# Cogito Ergo Ago: Foundations for a Computational Model of Behaviour Change

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**Abstract**

So far AI researches in the health care promotion have considered strategies and techniques for making people aware of their health related problems and helping them to change their behaviour in order to have a better life style and be healthier. Very few researches though, to our knowledge, have focused on the deeper meanings behind a behaviour change. We argue that taking into account cognitive aspects, supported by solid psychological and philosophical theories, might help us to provide the right advice, to the right person, at the right time.

## 1 Introduction

This research represents our contribution to PIPS, one of the leading projects in the health care delivery arena and funded by the European Union under the FP6[1] Integrated Projects. PIPS, Personalised Information Platform for life and health Services, is a four year project started in January 2004 aiming to improve the current health care delivery models. Recognising the importance of personalised and prevention-focused health care services, PIPS will be providing the right support to the European public by means of special Virtual Agents. These agents will also be in charge of giving health related advice to citizens/patients (helping them to stop smoking, to follow a certain diet, to improve their physical activity etc.). Our own experience and many scientific studies (Prochaska et al. (1995) among others) have proven that changing one's behaviour is not an easy task and, sometimes, represents one of the hardest challenges of our life. Such a change though becomes a critical step to take when its consequences have an impact on our health and our well-being.

We seek to create a computational framework of how changes take place, able to capture and handle the processes behind a behaviour change. Several philosophical, psychological and sociological theories of behaviour change exist and our attempt is to ground our research in some of the most solid theories in those areas. Understanding the hidden causes behind changes will help us not only to model a more believable agent capable of reasoning about, and modifying, its own behaviour, but we also believe it to be essential in order to reason about other agents' motivations and emotional states.

In this paper we present an overview of the theories that seem most appealing to our purposes, then we introduce our proposal for integrating these theories and, finally, we offer some preliminary considerations on computational issues.

## 2 Theoretical Foundations

Research on Medicine and Nutrition give us details of WHAT needs to be changed in our behaviour in order to have a healthier life-style, prevent or cure diseases and so on. Unfortunately though, this information is not enough for our purposes since they do do not lead us to understand the dynamics behind a behaviour change or, in other words, HOW such a change occurs. The *Stages of Change Model* (Prochaska et al., 1995) defines, instead, very clearly HOW we deal with changing our behaviour by presenting six stages ultimately leading to the change and pointing out the importance of applying different techniques tailored to the particular stage involved. The Stages of Change Model, recognises that behaviour change is a process,

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Figure 1: Stages of change

a series of steps (Fig.1)[2], rather than a one-off event.

While giving scientific evidence of this assertion by examining how successful self-changers change, the model identifies stages of change and other factors that predict treatment outcomes. There are six stages of change:

- *Precontemplation*: no intention to change or unaware of the problem.
- *Contemplation*: intention to change but not ready for the action.
- *Preparation*: intention to take action within one month.
- *Action*: behaviour change.
- *Maintenance*: consolidate the result.
- *Termination*: finally out of the problem.

In order to succeed, one must go through all these stages and in the same order (from Precontemplation to Termination). There is always the possibility, though, of returning to some prior stages and this phase is called Relapse. The Stages of Change Model identifies also nine key "change processes" and suggest their use depending upon the particular stage involved. The basic idea is that all individuals have the potential to change. Self-motivated changers are much more effective than guided changers (Prochaska et al., 1995, pg. 21) but the structure of this model can certainly strengthen and significantly improve the chances of succeeding. We strongly believe, though, that the merely knowledge of `WHAT` and `HOW` to change is not enough to create a believable model of behaviour change; we need to have some understanding of the reasons behind our changes or, in other words, `WHY` we change. *Cognitive Dissonance Theory* (Festinger, 1957) proposes the concept of dissonance as one of the main drive in our behaviour. For nearly half a century Festinger's theory has been representing, and still represents, one of the most solid and influential theory in social psychology. Its revolutionary idea is that human mind cannot hold two conflicting thoughts at the same time. It might look a bit too simplistic, but its implications and applications are wide and sometimes unexpected. Most of the smokers, for instance, know that smoking is unhealthy but, careless, they continue to do it. They typically deny the gravity of their habit, or find justifications to smoking, because the alternative would be to face the dissonance between their behaviour and their knowledge. Studies in Health Psychology and Medicine have also demonstrated the existence of relations between various health problems. People who smoke, in fact, are much more likely to develop other bad habits such as poorer diet (Shah et al., 1993), higher alcohol intake (Morabia and Wynder, 1990) and less physical activity, and even ex-smokers can develop bad habits (French et al., 1996). These and many more studies demonstrate how, most of the times, problem behaviours represent only the tip of an iceberg and we believe that Cognitive Dissonance Theory might allow us to understand and fight back all these problems to their very common root. Festinger's theory states that pairs of *cognitions*, that is *"any knowledge, opinion, or belief about the environment, about oneself, or about one's behaviour"*, can be either relevant or irrelevant to one another. Moreover, relevant pairs represent either *consonant* or *dissonant* cognitions. Consonant cognitions occur when they follow from one another, dissonant cognitions occur when the opposite of one of them follows from the other. The size of the dissonance is measured by its magnitude and it is proportional to the importance of the dissonant cognitive elements. This concept has also been extended to groups of cognitive element. The first symptom of dissonance is pressure, a feeling of uncomfortable tension, which can be seen as an attempt of the mind to reduce dissonance (or, at least, to avoid further increases). This Pressure, whose strength is a function of the magnitude of the dissonance (Festinger, 1957, pg. 18), is a very powerful motivator that pushes the individual towards eliminating the dissonance. According to the author, dissonance could be seen as a trigger for a dis-

[2]Source: http://www.cdc.gov/nccdphp/dnpa/physical/starting/ (last updated 6 Feb 2003), Centers for Disease Control and Prevention, Department of Health and Human Services, USA.

sonance reduction's activity as much as hunger triggers a hunger reduction's activity. The tension can be released in different ways:

- by changing dissonant cognitions
- by adding new consonant cognitions
- by reducing the importance of dissonant cognitions

Of course *"The maximum dissonance which can exist between two elements is equal to the resistance to change of the less resistant of the two elements."* (Festinger, 1957, pg. 266).

Dissonance Theory has been generating slightly different variations of the theory itself in the past 50 years. All these revisions, though, have reconfirmed dissonance as a motivation for cognitive changes. Among these, interestingly Aronson (1968) interpreted the theory in terms of the discrepancy between one's *self-image*[3] and behaviour.

A complementary theoretical perspective is given by the concepts of *Reciprocal Determinism* and *Self-Efficacy* (Bandura, 1986). Reciprocal determinism states that a person's behaviour, environment, and psychological processes influence each other in a *"triadic reciprocality"* (Fig.2).

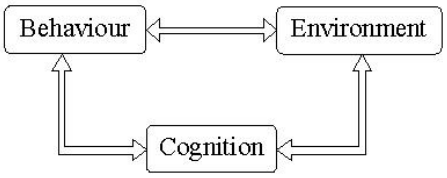


Figure 2: Reciprocal Determinism

Self-efficacy is the *"people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives."* and therefore *"Self-efficacy beliefs determine how people feel, think, motivate themselves and behave."* (Bandura, 1997).

Cognition, in this view, not only plays a critical role in people's capability to adapt, change and self-regulate, but also contribute to create the reality around them. In fact, *"what people think, believe, and feel affects how they behave"* (Bandura, 1986, pg. 25). The problem is that, since we are working with people and not with machines or theorem provers, we must consider that *"people's level of motivation, affective states, and actions are based more on what they believe than on what is objectively true"* (Bandura, 1997, pg. 2).

[3] An individual's conception of himself/herself and his/her own identity, abilities, worth etc.

# 3 Towards a Cognitive Model of Change

Putting together these views, we can look at behaviour changes from a different perspective: if our self-image determines the way we behave, this means that we could change our behaviour by "simply" changing our self-image. In other words, what we think of ourselves make us act in a certain way. Coherently with the Stages of Change Model, where a bad behaviour cannot be changed whilst still being in the earliest stages of Precontemplation, Contemplation and Preparation, Dissonance Theory explains why it is not possible to jump stages and, even if this happens, why it is not going to last, as the Relapse stage is always on the doorstep, since the self-image is not coherent with the action that has been taken. Dissonance between one's inner and outer self needs to be created and amplified in order to modify his/her behaviour because, as long as one keeps holding an old picture of himself/herself, he/she will simply and coherently behave according to that image.

In conclusion, we interpret each move from one stage to the next one as a cognitive dissonance reduction process. The Stages of Change Model explains very well `HOW` the changes take place, what and in what order the different phases are, whereas the Cognitive Dissonance Theory focuses its attention on the particular individual, on one's self-efficacy, on one's ability of changing the outside by changing the inside first, and move through the stages of change with a new image, from time to time, targeted to the particular processes in each stage.

With this in mind, our efforts are concentrated towards formalising a computational cognitive model of the processes behind a behaviour change. In particular: the *Agent Model* will be a formalisation of the Cognitive Dissonance Theory, specialised to the concept of self-image. The *Change Model* will be instead a formalisation of the Stages of Change Model.

We think of associating different self-images' stereotypes to the different stages in the Stages of Change Model. By making assumptions on what the self-image ought to look like in the next stage the advisory agents will try to help the user in modifying his/her self-image by producing truly tailored advice. We expect our formalisation to be an extension of the classic belief-desire-intention (BDI) architecture.

The feasibility of this approach from the computa-

tional point of view has been reassured by Gawronski and Strack (2004), who observed the *propositional nature* of Cognitive Dissonance Theory.

Moreover, important philosophical studies (Thagard and Verbeurgt, 1998) have proven cognitive dissonance to be essentially a *constraint satisfaction problem*. This idea has led (Shultz and Lepper, 1996) to the formulation of a computational model for cognitive dissonance based on a constraint satisfaction network. This model might be well out of our interests, being a connectionist approach rather than a logical approach, but it still represents a tangible proof of the Cognitive Dissonance theory's computability.

The cognitive theory for *agent communication pragmatic* (Pasquier and Chaib-draa, 2003) applies, instead, the cognitive dissonance theory to multi-agent systems in order to give agent communication more degrees of automation. This computational framework has been successfully employed in modelling dialogue games and simple attitude change processes but, despite being very inspiring, gives only a partial answer to our problem which is modelling behaviour changes in health related domains.

# 4 Conclusion and Evaluation Issues

In this paper we have presented an overview of some of the most interesting theories behind behaviour change, we have also briefly illustrated our proposal for integrating these theories in a computational cognitive model of change and, finally, we have offered some preliminary thoughts on computational issues.

The work is very preliminary, but, nevertheless, it is progressing by taking advantage of various collaborations with our partners in PIPS and their diversified expertise in health, medicine, nutrition and counselling. They will be providing us assurance about the validity of the theories we refer to and feedback about our results and conclusions. We also plan to evaluate our model against real cases in two different PIPS demonstrators (in Spain and China) before the end of the project in 2008.

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# References

E. Aronson. Dissonance theory: Progress and problems. In *Theories of cognitive consistency: A sourcebook*, pages 5–27. Chicago: Rand McNally, 1968.

A. Bandura. *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall, 1986.

A. Bandura. *Self-efficacy: The exercise of control*. New York: Freeman, 1997.

L. Festinger. *A theory of cognitive dissonance*. Evanston, IL: Row, Peterson, 1957.

S.A. French, D.J. Hennrikus, and R.W. Jeffrey. Smoking status, dietary intake, and physical activity in a sample of working adults. *Health Psychology*, 6(15):448–454, 1996.

B. Gawronski and F. Strack. On the propositional nature of cognitive consistency: Dissonance changes explicit, but not implicit attitudes. *Journal of Experimental Social Psychology*, (40):535–542, 2004.

A. Morabia and E.L. Wynder. Dietary habits of smokers, people who never smoked, and ex-smokers. *American Journals of Clinical Nutrition*, (52):933–937, 1990.

P. Pasquier and B. Chaib-draa. The cognitive approach for agent communication pragmatics. In *Second International Conference on Autonomous Agent and Multi-Agents Systems, AAMAS'03*, pages 544–551, Melbourne, Australia, July 2003.

J. Prochaska, J. Norcross, and C. DiClemente. *Changing for Good*. New York:Avon Books, 1995.

M. Shah, S.A. French, R.W. Jeffrey, P.G. McGovern, J.L. Foster, and H.A. Lando. Correlates of high fat/calorie food intake in a worksite population: The healthy worker project. *Addictive Behaviours*, (18):583–594, 1993.

T. R. Shultz and M. R. Lepper. Cognitive dissonance reduction as constraint satisfaction. *Psychological Review*, (103):219–240, 1996.

P. Thagard and K. Verbeurgt. Coherence as constraint satisfaction. *Cognitive Science*, (22):1–24, 1998.