# Improving the Effectiveness of Ideation Using Analogies: Choosing the Right External Stimuli

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## Abstract

The purpose of the research described in this paper is to improve the understanding of the analogy technique for generating ideas, in particular for business applications. There has been very little research done on this topic, and thus hardly any advice is available for innovation managers and marketers, who rely on good ideas to achieve their objectives. Our goal is to provide concrete guidelines to practitioners for improving the effectiveness of the analogy technique.

We have created a model that distinguishes between two classes of stimuli (*concrete* and *abstract*) that are used to generate analogies and two classes of analogy (*near* and *far*) that can be used to inspire ideas. We hypothesize that abstract stimuli will lead to more far analogies and that far analogies will lead to a larger number of good ideas. We performed an experiment to obtain evidence for these hypotheses in which subjects were asked to come up with solutions for a simple marketing task using both concrete and abstract stimuli to generate first analogies and from these, ideas.

The experimental results show strong support for both hypotheses. We conclude that abstract stimuli are superior to concrete ones when the analogy method is carried out in two phases and that far analogies are to be preferred when a single-phase version is to be used. This knowledge is immediately applicable in a wide range of ideation settings and gives rise to new research questions regarding the best choice of stimuli.

**Keywords:** ideation, cognitive model, analogical thinking, external stimuli, analogies, good ideas.

## Introduction

The analogy method is one of the most versatile and effective methods for idea generation. Analogies are concepts that are related in some way to the task to be solved and which serve as inspiration (stimuli) for new ideas. Gavetti and Rivkin (2005) show, for example, how analogies were used by Intel to come up with the idea for its Celeron microprocessor and how the Toys 'R Us and Staples chains of stores were inspired by analogies with supermarkets.

However, there is little research available on the relationship between the stimuli employed and the resulting analogies and ideas generated with their help, so the practitioner is forced to rely on personal experience or to use generic approaches which may not be very effective. In this paper, we propose two hypotheses regarding these relationships, which, if supported by empirical

evidence, would provide a helpful guideline for facilitators and innovation practitioners. A causal model is introduced that proposes interdependencies of the type of external stimuli used, the cognitive load of the user and the number of good ideas generated. Empirical results from different studies are combined and analysed to test the model's validity. Results show a statistically significant effect of the type of stimulus used on the result quality (number of good ideas) of the analogous thinking process.

**Related work**

Our research uses a cognitive model called 'Search for Ideas in Associative Memory' (SIAM) (Nijstaad & Stroebe, 2006) to specify and analyse the cognitive process of an individual using analogical thinking. The model is based on Raaijmakers and Shiffrin's (1981) model called 'Search of Associative Memory' (SAM); a theory of memory retrieval that combines elements of associative network models and random search.

SIAM describes the creative process as an associative process that proceeds in two stages (Nijstaad & Stroebe, 2006). In the first stage, the individual retrieves knowledge from Long Term Memory (LTM) by using a search cue. This search cue is generated in the Working Memory (WM) by external stimuli that are received through the five senses. The individual can modify a given search cue in the WM by adding previously retrieved knowledge or combining different stimuli. Which image in the LTM will be activated is probabilistic and depends on the association between the search cue and the concepts of the image. The activated image is temporarily stored in the WM, after which the concepts and associations of that image become accessible. In the second stage, an individual uses active knowledge in the WM to generate ideas by forming new associations or by applying knowledge to a new domain (Mednick, 1962). Therefore, the individual forms new associations by combining the concepts of the image with one another or with elements of the search cue. The individual goes back to the first stage to generate a new search cue if the active knowledge only leads to few new ideas.

Nijstad and Stroebe (2006) assume that without any more external stimuli, the individual will only modify the search cue by adding previously generated ideas or activated knowledge, which leads to an activation of semantically related images. As a result, the individual will think primarily within bounded areas of the knowledge network. The likelihood of forming new associations between previously unrelated images decreases, and only a small area of the solution space will be considered. However, creativity research assumes that these unexpected associations between previously unrelated images lead to the formation of creative ideas (Gettys, Pliske, Manning, & Casey, 1987; Mednick, 1962).

Many studies propose the use of external stimuli as an intervention to lead the individuals to different areas of their knowledge networks. The resulting new perspectives on a given problem or task allow the individual to combine concepts of semantically unrelated images. Therefore, generated ideas will cover larger

areas of the possible solution space. In practice, many idea generation techniques are available which provide a variety of approaches to generate and use external stimuli (Higgins, 1994; VanGundy, 2005). For example, the technique *Combo Chatter* (VanGundy, 2005) combines different words related to the given task and uses the combination as semantic stimulation. In contrast, *Greeting Cards* (VanGundy, 2005) uses random pictures from magazines as stimuli to generate ideas. However, most of these techniques are presented as a generic sequence of actions to generate and use haptic, visual or acoustic stimuli. However, no clear guidelines have been available for the selection and combination of appropriate idea generation techniques for a given strategic goal. As a result, innovation managers still have to rely on experience for the design of ideation workshops.

Various creativity researchers (Smith, 1998; Knoll & Horton, 2011a; Herring, Jones, & Bailey, 2009) have analysed the ingredients of idea generation techniques to understand the relationship between the creative task, the instructions provided, the material used, and the intended mental and physical activities of an individual. The results show a strong use of a cognitive mechanism called analogical thinking, in which the individual utilizes information from different situations to generate new ideas. With regard to the cognitive model SIAM, analogical thinking describes a multi-stage process. Confronted with a creative task, an individual creates a search cue in the WM to access useful knowledge domains in the LTM. This process will terminate when activating an image with an analogical connection to the creative task. Such a connection is given if some basic elements of the creative task and the analogous situation are similar. The activated analogical image will be temporarily stored in the WM, where the individual can map corresponding parts of the knowledge domains onto each other, and finally apply the transferred knowledge to generate ideas.

The amount of overlap in attributes and relations between the images can be used to characterize an analogy on a continuum from 'near' at one extreme to 'far' at the other (Gentner, 1983; Ward, 1998). Near analogies have 'literal similarities' (Gentner, 1983) and present smaller conceptual distances, while far analogies typically require the identification of similarities in the relational structure between the creative task and the analogy.

Since near analogies share the same or a close conceptual domain with the creative task, they would probably support the generation of incremental innovations. On the other hand, far analogies serve as the basis for 'mental leaps' that could support the generation of radical innovations (Holyoak & Thagard, 1995). However, creativity research argues that the identification of analogies typically depends on the cognitive abilities and the personal experience of an individual (Gentner, Rattermann, & Forbus, 1993; Dahl, & Moreau, 2002). Without the use of any external stimuli, individuals can only activate analogies whose elements were already associated by the individual to the creative task (Gick & Holyoak, 1980).

One approach to support the individual during analogical thinking is given by idea generation techniques that provide step-by-step instructions to support the

activation and use of analogous situations. Thereby, external stimuli can be used to guide the individual during the retrieval and selection of analogous situations as well as to support the mapping process during the generation of new ideas. However, a review of literature on idea generation techniques and analogical thinking shows that most techniques use abstract instructions to support analogical thinking. For example, the technique *Copy Cat* (VanGundy, 2005, p. 47) instructs the individual 'to think of who is doing similar things or making similar products'. In contrast, the technique *Stereotype* (VanGundy, 2005, p. 68) suggests using 'a random occupation and how a person in this position would solve the problem' as a stimulus.

From practice, Gassmann and Zeschky (2002) analysed how organisations use analogical thinking for the development of product innovations. The authors found that organisations only identify far analogies by abstracting the creative task to its structural relationships. Similar results were found by Kalogerakis, Lüthje, and Herstatt (2010), who analysed the use of analogies in design and engineering consulting firms and propose a positive correlation between the analogical distance and the solution novelty. Furthermore, researchers evaluated the influence of external stimuli on analogical thinking processes by possible solution for the creative task (Dahl & Moreau, 2002) or criteria for a good solution (Santanen, Briggs, & de Vreede, 2003). However, little literature focuses on the use of external stimuli during the different stages of the analogical thinking process. This represents a gap in research and practice. To gain further insight about the influence of external stimuli on the analogical thinking process, this article focuses on the research question: *How do the characteristics of an external stimulus influence the ideation process of an individual using analogical thinking?*

**Causal model of analogous thinking**
Based on the foundations presented in the preceding section, we now introduce a model to describe the causal relationships between the possible use of external stimuli and the cognitive mechanism called analogical thinking (see Figure 1). In this model, Cognitive Load is defined as the cognitive effort made by an individual to apply acquired knowledge and skills to new situations (Sweller, 1988).
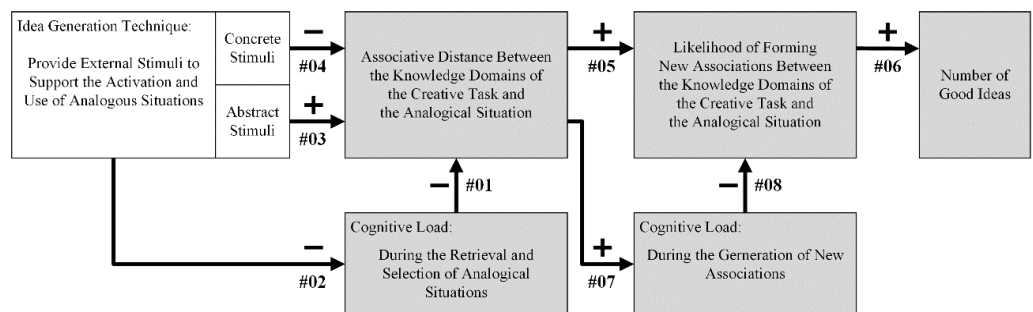


Figure 1: Proposed causal relationships between analogous thinking and the use of external stimuli.

According to the initial stage of analogical thinking, the individual analyses the creative task for major principles and concepts that can be used to identify analogous situations. Creativity research proposes that the identification of analogies typically depends on the cognitive abilities and the personal experience of an individual (Dahl & Moreau, 2002; Reeves & Weisberg, 1994). Individuals can only activate analogies whose elements were already associated to the creative task (Gick & Holyoak, 1980). Without using external stimuli, individuals tend to activate semantically related images rather than analogous situations with a large associative distance to the creative task (path-of-least resistance (Ward, 1998)).

The model proposes that *as cognitive load increases, the associative distance between the knowledge domains of the creative task and the analogous situation decreases* (Proposition #01 in Figure 1). Furthermore, the model suggests that idea generation techniques can be used to decrease the *level of cognitive load during the retrieval and selection of analogous situations by using external stimuli* (Proposition #02). Such external stimuli can describe the creative task by a variety of attributes ranging from concrete details of a creative task to the abstract description of a creative task. Far analogies typically require the identification of similarities in the relational structure between the creative task and the analogous situation. As a result, the model claims that *the associative distance between the knowledge domains of the creative task and the analogous situation increases, when external stimuli describe the creative task in a more abstract way* (Proposition #03)*. On the other hand*, *the associative distance between the knowledge domains of the creative task and the analogous situation decreases, when external stimuli describe the creative task in a more concrete way* (Proposition #04)*.

After the activation of an analogous image, the individual can map corresponding parts of the knowledge domains onto each other, and finally form new associations by combining the concepts of the knowledge domains. As far analogies serve as the basis for 'mental leaps' (Holyoak & Thagard, 1995), the model proposes that *as the associative distance between the knowledge domains of the creative task and the analogous situation increases, so too does the likelihood of forming new associations between those domains* (Proposition #05)*. Furthermore, *as the likelihood of forming new associations between the knowledge domains of the creative task and the analogous situation increases, so too does the likelihood of generating more good ideas* (Proposition #06).

The amount of overlap in attributes and relations between the knowledge domains provides an indicator to characterize the cognitive effort made by an individual to map the knowledge domains and form new associations. Knowledge domains with a relatively small conceptual distance show a high degree of both shared relations and shared attributes, whereas far analogies have a smaller number of shared attributes. Consequently, an individual will need more conceptual effort to identify similarities in the relational structure between the knowledge domains. The model therefore proposes that *as the associative distance between the knowledge domains of the creative task and the analogous*

situation increases, so too does the cognitive load during the mapping and generation stage (Proposition #07). Additionally, *as the cognitive load increases, the likelihood of forming new associations between the knowledge domains of the creative task and the analogous situation decreases* (Proposition #08).

Based on the presented model, the following hypotheses are defined:

$H_0$: *When using analogical thinking in combination with a set of predefined external stimuli, there is no significant impact of stimuli characteristics on the outcome of the ideation process.*

$H_1$: *When using analogical thinking in combination with a set of external stimuli that describe the creative task in a more abstract way, an individual will generate a higher number of far analogies and a smaller number of near analogies, compared to an individual using a set of external stimuli that describe the creative task in a more concrete way.*

$H_2$: *When using far analogies during the mapping and generation stage, an individual will generate a higher number of good ideas compared to an individual using near analogies.*

**Experiment and data description**

To test the hypotheses, we used the data from an earlier experiment by Knoll and Horton (2011b), who analysed the influence of external stimuli on an ideation process using analogical thinking. The creative task of the experiment was '*How can a supermarket increase its popularity among its customers?*' During the experiment, twenty-two participants were instructed to write down different analogous situations for a set of statements about the creative task and to use their knowledge of these situations to generate ideas.

The statements provided were characterized by their relationship to the context of the creative task. An external stimulus was marked as *typical* if it described the context of the creative task in more detail. For example, the context of the creative task '*How can a supermarket increase its popularity among its customers?*' is a supermarket. Concepts which are strongly associated to the image *supermarket* are '*has shopping carts*' or '*presents goods on long shelves*'. If an external stimulus was strongly associated to the creative task itself, it was marked as *relevant*. Here, the image *customer* provided concepts that represent problems (e.g. *at a supermarket customers have to stand in a queue)* or purposes (e.g. *a supermarket treats all customers equally*) which can be used to generate ideas.

Figure 2: Characteristics of the stimuli used by Knoll and Horton (2011b).

Figure 2 presents the twenty external stimuli that were used during the experiment: five stimuli for each of the four categories typical/relevant (T/R), typical/not-relevant (T/¬R), not-typical/relevant (¬T/R) and not-typical/not-relevant (¬T/¬R). Typical stimuli such as a *supermarket provides similar goods with different prices* describe the creative task in a more concrete way as not-typical stimuli such as *at a supermarket you meet many strangers.*

The stimuli for each category were randomly selected and organised in a way that each stimulus belonged to a category that was different from the one that preceded it (A-B-C-D-A-B-C-D…). During the experiment, each of the twenty statements was used at least ten times as a stimulus. To assign an analogous situation and the resulting ideas to a provided stimulus, the participants received a set of forms that documented these relations by predefined identification numbers. The process sequence used is described as follows:

*Repeat the following steps until all of the provided stimuli have been used:*

Step 1: *The participant receives a statement as a stimulus for the creative task.*
Step 2: *The participant generates a list of analogous situations which he or she associates with this statement* (duration: 1 minute).
Step 3: *The participant uses the list of analogous situations to generate solutions for the creative task, by thinking how this task has been or might be solved in this analogous situation* (duration: 4 minutes).

With this approach 1262 ideas were generated. Additional data collected was 1) the participant who generated the idea, 2) the analogous situation used, 3) the stimulus, which was used to generate the analogous situation, and 4) the position of the used stimulus in the set of stimuli of the participant. As the former analysis of this data by Knoll and Horton (2011b) did not focus on the characteristics of the generated analogies, the influence of possible generated near and far analogies on the generated ideas is still unknown.

**Analysis of the generated analogies**

With regard to the path-of-least resistance (Ward, 1998), individuals tend to activate and use near analogies rather than far analogies during an analogical thinking process using no external stimuli. In context of this article, this property of analogical thinking is used to collect a set of near analogies for the creative task: '*How can a supermarket increase its popularity among its customers?*' A pre-study was designed that implements the first phase of an ideation process using analogical thinking to collect a set of near analogies for a supermarket. During the study, eleven PhD students from a large university participated individually. Each participant received an introduction on how to use analogical thinking to generate ideas for a creative task. An example was used to demonstrate the process in detail. After the introduction, each participant received a sheet of paper containing the task to list all analogies for a supermarket that came to their mind. The participants were allowed to use as much time as needed to complete the task.

Adapting the procedure used by Ward, Patterson, Sifonis, Dodds, and Saunders (2002), *output dominance (OD)* was determined for each of the analogies generated. The number of participants who listed a distinct analogy was counted. Each analogy was also coded for *rank*, defined as the average output position across all lists on which the analogy appeared. *Output precedence (OP)* was computed to reflect the combined influence of frequency of listing and output position. Thereby, the output position of a distinct analogy in a list was subtracted from the total number of analogies in this list. The resulting values were summed for each analogy across the participants.

| analogy | OD | rank | OP |
|---|---|---|---|
| building supplies store | 7 | 4.86 | 53 |
| car dealer | 6 | 6.50 | 39 |
| shopping mall | 6 | 4.33 | 58 |
| food store | 6 | 2.83 | 61 |
| discount shop | 5 | 6.60 | 33 |
| department store | 5 | 3.00 | 35 |
| market | 5 | 4.20 | 43 |
| online shops | 5 | 4.20 | 48 |
| small corner shop | 5 | 1.80 | 42 |
| electronic shop | 4 | 5.00 | 22 |
| fleamarket | 4 | 8.25 | 38 |
| furniture shop | 4 | 8.25 | 28 |
| library | 3 | 11.00 | 18 |
| bookstore | 3 | 12.33 | 6 |
| drugstore | 3 | 6.67 | 17 |

Table 1. Output dominance (OD), rank, output precedence (OP) of the generated analogies, listed by three or more participants.

In total, the participants generated 56 distinct analogies for a supermarket (M: 11.18, SD: 4.69). Output dominance for these analogies ranged from 7 (for *building supplies store*) to 1. Table 1 includes all analogies that were listed by three or more participants, along with the output dominance, rank and output precedence. The analysis of the generated analogies shows a high output dominance and a low rank for analogies with a strong analogical connection to a creative task (e.g. *food store* (OD: 6, rank: 2.86) and *small corner shop* (OD: 5, rank: 1.80)). On the other hand, analogies with a low output dominance and a high rank show a weaker connection to the creative task (e.g. *bookstore* (OD: 3, rank: 12.33) and *library* (OD: 3, rank: 11.00).

The resulting set of analogies was used as comparative value to categorize the generated analogies of the data set from Knoll and Horton (2011b). Before the evaluation of the data set, analogies for each participant and each stimulus were excluded that represent a duplicate. In total, the data set provides 1079 distinct analogies (M: 49.05, SD: 7.81) for all of the twenty stimuli used. An analogy was categorized as *near analogy* if it was generated during the pre-study, represented a synonym or a specific example. For example, the analogies *ebay* and *amazon* represent specific examples of the analogy *online shop.* Table 2 provides an overview of the categorized analogies by the means and standard deviations for the dependent variables typical and relevant.

A multivariate analysis of variance (MANOVA) was conducted to test the hypothesis that there would be a difference between the stimuli characteristics and the type of the generated analogies. The Box's M value was 7.857 with a p value of .583, which shows equality of variance in the two groups at the .05 level

of significance. From Table 3 it can be seen that the attribute 'typical' of an external stimulus has a significant effect on the number of near analogies ($F = 33.538$, df = 1, $p < .0005$, $\eta^2 = .003$) and the number of far analogies ($F = 110.126$, df = 1, $p < .0005$, $\eta^2 = .000$). Furthermore, the attribute 'relevant' of an external stimulus has a significant effect on the number of far analogies ($F = 6.883$, df = 1, $p = .010$, $\eta^2 = .004$). In conclusion, these results provide significant support for the Hypothesis $H_1$.

| source | typical (T) | relevant (R) | n | M | SD |
|---|---|---|---|---|---|
| near analogy | not typical | not relevant | 84 | 3.82 | 2.04 |
| | | relevant | 96 | 4.36 | 2.57 |
| | typical | not relevant | 150 | 6.82 | 2.08 |
| | | relevant | 153 | 6.95 | 2.32 |
| far analogy | not typical | not relevant | 241 | 10.95 | 2.92 |
| | | relevant | 193 | 8.77 | 3.31 |
| | typical | not relevant | 91 | 4.14 | 2.66 |
| | | relevant | 71 | 3.23 | 2.00 |

n = number of generated analogies
M = means
SD = standard deviation

Table 2. Means and standard deviations for the dependent variables for the generated analogies of the data set from Knoll and Horton (2011b).

| source | dependent variable | F | df | p | η² |
|---|---|---|---|---|---|
| typical | near analogy | 33.538 | 1 | **.000*** | .003 |
| | far analogy | 110.126 | 1 | **.000*** | .000 |
| relevant | near analogy | 0.499 | 1 | .482 | .001 |
| | far analogy | 6.883 | 1 | **.010#** | .004 |
| typical x relevant | near analogy | .180 | 1 | .673 | .000 |
| | far analogy | 1.167 | 1 | .283 | .000 |

F  =  the ration of two mean
df  =  the degree of freedom Squares
p  =  the p-value
η²  =  ratio of the variation
*  =  is significant at the level 0.005
#  =  is significant at the level 0.05

Table 3. Results of the MANOVA test for the generated analogies of the data set from Knoll and Horton (2011b).

**Analysis of good idea count for near and far analogies**

The categorized analogies were used to test the hypothesis that far analogies generate a higher number of good ideas compared to near analogies. Three research assistants, who were blind to the experiment conditions, assessed the generated ideas of the data set from Knoll and Horton (2011b). The raters used a four-point scale to score the ideas for originality:

Score of 4:   the idea is not expressed before (rare, unusual) AND surprising
Score of 3:   the idea is unusual, AND interesting
Score of 2:   the idea is interesting
Score of 1:   the idea is common, mundane, OR boring

The procedure for scoring the ideas was as follows: In a first phase, each rater independently scored the ideas using the four-point scale which eventually resulted in a 78.92 percent overlap in their scoring lists. The raters then met to discuss and reconcile all discrepancies in a group decision workshop.

Many academic papers in creativity research tend to use the idea-count, sum-of-quality, and average-quality measures to evaluate ideation interventions. From a practical point of view, however, these metrics are not very useful, since in real-life, at most a handful of ideas can be implemented, each of which should be of the highest possible quality. For this study, the good idea measure, as recommended by Reinig, Briggs, & Nunamaker Jr. (2007), was used to evaluate the influence of near and far analogies on the ideation process. Three different good-idea-count measures were computed which represented different clusters

of good ideas: number of ideas that were surprising and not expressed before (score of 4), number of ideas that were indicated as unusual or surprising (score of 3 or 4), and number of ideas that were not common (score of 2, 3 or 4).

| | | near analogy (N=22) | | | far analogy (N=22) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | n | M | SD | n | M | SD | F | df | p |
| | idea-count | 635 | 28.86 | 7.73 | 627 | 28.50 | 11.91 | .015 | 1 | .904 |
| good-idea-count | score (2,3,4) | 116 | 5.27 | 2.66 | 150 | 6.82 | 3.80 | 2.443 | 1 | 126 |
| | score (3,4) | 57 | 2.59 | 1.68 | 87 | 3.95 | 2.28 | 5.105 | 1 | **.029#** |
| | score (4) | 13 | 0.59 | 0.80 | 15 | 0.68 | 0.99 | .112 | 1 | 740 |

```
 n  = number of generated analogies
 M  = means
SD  = standard deviation
 F  = the ration of two mean
df  = the degree of freedom Squares
 p  = the p-value
 #  = is significant at the level 0.05
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Table 4 Means, standard deviations and ANOVA test results of good-idea-count for near and far analogies

A one-way ANOVA was conducted to compare the effect of near and far analogies on the number of good ideas that were generated during an analogous thinking process. From Table 4 it can be seen that there was a significant difference in the number of good ideas (score for 3 or 4) at the $p<.05$ for the use of far analogies (M=3.95, SD=2.28) compared to near analogies (M=2.59, SD=1.68) [F(2, 42) = 5.105, p = .029]. In conclusion, the results provide significant support for the Hypothesis $H_2$.

**Indications for Practice**
The analogy method is an important ideation tool with many business applications which typically relies on stimuli that are prepared in advance by the facilitator. Although the choice of stimuli can have a significant effect on the number and quality of the ideas produced, very little advice is available on what types of stimuli might perform best. This research gives a first answer to this question: The number of high-quality ideas is higher when far analogies are used, and more far analogies can be obtained from abstract stimuli than from concrete ones.

This result has immediate practical implications: practitioners are advised to select abstract attributes if they plan that their workshop participants generate

the analogies. If, on the other hand, they are supplying the analogies themselves, then far analogies are to be preferred to near ones.

In this study, we have looked at analogies to the given situation (*who is like us?*) Another variant of the method uses analogies to the goal (*who has achieved what we want to achieve?*) A similar research question arises as to the most effective type of attribute and analogy. Furthermore, the question may be extended to ideation techniques other than analogies: can, for example, a similar result be obtained for near and far random stimuli?

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