BrainTranscending: A Hybrid Divergent Thinking Method to Exploit Creator Blind Spots

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Abstract. Divergent thinking methods play a very important role in creating new ideas for planning and/or development activities based on specific themes or existing objects. However, even when using existing divergent thinking methods, it remains difficult to conceptualize truly novel ideas because creators are typically constrained by their fixed ideas. Therefore, we propose a novel divergent thinking method named "BrainTranscending (BT)" that exploits Brainstorming (BS), a typical divergent thinking method, as a way to identify the creator's fixed ideas, rather than generate ideas, and thus support the further expansion of those ideas. We conducted user studies and confirmed that the number of idea groups that were created by BT significantly increased compared to typical brainstorming. Furthermore, the subjects evaluated the final ideas created with BT and determined that the quality was better than that of BS. We also propose the "Reduced BrainTranscending (RBT)" method for alleviating the heavy cognitive load that BT imposes on creators. We conducted user studies of RBT to investigate its usefulness and, consequently, concluded that BT and RBT are effective methods for supporting divergent thinking aimed at improving existing products.

Keywords: Divergent thinking, Brainstorming, Fixed ideas, Blind spots

1 Introduction

Creation of novel ideas and products based on existing ideas and products is often done in the fields of planning and development. In such activities, it is very important to collect as many various seeds of new ideas as possible from a broad range of viewpoints [10]. To support it, various divergent thinking methods have been developed and utilized. Brainstorming (BS) [10] is one of the most famous methods, and it has been widely used. A BS session is usually conducted by a group, whose members try to create ideas while following four rules:

1. Focusing on quantity, not on quality,

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2. Withholding criticism,
3. Welcoming unusual ideas, and
4. Combining and improving ideas.

By following these rules and referring to the other members' ideas, it is expected that each member becomes able to create many novel ideas.

Howewver, a lot of experimental studies indicated that people in face-to-face brainstoming meetings are less efficient at genrating ideas than when working alone [12].These results have been mainly attributed to features of group activities, that is, social loafing, evaluation apprehension and production blocking [2]. Furthermore, if there is a member with a dominant pesronality, the direction of the entire thinking may be led by his/her ideas, or some other members may feel pressure to withhold their ideas.

To solve these problems deriving from group thinking, a lot of various attempts have been done. Involving a facilitator in the group's discussion, to coordinate the balance of utterance frequencies and encourage inactive members, is one solution to these problems [10]. The Brain-writing (BW) [13] method, which is an improved BS method, can be considered superior to BS because the problems of the dominant person and unbalanced utterance frequencies never arise. Therefore, social loafing and production blocking can be avoided by BW.

Not only such apporaches to improve the BS methodology itself, but also many approaches to create supprt systems for the group BS have been attempted. Gallupe et al. [2] showed that an on-line communication tool for group BS sessions (so-called "electronic brainstomring") is effective to solve these problems. Presmo Brainstormer [7] is a web-based electronic brainstoming system that supports wider phases in idea generation process including problem definition, idea generation, group discussion and presentation. Idea Expander [14] dynamically retrieves and shows pictorial stimuli based on conversational content in a group brainstorming session. Meeting Mediator [6] detects social interactions among people. For example, it can detect who are dominant people in a group and measure their influence on other people. By utilizing this system, abovementioned dominant people problem can be alleviated. Furthermore, recently, large-scale ideation by hundreds of (or more) people has been attempted by utilizing crowdsourcing [1]. This can be another promising approach to solve the three problems.

Thus, solving the problems of BS has been mainly addressed from perspectives on group. However, it is also very important to address to problems deriving from the individual to enhance the productivity of BS. Regardless of either nominal groups or interactive groups, productivity of idea creation depends on individuals performances. Generally, everybody has some fixed ideas. Such fixed ideas are formed from our experiences and the knowledge we have obtained. In this sense, fixed ideas can be regarded as an intellectual basis for creating new ideas. On the other hand, they also constrain the free creation of ideas. In creating ideas, even if there are actually possibilities of new ideas, the creator's thinking tends to adhere to his/her fixed ideas, which leads to the creator going around in circles and finally arriving at a deadlock situation [9]. Therefore,

to support and enhance the individual idea creation, it is important to provide effective clues that support him/her in thinking beyond his/her fixed ideas.

Osborn's checklist method [10], which is one of the forced relationship techniques, provides nine viewpoints, such as "Magnify" and "Reverse," in a checklist and forces a creator to create ideas based on each viewpoint. As a result, he/she can avoid overlooking some of these viewpoints. However, it is difficult to fully adapt such a generic checklist to someone's own ways of thinking and to specific problems.

Providing related information from knowledge resources outside can be one of the good support methods. Kantorovitch et al. [5] utilized annotated knowledge-base and ontology to support the initial stage of the conceptual product design. The first author of this paper developed an outsider agent [8] that extracts keywords from the ideas submitted by the creators and retrieves pieces of information that even have weak relationships with the creators' ideas. Such information from the database can be located outside of the creators' fixed ideas. Therefore, by referring to such pieces of information, it is expected that the creators would notice their fixed ideas. However, it is not always assured that the pieces of information are located outside of the creators' fixed ideas. In order to effectively support human creative thinking considering the fixed ideas, we should take into account various human cognitive phenomena [11].

This paper proposes a novel divergent thinking method named "BrainTranscending (BT)." BT is a method mainly for improving and developing existing popular products such as consumer electrical appliances like refrigerators and vacuum cleaners. The most prominent feature of BT is that it exploits BS as a method for finding "blind spots" of the creators, rather than being a method for creating new ideas. Here, the "blind spot" is a potential target that is overlooked due to some cognitive biases and thus not regarded as a target of idea creation by the creators, although it should be regarded as a target of idea creation. In other words, the blind spot is a target of idea creation that is located outside of the creators' fixed ideas.

The rest of this paper is organized as follows. Section 2 describes the BT method in detail. In addition, it presents user studies to investigate whether BT is effective, by comparing it with a baseline method, and discusses the results of those studies. Section 3 proposes an alternative BT for alleviating the creators' cognitive load, and investigates its effectiveness based on user studies. Section 4 concludes this paper.

2 BrainTranscending

2.1 BT Method

As mentioned in Section 1, in the ordinary BS method the creators tend to create ideas that are strongly influenced by their fixed ideas. It has generally been assumed that such situations should be avoided, and various modified BS methods have been developed so far. However, many informative clues about the creators'

fixed ideas can be found in the submitted ideas of a BS session. Therefore, based on this feature of BS, we can utilize BS as a method for extracting the fixed ideas of the creators who join a BS session, rather than using it as a method for creating new ideas. This is the most fundamental idea of this study.

We propose, in this paper, a novel divergent thinking method named "Brain-Transcending (BT)." BT is a method mainly for improving and developing widely used products such as consumer electrical appliances. BT consists of the following five steps:

1. **Creating initial ideas:** Creating ideas to improve and develop a target product (e.g., a vacuum cleaner) by the ordinary BS approach. Each idea is written down on a label.
2. **Grouping ideas:** Pasting each label onto the part of the target product that the idea on the label refers to and finally grouping all labels based on the parts of the target product. For example, the ideas that relate to the flexible hose of the vacuum cleaner are gathered in one group relating to the hose.
3. **Making blind spot list:** Listing up the parts onto which no label is pasted. Such parts are called "overlooked elements."
4. **Creating further ideas:** Creating further ideas in a similar way to the ordinary BS conducted in the first step. However, in this step, the creators are required to refer to the blind spot list made in the previous step and to create ideas that improve and/or develop the overlooked elements in particular.
5. **Crystalizing final idea:** Finally, integrating all ideas obtained in the first step and the fourth step toward crystalizing a final idea.

The parts listed in the blind spot list made in the third step are parts of the target product. Therefore, the creators should be able to recognize them. However, they are not recognized as objects that should be improved and/or developed: no ideas are created for these objects. In this sense, this list can be regarded as a list of the creator's "blind spots." Thus, the BT method utilizes BS in the first step as a method to extract the blind spots, not as a method to create new ideas, although the creators may think that they are creating new ideas. In addition, the second BS session conducted in the fourth step can be regarded as a "forced relationship technique" in which the blind spot list is used as a checklist. In this sense, BT is a hybrid divergent thinking method that consists of a free-association technique (i.e., conventional BS) and a forced relationship technique.

2.2 User Study

We conducted a user study to investigate the effectiveness of the proposed "BrainTranscending (BT)" method described in 2.1. We prepared a baseline method to confirm the effectiveness of BT through a comparison. The baseline method consists of the following steps:

1. **Creating initial ideas:** The same as the first step of BT.

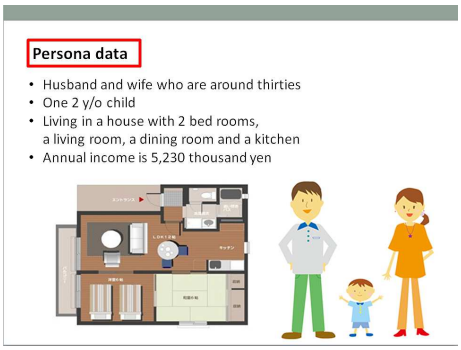

Fig. 1: Persona of a typical family as the users of the target products.

2. **Grouping ideas:** The same as the second step of BT.
3. **Creating further ideas:** Creating further ideas in a similar way to the conventional BS conducted in the first step. However, in this step, the creators are required to refer to "the grouping results" (not the list of blind spots) made in the previous step.
4. **Crystalizing final idea:** Finally, integrating all ideas obtained in the first and third steps and then crystalizing these into a final idea.

Briefly speaking, the baseline method is one that omits the "Making blind spot list" step from BT.

Procedure We employed six subjects in their twenties who are students of design and media development. All of them had experience with brainstorming in their course work. We asked each subject to individually improve two target products, i.e., an electric fan and a vacuum cleaner, by using the baseline method and BT. If we had conducted BT first and then the baseline method, the subjects would have inevitably come to pay attention to the originally overlooked parts, even in the baseline method, making it impossible to accurately estimate the effectiveness of BT. Therefore, to avoid this problem, we always conducted the baseline experiment before the BT experiment for all subjects.

At the beginning of the experiment, we showed the subjects the persona data shown in Figure 1. The persona data illustrated a typical family as the users of the target products. We asked the subjects to create novel features to be used by the persona family.

We required the subjects to write down each idea on a label with the name of the part to be improved, the reason why it should be improved, and a sequence number to manage the labels sequentially. As reference materials, we provided them some pictures of the target products such as those shown in Figure 2. The pictures include entire images of the products as well as detailed partial images of the products. In addition, we orally explained to the subjects how the products work and detailed functions that cannot be perceived only by looking at the still pictures.

Fig. 2: Example pictures of the target product.

Table 1: Sequence and time of each step in the baseline method

Step	Time
Creating initial ideas	20 min.
Grouping ideas	10 min.
Creating further ideas	25 min.
Crystalizing final idea	20 min.

Table 2: Sequence and time of each step in BT method

Step	Time
Creating initial ideas	20 min.
Grouping ideas	10 min.
Making blind spot list	10 min.
Creating further ideas	25 min.
Crystalizing final idea	20 min.

As they were thinking of ideas, we asked the subjects to speak aloud everything that they were thinking, such as on what they were focusing at a given moment. All speech protocol data were recorded. After finishing each experiment, we interviewed the subjects about their introspection and changes in impressions of the product. In order to investigate the effectiveness of BT, we used the following data: the number of the labels and the number of the groups as quantitative data, and speech protocol data as well as interview data as qualitative data.

Procedure of the baseline method experiment Table 1 shows the sequence and time of each step in the baseline method. In the first step, each subject individually created ideas in a conventional BS manner for 20 minutes, while referring to the sample pictures of the target product. In the second step, each subject grouped all of the labels created in the first step by him/herself for 10 minutes,

using the sample pictures of the target product based on the relations between each idea and the corresponding part of the product. In the third step, each subject individually created ideas in a conventional BS manner for 25 minutes, again referring to the grouping results. Finally, in the fourth step, each subject crystalized a final idea for 20 minutes, while referring to the ideas created in the first step as well as in the third step. After finishing all of this work, we asked the subject to add the labels created in the third step to the grouping results obtained in the second step, and we counted the number of newly created groups.

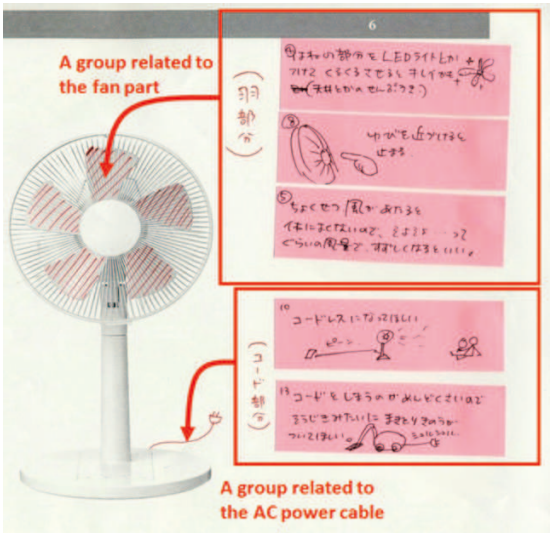

Fig. 3: Example of provided picture of target product and grouping labels related to the fan part and AC power cable part.

Procedure of BT experiment Table 2 shows the sequence and time of each step in BT. In the first step, each subject individually created ideas in a conventional BS manner for 20 minutes, while referring to the sample pictures of the target product. In the second step, each subject grouped all of the labels created in the first step by him/herself for 10 minutes, using the sample pictures of the target product based on the relations between each idea and the corresponding part of the product (An example is shown in Figure 3). In the third step, each subject listed up the parts where no ideas were created, indicated by the no-idea-parts in the pictures (An example is shown in Figure 4) and made a blind spot list for 10 minutes. In the fourth step, each subject individually created ideas by a forced relationship technique for 25 minutes, while referring to the blind spot list. Finally, in the fifth step, each subject crystalized a final idea for 20 minutes, while referring to the ideas created in the first step as well as in the fourth step. After finishing all of this work, we asked the subject to add the labels created

in the fourth step to the grouping results obtained in the second step, and we counted the number of newly created groups.

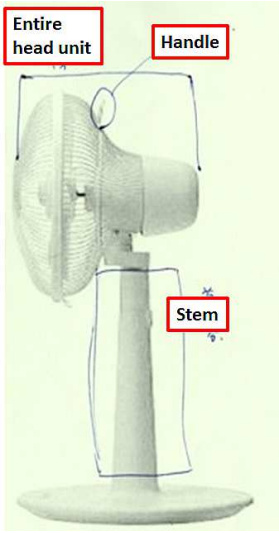

Fig. 4: Example of listing up overlooked parts.

Results Table 3 shows the number of labels created in both experiments and Table 4 shows the number of groups obtained in both experiments.

Common results for both experiments All subjects had experience in BS sessions by a group but no experience in BS sessions by an individual person. Therefore, in the first step (first BS session) of both experiments, they felt uneasy about not being able to obtain any stimuli from other participants. They also felt that it was difficult to expand and to go beyond the scope of their ideas in the first step's BS session.

Results of the baseline method experiment In the interview, the subjects answered, "Categories of ideas became evident by grouping the labels" and "I could review the created ideas by the grouping." These opinions suggest that the grouping task is effective for organizing the created ideas. However, in contrast, the grouping task is seemingly not effective for providing novel viewpoints on the subjects. As shown in Table 4, the increased number of groups after the third step (second BS session) was only 1 to 3 ($Av. = 1.8, STDV = 0.69$). Most of the newly added groups were ambiguous ones that were difficult to relate to specific parts in the pictures of the target object. Furthermore, self-evaluation results on the quality of the final ideas were not so good.

Table 3: Results: Number of labels

Subject	Total num. of labels		Num. of labels (1st step) (Num. of ideas reflected to the final idea)		Num. of labels (3rd or 4th step) (Num. of ideas reflected to the final idea)	
	baseline	BT	baseline	BT	baseline	BT
a	27	22	16 (9)	11 (8)	11 (3)	11 (5)
b	28	22	19 (11)	11 (10)	9 (3)	11 (10)
c	19	20	7 (5)	8 (4)	12 (6)	12 (8)
d	41	27	20 (8)	16 (5)	21 (6)	13 (2)
e	48	52	22 (12)	28 (15)	26 (13)	24 (13)
f	19	24	11 (5)	15 (9)	8 (6)	11 (6)
Av.	30.3	27.8	15.8 (8.3)	14.8 (8.5)	14.5 (6.2)	13.7 (7.3)

Results of BT experiment As shown in Table 4, the increased numbers of the groups after the fourth step was 4 to 12 ($Av. = 6.33, STDV = 2.87$). We compared this result with the result obtained in the baseline experiment method by Mann-Whitney test and confirmed that the difference is significant ($p < 0.01$). Some subjects answered in the interview that the ideas created in the fourth step were incorporated into the final idea crystalized in the fifth step. Self-evaluation results on the quality of the final ideas were higher than those in the baseline method experiment. Thus, the results of the BT experiment were better overall than those of the baseline method experiment. On the other hand, as for mental aspects, some subjects pointed out that it was difficult to create new ideas related to the overlooked parts in the fourth step of BT, but the difficulty was different from that of the third step in the baseline method.

Discussion Based on the results of the user study, we confirmed that the list of the blind spots is useful to support creation of further ideas. Consequently, we can conclude that the proposed "BrainTranscending" method is basically effective.

The subjects' cognitive load in the second idea-creation step for both methods was quite high. In both methods, the time spent for creating a single idea in the second idea-creation step was longer than that in the first idea-creation step. However, the reasons for the high cognitive load were different between the methods.

For the baseline method, the reason for the high cognitive load was that participants fell into a deadlock situation. In the first step of the BS session, they extracted ideas that came easily to their minds but fell within the limits of their fixed ideas (the same situation also happened in the BT experiment). In such a case, the creators' thinking usually goes around in circles, and some assistance to get out of the deadlock is necessary. The grouping task of the labels in the second step would be useful not only for organizing the extracted ideas but also for finding overlooked points and new directions in idea creation. In this

Table 4: Results: Number of groups

Subject	Num. of groups (2nd step)		Num. of additional groups (After exp.)	
	baseline	BT	baseline	BT
a	9	6	1	4
b	7	6	2	8
c	7	8	1	12
d	9	6	3	5
e	9	9	2	5
f	8	5	2	4
Av.	8.2	6.7	1.8	6.3

sense, the grouping task has the potential to support participants in getting out of a deadlock. However, although these subjects pointed out that the grouping was useful for organizing the extracted ideas, they did not use it for finding overlooked points and new directions. As a result, they could not get out of the deadlock in the third step, and the number of additional label groups did not increase so much. Furthermore, the ideas included in the additional groups were not used in the crystalizing task of the fourth step. Accordingly, the cognitive load in the baseline method is a simple deadlock of idea creation, and the baseline method itself could not provide an effective solution to this problem.

In contrast, with BT, the reason for the high cognitive load was that participants were forced to think about elements outside the scope of their fixed ideas. In other words, completely different from the baseline, they were forced to think beyond their fixed ideas. The blind spots listed up in the third step of BT were originally out of their limited scope of ideas. Actually, some subjects answered in the interview that they did not regard the blind spots as targets for which they should create new ideas and, moreover, that they only did so after they were directed to create ideas using the blind spots in the fourth step of BT. This is apparently the principal reason for the high cognitive load in the second idea-creation step of BT. However, the blind spot list works as a support for them to think beyond their fixed ideas. The list clearly and concretely shows the novel targets for creating ideas. The ideas related to the blind spots naturally form several new groups. Therefore, as shown in Table 4, the number of additional groups increased by much more than it did in the baseline method. Thus, the proposed BT method makes the blind spots available for use, which has not been achieved so far due to the barrier imposed by fixed ideas.

Fredrik Haren [3] pointed out that the initial ideas are very similar, even if the idea creators are different. Such initial ideas are usually stale and do not lead to any novel idea. Rikie Ishii [4] pointed out that novel ideas can be obtained only after first extracting all ideas that easily come to the creator's mind. He named this stage the "next zone," which the creators can reach when they feel they have completely extracted possible ideas. Therefore, it is important for the creators to move to the next zone to obtain novel ideas. Naturally, however, this

is not easy. Some support methods are required, but conventional BS is not a good method for this purpose, as abovementioned. BT can be a good method to effectively lead creators to the next zone, although the applicable area of BT is restricted to improving the existing products. One of the subjects answered in the interview that he could create an idea that was unexpected, even by himself; such a user evaluation supports the potential of BT.

3 Reduced BrainTranscending

As we described in the previous section, BT is an effective method for creating diverse ideas that go beyond the fixed ideas of the creator. However, the step for creating further ideas imposes a very high cognitive load. Therefore, in this section, we propose an alternative BT for alleviating this cognitive load and investigate its effectiveness through user studies.

3.1 Method

Our alternative BT, called Reduced BT (RBT), is a method that simply omits the creating further ideas step from the original BT. As mentioned in the previous section, some subjects felt that it was difficult to create new ideas in the creating further ideas step of BT. Therefore, if we can obtain similar results to BT without this step, the creators' cognitive load will lessen and time will be saved. RBT consists of the following four steps:

1. **Creating initial ideas:** The same as the first step of BT.
2. **Grouping ideas:** The same as the second step of BT.
3. **Making blind spot list:** The same as the third step of BT.
4. **Crystalizing final idea:** Integrating ideas obtained in the first step while referring to the blind spots obtained in the third step to crystalize a final idea.

3.2 User Study

In this section, we describe the RBT user study employed to investigate whether RBT can achieve similar results to BT, but with a reduced cognitive load.

Procedure We used five subjects in their twenties who are students of media informatics. All had experience in group BS sessions in their course work, but no experience in individual BS sessions. We provided several pictures of a vacuum cleaner similar to that in the BT experiment and asked each subject to individually improve it using RBT. At the beginning of the experiment, we also showed the subjects the same persona data shown in Figure 1. We asked the subjects to create novel features to be used by the persona family.

The procedure of the user study was almost the same as that for BT. In the first step, each subject individually created ideas in a conventional BS manner

for 20 minutes while referring to the provided sample pictures of the target product. Each subject was required to write down each idea on a label with the name of the part to be improved, the reason why it should be improved, and a sequence number to manage the labels sequentially. In the second step, each subject spent 10 minutes grouping all of his/her labels created in the first step, using the sample pictures of the target product, based on the relations between each idea and the corresponding product part. In the third step, each subject was given 10 minutes to list up the parts where no ideas were created, indicated by the no-idea parts in the pictures, and make a blind spot list. Before starting the fourth step, we asked the subjects to be sure to create ideas for improving the overlooked elements included in their blind spot list. To do so, we allocated 45 minutes to this step and allowed them to freely draw sketches for creating ideas. Lastly, each subject crystalized a final idea that improved the overlooked elements. Figure 5 shows an example of a subject's crystalized idea by a subject.

As they were thinking of ideas, we asked the subjects to speak aloud everything that they were thinking, such as what they were focusing on at a given moment. All speech protocol data were recorded. After finishing each experiment, we interviewed the subjects on the following: 1) Total impressions of the RBT task, 2) Impressions of the fourth step, and 3) Self evaluation of the finally crystalized idea.

Results The total impressions were almost the same as those of BT. The subjects found the individual BS difficult; it was a totally new experience for them to arrange the idea labels based on their related parts, to list the overlooked elements, and to create further ideas based on these overlooked elements. The subjects also pointed out that, through these processes, they thought about things they had not been conscious of.

The fourth step of RBT, that is, crystalizing final ideas based on the blind spot list, was not easy for many of them; they were somewhat embarrassed about what they should think or do at first. Those who drew idea sketches found that these sketches were effective for glancing over all of the ideas and for creating further diverse ideas that were useful for crystalizing the final idea. Thus, in the RBT process, most subjects represented their ideas visually, while, in the BT process, the ideas were represented verbally.

The self-evaluation results were divided into good and not good. The subjects who evaluated their final ideas as good said that they were able to come up with a novel idea because they were forced to focus on areas they previously did not consider. These subjects were able to crystalize final ideas within 25 minutes. In contrast, the subjects who evaluated their final idea as not good said that thinking about what they usually do not pay attention to was difficult and, hence, their final ideas were unsatisfactory. These subjects spent more than 30 minutes crystalizing final ideas.

Discussion It is difficult for anyone to concept new ideas to improve overlooked elements. Therefore, both BT and RBT impose the same cognitive load on the

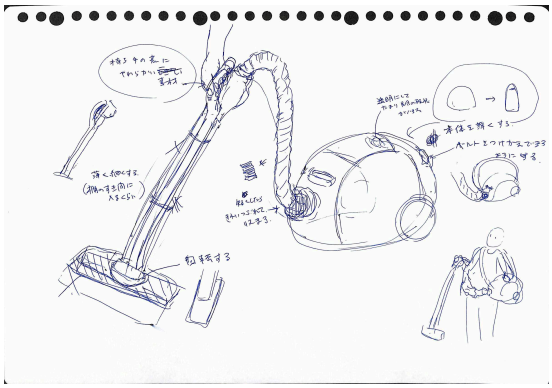

Fig. 5: Example of a subject's crystalized idea.

creators. However, the effectiveness of RBT depended on each creator, while BT was generally effective for almost all of the subjects, as shown in the previous section.

The BT process explicitly requires creators to generate further ideas based on the blind spot list. Therefore, no significant differences among the subjects were observed. In contrast, the RBT process does not explicitly require them to create further ideas based on the blind spot list. As a result, people who are good at creating ideas related to the overlooked elements were able to produce ideas even without any explicit instructions and eventually crystalize final ideas based on them. However, people who lacked skills for creating further ideas without explicit instructions were unable to achieve satisfactory final ideas. Thus, RBT chooses the users; it is suitable for people who are good at thinking about what is outside of their scope. We can expect that such ability can be fostered by continuously using BT. Hence, people should utilize RBT after obtaining sufficient experience with BT.

4 Concluding Remarks

This paper proposed a novel hybrid divergent-thinking method called "Brain-Transcending (BT)" that consists of a free-association technique (brainstorming) and a forced-relation technique (checklist method). BT exploits the BS session to find creator blind spots and is not used for creating new ideas. When using the forced-relation technique, the creators are compelled to create ideas related to the identified blind spots, which effectively leads the creators to the "next zone." We conducted user studies and confirmed that BS can be used as a method for identifying blind spots and that BT allows the creators to develop ideas related to their overlooked elements, which is difficult to achieve using conventional BS. Furthermore, we proposed the "Reduced BrainTranscending (RBT)" method, which omits the "creating further ideas" step of BT in order to alleviate a heavy

cognitive load for the creators. User studies of RBT revealed that it is as effective as BT; however, RBT chooses the users. The users are required to accustom themselves to "stepping outside" of their scope. Consequently, we concluded that BT and RBT are effective methods for supporting divergent thinking aimed at improving existing products. In the future, we would like to expand the applicable targets of BT to intangible objects (e.g., concepts) and software.

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