MetaVR: Understanding metaphors in the mind and relation to emotion through immersive, spatial interaction

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ABSTRACT

Metaphorical thinking acts as a bridge between embodiment and abstraction and helps to flexibly organize human knowledge and behavior. Yet its role in embodied human-computer interface design, and its potential for supporting goals such as self-awareness and well-being, have not been extensively explored in the HCI community. We have designed a system called MetaVR to support the creation and exploration of immersive, multimodal, metaphoric experiences, in which people's bodily actions in the physical world are linked to metaphorically relevant actions in a virtual reality world.

As a team of researchers in interaction, neuroscience, and linguistics, we have created MetaVR to support research exploring the impact of such metaphoric interactions on human emotion and well-being. We have used MetaVR to create a proof-of-concept interface for immersive, spatial interactions underpinned by the WELL-BEING is VERTICALITY conceptual mapping—the known association of 'good'='up' and 'bad'='down'. Researchers and developers can currently interact with this proof of concept to configure various metaphoric interactions or personifications that have positive associations (e.g., 'being like a butterfly' or 'being like a flower') and also involve vertical motion (e.g., a butterfly might fly upwards, or a flower might bloom upwards). Importantly, the metaphoric interactions supported in MetaVR do not link human movement to VR actions in one-to-one ways, but rather use abstracted relational mappings in which events in VR (e.g., the blooming of a virtual flower) are contingent not merely on a "correct" gesture being performed, but on aspects of verticality exhibited in human movement (e.g., in a very simple case, the time a person's hands spend above some height threshold).

This work thus serves as a small-scale vehicle for us to research how such interactions may impact well-being. Relatedly, it highlights the potential of using virtual embodied interaction as a tool to study cognitive processes involved in more deliberate/functional uses of metaphor and how this relates to emotion processing. By demonstrating MetaVR and metaphoric interactions designed with it at CHI Interactivity, and by offering the MetaVR tool to other researchers, we hope to inspire new perspectives, discussion, and research within the HCI community about the role that such metaphoric interaction may play, in interfaces designed for well-being and beyond.

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CCS CONCEPTS

• **Human-centered computing → Virtual reality**; **User interface design**; **Gestural input**.

KEYWORDS

Multimodal Interaction for Well-Being, Multimodal Affective Computing

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1 INTRODUCTION

Understanding factors that contribute to our own well-being is a constant challenge. Maintaining homeostasis (i.e., optimizing the body's variables for survival) is the cornerstone of well-being and is driven by both complex automatic, subconscious processes and more top-down cognitive control mechanisms that involve conscious feelings [3]. Advances in virtual reality (VR) technology through life-like graphics and immersive interactive environments have led to novel interfaces to address well-being. This has involved linking bodily/physiological or brain signals to impact interactions in a virtual world offering visual forms of biofeedback to improve aspects of well-being such as reduced anxiety or increased states of mindfulness [1, 15]. Interestingly, these experiences associate different concepts together. For example, an increased meditative state (brain rhythms) with the power to control virtual objects [1] or reduced anxiety (breathing rate) with successful exploration of a beautiful underwater fantasy world [15]. These interactive experiences likely evoke or tap into various metaphorical mappings (i.e., systematic or more novel associations between concepts). Nevertheless, the ways that users might be engaging metaphorically with virtual content and the ways that metaphoric interaction (i.e., any immersive, multimodal interactive experience that causes the user to associate a more concrete experience with an abstract concept) may impact emotion are largely unknown.

Moreover, prior work has placed much emphasis on biofeedback mechanisms that can provide greater awareness of certain bodily/physiological or brain states of users [16], but not necessarily greater awareness of how one's own metaphorical thinking (unconscious or more deliberate [12]) may relate to emotion processing.

Immersive, multimodal metaphoric interaction offers a means by which we can seemingly have greater agency/control over the design of the inner workings of our minds—how our thoughts and language patterns relate to our physicality (i.e., embodiment) and may impact our well-being, and how they may be changed.

In this work, we aim to address the above problems at a small scale by leveraging virtual reality technology to create a proof-of-concept interface that gives users agency and control to explore the WELL-BEING is VERTICALITY conceptual mapping through immersive, spatial interaction. According to conceptual metaphor theory, abstract concepts—including complex emotion concepts—are believed to be structured in part through links with concrete concepts that co-occur during human development [8]. For example, during development our experience with upward motion becomes associated with well-being (e.g., getting up in the morning), while downward motion is associated with ill-being (e.g., lying down when sick). This leads us to metaphorically conceptualize good and bad things in terms of verticality (e.g., 'she lifted her spirits') [4, 8]. However, metaphor not only acts as a bridge between embodiment and abstraction [6] but it also can provide a way to organize knowledge and behavior in a flexible way to accomplish a specific goal [2, 8], such as achieving well-being. The WELL-BEING is VERTICALITY conceptual mapping organizes knowledge and behavior by associating things with positive connotations with vertical motion or position in a 2D-space (i.e., GOOD is UP; BAD is DOWN).

As a team of researchers in interaction, neuroscience, and linguistics, we have created MetaVR to support research exploring the impact of metaphoric interactions on human emotion and well-being. Currently, MetaVR implements a proof-of-concept interface or 'cognitive interaction map' that organizes or *maps* entities in the virtual world that have positive sentiment or associations and have vertical motion as a possible affordance together with human gestures that also have a vertical dimension. As is illustrated in Figure 1, a person (e.g., a researcher, interaction designer, or study participant) using MetaVR to design new metaphorical interactions can choose among various candidate virtual objects (e.g., butterfly, flower, etc.) that meet these criteria for positive associations and vertical motion. MetaVR enables the *designer* to then select among a series of possible iconic gestures—based on resemblance [9] (e.g., 'flapping like a butterfly', 'blooming like a flower', etc.) that also have verticality as a dimension. In this work we only focus on personification—a type of metaphor (e.g., "Everyone should know the gesture by which a flower blooms in the morning")—as it lends itself easily to interaction through iconic gestures. Note that as the iconic gestures are increasingly used to also illustrate more abstract information they may become closer to definitions of metaphoric gestures [9]. The metaphoric interactions are customizable in that any virtual object and gesture that fits the conceptual mapping can be chosen.

MetaVR's virtual-gestural interactions do not involve a one-to-one mapping between the user's body and the virtual object. The user cannot randomly move his arms about and get a flower to bloom or move his foot and have the flower's stem move, for instance; rather, the mapping is more of an abstracted relational mapping. For example, a flower blooms progressively at a rate dependent on a set of customizable movement interaction parameters: (1) the amount of overall activity or speed of the human movement (e.g., slow not fast 'blooming gesture'); (2) verticality dimension of the human gestures performed (time spent above some hand height threshold); and (3) the correct gesture (or sequence of gestures) being recognized by the gesture recognition system (e.g., a "blooming" type gesture—bringing the arms upward and then expanding the arms before bringing them down).

MetaVR also allows these metaphoric interactions to be augmented with text. For example, as illustrated in Figure 2, the 'being like a butterfly interaction' can be experienced alongside different texts that have differing metaphoricity scores (i.e., how strongly figurative the text is). The first text in this figure ("Everyone should know the gesture by which a butterfly spreads its wings in the morning sun") is overall less abstract compared to the second text ("Everyone should know the gesture of a butterfly's morning prayer"). The latter text adds a more meditative context to the overall experience by explicitly referencing the more abstract concept of prayer. The above functionality is important as prior research suggests that metaphor impacts emotion not only by eliciting imagery associated with the source domain of the metaphor but 'rather is a result of meaning composition and interaction of the two domains [source and target] in the metaphor' [10]. We are currently conducting a behavioral experiment that uses this interface to qualitatively and quantitatively test the interplay between metaphoric interaction and emotion.

2 METAVR SYSTEM

MetaVR is implemented using the Unity game engine [13] and is composed of five main elements working together: the conceptual

Figure 1: User can select virtual objects with positive sentiment to interact with using iconic gestures. The common denominator linking the interactions is a vertical motion parameter.

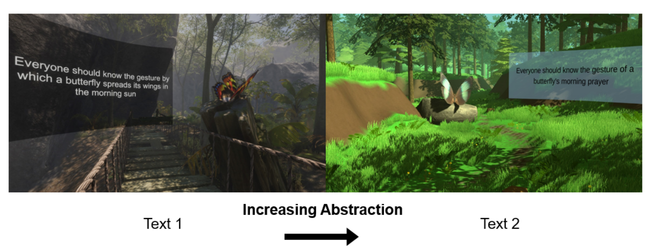

Figure 2: Accompanying text can help modulate the level of abstraction of the interaction

mapping system, the language system, the virtual world system, the gesture recognition system, and the cognitive interaction map system. The cognitive interaction map system provides the user interface for researchers (and potentially their study participants) and developers/designers to create and explore new metaphoric interactions. It uses the conceptual mapping(s) as a basis for flexibly organizing semantic knowledge and action behavior associated with the other modules. The aim of MetaVR is the creation of a repository of cognitive interaction maps that give agency/control to the user to creatively explore metaphors of the mind and relation to feelings and emotions that may be relevant to achieving well-being.

2.1 Conceptual Mapping System

The conceptual mapping system stores available conceptual metaphors and allows the user to locate metaphoric interactions associated with a specific metaphor. For this we will draw on MetaNet and other resources that have systematically identified conceptual metaphors that language users commonly use to discuss a wide range of topics [4, 8]. MetaNet provides a repository of conceptual metaphors and organizes it within a larger structured and hierarchical network of conceptual metaphors. In our proof-of-concept interface, MetaVR currently implements only the WELL-BEING is VERTICALITY conceptual mapping that entails the GOOD is UP conceptual mapping, but there are a host of other conceptual metaphors relevant to emotion processing that we plan to further support in the future.

2.2 Language System

The language system allows the user to select text-based metaphors (e.g., using keywords) relevant to a conceptual mapping for multimodal metaphoric interaction. This functionality gives users the ability to modulate the level of abstraction of the metaphoric interaction. The ways that metaphor impacts emotion are currently not well understood. However, it is believed that both the source and target domains of the metaphor contribute to the overall emotionality [10]. To achieve this we draw on state-of-the-art natural language processing (NLP) methods such as metaphor generation techniques, as well as corpus-based methods to identify conceptual metaphors from text and available metaphor repositories labeled for conceptual metaphor [11]. In the future, this system could also support embedding the metaphoric interactions within larger narrative contexts to support the exploration of more complex relation structures.

2.3 Virtual World System

The virtual world system links elements in a virtual world (e.g., game objects and their functionality) with meta tags (semantic and affordance tags) that facilitate their incorporation into a cognitive interaction map. The cognitive interaction map organizes semantic knowledge and action behavior together for the purpose of metaphoric interaction. In our proof-of-concept interface, our virtual world only consists of virtual objects (e.g., butterfly, flower, sun, etc.) and their associated functionality (e.g., animation scripts) within the Unity engine [13, 14]. These game objects have been tagged by their linguistic labels, by a positive sentiment tag as having overall positive associations, and by a verticality tag or having vertical motion as a possible affordance. The linguistic labels make it possible to link entities in the virtual world with distributional semantic representations that facilitate carrying out relevant semantic classification tasks (e.g., sentiment analysis).

2.4 Gesture Recognition System

The gesture recognition system allows the learning of a gesture (or sequence of gestures) using the hands and, importantly, links them with meta tags (semantic and affordance tags) that facilitate their incorporation into a cognitive interaction map. Here we leverage existing gesture recognition software that allows a user to train a machine learning algorithm to learn a number of gestures using the hand controllers of a VR headset, store them, and easily incorporate their use in the context of a game engine [5, 7]. In our proof-of-concept interface we are using the MiVRy gesture recognition software [7]. We use MiVRy to learn various iconic gestures (also metaphoric gestures), which have been given a text label (e.g., 'flapping like a butterfly') and a verticality tag for having vertical motion as an affordance. We anticipate that our future work will investigate interactive machine learning tools such as InteractML [5] to support more flexible gesture learning within MetaVR.

2.5 Cognitive Interaction Map System

Cognitive maps 'organize knowledge for flexible behavior' to achieve some specific goal [2]. Inspired by this concept, the cognitive interaction map system of MetaVR generates the appropriate interface that gives users agency over the design and exploration of a metaphorical mapping. Its purpose is to flexibly organize semantic knowledge and action behaviors associated with a metaphorical mapping in the support of some goal, in this case the creation of metaphoric interactions that may help people achieve well-being.

In our proof-of-concept interface the cognitive interaction map organizes elements in the virtual world that have been tagged as having positive sentiment and have verticality as an affordance together with gestures that also have been tagged with verticality as an affordance. This allows users to select among a series of metaphoric interactions or personifications ('being like a butterfly', 'being like a flower') and interact with them through iconic gestures (e.g., 'flapping like a butterfly','blooming like a flower'), or more abstract gestures (e.g., 'upwards movement'). It also links the above together with text-based metaphors relevant to the underlying conceptual mapping being explored for multimodal metaphoric interaction. This allows users to modulate the overall level of abstraction experienced. Critically, it also further specifies the abstract relational mappings that provide customizable movement parameters to constrain the interactions between entities in the virtual world and a user through gesture. Rather than implement one-to-one mappings between the movement of the user's hands and the movement of a virtual object, the current proof-of-concept employs abstract relational mappings in which the success of the interaction depends on a number of parameters including the verticality dimension (e.g., time the user's hand controllers spend above some height threshold). In this way, verticality can become a vehicle to achieving well-being. In the future, we seek to investigate allowing users to modulate the novelty of the metaphoric interactions allowed.

3 CONCLUSION AND FUTURE WORK

To our knowledge, MetaVR is the first system to explicitly support the design and exploration of interfaces that link metaphors in the mind to immersive, spatial interactions. While prior work on VR interfaces for well-being tends to leverage biofeedback-based mechanisms, we believe that it is worth investigating how interactions that draw on metaphors can support well-being and other goals. MetaVR contributes to growing research in human-centered computing and affective computing centering on multimodal interaction for well-being. This work also informs recent research in multimodal semantics in natural language processing leveraging virtual reality to further understand the grounding of language in sensorimotor interaction with the world.

In the current proof-of-concept interface we only explore the WELL-BEING is VERTICALITY conceptual mapping, but in future work we have planned to experiment with a host of other metaphors relevant to emotion processing. This will facilitate the creation of a repository of cognitive interaction maps that explore a range of conceptual mappings relevant to well-being. Furthermore, we are currently conducting a behavioral experiment to test whether MetaVR can be used to have a measurable impact on promoting a sense of well-being, as well as increasing awareness of metaphorical thinking and its relation to emotion processing. MetaVR provides the ideal controlled environment to systematically investigate the interplay between metaphor and emotion.

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