing their ability to generate new ideas of their own. It is not the lack of speaking time in total that causes the alleged inhibition, as many times the flow of ideas ends before the end of a brainstorm session. Rather, it has been claimed that some participants' ideas are suppressed or forgotten later in the process, as they may seem less relevant or less original than others being expressed. Furthermore, being in a situation where participants must passively listen to others' ideas may distract and interrupt their thought processes and ability to record their own ideas. Examples of studies looking into this hypothesis can be found in [3, 24, 8, 16].

Evaluation apprehension

Creativity by definition is an unconventional act, and being creative therefore involves taking personal risks [13]. Even though one of the most important rules for successful brainstorming is to "defer judgment," the fear of being criticized for having original ideas is often pervasive. Numerous authors have studied this phenomenon of "evaluation apprehension." Maginn and Harris [29], for example, performed an experiment in which a brainstorming group was told that there were expert evaluators watching them through a one-way mirror. No major difference was observed between brainstorming performance in this condition relative to a control condition in which participants were not informed that they were being observed. In another study [5], groups of brainstorm participants were informed that some members of the group were "undercover" experts on the topic at hand. In this case, productivity loss was observed in groups that had been informed of their presence relative to a control group that had not been told.

Free riding

It may be the case that a brainstorming participant's motivation to work decreases if they do not perceive that they will be recognized for their participation. Since brainstorming is a group activity in which all the generated ideas are ultimately grouped together, it is often the case that the generated results are not attributed to their specific contributor. Indeed, lower identifiability of ideas may increase participants' motivation to contribute less, compared to an individual task where they know that their contribution will be recognized. Furthermore, many studies have shown that there is a lower perceived effectiveness of the individual in a group setting [8].

Structuring Ideation: Three Approaches Defined

In most of the aforementioned studies, proponents of brainstorming as an ideation technique tend to be its practitioners in the business and design communities (such as Osborn himself), while its detractors tend to be researchers interested in studying creative techniques but divorced from the nuances of its deeply embedded and culturally contextual practice [21]. Yet because the act of brainstorming incorporates numerous independent and complicated social variables—not least the makeup and experience of the team, the project objectives, the rules employed, and highly contextual success criteria—its effectiveness is difficult to study and empirically discern. Indeed, given that different ideation workplaces are likely to have differing communication patterns and communication needs depending on their cultural makeup and personnel, we find measuring the output of group ideation as a replacement for individual work to be an unsatisfactory approach. More compelling is the question of how intrinsic social and collaborative factors influence group ideation results by introducing "strangeness." Perhaps this reflects our team's ideological bent as design practitioners, but in today's world, problem solving often requires experts from different fields, and new ideas are frequently sparked from novel combinations of existing concepts or the introduction of an existing concept to an unfamiliar context of use [27, 41].

Many authors have addressed the role of social factors in ideation. In this work, we ask how social factors and their resulting effects can be leveraged to develop more effective methods of group ideation online. Research has shown that social factors provide fresh sources of unexpected ideas that can help to reframe the design challenge, with design tools such as extreme characters and interaction labeling proposed as ways of dialing in the necessary "strangeness" for ideation to occur [9, 17]. Other classic ideation techniques include the use of 'random input' [6] and 'oblique strategies' [11] to generate fresh associations; by drawing on unexpected prompts and unrelated ideas to un-stick conventional thinking, such 'trigger concepts' bring fresh associations to the context of ideation, stimulating other associations "Like pebbles dropping in a pond." [43] Drawing on these sources, we ask how brainstorming could be improved as a collaborative ideation technique through alternative methods of random input.

In general, we classify three common social configurations of idea generation behavior: (1) face-to-face brainstorming in groups; (2) individual (or "nominal") idea generation sessions; and (3) computer-mediated ideation. We discuss the unique traits of each of these approaches in turn:

Face-to-face Brainstorming Groups

The classic brainstorming session is done in face-to-face groups during a fixed period of time, usually between 15 to 45 minutes [33, p. 178], and is facilitated by a trained brainstorming expert that enforces the rules of brainstorming on the group. Participation is simultaneous and spontaneous: all participants can see each other's ideas and are encouraged to build upon them. The ideas are recorded as they are suggested. At the end of a brainstorming session, Kelley *et al.* [23] suggest that participants vote on their favorite ideas as a way of generating closure and group consensus about which ideas are most compelling for future work. As for the optimal group's size, in his original writings on brainstorming, Osborn suggested group sizes of up to 12 as effective [33, p. 159]. But there is no agreement in more recent literature as to optimal group-size (*e.g.* [16, 36, 4]), partly because it is difficult to define "optimal" in the context of real-world practice.

Nominal Idea Generation Sessions

Nominal idea generation is done individually. The main element that defines this method is that participants are not influenced by the variety of social factors at play in a traditional brainstorming group: they cannot build on other participants' ideas because they are not exposed to them, they will be less influenced by perceived criticisms to their ideas in real-time (although they may be reluctant to share them afterwards), they may be highly motivated to perform their work in the anticipation that their efforts will eventually be rewarded, and so on. Extensive research has been done to study the benefits and shortcomings of classic vs. nominal brainstorming, as described above. In general, it appears that nominal brainstorming has some benefits in terms of both quality and quantity of ideas [20, 30, 10, 28] due to psychological effects defined by Diehl & Stroebe [8].

Computer Mediated Ideation

Advances in digital technology have led to the potential for a variety of computer-mediated ideation techniques. Within this category, the term "electronic brainstorming" refers to any kind of brainstorming mediated by computers (*e.g.* [40, 7, 1]). One issue attempting to define electronic brainstorming is that *any* online activity that involves people entering information into cloud-based systems can be considered the contribution of "ideas" to a digital pool. For our purposes we therefore consider an electronic brainstorm to be only that subset of software-mediated interactions in which users are asked to specifically generate creative responses to a question or prompt. This differs slightly (with regard to intent) from forums in which people are asked to contribute "best practices" or "suggestions" based on prior-knowledge simply as an act of knowledge-transfer (*e.g.*, suggestion portals wherein users can recommend local restaurants or hotels). It also differs from critique feeds and forums, such as post-blog comment streams debating the relative merits of an advanced position and/or themed around a topic of debate—although such kinds of activities are certainly related to electronic brainstorming and can be useful tools for the evaluation of brainstorming results as well as later phases in the ideation process.

The various possible ideation approaches described above (group brainstorming, nominal idea generation, and computer-mediated ideation) are not mutually exclusive, and can be combined and mixed to make the most of each method. A brainstorming session could be performed in two parts, for example, the first in the nominal style followed by a face-to-face method to evaluate and combine ideas across participants. Electronic brainstorming can also support both nominal and group methods, or implement a diverse array of combinations between them. Indeed, it is precisely because of the flexibility of electronic methods to distribute various aspects of the brainstorming task across asynchronous distributed teams that we performed the studies described in the following section. Group ideation is an integral part of HCI research practice, and an area where the implementation of improved software interactions could greatly enhance how ideation happens in research laboratories, design firms and product companies alike.

METHODOLOGY AND DESIGN RESEARCH

Our investigation began with the simple premise that collaborative ideation could be enhanced through the use of distributed online tools, and design-driven approaches could be used to explore and investigate the potentialities of this space. Our design team consisted of four members with diverse backgrounds including design consulting, software engineering, anthropology, and management. We held regular meetings over the course of several months to conduct freeform exploratory design research. Sessions were held once or twice weekly for 1-3 hours per session. The setting was a design studio in the HCI Institute at Carnegie Mellon University. This section describes our design research process, consisting of the following phases: (1) opportunity finding; (2) electronic brainstorming; (3) concept selection and refinement; and (4) experimentation and discussion.

Opportunity finding

We began with a vision for an online space to browse and share ideas where they could be tagged, filtered, and contextualized in the cloud. This vision was founded on two beliefs: that creators are everywhere, and that they are driven by creative ideas for which they seek open outlets. Although a clear plan for how to develop such a system was not yet evident, we first created a series of exploratory concept sketches to help envision possible outcomes and establish goals. We then analyzed aspects of our concept drawings and generated a set of Post-It notes chronicling our complete list of observations and desires.

Next, we arranged these notes on a 2x2 matrix to help group them into clusters and synthesize common themes. Because our aim with this stage was to work on a meaningful project that was enjoyable and inspirational to the team, the axes of this matrix we created, ranging from low to high in each dimension, were “Fun Impact” vs. “Social Impact.” Seven areas of opportunity emerged from this exercise: (1) Reveal hidden (personal) meanings through metaphorical leaps of imagination; (2) Facilitate the discovery of thinking patterns; (3) Track creative influence to motivate participation; (4) Associate and juxtapose unexpected ideas; (5) Help people find ideas that are important to them; (6) Invent and embody “creative movements”; and (7) Spark and inspire interest and freedom.

Electronic Brainstorming

Given our interest in exploring the possibilities of electronic brainstorming we decided to experiment with distributed ideation online. Using the identified opportunity areas as jumping-off points for generative design, we restated each of the seven opportunity statements described above as a “How could we...” question (*e.g.* “How could we facilitate the discovery of thinking patterns?). Each question was placed at the top of a separate new Google Docs file. We then invited some 30+ interdisciplinary undergraduate and graduate students in the HCI Institute to these seven files. All of these students had prior experience with group brainstorming, and were given the instruction to each contribute at least five ideas in response to one or more of the brainstorm questions. We performed this activity over the course of a four-day weekend, with the stated goal of achieving at least 50 ideas in response to each question. On the fourth day, five of the seven questions had more than 50 ideas. For the remaining two questions the research team made a concerted effort to generate the remaining necessary ideas. In total, 350 distinct opportunity concepts were generated. Next, seven of the most involved members of the laboratory team were asked to “vote” on their favorite ideas in each file by adding a brightly colored symbol next to the item number. In this way, a selected group of 35 “favorite” ideas were agreed upon from across all seven questions.

Concept Selection and Refinement

Favorite ideas were printed out on paper, cut into strips, and placed on an Impact/Achievability matrix [15]. We then gave each of these ideas a more concise name by applying colorful Post-it notes on top of them and drawing broad categories around them with a colorful marker. The main outcome of this phase was two key concepts, each in the “easy” and “high-impact” quadrant. The first was a group of ideas we labeled “idea factories.” Of these there was one particularly compelling idea—the concept of an idea “broken telephone” game. We refer to this concept in general as “*chainstorming*.” The second was a category of ideas we identified as “creative judgment tasks” involving quickly voting on pre-existing ideas, much as we had done at the end of our electronic brainstorming sessions. We refer to this concept in general as “*cheatstorming*,” as described in studies 1 and 2 below. Finally, while not discussed here in detail, we are currently building a working prototype system that combines chainstorming with cheatstorming, called *Tweetstormer*, also described below. To clarify, the relationship between brainstorming, chainstorming, cheatstorming, and tweetstormer is shown in figure 1.

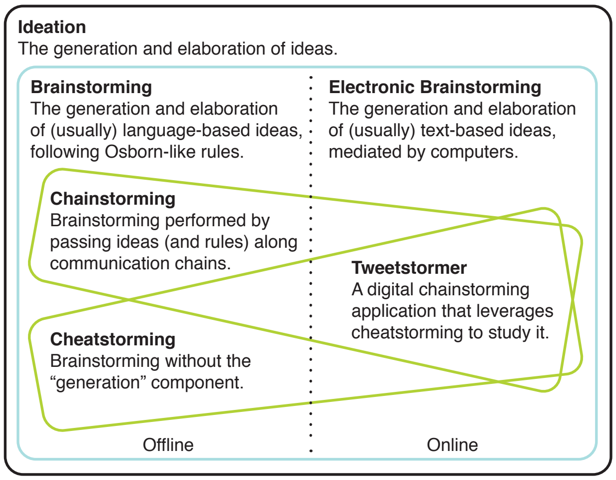

Figure 1. A taxonomy of interrelated ideation techniques.

Experimentation: Cheatstorming (Study 1)

Our main work in this paper explores the cheatstorming concept. The basic premise of this paradigm is as follows: imagine a brainstorm has been performed, resulting in 50 ideas. Participants vote on their favorite ideas, and some of them are selected for implementation. Now another brainstorm is performed on a different topic, resulting in 50 more ideas and additional voting. In time, many hundreds of brainstorm questions are asked, and thousands of ideas are generated and saved. Some have been implemented, and others have not. At this point, a wealth of valuable brainstorming has already occurred. The cheatstorming paradigm proposes that *no new ideas are necessary for further ideation to occur*. Given a new prompt question and a set of 50 random previous ideas to draw from, cheatstorming simply bypasses the concept generation phase altogether and jumps directly to voting on which ideas to advance.

To test this concept we performed a simple pilot experiment. First, each member of our team generated 3-5 "totally random" brainstorm questions on Post-It notes, not in response to any particular question or stated need (*e.g.* "What is the easiest way to make the most people happy cheaply?"). Next, a set of 60+ solution concepts was generated equally at random (*e.g.* "Magnetic cellphones", "Non-linear presentation tool", "Magic annoying elf that re-arranges your clothing," etc.). Finally, one of the previously generated brainstorm questions was selected at random and paired with 10 of the concept Post-Its at random. From these 10 ideas, the four concepts that most closely resonated as solutions to the given question were selected as "winners." We repeated this process four times with four different questions. For example, one of the sample solution pairings is shown in figure 2.

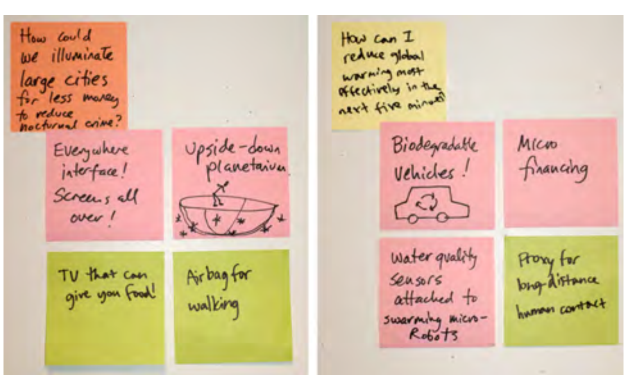

Figure 2: Sample results from our first *cheatstorming* trial.

We were both surprised and delighted by the results of this method. Not only did we have little difficulty identifying those ideas that best resonated with the questions being asked, the resulting set of ideas was remarkably unexpected and fresh. Most exciting, the process was fast, fun, and required low effort, and the solutions revealed unexpected combinatory patterns and juxtapositions. In the first example shown in figure 2, for instance, the question asks "How could we illuminate large cities for less money to reduce nocturnal crime?" Surprisingly, three of the selected solution concepts are screen-based ideas that all emit light. Not only was this an unanticipated means of illumination, it was also one that could provide other forms of safety from nocturnal crime—via an interactive "call for help" kiosk or informative map, for example. Furthermore, the fourth idea in this set, "airbag for walking," suggests that perhaps solutions for reducing nocturnal crime could be built directly into a user's clothing. Combined with the other cheatstormed ideas, this in turn sparks a train of thought that perhaps clothing should be illuminated, or—alternatively—that the city's streets should be padded. Finally, each of the other cheatstormed questions resulted in an equally compelling set of results. In response to the question "How could we reduce global warming effectively in the next five minutes?," for example, "biodegradable vehicles" and "micro-financing" were among the selected concepts. While neither of these ideas may enable global warming to be reduced in the next five minutes alone, when combined together they indicate a potential direction for immediate action (*i.e.*, green-vehicular crowdfunding).

Experimentation: Cheatstorming (Study 2)

There are many variables in the way that cheatstorming could be performed that we were curious to explore, such as how the variable effects of different types of "idea input" would affect cheatstorming results. We also wanted to compare cheatstorming results with results from a traditional brainstorming session. To this end, our next study leveraged the results of five previously completed brainstorming sessions from other unrelated projects as input. We chose this data from prior brainstorming sessions that had been well documented with clear questions and solutions, and which had generated more than 50 ideas apiece. These ideas had also been voted upon in the previous iteration, enabling us to track the success or failure of previously successful ideas in the new cheatstorming context. Finally, it was important for us that the brainstorming sessions had been performed by different groups of participants spanning a diverse set of HCI topics, to

Figure 3: Input data for the *cheatstorming* study.

ensure that we had a wide variety of ideas in our pool to draw from overall, and so that unanticipated biases based on the authorship of ideas was reduced.

The prompts from the five selected sets of data were as follows: (1) "*How could we summarize text-based information to make browsing it intuitive, useful, magical and fun?*", from a project on digital mind mapping; (2) "*How could we sculpt and craft using digital tools?*", from a project on tangible computing; (3) "*How could we encourage self-actualization and the experience of new experimental dynamics?*", from a project on augmented reality; (4) "*How could we support the successful publication of confident high quality writing?",* from a project on narrative fiction; and (5) *"How could we rigorously craft and curate the design of aesthetically pleasing narrative products and services?"*, also from the narrative fiction project.

Our study design involved four experimental conditions drawing on brainstorming results from the above-mentioned sets of data. All of the previously generated raw ideas from each set of data were printed on cards in a unique color, one color per set (Figure 3). These raw-idea cards were used as input data for each of our study conditions. In addition, those idea cards that had been originally selected within each set as the "winners" for that set were clearly marked with an asterisk; this allowed us to trace which previously successful ideas prevailed through the cheatstorming process.

The study conditions were designed to be structurally equivalent. In each case, 50 raw "input" ideas would be pared down to 10 "winning" ideas in response to the ideation prompt. We used the same ideation prompt across all conditions: question 5 (*"How could we rigorously craft and curate the design of aesthetically pleasing narrative products and services?"*). The experimental conditions, illustrated in figure 4, were as follows:

Condition A (brainstorming baseline). Previously selected brainstorming results from set 5 (those with asterisks) were chosen automatically as *de facto* winners.

Condition B (overlapping diverse input). 17 ideas were each selected at random from sets 2, 3, and 4, combining to make a total of 51 ideas. One idea was removed at random, resulting in 50 ideas. Cheatstorming then commenced using question 5 as the ideation prompt. Because set 4 was drawn from the same project as set 5, cheatstorm results were anticipated to be most similar to condition A.

Condition C (unrelated diverse input). The same diverse

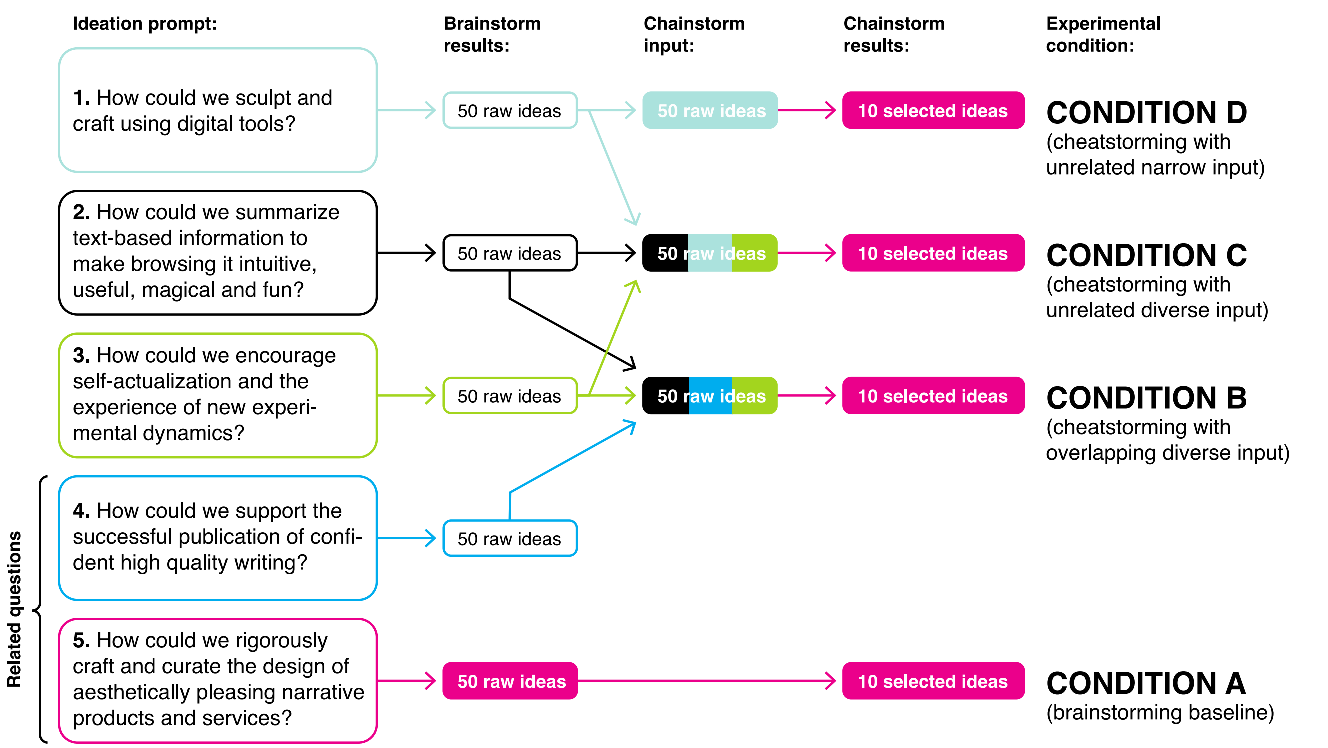

Figure 4. Experimental conditions for cheatstorming study 2.

input structure was used as in condition B, except input ideas were drawn from sets 1, 2, and 3. These ideas were not intentionally related to set 5 in any way.

Condition D (unrelated narrow input). This session used a single unrelated set of ideas as input, from set 1.

Cheatstorming proceeded by laying out all 50 input ideas for a given condition below the ideation prompt, then working through each of them one-by-one as a team, attempting to find ideas that would match with the brainstorming prompt (figure 5). Ideas that didn't seem related were put aside. Remaining ideas were grouped together into 10 "winning" clusters, such that each cluster created a meaningful concept relevant to the prompt. Each cluster was then given a more concise and meaningful title so as to relevantly depict the newly synthesized idea (figure 6).

DISCUSSION

As described in detail by Isaksen [21], evaluating the effectiveness of group ideation outcomes is fraught with methodological and practical problems. These include the necessity of identifying and isolating the different factors in the ideation tool or process likely to influence its effectiveness, being aware of the level of training (if at all) the facilitator had gone through to run the session, determining the group's experience with creative ideation in general (and their orientation to the task at hand in particular), the preparation and presentation of the task in such a way that it promotes ideation, the effectiveness of the ideation method in highly-contextual real-world practice, and the criteria employed to evaluate the outcomes. Given these challenges, we believe it is difficult if not impossible to generalize the effectiveness of a specific culturally embedded creative activity without first recognizing the serious practical limitations of attempting to do so. For this reason, the approach taken in this study was design-oriented, in line with Fallman's characterization of design-oriented HCI as giving form to previously non-existent artifacts to uncover new knowledge that could not be arrived at otherwise [12]. We attempted to replicate a controlled methodology as precisely as possible during our cheatstorming study four times, each time varying only the set of ideas input into the selection process. Each time, 50 previously defined ideas were reduced down to 10 "winning" favorites by the same team of researchers, and each time our 10 favorite ideas were unique. Given the creative and intentionally unpredictable nature of ideation, we believe that even though we held all of these variables constant (*i.e.* same team, same brainstorming rules, same prompt question, etc.) we would likely have generated differing ideation results if we attempted to repeat this study again. This stated, some noteworthy qualitative observations can be made, and we will now reflect on the qualitative differences in both the application of the process and the outcomes it produced between differing conditions of study 2.

Figure 5: The 50 candidate cheatstorm ideas in condition C.

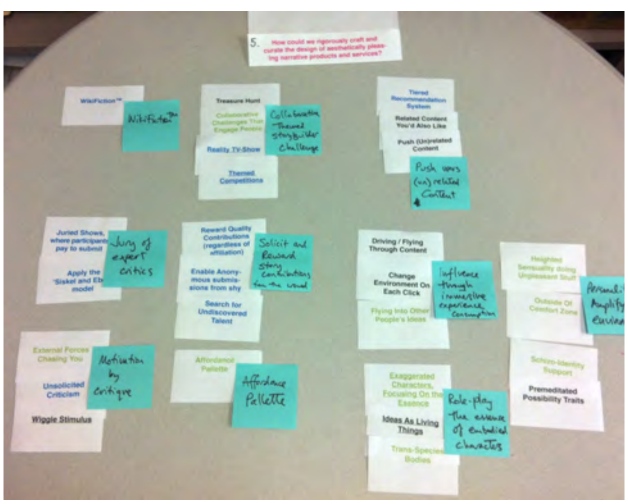

Figure 6: "Winning" concepts from condition B.

Findings: Process

Cheatstorming was shown to be a fast and enjoyable means of creative ideation. Especially when cheatstorming ideas that came from different and diverse input sets, we find that this method works well as a mechanism of introducing novel concepts across creative cultures, a process akin to "technology brokering" among brainstorming teams whose ideas cross-pollinate [41]. Indeed, the greatest challenge and thrill of the cheatstorming method is being faced with the task of combining what often seem to be nonsensical results from previous brainstorming sessions—in that they contain remarkably little context by which to understand them—with ideation prompts that are likely to be equally without adequate context (especially should cheatstorming be widely deployed in a distributed setting). The natural reaction of the cheatstormer—indeed, their only real option—is to force an inventive connection between ideation and prompt. In this regard we posit that the more tightly constrained the input data given to the cheatstormer when synthesizing across large sets of data, within reason, the more effective they will be at identifying such juxtapositions. We note, for example, that our first study involved the reduction of 10 input ideas to four "winners," which could be accomplished very quickly because the cheatstormer had no alternative than to pick something quickly that worked. Study 2, with its larger set of inputs and greater creative freedom, introduced a more overwhelming quantity of possible connections and, consequently, felt more tedious and less productive.

Based on this observation, we believe that setting time-oriented constraints might help to improve the cheatstorming experience. While the mandatory rigor of matching 10 winning concepts per question in study 2 was nice, it also resulted in additional room for idea comparison and judgment, leading more nuanced but ultimately (we feel) less inspired ideas. Adding a time limit or other kinds of creative constraint might encourage spontaneous connections and force weaker ideas to be eliminated more quickly on a visceral basis.

Comparing the process across experimental conditions, it seemed both easier and more immediately intuitive to group together ideas that came from the same original source. Looking at the results of our final synthesis, however, we notice a distinctly integrated mixing of source material in the creation of our final generated concepts. This also highlights one of the possible biases that became evident as a result of our process. In retrospect we wished that we had not color-coded the input ideas, as it introduced a perceptible value judgment into the study. Indeed, the simple awareness that such a bias may have existed is likely to have resulted in our intentional or unintentional effort to use equal numbers of ideas of each color, for example. As a result, it is difficult to say if the approximately even survival rate of resulting ideas across input pools within each condition resulted from this bias.

Another source of bias were ideas that repeated themselves in subsequent iterations. This influence was twofold: foremost, since the prompt remained the same for all four cheatstorming iterations, arriving at similar ideas with each round became quickly redundant. Furthermore, because each cheatstorm used a random mix of input material, about a third of the ideas from previous conditions re-appeared with each subsequent effort. In this regard, we believe that ideas that have been previously "used" by participants should be removed from the input pool in successive rounds. Using digital systems, we anticipate the implications of scaling these methods up to large crowds of users, and recommend tracking previously viewed ideas to prevent them from appearing again. Not only did ideas seem "less interesting" on the second occasion, they also became harder to associate with new outcomes and meanings. Indeed, if creativity systems are to be tasked with delivering unconventional content to users it's essential that the content should not be familiar.

Findings: Results

In addition to the cheatstorming team's qualitative reflections on process, we consulted with an independent judge who had worked on the narrative fiction project to which the ideation prompt had originally belonged. Together we evaluated the top 10 "winning" idea clusters from each of the 4 conditions, to see if cheatstorming results would be applicable for potential real-world use on her project.

Relative to the baseline brainstorm condition (condition A), the most noticeable quality of the winning cheatstormed ideas was that all of them were dramatically technological in nature. This is not surprising, given that the narrative fiction project was the least technologically oriented of the prompts (the other three questions having been drawn from projects on augmented reality, tangible computing, and digital mind mapping, respectively). Furthermore, the degree to which ideas felt un-helpful to the project was directly proportional to their degree of strain. In condition A, the baseline condition, the ideas felt the most immediately useful and applicable to the project because they did not all have such a technology focus. We should also note, however, that our judge had originally been involved in selecting the baseline winners, but not the cheatstorming results, introducing a likely source of bias. Condition B, the overlapping diverse input group, was the most palatable set of the remaining ideas. It seemed to introduce fresh new ideas that were grounded in something familiar. Condition C, the unrelated diverse input group, was described as "the most random." Ideas in this set—with names such as "tempo of experience control" and "real-time story-world generation"—were exciting but felt out-of-touch with project goals. Condition D, the unrelated diverse input group, were the most technologically immersive. Ideas such as "magic story wand" and "crowdsourced tangible narrative sculpting" were described as "nice to pursue if I had a team of designers and developers, but that would change the focus of what the project is really about."

In summary, all of the ideas that resulted were related to the ideation prompt, but clearly reflected the spirit of the brainstorm from which they originated. This is not surprising, but it does indicate that a diverse mix of somewhat related (but also diverse and different) ideas could have a positive impact at broadening the scope and breadth of a project's ideation.

CONCLUSIONS AND FUTURE WORK: CHAINSTORMING, TWEETSTORMING, AND CHEATSTORMING AT SCALE

This work has investigated distributed ideation from a design-driven perspective by designing and building prototypes of possible ideation mechanics and reflecting on the qualities of the outcomes. Our aim with this approach is to improve the design of HCI tools that facilitate efficient and effective group ideation.

Reflecting on our findings, we realize that we have revealed a model for group ideation with four distinct stages of progressive activity. Each stage carries with it a set of differing requirements and resulting behaviors, and we expect that the criteria leading to effective ideation outcomes at each stage will be different. These stages are: (1) *prompting*, the stage during which the ideation facilitator presents a challenge to the group that will drive ideation; (2) s*haring*, the stage in which participants suggest and communicate ideas within the context of the medium that frames the activity (*i.e.*, orally, and/or using a whiteboard, sticky-notes, database system, and so on); (3) *selecting*, the phase during which participants vote and/or otherwise determine their favorite ideas; and (4) *committing*, the stage at which a final criterion is set to evaluate and prioritize ideas, ultimately determining which ones the team moves forward with and (ideally) develops.

This framing is in contrast to previous ideation models (*e.g.* Jones' "divergence, transformation, convergence" model [22], Nijstad *et al.*'s dual pathway ideation model [32], etc.) in that, while it recognizes the cognitive distribution of ideation across social structures, *it does not view creative behavior as a "generative" activity*. Instead, ideas are simply transferred (or "shared") between people, and the act of sharing is the source of the ideation: it involves the expression and interpretation of possible conceptual meanings. Even in traditional brainstorming sessions, we propose, it is this communicative interplay between one person's conception of an idea and another's (mis)interpretation that results in the so-called "generation" of ideas. Cheatstorming demonstrates that ideas need not be created by the team for ideation to occur—they simply need to be interpreted as possibilities resulting from a collision of shared meanings. The only requirement for a successful ideation outcome is that the ideas introduced in the sharing stage are unconventional to the ideating individual, team, or culture [24] (*i.e.* "strange" [18]), and that they be interpreted as relevant (or not) to the ideation prompt.

We have introduced the concepts of *cheatstorming* as ideation without the "idea generation" component, and *chainstorming* more generally as a paradigm of communicative ideation (figure 1). Rather than conceiving of creativity as a spontaneous act of personal imagination, chainstorming is intrinsically social by nature. It is inspired by the "broken telephone" (or "Chinese whispers") social group game, in which one person (Alice) secretly tells a story to another person (Bob), such that none of the other people present can hear it. In turn, Bob tells the story as he remembers it to a third person (Carol), and so on, until all of the people in a continuous chain back to Alice are reached. The last person to hear the story shares what he or she remembers with the entire group, and that story is compared with the original story.

In chainstorming, much like this game, each participant is asked to build on the story of the previous participant in the chain. The first person in the chain generates the prompt question and one or two ideas that respond to the question before sending it off to a network of friends. Each subsequent person sees the prompt question, along with a subset of the ideas from the previous participant, and uses these ideas to build on them and generate new ideas. Using this method, which introduces a degree of randomness at each stage and which can also be controlled by the design of the communication and its rules, we propose that collective creativity can be embedded in social networks through simple interactions that reduce cognitive effort. Indeed, similar approaches have been developed in recent related work, promising the development of evolutionary creativity algorithms wherein humans pick the "fittest" ideas to result in emergent solutions to potentially complex tasks [45]. In chainstorming, where a random subset of each participant's previous ideas could be selected and passed along with each interaction, the continued juxtaposition and "constructive strain" [18] from potentially unrelated or even contradictory ideas could consistently spark unexpected new socially-generated concepts. Indeed, it is the unique ability of cheatstorming to "dial in strangeness," as explored in our study, that makes it such a compelling example of the future of ideation online. In the case of cheatstorming, this is far more nuanced than existing methods of random input, such as future workshops [31], inspiration card workshops [19], or other similar methods for lateral thinking, in that it enables operational changes to the ideation methodology and content directly, and thus can facilitate targeted and highly contextual "leaps" from an original set of ideas to a much wider framing of the problem domain.

Clearly the success of chainstorming as paradigm depends largely on details of its implementation since, as noted in our discussion of brainstorming best practices, several factors will greatly influence the most effective outcomes. Much like offline group brainstorming, effective chainstorming is likely to depend heavily on the social constitution of the chain, the level of training (if any) that participants receive, the group's experience and orientation with the task at hand, and the criteria employed to evaluate its outcomes. Moreover, ideation of this nature introduces additional factors that will need to be addressed—especially the potential lack of context accompanying the prompt communication, which (and how many) prior concepts accompany the message as it is passed from user to user, how is their selection determined, as well as how to handle redundant concepts, dead ends, cross-posting and parallel chains, and so on. Indeed, these are complicated issues that underlie all social messaging and communication networks.

In order to investigate these questions of ideation more deeply, and identify best practices for chainstorming networks, we have begun the design and development of a new social media platform for ideation—*Tweetstormer*—which will leverage Twitter messages as the transactional medium of the chainstorming system. Using this platform, members of the online community will be able to post and respond to tweeted prompt questions to virally distribute the chainstorm. Not only will this enable Twitter users to ideate anytime from anywhere using their computer or mobile device, our plan is to implement a custom website that allows users to see other users' questions, reply to them selectively, browse other users' replies to prompts, and vote on their favorite ideas to select them. Our hope is that ideation via this and other similarly inspired platforms will enable a more nuanced empirical study of the chainstorming paradigm and how best to integrate it effectively into the social fabric of online innovation.

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