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Conceptual Combination versus Critical Combination: Devising Creative Solutions using the Sequential Application of Crowds

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Abstract

The purpose of this study was to examine the steps involved in the sequential application of crowds to produce creative solutions for social problems. 127 university students generated, criticized, modified, and evaluated text solutions for reducing misinformation on the Internet. One crowd generated solutions based on two ideas randomly paired from previous crowds' ideas. The other crowd came up with solutions based on one idea and a criticism for this idea generated by previous crowds. Whereas solutions based on two ideas were on average rated more creative than those based on an idea and criticisms, the five most creative solutions that addressed criticisms were rated significantly more creative than the five most creative ideas that combined two ideas. We conclude that a critical crowd can be useful if the goal is to collect a small number of highly creative ideas using the sequential application of crowds.

Keywords: Creativity; wisdom of crowds; collective intelligence; critical thinking

Introduction

Advances in communications technologies have changed the way people collaborate. In many websites, crowds work in isolation for the most part, and their ideas are aggregated later. For example, users may rate news stories posted on a website, and the website may show the aggregate rating for each story. There are many web services for collaborative tagging and filtering, online auctions, and prediction markets, which allow users from afar to collaborate efficiently without knowing the others.

The current work examines how crowds can be used to collect creative ideas. In particular, we examine the steps involved in the sequential application of crowds to design solutions for social problems. We think the use of crowds has a great potential for solving many difficult problems. Although online crowds work for free or for nominal fees, collective solutions of crowds can be as useful as those of a few experts (Surowiecki, 2004). Aggregation cancels out individual errors and highlights "correct" solutions (cf. Estes & Maddox, 2005; Galton, 1907), leading to the wisdom of crowds. Moreover, the idea of crowds generating goods and services has been regarded as a viable alternative to firms and markets (Benkler, 2006; Howe, 2006).

In our past work (Nickerson & Sakamoto, 2010), we have examined one way of using crowds to design creative ideas. The basic procedure was to ask the first crowd to generate a set of ideas, akin to divergent thinking, in which diverse ideas are generated. The second crowd combined two ideas from the first crowd, akin to convergent thinking, in which ideas are filtered and integrated. Then the third crowd combined two ideas from the second crowd, in the hopes of further improving the creativity of the ideas.

Letting crowds combine ideas is a reasonable approach for improving the creativity of the variants. Cognitive scientists have proposed that creativity depends on conceptual combination, in which separate ideas or concepts are merged (e.g., Ward, 2004). According to Rothenberg (1979), creative accomplishments, such as original arts and scientific discoveries are the results of synthesizing two opposing ideas. Thagard and Stewart (2011) propose that novel combinations of mental representations underlie many kinds of creativity.

In crowd creativity, the results from the past work are mixed. For some tasks, such as designing children's chairs in drawings, letting crowds combine previous designs resulted in more creative designs (Yu & Nickerson, 2011). For other tasks, such as generating solutions for oil-spill problems in texts, there was little if any improvement in creativity of ideas generated by later crowds (Bao & Sakamoto, in preparation). Perhaps combining two text ideas for solving social problems is difficult, especially when the two ideas are non-alignable and there is no easy way to integrate elements from different ideas (cf. Markman et al., 2009). Such situations are common with text ideas for solving social problems such as dealing with oil spills, but less common with designs of chairs.

An alternative to combining ideas is to let the crowds address criticisms of ideas. A critical crowd can find a problem of an idea, and the next crowd can address the problem. Defining a problem, which is an important component of critical thinking (Ennis, 1987), interacts with

generating ideas in creative problem-solving (Treffinger, et. al., 1994). In this way, critical thinking is related to creativity (Brookfield, 1987; Moon, 2008). By addressing criticisms, the crowd will refine and elaborate on an idea, which will improve the quality of the idea (Runco & Pritzker, 1999). Thus, we hypothesize that including a crowd, which concentrates on finding problems into crowds will contribute to generating creative ideas.

Like the past work, the first crowd generates a set of ideas. Instead of combining two ideas from the first crowd, the second crowd generates criticisms for given ideas. The third crowd generates a new set of ideas based on an idea from the first crowd and its criticism from the second crowd. By addressing the criticism of the idea, the third crowd will refine and elaborate on the given idea. Here we compare this sequence involving a critical crowd, which we call the idea-criticism condition, with the sequence from the past work involving only combination crowds, which we call the idea-idea condition.

One theoretical contribution of our work is that we apply work in critical thinking and conceptual combination to crowd. In practical terms, by better understanding the processes of crowd creativity, we can help design social-computational systems that are tailored to the goals of the systems. In terms of societal impacts, if the use of crowds in generating creative solutions works, we may be able to find creative solutions for many challenging social problems.

Method

Participants

In total, 127 Japanese undergraduate and graduate students (60 men, 67 women) at Kyoto University participated in four crowds, with the mean age of 22 (*SD* = 3). Each participant was in only one crowd. Each participant received a bookstore gift card in the amount of 500 Japanese yen (about $6) after completing the task.

Apparatus and Materials

Data were collected using Excel spreadsheets on a 15-inch monitor in a laboratory. The following social problem was used: "There is diverse information on the Internet, including wrong information, deceptive information, and information that is not based on fact. What can we do to avoid or reduce the negative influences of misinformation on Internet users?"

Design and Procedure

Table 1 summarizes the design of the current study. There were four crowds. Crowd 1 generated 30 ideas. In the idea-idea condition, Crowd 2 generated another set of 30 ideas, and Crowd 3 generated 90 ideas based on 30 pairs of an idea by Crowd 1 and an idea by Crowd 2. In the idea-criticism condition, Crowd 2 generated 30 criticisms, one criticism for each of 30 ideas, and Crowd 3 generated 90 ideas based on 30 pairs of an idea by Crowd 1 and a criticism by Crowd 2. Crowd 4 evaluated 180 ideas by Crowd 3 on novelty and practicality, which are two important components of creativity (Runco & Pritzker, 1999), and are often used in measuring creativity (cf. Dean, 2006; Finke et al., 1992). In crowd 2 and crowd 3, participants were randomly assigned to either the idea-idea or idea-criticism condition.

Table 1: The design of the current study

Crowd	Idea-idea	Idea-criticism
1 (*n*=10)	Generated 30 ideas	
2 (*n*=10, 10)	Generated 30 ideas	Generated 30 criticisms of 30 corresponding ideas by Crowd 1
3 (*n*=30, 31)	Generated 90 ideas based on 30 pairs of an idea by Crowd 1 and an idea by Crowd 2	Generated 90 ideas based on 30 pairs of an idea by Crowd 1 and its criticism by Crowd 2
4 (*n*=36)	Evaluated 180 ideas by Crowd 3 on novelty and practicality	

Crowd 1 Each participant was asked to generate three ideas. For each idea, the participant filled in the three blanks: "One way to avoid or reduce the negative influences of misinformation on Internet users is to [blank]. An example is to [blank]. The advantage of this is that [blank]." Participants typed their answers into an Excel spreadsheet. In total, Crowd 1 generated 30 ideas.

Crowd 2 In the idea-idea condition, each of 10 participants was asked to generate three ideas in the same fashion as those in Crowd 1, resulting in 30 new ideas.

In the idea-criticism condition, each of the other 10 participant was shown three ideas generated by Crowd 1, one at a time, and asked to point out a problem of each idea by filling in the blank: "The problem of this idea is that [blank]. Therefore, it is difficult to avoid or reduce the negative influences of misinformation on Internet users." This resulted in 30 problems associated with 30 ideas by Crowd 1, one problem for each idea. Participants were also asked to explain the reasons behind their responses.

Crowd 3 In the idea-idea condition, each idea by Crowd 1 was paired with a randomly selected idea from Crowd 2 of the idea-idea condition. Each of 30 participants was asked to generate a new idea based on one of the 30 pairs. This procedure was repeated three times for each participant.

In the idea-criticism condition, each idea by Crowd 1 and its criticism by Crowd 2 of the idea-criticism condition were presented together. Each of 31 participants was asked to generate a new idea based on one of the 30 pairs. This procedure was repeated three times for each participant.

The two conditions shared the 30 ideas by Crowd 1. In both conditions, participants typed their answers on the Excel spreadsheet. In total, removing unfinished responses in time, 90 ideas were generated in each condition.

In Crowds 1–3, each participant was asked to generate three ideas or criticisms in 30 minutes. Excepting idea-criticism condition in Crowd 2, participants were encouraged to generate creative ideas. The instructions stated that the more novel and practical an idea was, the more creative it would be considered.

Crowd 4 The 180 ideas by Crowd 3 were randomly numbered from 1 to 180. Each participant was given a 30 × 30 matrix on an Excel spreadsheet. The vertical axis was labeled novelty, and the horizontal axis was labeled practicality. Both axes ranged from 1 (low) to 30 (high).

In the center of the matrix (novelty = 15, practicality = 15), the identification number of the following idea, which was randomly selected from the 180 ideas, was shown as a reference: "*[#138] Educate students so that they develop an awareness that wrong information, deceptive information, and information that does not based on fact exist on the Internet, the ability to check the truth of such information, and the skill to judge and criticize whether the information is useful for solving the problem at hand.*" Participants evaluated the other 179 ideas, putting each idea's number in the matrix to indicate how novel and practical they thought the idea was. Only one number was allowed in each cell. They were asked to evaluate all ideas within 40 minutes.

Our main interest was comparing the novelty and practicality values of 90 ideas from the idea-idea condition with 90 ideas from the idea-criticism condition.

Results

Of 36 participants in Crowd 4, one participant who did not complete the evaluation task within the time limit was excluded from the analyses.

Relationship Between Novelty and Practicality

We first examined the relationship between novelty and practicality. Novelty was negatively correlated with practicality, $r = -0.47$, $p < .001$: The more novel an idea was, the less practical it became.

Participants were more willing to provide extreme values on the practicality dimension than on the novelty dimensions. Table 2 shows the maximum and minimum values participants used for novelty and practicality in each condition, and Table 3 shows the average based on each idea's standard deviation value. A parent type (idea-idea vs. idea-criticism) by creativity (novelty vs. practicality) analysis of variance (ANOVA) was conducted, with each idea's difference between maximum and minimum values (range) as a dependent variable. The range of novelty was significantly smaller than that of practicality, F (1, 34) = 11.22, $p < .005$. The main effect of parent type and the parent type by creativity interaction were not significant, $F < 1$ for both. Further, a Ryan' multiple comparison analysis showed that the standard deviation was higher for practicality than for novelty in both conditions. In the Discussion section, we speculate why practicality results in more extreme values than novelty.

Based on these results, we decided not to integrate novelty and practicality scores into a single creativity measure. Instead, we analyzed novelty and practicality separately.

Table 2: Means, standard deviations, maxima, and minima for novelty and practicality in the two conditions.

	Idea-idea (*n*=35)		**Idea-criticism** (*n*=35)	
	Novelty	Practicality	Novelty	Practicality
Mean	15.38	14.87	14.94	14.07
(SD)	(2.35)	(2.57)	(2.27)	(2.42)
Max	20.71	21.54	23.46	22.40
Min	9.00	5.14	8.03	1.77

Note. Ranged from 1 (low) to 30 (high)

Table 3: Means of standard deviations for novelty and practicality in the two conditions.

	Idea-idea (*n*=90)	**Idea-criticism** (*n*=90)
Novelty	6.49	6.71
Practicality	7.23	7.23

Idea-Idea vs. Idea-Criticism

Our main interest was whether the idea-idea or idea-criticism condition resulted in more creative ideas.

All Ideas First, we compared all 90 ideas from the idea-idea condition with all 90 ideas from the idea-criticism condition. Surprisingly to us, the idea-idea condition generated more novel and practical ideas than the idea-criticism condition, F (1, 34) = 30.48, $p < .001$ (see left four bars in Figure 1). The main effect of creativity and the parent type by creativity interaction did not reach significance, F (1, 34) = 1.31, $p = 0.26$, and F (1, 34) = 2.32, $p = 0.14$, respectively.

Top 5 Ideas Based on the average novelty and practicality scores of 35 participants, we selected top five ideas out of 90 ideas in the idea-idea condition with respect to each creativity dimension. We selected top five ideas of the idea-criticism condition in the same manner. Then, we calculated each participant's average score for the top five ideas, resulting in 35 mean values for each category dimension in each condition.

Interestingly to us, the idea-criticism condition generated more novel and practical ideas than the idea-idea condition when we compared the top 5 ideas, F (1, 34) = 4.22, $p < .05$ (see right four bars in Figure 1). This pattern of results is the opposite of that for all ideas. The main effect of creativity and the parent type by creativity interaction was not significant, $F < 1$ for both.

We further analyzed the top 5 ideas from each condition and found that the most novel idea of all 180 ideas was generated under the idea-criticism condition. This is the summary of the most novel idea: "*[#175] Build an Internet police into every computer during the manufacturing*

process. The Internet police has knowledge of experts in every field and is aware of current information in common use around the world." Its novelty score was 23.46 (the practicality score was 6.83). Further, the three most novel ideas from the idea-criticism condition were also the three most novel of all 180 ideas.

The pattern was similar for the analysis of practicality. The most practical idea of all 180 ideas came from the idea-criticism condition. This is the summary of the most practical idea: "*[#007] Set up a comment column on a website where visitors can leave their comments and opinions. Visitors can grade opinions posted on the website according to five scales. They describe the reason for the grading, post suggestions for improving the site, and so on.*" Its practicality score was 22.40 (the novelty score was 11.06).

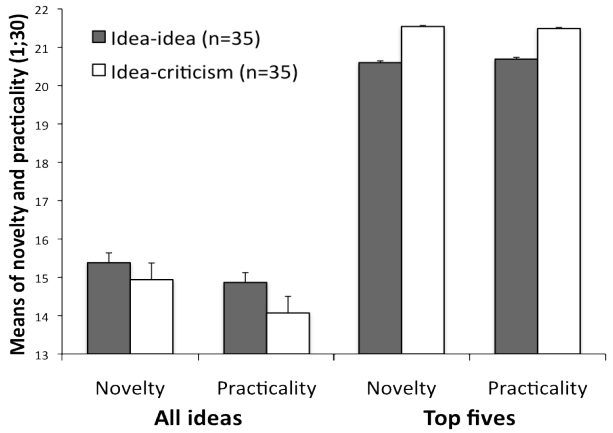

Figure 1: The analysis of all ideas revealed that Crowd 4 rated the ideas from the idea-idea condition more novel and practical than the ideas from the idea-critical condition. This pattern was reversed in the analysis of top 5 ideas. Each bar shows the mean of 35 participants. Error bars represent standard errors.

Top 10 and 20 Ideas Top 10 and 20 ideas were selected in the same fashion as the top 5 ideas. There was no significant difference between the idea-idea condition and the idea-criticism condition, F (1, 34) = 2.13, p = 0.15, for top 10 and $F < 1$ for top 20. All the other effects were not significant, $F < 1$ for all.

Of 10 most novel ideas out of all 180 ideas, five ideas were generated under the idea-criticism condition. Of 10 most practical ideas out of all 180 ideas, seven ideas came from the idea-criticism condition. Coupled together, our results show that the idea-criticism condition generated a small number of highest quality ideas.

Discussion

The present study investigated two ways of generating creative ideas for problem solving using crowds; asking a crowd to generate a new idea based on two ideas or on a pair of an idea and a corresponding problem by the previous crowds. The former idea-idea approach is essentially conceptual combination in crowds. The latter idea-criticism method can be seen as critical thinking in crowds. We compared the idea-idea method with idea-criticism method by asking crowds to generate ideas sequentially.

Comparing Idea-Idea with Idea-Criticism

We found an overall tendency that the idea-idea method generates both more novel and more practical ideas than the idea-criticism method. One advantage of the idea-idea method is that two ideas can provide much more diverse information. What Crowd 2 in the idea-idea condition did was to generate new ideas independently of ideas by Crowd 1. On the other hand, Crowd 2 in the idea-criticism condition pointed out a problem for each idea generated by Crowd 1, and did not have to generate new idea nor an alternative idea to overcome the problem. In other words, whereas 20 participants generated initial ideas in the idea-idea condition, only 10 participants generated the initial ideas in the idea-criticism condition: The idea-idea condition had twice as many initial ideas as the other condition. In this way, the idea-idea method focuses the crowds to integrate a more diverse set of ideas.

When we examined the five most novel ideas, we found the opposite pattern of results: The idea-criticism method generated more novel ideas than the idea-idea method. This was also the case for the five most practical ideas. It is interesting to note that although the idea-idea condition had twice as many initial ideas as the idea-criticism condition, the three most novel ideas out of all 180 ideas came from the idea-criticism condition.

It makes sense that the idea-criticism method results in highly practical ideas because one crowd was designed to address the problems associated with the initial ideas. Here is an example of a participant addressing a criticism:

> A participant from Crowd 1 said: *"Judge whether the information acquired on the Internet is accurate or not by using something other than the Internet, such as books, papers, or interviews."*
>
> A participant from Crowd 2 pointed out: *"The problem of this idea is that the advantage of the Internet that we can acquire information easily is lost."*
>
> An idea generated in Crowd 3 based on these two inputs was: *"Open highly reliable text media, papers, and the like on the Internet."*

In this example, the participant from Crowd 2 evaluated the initial idea generated by a participant in Crowd 1, and the participant from Crowd 3 refined the initial idea by addressing the identified problem. This overcoming process makes Crowd 3' ideas more realistic and practical.

Interestingly, this overcoming process can also be effective on novelty. Here is the process by which the most novel idea was generated:

> The initial idea was: *"Develop something like an Internet police by outsourcing companies."*
>
> Its criticism was: *"The problem of this idea is that adequate knowledge is needed to judge whether information is wrong or not. Who can judge if information is right or wrong? What criteria are used? In addition, there are a large number of websites on the Internet. It seems difficult to examine every content of the websites one by one."*
>
> The final variant was: "*Build an Internet police into every computer during the manufacturing process. The Internet police has knowledge of experts in every field and is aware of current information in common use around the world*."

In this example, although the final variant owes its novelty to the initial idea of an Internet police, its novelty is improved by addressing the criticism, which resulted in the removal of the idea of entrusting companies, and the addition of the new idea to put AI-like systems into computers during the manufacturing process. In this way, the idea-criticism method can result in highly novel and practical ideas.

However, we did not find any difference between the idea-idea and idea-criticism conditions in the top 10 and top 20 ideas. Thus, the idea-criticism method can generate high quality ideas, but only a small number of them.

Novelty and Practicality

Although novelty and practicality scales are often used to measure creativity (Dean et al., 2006), how people use these scales are not studied well. In the current work, a more novel idea tended to be less practical. In fact, the most novel idea in the idea-idea condition was ranked the second worst in practicality. Thus, there is a trade-off between novelty and practicality.

An interesting finding with respect to novelty and practicality was that the novelty scores resulted in lower variance than the practicality scores. Participants avoided the use of maximum and minimum values when evaluating novelty, compared to when evaluating practicality. This is, we think, related to each participant's confidence in judgment on novelty and practicality. Judging whether an idea is 100% novel is more difficult than judging whether an idea is 100% practical. A 100% practical idea can mean an idea that can definitely be put into practice without problems. Imagining a 100% novel idea is hard because novelty is a boundless concept. Even when we think an idea is very novel, there is still a possibility of a more novel idea. Thus, it is difficult for evaluators to give an idea a very high or very low point in novelty.

Conceptual Combination

In the idea-idea method in the current work, two ideas were randomly paired, and the crowd was asked to generate a new idea based on the two ideas. Work on conceptual combination in creativity suggests that trying to combine dissimilar or even opposing ideas can lead to more creative ideas (Estes & Ward, 2002; Kunda et al., 1990). Applying this finding to crowds, we should test a crowd that evaluates the similarity of ideas, so that the next crowd can combine pairs of ideas that are dissimilar.

Past work on conceptual combination also suggests that how one instructs participants is important (Mumford et al., 1997). When two ideas to be combined involve related concepts, focusing on shared attributes can result in creative solutions. In contrast, when two ideas are dissimilar, focusing on abstract representations can result in creative solutions. This idea of priming abstract representations may be effective for combining two text ideas that lack any similarity on surface.

Critical Thinking

In the idea-criticism method in the current work, the process consists of two crowds generating new ideas and a crowd defining problems. Considering problems is an important characteristic of critical thinker (Zechmeister & Johnson, 1992), thus, this process is regarded as a division of labor process that includes crowds concentrating on creative thinking and a crowd on critical thinking. Avoiding trying to think both creatively and critical at the same time seems to make the whole process more effective One way for it is switching perspectives in an individual using a tool such as *Green Hat* and *Black Hat* in *Six Thinking Hat* (Bono, 1985). The other way is each crowd takes responsibility for one aspect of thinking like the current work. An advantage of the latter way is a load of thinking on each participant is light because it not necessary to switch thinking or to think from several perspectives.

Crowd Creativity and Brainstorming

The use of novelty and practicality in creativity evaluation implies that creativity results from generation of diverse ideas and subsequent pruning of these ideas. Also, cognitive theories of creativity focus on generation of many candidate ideas and exploration and modification of these ideas (Finke et al., 1992; Ward et al., 1997). Generation and exploration are similar to divergent thinking and convergent thinking often seen in brainstorming (Osborn, 1957).

In a brainstorming session, the facilitator collects many different ideas from a group before people in the group have the chance to evaluate these ideas. Then, the ideas are evaluated, filtered, and integrated by the group. One difference between brainstorming and the sequential application of crowds in our study is that whereas our crowds are not co-present, the participants in a brainstorming session are. The presence of others can hinder creativity by preventing self-conscious individuals to contribute ideas, and vocal members can sway the opinion

of the group (Mullen et al., 1991). Moreover, we can recruit more people from diverse background in crowds than in a brainstorming environment. Consequently, we can collect numerous ideas in a short time using crowds. We think these advantages make the use of crowds to solve problems highly attractive and promising.

Limitation and Future Research

One limitation of the current work was that a crowd, not experts, judged the creativity of the ideas. The crowd may not have appropriate knowledge for evaluating the potential solutions. This leads to another direction for future research: The effects of quality of a crowd. Perhaps the effects vary as a function of the topic of the problem to solve and/or the purpose of collecting creative ideas.

A natural next step is to integrate the idea-idea and idea-criticism methods: One crowd generates ideas, the next crowd combines two ideas, the next crowd addresses the problems, the next crowd generates ideas from pairs of an idea and a problem, and these steps can continue until the ideas are refined that identifying problems become difficult. The ordering of the crowds might become important.

Conclusions

Generating creative ideas through the sequential application of crowds seems promising. Based on our results from comparing two ways of generating creative solutions with crowds, we make three conclusions: 1) combining two ideas is suitable for generating many ideas that are moderately novel or practical; 2) addressing a criticism of an idea is suitable for generating a small number of ideas that are notably novel or practical; 3) thus, if the purpose of using crowds is to collect a few remarkable ideas, pairing an idea with its criticism is more effective than pairing two ideas.

Finally, our work integrates work in critical thinking, creativity, and crowd. Believing that integrating separate ideas is a key to many kinds of creativity, we hope that the present work will soon result in scientific discovery and technological innovation.

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