# IMPACT OF SEMANTIC TECHNOLOGIES TO HUMAN BEHAVIOR MODELING
## *A Psychosocial Rationalization*

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Abstract: The promotion of healthy habits have lots of benefits. In this way, the discovery of human health habits will allow to experts, among others advantages, evaluate the accuracy of the promotion models. Nevertheless, to design and develop a model that correctly predict and anticipate the behavior of an individual or a group is a difficult task, in the sense that the challenge of representing the behavior includes such diverse areas as simulating the effects of making decision, modeling the cognitive processes that take place in making that decision, or simulate the perception of motor skills. The design of an unified method to access the current human behavior theories will facilitate the application of motivation technologies in an holistic way.
In this paper, a review about the factors involved on human behavior modeling, and the most important theories on people health behavior is made and a first attempt for the creation of a unified health behavior model is presented.

## 1 INTRODUCTION

The discovery of the human behavior is one of the hardest current challenges in multiple research fields. The difficulties that scientist find in their way are not only the problem of detect what are the rules and factors that affects to human behavior, but also how that knowledge can be represented.

The model of human behavior has been treated from psychological and psychosocial research fields from lots of years ago (Hochbaum, 1958), (Lewin, 1943). One of the fields where the human behavior discovery has more applications is the healthy habits promotion. The promotion of healthy habits have lots of benefits, not only in the health of individuals of current society, but also in economical situation, cause the large account of money that could be saved in treatments for illnesses directly related with the unhealthy habits of people. For that, the governments year by year, apply an important part of their budget in healthy habits promotion. Nevertheless, despite these waste of money it is very difficult to know what is the exact impact of their promotion activities.

In literature, some emerging technologies in the automatic human behavior modeling based on in the pattern recognition research field could be used to test the capabilities of health promotion techniques applied by governments and health professionals. Complex Event Processing (Wasserkrug et al., 2008) techniques allows process events and discover complex patterns among multiple streams of event data; Plan recognition Models (Phua et al., 2009) allows the alignment of habits of individuals to detect unhealthy situations and evaluate the compliance to promotion campaigns. Process Mining (A. K. A., Workflow Mining) (Fernández-Llatas et al., 2009) techniques allows detecting changes in the behavior of individuals or people as a whole detecting if the promotion campaigns has enough impact over their.

Nevertheless the huge amount of factors and different theories make difficult to these techniques to focalize what are the factors to be taken in to account. Although the different psychological and psychosocial research lines seem to be theorically complementaries it is needed an effort to create a common framework to condense the psychological theories. The use of ontologies to describe de concepts and to provide an mechanism to semantically interoperate among them.

In this paper, a review about the factors involved on human behavior modeling, and the most important theories on people health behavior is made and a first attempt for the creation of a unified health behavior model is presented.

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# 2 PSYCHOSOCIAL THEORIES IN HUMAN BEHAVIOR MODELING

Based on the human behavior factors previously described the scientific community has implemented some theories in order to explain in what way these factors affects to human behavior in their Health motivation. The most important theories are the Health Belief Model, the Theory of Reasoned Action, the Social Action Theory and Self-Efficacy Theory

## 2.1 Health Belief Model

This theoretical development was first formulated by Hochbaum (Hochbaum, 1958), and subsequently extended by Rosentock (Rosenstock, 1974) applied to the explanation and prediction of a wide range of health behaviors. The proposal is the explanation of behavior by focusing on psychosocial variables, from a body of psychological theories such as Field Theory by Lewin (Lewin, 1943) (Lewin, 1946), Expected Value Theory, and the Theories of Decision making Under Uncertainty. The initial hypothesis of this model is in the following way: an individual does not perform a healthy behavior if she dont have minimum levels of relevant motivation and information to health, she sees herself as potentially vulnerable, and she sees the disease (or risk) as threatening, she is convinced of the effectiveness of the intervention, and find little difficulty in the practical action of healthy behavior (Rosenstock, 1974)).

In the first place, according to the Health Belief Model, the probability of making a healthy behavior depends on the subjective state of intention of the individual to do so. The intention is determined by the threat of the disease in question (according to the belief of the individual). The perceived threat is determined by: the perceived susceptibility for the disease, perceived severity of the consequences of suffering this disease, and keys to trigger action to an appropriate health behavior. These keys may come from internal sources (symptoms etc.) or external (interactions with other, media etc.) (Becker and Maiman, 1982).

Secondly, the probability that an individual develops and maintains a healthy behavior depends on an assessment that makes such behavior in terms of practicability and effectiveness, countered with the perceptions of the physical, economic costs and other barriers involved in the proposed action. These perceived costs have been assessed in different ways in different studies: in terms of security on the effectiveness of the treatment prescribed, the patient satisfaction about the communication with the doctor, patient satisfaction about matters such as the way in which the health organization provides medical care, etc.

Third, the threat perception triggered by some key event starting the process of making healthy behavior. Health Belief Model is based on the premise that socio-demographic, structural and individual factors may influence health behaviors. However, it considered that these variables act through their effects on individual health beliefs, and not so direct causes of wholesome actions (Becker and Maiman, 1982).

Most explanatory research on the effectiveness of Health Belief Model are retrospective and it isnt possible to determine, from them, if the health belief existed before or it was created after the conclusion of the studied behavior. Its an appropriate model as an explanatory model of preventive behavior, and an inappropriate model to explain behaviors oriented to health promotion.

## 2.2 Theory of Reasoned Action

Fishbein (M. and Ajzen, 1975) developed the Theory of Reasoned Action, and then further developed in the Theory of Planned Action (Ajzen, 1987) (Ajzen, 1988), which attempts to explain the behaviors that are under conscious control of individuals from different determinants that precede and explain them. For the authors, the immediate determinant of behavior is not the attitude itself, but the intention to do. In turn, behavioral intention has two forerunners that explain it: a single precursor, that is, the attitude about the behavior, and another social and collective that refers to the socio-cultural context of the individual, named as the subjective norm (M. and Ajzen, 1975). Both attitude and subjective norm are determined by other factors that precede them, helping to better understand the behavior. As regards the attitude, it is determined by each of the beliefs that person has to an object and the assessment based on those beliefs. This assessment represents the affective component of attitude, determining the motivation and the strength of behavioral intention.

According to this theoretical construct, beliefs vary according to their origin, and can be formed from different processes:

- *Direct experience regarding the attitude object*, through which information is collected on the characteristics of the object (a person, thing etc.). The attitudes formed from this process have greater strength and they are more resistant to change.
- *Indirect experience regarding the attitude object*, which brings the same features of that object by the similitude to other objects with which it has

had previous direct experience. Such beliefs are called inferential.

- *The information collected from other* (media, family, friends, etc.). Information is accepted as real, unless it contradicts the beliefs formed from the direct or indirect experience (M. and Ajzen, 1975).

Regarding to the subjective norm, it has determined by the perception of the beliefs that others have about the conduct that the individual must perform and, moreover, it is also determined by the individual's motivation to meet the expectations that others have about her. Its a differential process of beliefs formation that contributes to each of the beliefs have a particular weight and value according to each individual and the attitude object. Outstanding attitudes, together with their evaluation, will better predict the behavior intention (M. and Ajzen, 1975). Furthermore, knowledge about the specific beliefs of what others persons think of each of the specific behaviors (for example smoking, physical exercise, healthy eating, etc.) will Influence the intention to carry out or not a general behavior (maintaining a healthy lifestyle), depending on the motivation to please.

However, not all behaviors are consciously controlled by the individual, because there are many situations in which contingency may occur, or in which it requires skills or resources that could interfere with the intention of performing a behavior. Its necessary a third determinant of behavioral intention, the perceived control (Ajzen, 1987) (Ajzen, 1988)). Although the individual has a favorable attitude toward a behavior, the probability of carrying it out will depend on, among other factors, the perception of control by the individual about her behavior. A person may have a favorable attitude toward health care, for instance to give up smoking, but if that individual perceives that she has low ability to control and to quit smoking, either because she considers she hasnt capacity enough, or because she believes that behavior of other people can interfere with her decision to quit, this healthy behavior will not be performed. The perception of control is a factor consisting of internal variables (perceived ability, skill of action etc.), and external variables (opportunity to action, obstacles, time, cooperation, etc.). This is a determinant that helps to improve forecasting and modeling of the behavior (Ajzen, 1987).

The Theory of Reasoned Action doesnt take into account factors such as attitudes towards goals, personality characteristics, sociodemographic variables, social role, etc. For this model, these factors are external variables that can influence behavior, but no necessary relationship between them.

## 2.3 The Social Action Theory

This model proposed by Ewart (Ewart, 1991) presents the individual as a self-regulatory system that actively trying to achieve goals, and also as a feedback system consisting of a set of serially arranged elements, or stages: a first input stage, which represents stimulus field and sets the targets. A second output stage, or production of response, which provides the plans, the selection and development of responses. And a third stage of supervision that involves the consideration of the consequences of action in relation to the initial set of objectives. This model stresses the role of social context in the development and maintenance of healthy routines and habits; it provides the causal structure linking the self-change processes in interpersonal environments; and it also specifies the social and environmental influences that make possible personal change.

According to Social Action Theory, preventive interventions involve the creation of protective habits in the form of routines behavioral sequences that reduce personal risk. The actions are guided by their consequences in a control loop, and variations in the results produce compensatory behavioral adjustments. The result is a steady state-action, but constantly fluctuating. The starting point for intervention is an analysis of the relations between the harmful or beneficial behaviors to health and its effects experienced. This is an analysis that allows extracting those aspects in which behaviors are more accessible to prevention, and it also allows extracting effective procedures for the design of new schemes that promote health (Ewart, 1991).

The Social Action Theory remarks that personal action schemes are socially interconnected to schemes of close social environment (friends, family, peers etc.) so they raise significant obstacles to long-term changes. Its necessary to extend the concept of state-action focused individually to include social interdependence as a determinant of a change in behavior. Close social relations mean that the patterns of action of each person are interconnected, thereby increasing the likelihood of someone trying to modify a routine, influencing and conditioning routines of other individuals.

This model implies the existence of mechanisms that enable people to make transitions from old states-action to other new, causing a change. According to this theory, attitudes and reinforcements do not determine and cause behavior. People motivate themselves by taking into account the possible outcomes, assessing their capabilities and creating goals that guide and energize the solution of various problems. The

health related behaviors are included, according to the Theory of Social Action, in a set of norms of behavior focused toward some important goal. This set of schemas is composed of individual's personal projects, it refers to basic tasks (such as getting social influence, acquire material resources, be accepted by others, etc.), and it affects to protective rules of behavior making people generate aimed objectives to evaluate their own conduct.

The schemas represent organized sets of behaviors that focus our attention to specific aspects of situations and scenarios. They drive the encoding of experience in memory over the long term. And finally they provide routines to make tasks. These ways of knowledge integrate capabilities which allow to consider alternative goals, and to create new action strategies. Capacities are the mechanisms through which physical and social contexts affect to self-regulatory conducts. Cognitive control schemes influence the choices of behavior, increasing trust in the individual's ability to maintain or change a behavior. The context or environment in which people live adjust the personal capacities and the social relations, affecting the establishment of goals, the consideration of opportunities for action, and the design of relevant health strategies. The physical characteristics of the environment determine the access to material resources, and they also influence in the behavioral strategies. Social relationships involve a set of benefits, expectations and obligations that likewise influence on the objectives aimed. In addition, social relationships provide behavior models that facilitate or inhibit the action guidelines (Rodriguez, 2001).

## 2.4 Self-efficacy Theory

Bandura (Bandura, 1977) (Bandura, 1988) developed the Self-efficacy Theory to explain human behavior and the factors involved in motivation. Self-efficacy can be defined as the evaluation of the own personal abilities in view of the possibility of action. There are different processes that contribute to the configuration and development of self-efficacy. They are elements that describe how certain characteristics, both internal and external to the individual, which also help to shape the beliefs that she has about what is able or unable to do:

- *Direct experience* is the main source of formation regarding the self concept that an individual has. In this sense, the consequences obtained after executing the behavior make it possible to report about one's ability to carry out the same behavior, and if is probable to control the situational variables in which this behavior has to be done. Thus, the experience and consequences obtained contribute to the formation of self-concept, and contribute also to develop of personal self-worth feeling, both required to deal in different situations.
- *Learning by observation* is also a source of valuable information. To observe and analyze the consequences that any action cause in another individual executing such action can lead both to inhibit and to promote the own action, depending on positive or negative assessment of the observed consequences in other individuals. Its a process of social comparison in which the individual shape her perception of her own capabilities to deal with different situations.
- *Persuasive Messages*. The attempts of people in the environment to convince and encourage the individual to take a specific action can provide security and support, in order to really produce a behavior. However, persuasion is a weaker resource than previous ones, and it will vary depending on different variables such as, for example, certain features related to the personality of the individual who tries to persuade, the credibility that individual has to pass on, or her ability to get another individual execute the action.
- *Physiological activation* may also be an important modulator of the capabilities that a person believes she has, can influencing in the process of self valuation. According to (Bandura, 1988), the information provided by the psycho-physiological activation influences the perceived effectiveness through assessment processes. Therefore, when such activation happens in the view of the possibility of executing a behavior, the individual evaluates different factors, stressing the sources that cause the activation of behavior, the intensity of activation, the circumstances in which that activation happens, and the way in which the activation influences over the efficiency. When physiological activation is successful after the execution of a behavior on previous experience, this activation is considered by individuals as a facilitator of the action, while, in opposition, when it is unsuccessful, it is considered as harmful or inhibitor of the action (Bandura, 1988).

People increasingly develop their self-efficacy perception based on executed behaviors, based on said explanation in their environment, and on the reinforcements that other people around them do respect the conduct has been made.

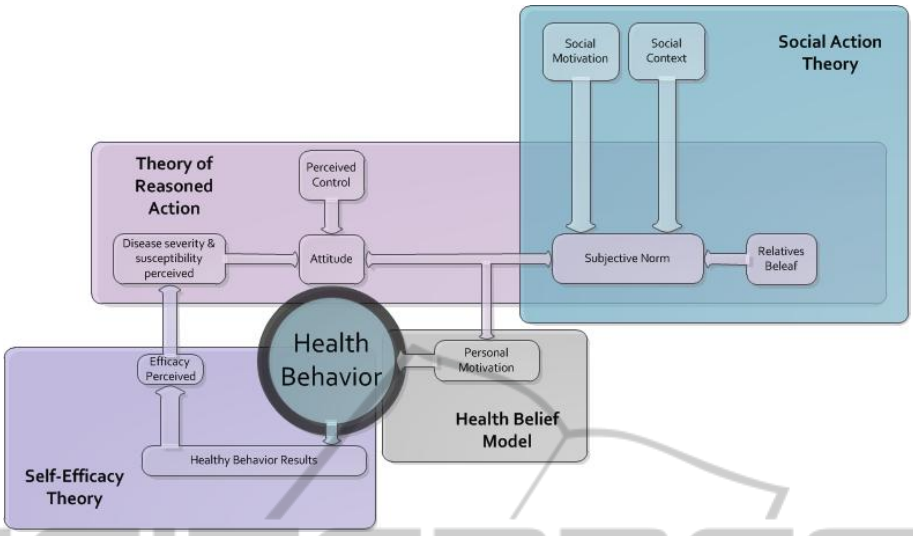


Figure 1: General Architecture of the unified semantical model.



## 3 TO AN UNIFIED SEMANTICAL MODEL TO REPRESENT THE PSYCHOLOGY OF HEALTH BEHAVIOR

In literature, there are some examples of how the psychology of patients is taken into account to help the motivation of healthy behaviors (S. and Price, 2009), (del Hoyo-Barbolla E. et al., 2006), (Hu and Sundar, 2010), (Gustafson et al., 2011). The research in that field has been based on psychological and psychosocial research fields that are limited to the theoretical framework that the authors follows. This is because, in practice, the health social psychology scientific community follows those models in parallel, representing the same knowledge from different points of view. Nevertheles, although described models have differences in the theoretic perspective, they seems to be complementary. In figure 1 a general approach to a collaborative model of the different research theories is presented.

In that schema, the different models are interconnected according to their main hypothesis in order to resolve the psychological causes of health behavior

The *Health Belief model*, mainly based on personal motivation can be enriched by results achieved by *Theory of Reasoned Action*. In this case, the personal motivation available data might be improved by the attitude and Subjective Norm of the second theory. At the same time, according the *Self-Efficacy Theory* the attitudes can be continuously evolving depending on the health Behavior results perceived by the user. Finally, the Subjective Norm user profile can be enriched with the thesis of Social Motivation, Social Context and Relatives Belief in *Social Action Theory*

The general concepts that these models handle are equivalents. This allows that the result of the research on one of the lines can be useful as an entry point for the rest. In this way, the formal representation of the results using ontologies allows their use not only in the same research field but also in the others. In addition, based on that unified model and representing the knowledge of the thesis of those different theories in a semantically tagged concepts it was possible to perform automatic reasoning over the whole theories in the psychology of health behavior research field.

The creation of an unified semantic framework to represent the thesis of Psychology of health behavior will suppose a great advantage in order to provide a unified view of the knowledge in that field where, psychologist, sociologist and health professionals not only will allow to share their knowledge, but also will be able to enrich their thesis with the direct result of the investigation of their colleagues.

## 4 CONCLUSIONS

The use of ontologies to allow the semantic interoperability among systems that represent the different health behavior models will enable de creation of an unified model that explain the whole health behavior of people. Experts will be able to share not only in theory but also their knowledge might be used to reason over the data available in order to create basic

knowledge that could be used by other research fields.

These systems can offer a better knowledge that can be used in conjunction with emerging pattern recognition theories in order to validate the use of health promotion techniques.

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