An Ontological Representation for the Transtheoretical Theory

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***Abstract*—Ontologies are widely used in computer science and medicine. Ontologies may be useful in health promotion and disease prevention for intervention development. Interventionists usually use theory to guide intervention design and evaluation, but there is no standard vocabulary for health behavior theory. A formal mechanism for converting theory to a computer-based representation may provide a tool that can assist in the development of computer-based interventions. This paper demonstrates how ontology can be used to represent a health behavior theory using the Transtheoretical Model (TTM) of behavior change as an example.**

Keywords—Ontology; Health Behavior Theory; Transtheoretical Model

I. INTRODUCTION

Ontology is crucial in data exchange, integration, and reuse in biomedical research [1-3]. Another potential ontology application is in the field of health promotion and disease prevention, specifically in designing effective theory-driven computer-based interventions. Health behavior theories provide an organized and efficient tool to design and evaluate health behavior interventions [4-6]. Most health behavior theories, however, have not been formally defined using ontologies. The interpretation of health behavior theories and their constructs often vary across research labs, making comparisons difficult. This paper discusses how ontology can assist interventionists with designing effective theory-guided interventions, and provides an example of a health behavior ontology using Transtheoretical Model (TTM) [7-10].

The TTM is comprised of 15 constructs: (a) Stages of Change, (b) Pros and Cons, (c) Situational Self-efficacy and Temptation, and (d) the 10 Processes of Change. The central organizing construct of the model is the Stages of Change. Stage is defined by an individual's intention to meet a specified health criterion (e.g., Perform 150 minutes/week of moderate intensity exercise or not smoke). The pros and cons of changing are the two decision making constructs. Situational Self-efficacy is an individual's confidence in successfully performing a healthful behavior whereas Situational Temptation is one's ability to resist engaging in the unhealthful behavior in challenging situations. The processes of change are the cognitive and behavioral activities or strategies that promote behavior change. These constructs are expressed to a greater or lesser extent depending on the individual's stage, and can be targeted in an intervention to facilitate progression through the stages of change.

II. METHODS AND RESULTS

An ontology of the TTM was created. The description of the TTM was gathered from books [5, 11], literature [7-10], and domain experts. Domain experts were asked to respond to a list of core competency questions (e.g., "What variables in the theory may be involved in each stage transition?"). A list of important terms was created (see Table 1). Those terms are organized based on parent-child relationship. Protégé was used to construct the TTM ontology [12]. The ontology's class and logical consistency was evaluated with the FaCT++ [13]. The resulting ontology defined 82 classes including stages of change, processes of changes, and self-efficacy and 12 types of relationships including *parent-child*, *hasComponent*, and *hasApplication.*

Table 1: Important terms in the TTM ontology

Stages of Change	**Processes of Change**
Precontemplation (PC)	Consciousness Raising (CR)
Contemplation (C)	Dramatic Relief (DR)
Preparation (PR)	Environmental Re-evaluation (ER)
Action (A)	Social Liberation (SO)
Maintenance (M)	Self-reevaluation (SR)
Termination (T)	Reinforcement Management (RM)
Decisional Balance	Counter Conditioning (CC)
Pros of changing	Helping Relationships (HR)
Cons of changing	Stimulus Control (SC)
Temptation	Self-liberation (SL)
Habit Addictive	**Self-efficacy**
Negative Affective	Confidence
Positive Social	Temptation

III. DISSCUSION

A. TTM Ontology

This work demonstrated how to use an ontology application to represent a health behavior theory. An ontology provides a way to communicate between domain experts and ontology users. Domain experts provide knowledge of the TTM during ontology construction. Users (e.g., interventionists and IT professionals) can implement the TTM knowledge with assistance of the ontology. For example, ontology can be used to guide the development of computer-based behavior interventions such as an automated telephony system [14].

B. Standards Efforts in Behavior Medicine

Ontology has been widely adopted in science especially in biomedical filed. Scientists rely on definitions and taxonomy in order to communicate with each other, disseminate their work and advance scientific knowledge. Behavioral scientists have realized the importance of standards and ontologies.

Several ongoing projects aim to establish repositories for standard behavioral measures including grid-enabled measures (GEM)[18], consensus measures for phenotypes and exposures (PhenX) [19], patient-reported outcomes measurement information system (PROMIS) [20], NIH toolbox for the assessment of neurologic and behavioral functioning [21], and the national collaborative on childhood obesity research [22]. The National Cancer Institute has developed a grid infrastructure to share behavioral data through the GEM and registered them in the cancer data standards registry and repository (caDSR) [23].

A theory-linked taxonomy of behavior change techniques (BCTs) used in interventions has been developed [24-27]. This taxonomy provides standard definitions for 93 BCTs. It provides a foundation to identify content of complex BCTs and facilitates the development of more effective interventions to improve health. The taxonomy, however, does not represent theories, only techniques of BCT. In this paper, we developed an ontology for one behavioral model using description logic. The difference between taxonomy and ontology is that taxonomy contains hierarchical relationship of concepts (i.e. parent/child, or subClass/superClass, or broader/narrower) while an ontology has arbitrary complex relations between concepts.

C. *Limitations*

This study explores the ontology representation (OWL) for one health behavior theory. Thus, it lacks testing for general ontology representation of other health behavior theories.

IV. CONCLUSION

This work demonstrated that an ontology can be utilized to represent the TTM knowledge. The TTM Ontology provides a starting point for ontology research in behavior theories.

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