
Patterns of Experience in Thermal Conceptual Metaphors

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Abstract

Thermal sensations have potential for use in technology for information and interactive systems. Experiences correlating to temperature structure our understanding of many abstract concepts that could be useful in such systems. In this study, the experiential nature of conceptual metaphors was analyzed, and an experiment was conducted in which participants were presented with six thermal conceptual metaphors for interpretation. The validity of the metaphors was assessed, and the results of the experiment provided examples of both consistent and inconsistent patterns of experience when the concepts were interpreted in terms of temperature. Recommendations for furthering the identification of thermal conceptual metaphors with potential were discussed.

Author Keywords

Population stereotype; conceptual metaphor; thermal sensation

Introduction

Thermal sensations are pervasive tactile stimuli that contribute a significant structuring of abstract concepts into experiential understanding for people [4, p.45-49]. Despite its potential for representing other concepts in interaction, there has been very little precedent for its use in information and interactive systems [7]. In our previous study [1], we investigated the potential of population stereotypes [2] for thermal sensations to counteract the inherent ambiguity of using temperature as a representation of the properties of a possible system, without an established mental model for its meaning. The ambiguity that resulted in preceding studies [6,7] suggested that the lack of a mental model for interpreting the thermal sensations intended for interpersonal communication was a factor. We claimed that situating the thermal sensations in a context in which an appropriate mental model exists would counteract the ambiguity, and result in a pattern language for thermal sensations in interaction design [1].

Conceptual metaphors [3, p.4] of the form WARM is CLOSE, COOL is FAR (proximity) and WARM is FULL, COOL is EMPTY (vacancy) were analyzed as possible population stereotypes. The former metaphor was found to be valid (with a 100% agreement amongst participants in the study), while the latter was too ambiguous (54% agreement). These findings indicated that the valid metaphor is interpreted significantly more consistently in day-to-day human experience, while the invalid metaphor, despite also being a commonly encountered physical property, does not have a consistent mental association with thermal sensations in the population [1].

In this study, we venture to provide the initial validation of six new thermal conceptual metaphors with a small sample of participants. Considering the importance of associations that are deeply rooted in common experiences, the six metaphors were chosen with the expectation that they represent such experiences. It is our aim to further the knowledge of what recommendations should guide the selection of thermal conceptual metaphors that have potential as population stereotypes, by clarifying observed patterns between a selection of metaphors.

Related work on defining conceptual metaphors and population stereotypes are discussed, followed by an outline of the experiment that was run to validate our metaphors and produce data for analysis of possible patterns, the results of the experiment, a discussion of the meaning of our discoveries, and clarification of the recommendations we arrived at.

Relating Population Stereotypes and Conceptual Metaphors

Population stereotypes are defined by abstract options being favoured over others by the population at large, in accordance with a pre-conceptual mental model [2]. These mental models are crucial to widespread understanding of abstract concepts and are fundamentally metaphorical in nature. [3, p.3]

Conceptual metaphors are mappings across domains that structure our reasoning, our experience and our everyday language [4, p.31]. Metaphors form a filter through which the majority of our experience is fed, in order to structure a new concept in terms of something known. Since there is minimal precedent for using thermal sensations for representation in technology [7],



Figure 1: Objects used in experiment

this need to correlate disparate domains is paramount to properly understanding the use of thermal sensations in such an application.

“Cross-domain” mapping is central to the importance of metaphor in interaction design; it creates a model from familiar experiences and casts them onto unfamiliar abstract concepts to give them structure and meaning [8]. We approach this study with the hypothesis that thermal sensations are pervasive enough in everyday life that they can provide a domain for conceptual mapping. In other words, abstract properties can be understood in terms of the concept of “temperature”, or vice-versa [3, p.3].

These metaphors were selected by virtue of their potential to have pre-conceptual mental models defined in terms of temperature, and for having both related and distinct properties that fall into two main categories: energy states (i.e. motion, luminosity) and physical properties (i.e. texture, pliability). We believed that these six metaphors would provide a suitable opportunity to study what possible correlations could be made for each individual metaphor, between metaphors, between the two categories above, and possibly beyond. The goal was to clarify any observed patterns, be it through correlations, or through group interpretation tendencies, and use the patterns to further establish recommendations for identifying potential population stereotypes for thermal sensations.



Figure 2: Setup of experiment

Method

Experiment Design

To test the effectiveness of conceptual mapping using thermal sensations, we designed an experiment in which the following six thermal conceptual metaphors were tested:

Metaphor:	Linguistic Example:
WARM is FAST COOL is SLOW	<i>Blazed</i> through the book. You should <i>cool</i> your heels.
WARM is MOVING COOL is STOPPED	It was a <i>hot</i> start. He was <i>frozen</i> in place.
WARM is BRIGHT COOL is DIM	The light <i>burned</i> bright. She was <i>burned out</i> after.
WARM is SOFT COOL is HARD	<i>Warmed/softened</i> up to it The ground was <i>stone cold</i>
WARM is FLEXIBLE COOL is BRITTLE	None immediately clear
WARM is COARSE COOL is SMOOTH	None immediately clear

Table 1. Metaphors used & examples in language

Materials

For the experiment, two pairs of objects that embodied the chosen properties in each metaphor were placed in cups, invisible to the participants, and arranged in a 2x2 grid. Objects used included: fast and slow-moving children’s toys, stopwatches that were running or stopped, LEDs set to differing levels of brightness, soft and hard extruded polyurethane foam, lengths of flexible wire and broken wooden dowels, and sheets of sandpaper and clear acrylic.

Peltier plates (TEC112705), which become warmer and cooler based on the direction of current, were placed next to each cup on top of a cooling fan, to prevent overheating. A circuit powered by an Arduino microcontroller and Adafruit Motor Shield V1.0 to deliver the correct thermal feedback pertaining to each object controlled the plates. The arrangement of the thermal feedback given at each position was randomized, so that no pattern unrelated to the

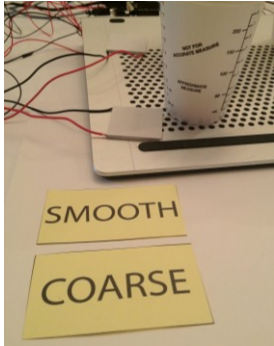


Figure 3: Metaphor property labels set next to Peltier plate and cup



Figure 4: Example of polyurethane foam objects used (Soft and hard metaphor)

interpretation of the metaphors would emerge.

Participants

Fifteen participants (8 male, 7 female) participated in the study, in five groups of three, each of which had a two-to-one gender distribution. All participants were from the Vancouver area, with an average age of 26.33 (range of 22-30), and included primary spoken languages of English, Mandarin, Cantonese, Vietnamese and Urdu.

Procedure

Each group of three participants was separately introduced to the experiment area and briefed on the nature of the activities. They were encouraged to discuss what they were feeling from the plates, and their initial interpretation of the meaning, but given an opportunity to change their minds. After being instructed to touch one plate of their choosing, the participants' final decisions on the properties of each object were given by selecting one of two cards with the properties in question written on them, which were placed next to each cup. Once their decisions were finalized, the participants revealed the object in their cup, to see if they were correct, and wrote about the rationale for their decision in our questionnaire. Then, the next metaphor group was brought out, and the procedure repeated, until the completion of the experiment.

Results

Metaphor:	Correct:	Incorrect:	Strength:
FAST/SLOW	12	3	0.60
MOVING/STOPPED	14	1	0.87
BRIGHT/DIM	14	1	0.87
SOFT/HARD	14	1	0.87
FLXBL/BRTLE	13	2	0.73
COARSE/SMOOTH	7	8	-0.07

Table 2. Participants' metaphor interpretation results

We used Cohen's kappa coefficient (the measure of agreement amongst participants) as our validation method for the six metaphors, as in our prior study, which equates to the following:

$$\text{strength} = \frac{\% \text{ observed agreement} - \% \text{ chance agreement}}{1 - \% \text{ chance agreement}}$$

As shown in Table 2, the result was that only three of the six metaphors achieved a strength value of 0.80 and above which, according to Landis and Koch [5], constitutes a significant agreement, thus, a valid population stereotype. However, it is likely that two of the three invalid metaphors may potentially be valid if tested with a larger population sample, since they were only one or two agreements out of the fifteen participants short of a valid strength value. Our findings for the validity of each of the metaphors excluding 'WARM is COARSE, COOL is SMOOTH' are strictly preliminary, and we recommend that they be studied further to solidify any claim of validity, despite the demonstrated potential in this study

Discussion

Our results from the questionnaire pointed to a pattern between the three energy state metaphors. Nearly all of the participants correctly interpreted these three, and did so stating that they believed an increased energy level (in speed, motion and luminosity) equated to a “warm” object, and a decreased energy level equated to a “cool” object. The experiential basis of this association is clear: heat itself is energy, so an increase in energy should mean an increase in heat. This pattern comes from repeated experiences in life during which more and less heat is conceptualized in terms of more and less energy of various forms, creating the expectation described.

On the side of the physical property metaphors, no such consistent pattern for interpretation was observed. The WARM is COARSE, COOL is SMOOTH metaphor failed, and despite the success of the other two, no definitive patterns encompassing both could be identified. The connection between the physical properties and temperature was not as explicit as the former group, so the interpretation of these metaphors was reliant on the existence of a correlated experience involving temperature for each property individually. Consequently, there were no patterns relating any of the physical property metaphors together, but once temperature became the context for their interpretation, correlated experiences for each property, such as “hard” being associated with objects that are frozen, emerged with enough consistency for two of the three metaphors to show potential as population stereotypes.

Group interpretation of the metaphors played a minimal

role in the experiment. Although we did observe isolated effects on some participants once they observed the actions of the others in the group, we did not consider group effects to be significant. Participants tended to rely on their own judgment, since they felt that the others might not feel the thermal sensations in the same way, or share the same experiences to inform them. One participant explicitly stated that his interpretations were based on his own unique experiences, and that he consequently did not trust the others’ decisions.

Investigating the patterns of effective thermal conceptual metaphors was beneficial to strengthening our recommendations for identifying potential population stereotypes in this realm. Through this initial study, we have identified several potential guidelines towards this end:

1. The predominant pattern that valid thermal conceptual metaphors form is one of repeated, consistent experience of properties in terms of temperature, or vice versa. Identifying these patterns requires an analysis of the most primal, early cross-pollination of temperature concepts onto other, abstract concepts that occur in order to understand them.
2. Properties involving energy state have a significant correlation to thermal sensations, due to an experiential understanding of heat as energy, and an abundance of types of energy that produce heat in greater amounts. Most participants had no trouble associating the energy of motion, as well as the energy of light, with “warm”. There may be potential for greater amounts of other types of energy to map to warmth as well.

3. The possibility for a population stereotype to emerge seems to hinge on a predominant experience or group of related experiences that comes to mind above all others to the contrary. Even when a property does correlate to temperature, if the experiences do not have a pattern of association, the inconsistency will make the metaphor too ambiguous. For example, in the WARM is COARSE, COOL is SMOOTH metaphor, participants were quick to relate temperature with these textures, however, the experiences ranged from warm relating to smooth candle wax, dough, or heat created by friction from a coarse material like sandpaper, to cool relating to smooth metal surfaces or rough surfaces such as rock or chipped ice.

Conclusion

It was found, through our experiment, that three of our six thermal conceptual metaphors are potentially valid as population stereotypes. Defining 'MOVING/STOPPED', 'BRIGHT/DIM' and 'SOFT/HARD' in terms of 'WARM/COOL' resulted in fourteen of fifteen participants correlating each of the properties in the same way when only provided with the thermal sensations. We made a secondary claim that two additional metaphors ('WARM/COOL' is 'FAST/SLOW' and 'FLEXIBLE/BRITTLE') may be validated if tested with a larger number of participants. Additionally, we found evidence of a pattern for interpreting thermal sensations in terms of energy states, but no pattern was observed for the effects of interpreting the metaphors in a group.

The examples in our discussion demonstrate our primary conclusion: although we did find evidence of working patterns that structure multiple thermal conceptual metaphors, thermal experiences are widely

varied, and often personal. For the three conceptual metaphors that were found to be valid, we discovered that the experiences first coming to participants' minds were largely shared. The least valid of our metaphors mapped well to temperature, but the experiences that structured the participants' understanding differed greatly. As a result, we expect that our success in identifying thermal population stereotypes will rely on finding and testing metaphors that touch on consistent, shared experiences.

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