Source Selection in Product Metaphor Generation:
The Effects of Salience and Relatedness

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To generate a product metaphor, designers must select a source, discern a property (or properties) of this source, and transfer this property to the product they design. The selection of any source in particular is affected by the extent to which it represents the meaning the designer intends to convey (i.e., its salience), and the strength of its association with the product (i.e., relatedness). In this paper, we tested how different levels of salience and relatedness influenced source selection in a study conducted with design students. The results indicate that a source was chosen only when it had the intended meaning as a highly salient property, and was highly related to the target product. It was also found that being novel yet understandable, having application potential, and creating a complete, functional product were also considered as source selection criteria by designers. This study aims to relate linguistic theories on metaphors to the domain of product design, and help to clarify how designers create comprehensible and aesthetic metaphors.

Keywords – Product Metaphors, Metaphor Generation, Source Selection.

Relevance to Design Practice – Understanding the composition of a product metaphor and the process of its generation will serve to further theoretical knowledge regarding the role of product metaphors in the field of product experience, while designers and design practice will greatly benefit from inspiration and insight into successful metaphor creation.

Introduction

Metaphors build associations between conceptually separate entities, whereby the attributes related to one entity are used to understand or represent another (Wee, 2005). This association is not confined solely to a linking of words, but concerns any transfer of meaning from one conceptual entity to another. Metaphor, in this wider sense, is not just a figurative aspect of language but a fundamental part of people's thoughts, reasoning, and communicative practices (Gibbs, 2008; Lakoff & Johnson, 1980). The power of metaphor lies in its ability to relate two distinct entities, which in turn initiates the production of new and deeper meanings. This potential allows metaphors to be valuable aids in fostering creativity, as the creative act is often associated with the ability to find parallel patterns, see relationships, and connect remote ideas or frames of reference (Casakin, 2007; Gruber & Davis, 1988; Leite, Pereira, Cardoso, & Pereira, 2000; Young, 1987). For this reason, they are often referred to as cognitive instruments used by "creative artists" to perceive relationships that bring in novel qualities to the problem at hand (Cupchik, 2003).

Product designers are one group of these creative artists who make use of metaphors to exhibit original and exciting solutions to design problems. In the design domain, metaphors are commonly used as a means to stimulate designers' creativity in the design process because they help to facilitate unconventional thinking by building relationships between distinct domains (Casakin, 2007; Leite et al., 2000; Snodgrass & Coyne, 1992; Young, 1987), identify design problems (Casakin, 2007; Hey,

Linsey, Agogino, & Wood, 2008), and "frame" the problematic design situation by seeing it from a novel standpoint and adopting a working principle associated with that position (Dorst, 2011; Schön, 1979).

Additionally, metaphors are used as a means to develop a form language to affect the symbolic qualities of products. Products are vehicles for communication between the expressive intentions of designers and the interpretative responses of users. They can be considered as "signs" to make sense of—a role of products that is addressed by product semantics (Boess & Kanis, 2008). Metaphors are extremely functional and effective in this respect; they imbue products with meanings and values (Boess & Kanis, 2008; Forceville, Hekkert, & Tan, 2006; Krippendorff & Butter, 2008; Van Rompay, 2008), by providing clues to users about product use, thereby turning a complex product into a comprehensible one, or by emphasizing the function, social or cultural meaning and personality of the product. In this paper, we adopt this semantic approach to metaphors, and our focus is on the expressive influence of deliberate metaphor use in product design.

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Designers generate metaphors by taking an attribute(s) from one entity and transferring it to a product they are designing. For instance, in the product metaphor seen in Figure 1, the designer implies an association between a memory stick and a padlock. Rather than building a piece of software into which users type their passwords, the designer forces users to use a real key to release the shackle and access the data. A padlock is an object representing "security." An explicit reference to this object helps users to see the expressive intention of the designer: Unauthorized people do not have access. For this reason, the padlock metaphor provides the users with a novel, yet straightforward interaction with the product.

In technical terms, the memory stick is a product that is assigned a new *meaning* and is thus referred to as the *target* of the metaphor, while the padlock is called the *source*, the entity that modifies the target in order to convey that particular meaning. The *meaning* in question is the "data security" provided by this particular USB, which the designer has emphasized by fashioning the product into a padlock (see Figure 2). This fashioning process, called *mapping*, physically builds metaphorical links between target and source by projecting properties of the source onto compatible properties of the target. In our example, the mapping process involves an explicit projection of a padlock's form and usage onto the form and usage of a memory stick.

There are many other examples of metaphor use in the design domain, yet little is known about the way metaphors are generated by designers. Metaphor generation is a topic that is mostly overlooked even in the linguistics domain, where most research is directed towards metaphor comprehension and appreciation (Flor & Hadar, 2005; Katz, 1989; Lubart & Getz, 1997; Silvia & Beaty, 2012). In this paper, we aim to investigate the process that designers go through when generating metaphors, with a specific focus on the *source selection* phase. More than two decades ago, Holyoak and Koh (1987) regarded this phase as "the least understood" (p. 332) decision among all the decisions that are made during analogical reasoning and metaphorical thinking

processes. Their argument still holds today. To our knowledge, there are no comprehensive studies that address the criteria for an entity to be employed in a metaphor as a source: Which considerations metaphor producers (especially designers) have when looking for a source remains unknown.

In this paper, we investigate two factors that we assume to play a key role in finding an appropriate source: the *salience* of the intended meaning for the source, and the source–target *relatedness*. Salience refers to the extent to which the meaning a metaphor producer wants to convey is a prominent attribute of a particular source (Ortony, Vondruska, Foss, & Jones, 1985). As can be seen in Figure 2, from among the various properties and associations a padlock has, in our example that of "security" is transferred to a memory stick. Salience addresses how central and prominent this property is for a padlock, relative to other aspects of a padlock. Relatedness has to do with the conceptual positions of a source and a target in one's representational system and refers to the association strength of these two domains. In our example, it refers to how easy it is to relate a padlock to a USB stick (see Figure 2). These two factors have mainly been studied in the context of metaphor comprehension and rarely in the context of production. Moreover, as far as metaphor generation has been studied, this research is primarily from the domain of linguistics.

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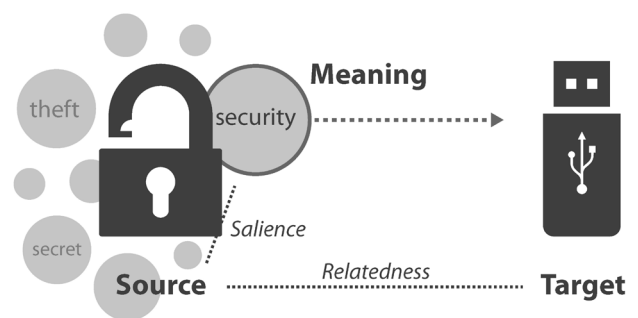

Figure 1. An example of a product metaphor
("Datenschutz" by dialog05)**.**

Figure 2. The relationship of the terms used in this paper.

Following this introduction, we will first present the relevant research on metaphor generation and source selection, and discuss the roles of salience and relatedness in this process. Next, we will present the study we conducted on source selection during the design of product metaphors, and finally we will discuss our findings in the light of metaphor and design theories.

Source Selection

By definition, metaphors have a communicative role that entails a transfer of meaning from one entity to another. This meaning transfer alters target perception in a novel way according to the expressive intentions of its producer (Forceville et al., 2006). Therefore, when people generate a metaphor, they have a particular meaning in mind that they want to attribute to the target and they look for an entity that embodies this meaning (Chiappe & Chiappe, 2007; Clevenger & Edwards, 1988; Jones & McCoy, 1992; Pierce & Chiappe, 2009). Appropriate selection of the exemplar enables the most effective expression of the meaning. In relation to products, this means that metaphor generation starts with deciding which particular quality of the product to emphasize and what kind of experience to offer users, and then seeking out a relevant source.

Creating a metaphor that is both appropriate and aesthetically pleasing demands careful selection of the source. The use of the term "selection" is also metaphorical to some extent. In the creativity research domain, a creative problem-solving process—of which the product metaphor generation process is an example—is considered to involve two kinds of thinking patterns: divergent and convergent (Brophy, 2001). While a range of ideas and concepts are generated in the divergent mode, the most appropriate solution among them is chosen in the convergent mode. As Brophy pertinently asserts, "More divergent thought occurs while generating problem definitions and solutions. More convergent thought occurs while selecting and developing them" (p. 440). In product metaphor generation, during the exploration phase of the design process, divergent thinking takes place when designers look for a source to associate with a target and create imaginary sets of potential sources. For instance, a possible set for the previous example could be "things that protect what is inside," and might include a vault, chest, castle, padlock, nest and so forth; this list is a product of the divergent thinking mode. Deciding which is the most fitting source out of the set—a padlock, in this case—displays a form of convergent thinking, which is influenced by various constraints. Our study focuses on this convergent selection phase, where designers come up with, decide on, or "select" an appropriate source to associate with a target. In other words, why the designer in our example selected a padlock, out of all the possible sources, is the question we aim to answer.

There is a small body of work on source selection in the domain of metaphor studies. For example, Clevenger and Edwards (1988) tested for the ideal proximity of target and source in the semantic space by asking their participants to match a famous person with an animal from the set they provided. Pierce

and Chiappe (2009) had participants complete metaphorical statements (e.g., "Some smiles are _____") with appropriate source terms, after providing them with a meaning to be attributed to the target (e.g., "Something that draws things to you"). In this way, they were able to investigate the effect of selected sources' aptness and conventionality on the quality of metaphors produced, and the time it took to produce them. To explore the links between target–source distance, source concreteness, and imagery of the metaphor producer, Katz (1989) took a similar approach by asking participants to complete metaphors, but this time participants were expected to choose sources from a set of predetermined alternatives. Source selection is also occasionally addressed in the creativity literature as a means of establishing a link between creativity and intelligence. For example, Silvia and Beaty (2012) studied the role of intelligence in creative metaphor generation by providing their participants with examples of emotional experiences and asking them to define these situations by using metaphors. Similarly, De Barros and her colleagues tested whether completing metaphors with appropriate sources might be a valid way to measure intelligence and creativity (De Barros, Primi, Miguel, Almeida, & Oliveira, 2010). Although these studies make an invaluable contribution to understanding the nature of verbal metaphors and metaphorical thinking, their main focus is not directly on the dynamics of the metaphor generation process or on the source attributes that might influence it.

We argue that in order to generate comprehensible metaphors, when a designer is selecting a source, two considerations should be taken into account. Firstly, the designer should consider the communicative role of the metaphor, and aim to emphasize the desired meaning as clearly as possible. For this reason, she should narrow down the number of potential sources by focusing on those that are "an ideal and salient exemplar of the category it represents" (Glucksberg & Haught, 2006, p. 375). The second consideration has to do with the relationship between target and source and involves whether the potential source enables an appropriate association to be built between these domains. In this paper, we examine how these two factors affect designers' selection of sources used in product metaphors, by employing a variant of the metaphor completion procedure used by Katz (1989) and Pierce and Chiappe (2009). Before proceeding with the study conducted for this purpose, we will further elaborate on the concepts of salience and relatedness.

Salience

Salience refers to the significance of a property in a person's representation of a "category" and is characterized by the qualities of importance, characteristicness, distinctiveness, and conceptual centrality (Katz, 1982; Ortony, 1979; Ortony et al., 1985). Each category has a graded structure, comprising members varying from "good" examples to "not-so-good" examples of that category (Barsalou, 1983). The sources considered in metaphor generation are also (ad hoc) categories comprising various dimensions and properties. Correspondingly, the graded structure implies that

some properties of the sources are more important, distinctive and central than others. In order to convey a new meaning, a person is likely to select a source that has this meaning as a salient property, as compared to other candidate sources. For instance, in Glucksberg's (2003) celebrated metaphor, "My lawyer is a shark" (p. 93), the lawyer's viciousness, aggressiveness, and mercilessness are emphasized using the salient properties of the source "shark." Although other entities like a dictator or the Devil may also embody viciousness, the statements "My lawyer is a dictator" and "My lawyer is the Devil" do not convey viciousness very accurately. The reason is that viciousness is not a particularly salient property of these entities; a dictator and a devil both have other properties that are more salient than viciousness. The former metaphor connotes the authority of the lawyer, rather than his or her viciousness, because being authoritarian and powerful are arguably the most salient properties of a dictator. For similar reasons, the latter metaphor stresses the lawyer's dangerousness and malignity.

It should be noted that, for a source, there is a difference between "having meaning X as a salient property" and "being a typical example of meaning X." When we consider the two statements "speed is a salient property of a lion," and "a lion is a typical exemplar of speed" for instance, it is highly probable that every person would agree with the first statement, but not with the second. Although lions are notorious for hunting their prey with immense velocity and agility, a lion is not an entity that best exemplifies speed. A cheetah, a Ferrari, or a bullet may symbolize speed more adequately. Typical entities surely have the most salient properties for that category (Murphy, 2004; Rosch & Mervis, 1975), while merely having a salient property does not automatically make an entity typical for that category.

We would argue that in metaphor generation, finding a typical source for a particular meaning is not required. It is important, however, to find a source that has that meaning as a highly salient property in order to communicate the meaning effectively. Therefore, the first hypothesis that will be tested in our study is:

H1: Designers will prefer to employ sources that have the intended meaning as a salient property rather than sources that have it as a less salient/non-salient property.

Relatedness

Salience is a necessary condition, but it is not sufficient on its own for source selection; a metaphor producer should also take the relationship between target and source into account. As Aristotle (trans. 1895/2008) stated, "to make good metaphors implies an eye for resemblances" (p. 47). At least some similarity between target and source is necessary for their combination to be construable as a metaphor (Forceville, 2012).

In some metaphors, the relationship between a source and a target may be obvious. For instance, it is easy for one to grasp the intention behind the statement "a rooster is an alarm clock," as a rooster and an alarm clock both wake people up. Alternatively, the relationship may be latent but pre-existent (Forceville, 2012).

We do not usually see any similarity between lips and corals, but in his Sonnet 130, Shakespeare defines the redness of his lover's lips by comparing it to that of coral. Then, we start to perceive the relationship between these two distinct entities: They are related in terms of belonging to the category of "red things." Whether an existing or a latent type of relationship, we maintain that the target and source of a metaphor must involve some degree of relatedness. Given the assumption that metaphors are generated to communicate, if one selects a source that has little overlap with the target, obviously the metaphor that links them would be uninterpretable.

In the field of linguistics, some scholars have asserted that the more two domains overlap, the better the metaphor becomes (Johnson & Malgady, 1977; Malgady, 1976; Marschark, Katz, & Paivio, 1983). Although one should avoid bringing together entities that are "too similar," so as not to end up with dull and uninteresting metaphors (Ortony, 1979; Tourangeau & Sternberg, 1982), one does need to associate entities that share some meaningful properties (e.g., alarm clock and rooster). Good metaphors have targets and sources that belong to distinct categories, yet have a high degree of similarity between them. We believe this is also valid for the metaphors used in product design: A high degree of relatedness between target and source generates a higher potential for appropriate associations, and a designer will associate them because of this relatedness. Therefore, the second hypothesis we will investigate in the study is:

H2: Designers will prefer to employ sources that are highly related to a target rather than sources that are less related or unrelated to it.

Method

Participants

Thirty-three MSc students (19 females) in the Industrial Design Department at Delft University of Technology took part in this research. All of them were unpaid volunteers who received no additional course credits for their participation.

Design Brief

In order to confine our study to source selection only, we decided on the target and the meaning to be communicated beforehand. We asked participants to design a vacuum cleaner (i.e., target) that conveys "power" (i.e., meaning to be assigned) using a metaphor. Such a task, where the designer is commissioned by the client to create a specific product with a specific character, is common in design practice (Rodgers & Milton, 2011). In our study, we chose a vacuum cleaner because it is a product that allows for the exploration of various multimodal interactions related to form, movement, sound, touch, and even smell. Power is a major feature of vacuum cleaners, and it is an open concept that can be conveyed through a product in different ways. This target–meaning combination was considered favorable to the exploration of metaphors focusing on different aspects of vacuum cleaners.

Stimulus Material

Generation and rating

To investigate the effects of salience and relatedness on product metaphor generation, a set of sources had to be identified that showed differing degrees of salience for power and relatedness to vacuum cleaners. For this, we followed a two-stage process. In the first stage, we conducted a focus group in which three experts, each with a BSc and an MSc degree in industrial design and several years of design teaching experience, participated in an extensive two-hour brainstorming session in which one hour each was devoted to "things that have power" and "things that are related to vacuum cleaners"[1]. The colloquial word "thing" was used here in order to guide the experts to think of entities with "physical substance," which can cover various areas from natural phenomena to man-made objects. We prompted the experts not only to come up with things that display high degrees of power and relatedness to a vacuum cleaner, but also to consider other degrees and levels. In this way, we intended to cover all possible salience–relatedness combinations: Some salient sources could also be related to a vacuum cleaner, while some others were of low relatedness. Similarly, vacuum-cleaner-related sources could display low and high degrees of power-salience.

At the end of the session, we obtained a list of 103 items that, for participants, evinced varying degrees of power and relatedness to vacuum cleaners. In the second stage, the items were listed in an online questionnaire, and 35 independent judges, from different professions and within an age range of 26–35, rated both the extent to which power was a salient property for each item, and the relatedness of each item to vacuum cleaners. We defined and exemplified salience as, "The extent to which an item expresses power. For instance, referring to an item as having power, being representative of it, or being frequently mentioned in conjunction with power makes that item express power." In a separate question, judges were asked about relatedness by assessing "The extent to which an item is associated with a vacuum cleaner. For instance, sharing similar sensorial and functional properties, or being mentioned together frequently, makes that item associated with vacuum cleaners." Judges were asked to rate each item on a scale from 1 (*not at all*) to 10 (*very strongly*).

Selection

After obtaining these ratings, we categorized them into nine groups according to their levels of salience and relatedness (Salience: High, Medium, Low; Relatedness: High, Medium, Low). As can be seen in Figure 3, the distribution of the items was not homogeneous. Items that have power as a highly salient property and are at the same time highly related to vacuum cleaners are less common than items having only one of these qualities. This unequal distribution is caused by the instruction we gave to our experts in the focus group: They generated sources for salience and relatedness separately. For this reason, we categorized the items according to their "relative" distance to each other by using 33rd and 66th percentiles (the lines in Figure 3 represent these values). Consequently, for the power dimension, items having a score equal to or higher than 6.33 were of high salience, scores equal to or lower than 3.47 indicated low salience, and the scores between these values indicated medium salience. For the relatedness to a vacuum cleaner, these values were 2.47 and 1.72. With this categorization, we placed the items in a 3 x 3 matrix.

We then selected three items from each of the nine cells of the matrix to use in the study. These items were selected to "best" represent a particular cell while maximally varying in salience and relatedness between conditions. For instance, from the high salience/high relatedness cell we took the three items that got the highest scores on both dimensions, and from the medium salience/ low relatedness cell we selected the ones whose salience scores were average within the cell while having the lowest relatedness scores compared to the other items in the same cell. Mean salience and relatedness scores of the items finally selected are presented in Table 1. The selection of three items from each cell instead of one was to minimize selection bias. By selecting three items and using one of these three in the source sets given to participants, we aimed to ensure the proper representation of each cell in the study.

Procedure

Each participant ($N = 33$) was tested separately. They first received a two-minute introduction on what a metaphor is through examples of a verbal metaphor ("football is war") and a product metaphor

Table 1. Items used in the study with their respective salience (Sal.) and relatedness (Rel.) scores.

		High Sal.			Medium Sal.			Low Sal.	
		Sal. score	Rel. score		Sal. score	Rel. score		Sal. score	Rel. score
High Rel.	Tornado	8.45	5.06	Magnet	6.06	4.00	Dust buster	2.85	8.28
	Engine	7.39	5.41	Power socket	4.15	6.06	Broom	2.42	8.41
	Elephant	7.74	4.84	Leaf blower	3.79	6.75	Mopping	2.31	6.56
Medium Rel.	Lion	8.94	2.09	Teeth	4.76	1.91	Tickling	1.97	1.81
	Lightning	8.09	2.16	Using a whip	5.35	1.91	Abortion	2.38	2.22
	Tank	7.82	2.31	SUV	4.90	2.00	Stroller	2.06	2.31
Low Rel.	Nuclear bomb	9.42	1.44	Antibiotic	4.97	1.38	Camera	2.34	1.41
	King	9.18	1.50	Poison	4.78	1.28	Hamster cage	2.26	1.56
	Crown	8.50	1.44	Vitamin	4.59	1.53	Fence	2.73	1.38

Figure 3. The distribution of the items according to the means of salience and relatedness.

(Senseo coffee maker from Philips, which alludes to the shape of a butler). Then, s/he was given the design brief along with a source set specifically assigned to him/her. We created these sets by taking one item out of three from each cell of the 3 x 3 matrix, resulting in a total of nine items in each set for each participant. In this way, all items were used 11 times in the experiment, but in different random combinations. No two participants were given the same source set.

After each participant received the design brief, first s/he was given 10 minutes to select three sources from the set of nine sources which s/he felt would make a good metaphor, and then sketch initial concept ideas. Then, s/he was instructed to select the one s/he found the most appropriate from these three sources, and work on this design concept for another 10 minutes. At the end of the design phase, we conducted an interview with the participant during which we asked him/her to talk about the design concepts,

why s/he selected one particular source and eliminated the other two, and why s/he did not adopt the six rejected sources. Asking participants for positive selection reasons as well as negative ones was to see if these two were actually polarized, i.e., if the reason for selecting a source was similar to the reason for not selecting a source. It also gave participants an opportunity to express reasons using a wider vocabulary.

The interviews were video-recorded with the permission of participants, and later transcribed verbatim by the first author. Content analysis of this data was made as a secondary observation tool for checking whether the participants made the expected considerations while selecting a source, and for identifying other possible source selection reasons in interview transcripts. The results of this analysis will be presented in the next section and will be used in the discussion section to further explain our findings.

Results

Comparisons of Salience and Relatedness Levels

Figure 4 indicates how many times each of the nine salience–relatedness combinations was selected by participants, together with the selection frequency of the particular items belonging to that category. As can be seen, the most frequently selected combination was high salience–high relatedness, and *tornado* was the most frequently selected item, followed by *elephant*, *engine*, and *tank*.

To determine which item characteristics contributed to source selection, we employed a 3 (Salience: High, Medium, Low) x 3 (Relatedness: High, Medium, Low) ANOVA. The final selection of the participants was used as the dependent variable. Consistent with our predictions, there was a significant main effect of salience and relatedness on source selection, $F(2, 288) = 11.22, p < .001, \eta^2 = .072$ and $F(2, 288) = 5.55, p < .01, \eta^2 = .037$, respectively, thus demonstrating that the salience of the meaning for a source and the relatedness of the source to the target directly influence the likelihood of its being selected for a product metaphor. Two separate Games-Howell *post hoc* tests were conducted in order to obtain between-group differences on means of salience and relatedness. As expected, participants selected the sources that have power as a highly salient property significantly more often than the sources with power as a moderately salient,

$MD = 0.14, p < .02$, or low salient property, $MD = 0.19, p < .01$. The selection of sources with medium and low salience was not significantly different. The results for relatedness showed a similar pattern. The sources highly related to vacuum cleaners were selected more often than the medium-related, $MD = 0.12, p < .05$, and low-related sources, $MD = 0.12, p < .05$, and the difference between the selection of medium- and low-related sources was non-significant. Results thus indicate that sources that have the intended meaning as a highly salient property and are highly target-related were preferred over their moderate- or low-degree alternatives during product metaphor generation.

A significant interaction effect was obtained between salience and relatedness, $F(4, 288) = 3.58, p < .01, \eta^2 = .047$ (see Figure 5). This interaction indicates that the effect of relatedness differs according to the level of salience, and vice versa. Specifically, simple effects analyses of the interaction indicate that there was an effect of relatedness on source selection only if the source had power as a highly salient property, $F(2, 96) = 6.64, p < .01, \eta^2 = .122$. When there was medium or low salience, the results were not significant for the effect of relatedness. Therefore, only when the salience was high were high-related sources preferred over medium ($p < .01$) or low-related sources ($p < .05$). The reverse situation was also observed: There was an effect of salience on source selection only when the source was highly related to the target, $F(2, 96) = 10.74, p < .01, \eta^2 = .183$.
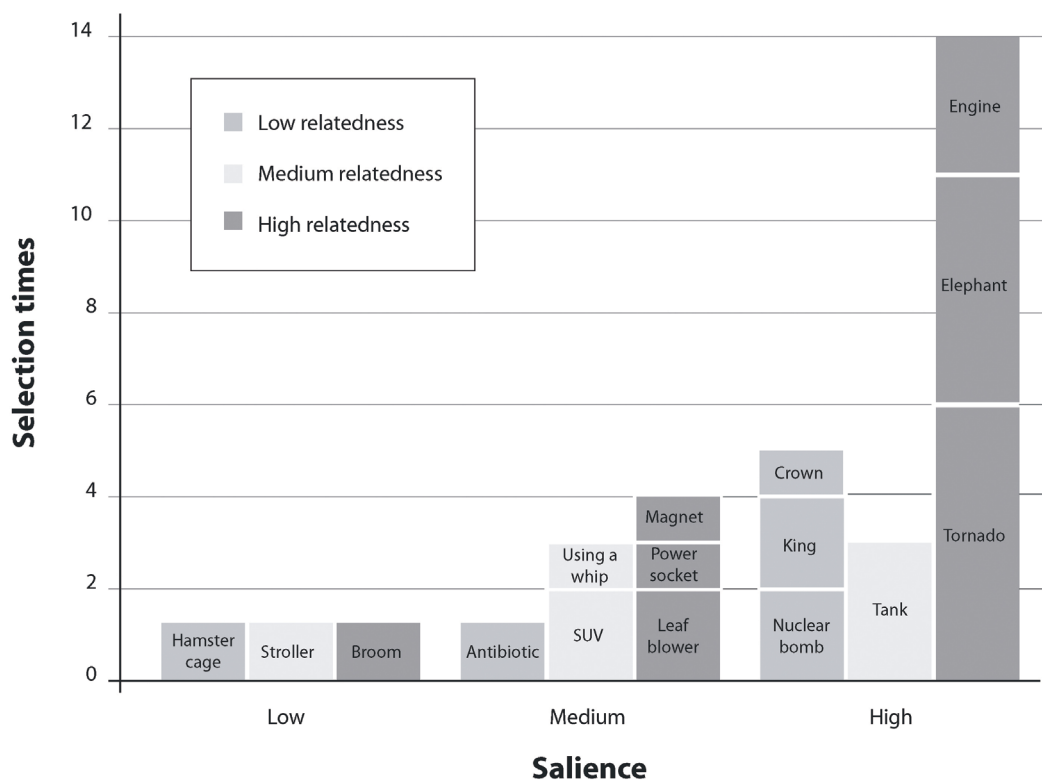

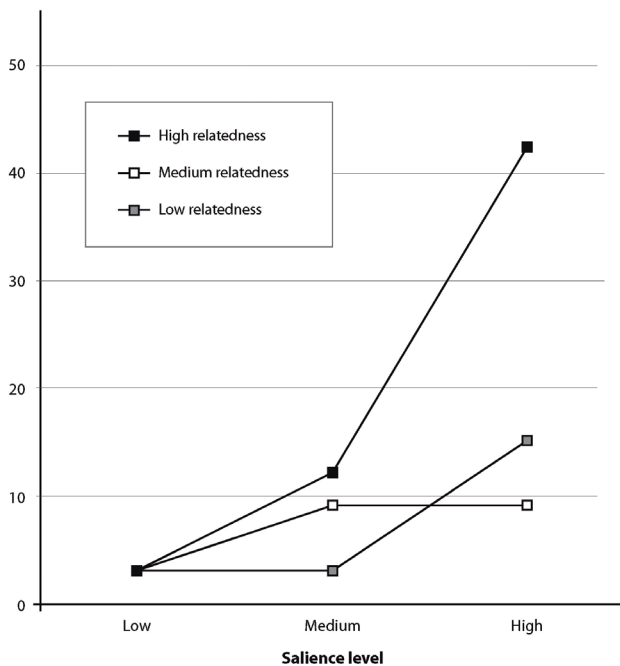Figure 4. Item selection frequency.

Figure 5. Salience and relatedness factor interaction.

Analysis of Interviews

Coding schemes were developed inductively from natural-language data in the transcriptions. The transcriptions were segmented into short phrases, and a total of 559 segments were identified. The segments that included physical descriptions of the products were removed (e.g., "The main body has this accordion-like structure" [Participant 1], "It has spherical wheels" [Participant 29]). The remaining 482 segments were used as the main units of analysis (i.e., units of meaning; Henri, 1992).

The first author did the initial segment coding. Coding was based on "latent content" (Graneheim & Lundman, 2004, p.106), meaning that the coder not only coded what was explicit in the data (e.g., "I chose the elephant because it is a powerful animal" [Participant 12]), but also inferred intentionality from the statements of the participants (e.g., "an SUV is something very strong and big" [Participant 4]). The segments were classified into two main categories, which comprised reasons for selection or non-selection of a source as subcategories. This coding scheme was checked for reliability by having the segments coded by a second independent judge. Agreement was found for 71.5% of the segments. This was followed by an elaboration phase, where the coder and second judge discussed discrepancies, renamed criteria where necessary, and tried to resolve conflicts. On the basis of consensus, the coding scheme was considered to be sufficiently reliable to proceed with further analysis.

A third independent judge—who had received training in this coding scheme and in protocol analysis in general—coded the segments using the scheme. Intercoder agreement was computed between the first and third judges' scores for selection

and non-selection reasoning, Scott's pi = .75, and .77 respectively, demonstrating a highly acceptable level of reliability[2]. Coding disagreements were resolved through discussion. The coding scheme is presented in the Appendix as Tables 2 and 3, in which the subcategories denoting reasons for selection or non-selection are listed, together with a brief characterization and example segment in each case. Also listed is the number of participants who had responses in each subcategory.

We categorized participant comments under six main categories of "source selection reasoning" including criteria from both Table 2 and Table 3. Their combinative percentages are as follows:

1. Having the intended kind of power as a salient property (46.5%): This category includes statements of participants concerning the extent to which a potential source conveys the "intended" meaning. Segments coded as *Powerful*, as a reason for selection, or as *Non-powerful*, or *Conveying a different kind of power*, as reasons for non-selection, are included in this category.

2. Being optimally related to a vacuum cleaner (30.9%): This category includes statements concerning the relationship/match of a potential source with certain properties of a vacuum cleaner. Segments coded as *Related in terms of function*, *Related in terms of appearance*, *Related in terms of sound*, *Related in terms of movement*, or *Related in terms of interaction pattern*, as reasons for selection, or as *Unrelated in terms of function*, *Unrelated in terms of interaction pattern*, *Unrelated in terms of appearance*, *Too related to the target*, or *Irrelevant*, as reasons for non-selection, are included in this category.

3. Being novel, yet understandable (6.5%): This category includes statements concerning the extent of novelty or creativity of a potential source. Segments coded as *Novel* or *Familiar*, as reasons for selection, or as *Hackneyed* or *Very common*, as reasons for non-selection, are included in this category.

4. Having application potential (6%): This category includes statements concerning the possibility of projecting a particular source onto a vacuum cleaner physically. Segments coded as *Abstract* or *Concrete*, as reasons both for selection and for non-selection, are included in this category.

5. Creating a complete, functional product concept (5%): This category includes statements concerning the contribution of the source to the unity and functionality of the end product. Segments coded as *Affecting major components of a target* or *Contributing to functionality*, as reasons for selection; or as *Affecting non-salient components of target*, *Used for decoration only*, or *Kitsch*, as reasons for non-selection, are included in this category.

6. Other (2.4%): This category includes statements concerning other factors that were mentioned to hinder selection of a source. Segments coded as *Beyond design skills* or as *Having negative associations* are included in this category.

The results of the content analysis indicated that more than 75% of the reasons for selection or for non-selection mentioned by participants concerned salience and relatedness of a source. The interviews were also helpful for identifying other considerations that the participants had when selecting a source, which will be discussed in the next section.

General Discussion

The results from the present study confirm both hypotheses: Sources that have the intended meaning as a salient property are likely to be selected over ones that do not, and sources that are highly related to a target are preferred over moderately and little related alternatives. The interaction between salience and relatedness suggests that these major effects of both variables operate only when the value of the other variable is high. This effect, albeit significant, must however be treated with caution since there were, as predicted, only a few sources selected from the middle and lower ranges of each variable.

The interviews conducted after the design phase provided converging evidence to support our main hypotheses. Corresponding with the first hypothesis, all of the participants asserted that they had selected a source because it referred to something really powerful (see Table 2), or used similar reasoning to explain why they had eliminated a particular source (see Table 3). Being powerful, however, was not the only concern. Participants also took into consideration whether a potential source expressed power in the intended way (see *Conveying a different kind of power* in Table 3). For instance, while many participants appreciated the power a *crown* confers upon its owner, they also explained they would not select the crown because the power of a vacuum cleaner was physical and related to suction, whereas a crown refers to political and social power. Therefore, in order to provide effective communication, a source's ability to accurately convey a particular meaning drives its selection. As demonstrated during content analysis, almost half of all criteria mentioned as reasons for selection or non-selection concerned whether the source had the intended kind of power as a salient property or not (46.5%), which makes it a highly significant factor.

The results of the content analysis were also in line with our second hypothesis. The second most often mentioned criteria in relation to the selection or non-selection of a source involved its relatedness to a vacuum cleaner (30.9%). Many participants argued that they employed a particular source in their designs because they were able to see some relationship between the two. Similarly, the lack of any relationship led to the elimination of some sources. This is in line with the results of the statistical analysis, which indicated that sources with a low relatedness level were not preferred during metaphor generation. However, some participants also mentioned that they did not choose a particular source because it was "too related" (see *Too related to the target* in Table 3). While this remark should not be seen as contradicting the main finding of the study, it will be useful to examine the difference between being highly related and overly related. The sources that were most preferred by participants were *tornado*, *engine*, and *elephant*, all of which share properties with a vacuum cleaner, but also have some clear dissimilarities. As briefly mentioned in the introduction, when two entities are members of a similar domain, resemble one another physically, or function in a very similar fashion, the metaphor they produce starts to lose its interestingness and metaphoricity. During the interviews, a comment was made that reflected the overly close relationship between a *dust buster* and a *leaf blower* and a vacuum cleaner. If one takes into account the practical function and mechanical operation of these two products, both could be considered members of the same product category; for this reason (and besides their inadequately conveying power), the metaphors generated by blending each with a vacuum cleaner were not considered to be appropriate. On the other hand, sources with equally similar traits to a vacuum cleaner but belonging to a different domain (e.g., *tornado*—natural events, *elephant*—animals) were very popular. Thus, we reiterate that sources that are highly related to the target product, yet belong to another domain, are favored in metaphor generation.

The analysis of the interviews also made a valuable contribution to our research by clarifying what relatedness entails in relation to product metaphors. The statistical results indicate what degree of relatedness should exist between target and source, but the interviews allowed us to distinguish the kinds of relatedness that may exist between the two. Upon analysis of interview transcripts, we were able to identify five types of relatedness: appearance, sound, function, movement, and interaction pattern (see Tables 2 and 3 in the Appendix). When participants recognized a similarity between target and source in any of these respects, they concluded that (should they select that particular source) the property could be transferred with ease. To elaborate on this, we want to present three sketches that include a reference to a *tank* in Figure 6. There are some components shared by a stereotypical tank and a stereotypical vacuum cleaner, e.g., both use wheels to move. In all three designs, participants used the appearance of the wheels of a tank (i.e., caterpillar tracks) to shape the wheels of the vacuum cleaner. Similarly, the correspondence between the form and movement of a tank turret and of the hose of a vacuum cleaner was used in the last example.
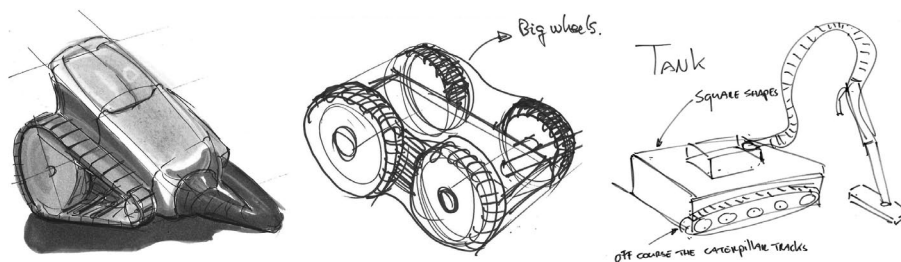

Figure 6. Extracts from sketches made by three participants who used *tank* as a source.

Mappability

These results indicate that a designer considers the subsequent mapping phase when selecting a source. After finding a source that has the intended meaning as a salient property, they carefully consider whether its properties can be matched to those of the target, which properties to transfer from it, and what kind of mapping strategy to follow. Here, the "mappability" of the source—the potential for a source's properties to be transferred to a target—plays an important role. Mappability explains why the relatedness of target and source domains affects source selection in product metaphors: When a target and a source carry corresponding properties, the source becomes more "mappable" as it is relatively easy to transfer its relevant properties to the target. This may make the source preferable over other possible sources that do not possess this relationship with the target. Highly target-related sources, especially if this relatedness is in terms of visual qualities, also have a high mappability.

As mappability pertains to the application potential of a source, it includes not only target–source relatedness, but also the level of a source's abstractness. Some participants' remarks also referred to this potential (6%). The positions taken here were rather conflicting: Some participants preferred to use a concrete source with a well-defined form that gives them clear directions on where to start and how to do the mapping (see *Concrete* in Table 2). They considered this kind of source to have a greater application potential. Other participants, however, preferred abstract sources without any defined form, which would not constrain their exploration and imagination and force them to employ the source as it is (see *Abstract* in Table 2). The only thing they agreed on was that neither too much abstractness nor too much concreteness was desired. When the source is too abstract, it becomes difficult to come up with an image supporting a source's application to the target by projection (see *Abstract* in Table 3); when it is too concrete, it limits the exploration of different properties that might be applied to the target (see *Concrete* in Table 3).

Novel Concepts

Another point we want to elaborate on is the potential of metaphors to produce new concepts/products. As mentioned in the introduction, metaphors encourage us to see things in a new light and bring novel perspectives to the topic at hand. Similarly, in our study we observed that participants "invented" various vacuum cleaners by associating them with different things. In one case, a participant created a new vacuuming concept whereby the vacuum cleaner first makes the dust magnetic and then attracts the dust without any effort. In another case, a participant got inspiration from the stately bearing of royalty and designed a vacuum cleaner whose form does not require users to bend over while cleaning. The creative power of metaphor usage is apparent in these cases. Correspondingly, the analysis of the interviews also indicated that the designers took into account the originality of the metaphors they would produce when selecting or not selecting sources (6.5%). They aimed for novel product concepts and tried

to avoid commonly used and hackneyed associations between the source and target. However, they also considered whether an association they made would be recognized and understood by users. That is why *Novel* and *Familiar* are both mentioned as source selection reasons (see Table 2). Establishing a balance between source novelty and comprehensibility is one of the major factors that play a role in metaphoric quality (Cila, Borsboom, & Hekkert, in press), which the participants also considered as a source selection criterion.

A small number of participants (5%) also considered whether a source leads to a complete design concept that helps them to shape the whole product accordingly instead of addressing only a small part of the design problem (see *Affecting major components of the target* in Table 2, and *Affecting non-salient components of the target* in Table 3), and makes a contribution to the functionality of the product, or instead is a mere styling issue (see *Contributing to functionality* in Table 2, and *Used for decoration only* in Table 3). Lastly, whether a source has negative connotations, and whether the implementation of its association with the target is beyond designers' skills, was also considered (2.4%).

Limitations

With respect to these considerations, we want to say a few words regarding the limitations of the study. The first is the omission of other factors that affect source selection. Although salience and relatedness make up the major portion of these factors, the interviews indicated that other factors were taken into account by some participants. We were able to identify four additional categories from interview content analysis and consequently attempted to include their role in source selection during our discussion of the findings. However, none of these considerations were systematically included in the experimental setup. They surely affect source selection to some extent and should be investigated in future studies.

Our second remark concerns the methodology. Making the participants select from a set of items allowed us to have experimental control over the salience and relatedness factors while at the same time permitting a wide range of selection options. In a free-generation process, one cannot guarantee that designers would consider unrelated or non-salient sources. By structuring sets including sources that have different degrees of salience and relatedness, we were certain that the designers would consider sources of varying levels of salience and relatedness. We are aware that designers are normally not provided with such external lists. Although there is a theoretical possibility that the selection of items in the sets might have affected the results of the study, the chances of this are considered limited.

Lastly, we want to remark on the duration we gave to participants to select the most apt source from three candidates. In the limited time frame offered (10 minutes), participants might have preferred to incorporate sources that are more intuitively applicable than sources that need a complex transformation

to be integrated into a vacuum cleaner. We aimed to limit this possible effect by giving the participants freedom and flexibility in the expected level of detail in their final designs. They did not have to worry about production constraints or the feasibility and practicality of the metaphorical products they generated. We consider that with this approach they could just have focused on evaluating the application "potential" of a source. There may certainly be a difference between envisioning the applicability of a source and actually producing it, but we believe that designers' gut feeling is a major cause of source selection, and they would most often find a creative way to implement their ideas into the product. How the actual application of a source (i.e., with a real design brief from a real client) would affect the selection of a source and metaphoric quality is an issue that needs to be addressed in further studies.

Conclusion

Currently, there is little empirical knowledge regarding the metaphor generation process in the design domain. The study reported in this paper focused on the source selection phase of this process and explored the effect of different levels of salience and relatedness on this particular activity. It was found that a source is selected when it has the intended meaning as a highly salient property and it is at the same time highly related to the target product. Furthermore, the study revealed three extra criteria for source selection: being novel yet understandable, having application potential, and creating a complete, functional product concept; and it indicated five types of relatedness between a target and a source of a product metaphor: function, appearance, sound, movement, and interaction pattern. The aim of a designer is to create comprehensible and aesthetically pleasing metaphors. Selection of a suitable source that conveys a certain meaning effectively and can be meaningfully associated with the target, helps to realize these goals. Our study is one of the first attempts to systematically include metaphor generation as a research subject in the product design domain, through which we intend to lay a foundation for future study to obtain an overall understanding of metaphor generation.

We can state that metaphor generation requires a considerable amount of decision-making. Designers have to decide on the meaning they wish to convey, the source that can convey this meaning, which attributes of this source they will project onto the target, and how they will execute the mapping. Understanding this process can help designers to make appropriate, creative decisions regarding these aspects, and create comprehensible and aesthetic metaphors that provide rich user experiences.

Acknowledgments

Endnotes

1. We considered that asking "experts" to come up with sources within this time frame is sufficient to find interesting associations, as we had found earlier that the time limit a designer has for creating a metaphor is not a relevant constraint on his or her ability to come up with an appropriate source. If the designer is experienced, s/he can generally find sources to emphasize the hidden qualities of a target better than novices regardless of the time given (Cila, Hekkert & Visch, in press).

2. Scott's pi is considered as a highly conservative index for reliability. For the coding of a variable to be reliable, it was required that Scott's pi be .70 or higher (Lombard, Snyder-Duch & Bracken, 2002).

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Appendix

Table 2. All criteria mentioned for selecting a source.

Criterion	Freq.[a]	Part.[b]	Brief characterization	Example segment
Powerful	56.4%	19	The source is powerful or represents power.	Tornado was the one that represents power mostly among them. (P6)
Related in terms of function	11.55%	19	Correspondence in the main function and/or operation.	[Tornado] sucks everything wherever it goes. So, I considered this one to be the most relevant with the vacuum cleaner. (P27)
Related in terms of appearance	6.22%	8	Correspondence in form, color, size, material, texture and/or posture.	I was like "Wow, they [tank and vacuum cleaner] look really alike!" It's very straightforward if you want to make really fast solutions. (P33)
Related in terms of sound	3.55%	8	Correspondence in the sound they produce.	Since it [lightning] makes a lot of noise, I was able to build a connection. Vacuum cleaners also make a lot of noise actually. (P22)
Related in terms of movement	3.55%	8	Correspondence in the way their parts move.	The turret moves like the hose of a vacuum cleaner. (P28)
Related in terms of interaction pattern	2.22%	5	Correspondence in the way they are used and/or operated.	The part you hold in vacuum cleaners is the hose, not the whole body. As it is also the same with the whip I selected this one. (P6)
Novel	4%	8	The source brings in a new design concept that has not been created before.	"Nuclear bomb" can lead me to a very interesting point. I can go beyond the picture and come up with a new solution. (P18)
Familiar	2.66%	5	The source is familiar, recognizable and understandable.	I prefer something more common to people, to a housewife for instance. She'd prefer to work with a broom instead of some sci-fi engine stuff. (P8)
Affecting major components of the target	1.77%	4	The transfer of the source influences all the key components of the target.	More important parts of the vacuum cleaner are influenced by this metaphor. (P11)
Abstract	1.77%	3	The source does not have a well-defined visual form.	The king is not a product yet. So, it is interesting to think how can a king be a product. (P15)
Concrete	0.88%	2	The source has a well-defined visual form.	I selected whip because it is more tangible and a visually defined object. (P5)
Contributing to functionality	0.44%	1	The implementation of the source contributes to the function of the target.	Here the engine has a function…. So, I thought that would work better than just taking a vacuum cleaner and shaping it like a tank. (P2)

[a] The percentage of the responses among all the criteria mentioned by participants (N = 33).

[b] The number of participants who mentioned that criterion at least once.

Table 3. All criteria mentioned for *not* selecting a source.

Criterion	Freq.[a]	Part.[b]	Brief characterization	Example segment
Non-powerful	24.15%	28	The source is not powerful or does not represent power.	With "antibiotic" I don't really have the power association. (P3)
Unrelated in terms of function	12.45%	20	Mismatch of the main function and operation.	The fence is more about keeping things out than cleaning things up. (P12)
Unrelated in terms of interaction pattern	2.26%	6	Mismatch of the way they are used and/or operated.	The whip is not a very clear metaphor here. Because the movement we do actually does not fit with it. (P6)
Unrelated in terms of appearance	1.13%	3	Mismatch of form, color, size, weight, material, texture and/or posture.	It was not easy to find a way to communicate the shape and strength of tornado in an object like a vacuum cleaner. (P26)
Irrelevant	15.09%	19	The source is considered irrelevant to the design brief.	Camera… I don't see a relation. Both with a vacuum cleaner and power. (P17)
Conveying a different kind of power	12.45%	19	The source emphasizes a different dimension of power.	A king is more like a political power. (P24)
Abstract	6.79%	12	The source does not have a defined visual form.	"Antibiotic" is too abstract. I can't really think of a shape to copy the style into a vacuum. (P20)
Hackneyed	4.15%	8	The source is obvious, one that anyone can come up with.	The lion is the first thing that came to your mind. That's why I preferred something interesting. (P8)
Too related to the target	3.77%	10	The source is extremely similar to a vacuum cleaner.	The dust buster already has dust inside. So maybe it's too close. That means there is little [scope] for exploration. (P24)
Kitsch	3.39%	8	The association of the source leads to toy-like or kitsch products.	I thought it was quite funny [tank-shaped vacuum cleaner], but I don't really see it as an actual product. (P2)
Having negative associations	2.64%	7	The source is associated with negative situations.	Poison is a mean thing. (P31)
Concrete	2.64%	5	The source has a well-defined visual form.	I didn't choose the dust buster because it is already a product. So then you are a bit stuck by the ideas you have about that product and how the product should look like. (P15)
Used for decoration only	2.64%	3	The implementation of the source is just for styling and decoration.	With the tank it more comes down to styling rather than incorporating in functional way into the design. (P2)
Very common	2.26%	5	The source is already used commonly in other products.	I didn't want to pick "tornado" because I mostly associate with Dyson. Most of the vacuum cleaners are concentrated on tornado. (P28)
Beyond design skills	2.26%	3	The source is difficult to draw and visualize.	So "engine" was a really good one for a metaphor, but my drawing skills are…. It became a mess. (P20)
Affecting non-salient components of the target	1.88%	5	The transfer of the source affects only unimportant components of the target.	They are focusing on small function that I could apply in the final product. I need something giving me general concept. (P10)

[a] The percentage of the responses among all the criteria mentioned by participants (N = 33).

[b] The number of participants who mentioned that criterion at least once.