Computational Modeling and Simulation of Attitude Change. Part 1, Connectionist Models and Simulations of Cognitive Dissonance: an Overview

Voinea, Camelia Florela

Veröffentlichungsversion / Published Version
Zeitschriftenartikel / journal article

European Quarterly of Political Attitudes and Mentalities EQPAM
Vol.2, No.3, July 2013
ISSN 2285 – 4916
ISSN-L 2285 - 4916

Computational Modeling and Simulation of Attitude Change Part 1: Connectionist Models and Simulations of Cognitive Dissonance. An Overview

Camelia Florela Voinea
Department of Political Science, International Relations and Security Studies
Faculty of Political Science
University of Bucharest,
Bucharest, Romania

Date of submission: May 24th, 2013 Submission of Revised Version: July 22th, 2013 Date of acceptance: July 24th, 2013

Abstract

Cognitive Dissonance Theory is considered part of the cognitive consistency theories in Social Psychology. They uncover a class of conceptual models which describe the attitude change as a cognitive consistency-seeking issue. As these conceptual models requested more complex operational expression, algebraic, mathematical and, lately, computational modeling approaches of cognitive consistency have been developed. Part 1 of this work provides an overview of the connectionist modeling of cognitive dissonance. At their time, these modeling approaches have revealed that a Computational Social Psychology project would acquire the community recognition as a new scientific discipline. This work provides an overview of the first computational models developed for the Cognitive Dissonance Theory. They are connectionist models based eitheron on the constraint satisfaction paradigm or on the attributional theory.Three models are described: Consonance Model (Shultz and Lepper, 1996), Adaptive Connectionist Model for Cognitive Dissonance (Van Owervalle and Joders, 2002), and the Recurrent Neural Network Model for long-term attitude change resulting from cognitive dissonance reduction (Read and Monroe, 2007). These models, and some others, proved from the very beginning the considerable potential for the development of cognitive modeling of the theories of cognitive dissonance. Revisiting the Cognitive Dissonance Theory once again only proves that this potential is even larger than expected.

Keywords: connectionist model, cognitive dissonance, cognitive consistency

Corresponding Author: Dr. Camelia Florela Voinea, Associate Professor
Affiliation: Department of Political Science, International Relations and Security Studies, Faculty of Political Science, University of Bucharest, Romania
Address: #24, St. Stephan Street – 023997 Bucharest, Romania
e-mail: camelia.voinea@fspub.unibuc.ro

European Quarterly of Political Attitudes and Mentalities - EQPAM, Volume2, No.3, July 2013, pp. 10-26.
ISSN 2285 – 4916
ISSN–L 2285 – 4916

ISSN 2285 – 4916
ISSN-L 2285 - 4916

1. Introduction

Cognitive Dissonance has been considered one of the most relevant theories in Social Psychology. Since 1957, when it has been formulated by Leon Festiger, the theory has provided the background for attitude change research. Its history and concept have been presented in many articles, books, handbooks, sourcebooks and encyclopedic works: Abelson et al. 1968; Aronson, 1969; 1992; 1997; Cooper and Fazio, 1984; Eagley and Chaiken, 1993; Cooper, 2007, to name but a few, emphasizing its huge potential for further development and application as both conceptual and computational models in cognitive, social and political sciences on issues going from self-affirmation to cultural diversity and social value change.

In its more than half-century history, research interest in Cognitive Dissonance Theory has been renewed several times, inducing conceptual and modeling advances. Its research domain grows and varies sometimes unexpectedly. A good example is the current renewed interest in cognitive dissonance research in the scientific and academic (online) media from Eastern Europe, Middle East, African, and Extreme-Orient countries[1]. Therefore, synthetic works on its history and concept are helpful in providing a comprehensive perspective over its beginnings, development and advances. Moreover, a thorough approach of the past usually helps in better appreciate the present and the future. This works for the Cognitive Dissonance Theory and not only.

2. History and Concept

Attitude is a central concept in Social Psychology. When analyzing social behavior, the issue of attitude change is fundamental for predicting the behavior of both individuals and collectivities. Attitude change is considered the source of behavioral expression and variability.

As it has been defined by Festinger (Festinger, 1957), the cognitive dissonance is an attitude change mechanism: it denotes a cognitive state of imbalance called “dissonance” and concerns the cognitive tensions which emerge from inconsistencies between beliefs and actions. Such imbalance states act as adriving forces towards attitude change either by modifying the attitude or by increasing the consistency of beliefs.

Deeply influenced by the Gestalt theory at its beginnings, conceptual and formal models of attitude change have been mainly concerned with experimental psychology (Eagly and Chaiken, 1993). Lately, cognitive dissonance theories have evolved towards more dynamic, complex views of the cognitive states and processes. The Gestalt-inspired ideas of equilibrium and consistency-seeking mechanisms of human cognition have remained the classical approach in dissonance reduction models, while new ideas about multiple, inconsistent, simultaneously active beliefs which shape our attitudes and actions have increasingly gained attention and credit (Wilson, Lindsay and Schooler, 2000; Cohen and Read, 2006). Computational modeling and simulation approaches have actually started to develope as these new ideas penetrated the classical Gestaltian framework of cognitive consistency theories.

Research on computational modeling and simulation of cognitive dissonance is headed towards developing prediction tools for the evolution of societal phenomena like major value change, social and

[1] Metin I., Camgoz S.M. 2011. *The Advances in the History of Cognitive Dissonance Theory,* International Journal of Humanities and Social Sciences, Vol. 1, No.6, June 2011, online at url: <http://www.ijhssnet.com/journals/Vol._1_No._6;_June_2011/14.pdf> accessed on July 22nd, 2013. The literature on the cognitive dissonance issue concerns the most diverse and unexpected areas like history, religion, ethnicity, culture. For getting an idea of the nature of interest in this subject, see:
De Moraes Farias P.F., 2010. *Local Landscapes and Constructions of World Space: Medieval Inscriptions, Cognitive Dissonance, and the Course of the Niger* , Afriques. Debats, methodes et terrains d'histoire, 02-2010 : Histoire de territoires, openEdition at url : <http://afriques.revues.org/896> accessed on July 22nd, 2013.

political change, social and political persuasion, social role. From this perspective, cognitive dissonance theories, as part of general theories of human cognition within the realm of Social Psychology, seem to have an unexpected potential for further development.

Following the huge interest in Social Psychology, especially in Social Influence Theory, from arround late 1910s until the end of the 1930s, attitude reasearch has mainly focused on definition and measurement. It was the time when great names like Thomas and Zaniecki (1918-1920), Leon Thurstone (1929), or Gordon Allport(1935), to name but a few, have introduced the concept of attitude and started to develop theories on attitude measurement concepts and instruments (Voinea, 2012). Soon afterwards, its focus has shifted towards general theories of cognition and theories of cognitive consistency with a major Gestaltian influence (Eagly and Chaiken 1993): Balance Theory (Heider, 1946, 1958), Congruity Theory (Osgood & Tannenbaum, 1955), Symmetry Theory (Newcomb, 1953), affective-cognitive consistency model (Rosenberg, 1956), and Cognitive Dissonance Theory (Festinger, 1957). By the end of the 1960s, the interest in the area vanished mainly because the cognitive dissonance static framework of interpersonal relations "in vogue" at that time did not offer much insight in the research of mental analysis (Simon and Holyoak, 2002).

Later developments in consistency theories proved a renewed interest for the cognitive dissonance theory, which has been the dominating theory in Social Psychology until the late 1970s.

New experimental approaches (Aronson, 1992; Harmon-Jones and Milles, 1999; Harmon-Jones E. & C., 2003) shed light on new theories of Social Psychology with a special focus on cognitive dissonance: self-affirmation theory (Steele, 1988), symbolic self-completion theory (Wicklund & Gollwitzer, 1982), self-evaluation maintenance theory (Tesser, 1988), self-discrepancy theory (Higgins, 1989), and action identification theory (Vallacher and Wegner, 1987).

3. Structural Dynamics

The cognitive theories developed within the Social Psychology have initially represented attitudes as memory-stored evaluations of the attitudinal objects. This kind of representation has been changed as further researches in Cognitive Psychology revealed that attitudes seem to be rather re-constructions of the perceived and/or imagined attitudinal objects. Introduced initially by Barlett in his seminal work on remembering (Bartlett, 1932), this idea has gained a major influence in cognitive consistency research (thorough reviews in (Wilson and Hodges, 1992), and (Wilson, Lindsey and Schooler, 2000)).

The cognitive theories are concerned with the organization, structure and dynamics of the cognitive processes (Zajonc, 1968). Structural dynamics refers to the unstable characteristics of the cognitive structural aspects. One such aspect regards the cognitive states, which are viewed as a result of merely the interaction of the structural elements and not of the structural elements themselves. This aspect has been modeled as a first principle of the structural dynamics of cognitive consistency.

Research on cognitive consistency is based on four main principles of structural dymanics (Read, Snow and Simon, 2004): (1) a cognitive state is considered to have a holistic nature, and it is produced as a result of the interaction of all its structural elements; (2) these interactions provide for the cognitive structural dynamics; (3) the structural dynamics settles down in equilibrium states, (which, in the cognitive dissonance theory, are called "consonance states"), and (4) cognitive consistency involves reconstructions processes of the cognitive structure, that is, modifications at both the semantic level (by modifications of the meanings of the structural elements), and at the structural level (by acquiring new elements).

ISSN 2285 – 4916
ISSN-L 2285 - 4916

This last principle has shaped a certain type of approach in computational modeling of cognitive consistency: models should be concerned with the dynamics of cognitive structures which consist in multiple, simultaneuosly active and simultaneoulsy varying elements.

4. Computational Modeling of Attitudes

Computational Modeling has become a basic research tool in Computational Sociology and in virtual experimental social and political analysis research. It provides the appropriate conceptual framework and instruments for a constructive approach to the research of attitudes in large human collectivities.

Computational modeling of social and political attitudes is useful in the simulation of the social behavior of large communities. During the past three decades, ccomputational simulations have been intensively used in the advent of experimental research on large social communities or entire societies.

There are several kinds of computational modeling approaches. The classical approach is the functional-descriptive model, which is designed so as to capture a fundamental attribute or functionality of a real system in few mathematical equations. The equations describe the behavior of the modeled system. Input data is then provided to the model and its outputs are used to analyse the behavior of the model and to approximate or predict the potential behavior of the real system in given contexts. Varying the contexts, the behavior of the model varies itself so as to capture essential aspects of the behavior of the real system.

Another type of approach is the artificial network model inspired by biological and neurological researches of the human organism and brain. This type of model works with a collection of nodes and their connections. The structure of the model, namely (i) the types of nodes and their activation parameters, (ii) the type of relational elements and their parameters, (weights), determines the behavioral characteristics of the model. Depending on the type of artificial network, input data are then loaded into the model so as to provide various degrees of activation levels to the input nodes. The overall output of the model represents its behavior. The model is run usually for a large number of times, so as to make observable the characteristics of its overall behavior and the micro-macro relations underlying this behavior.

5. Computational Modeling and Simulation of Cognitive Dissonance

Attitude research, in general, and cognitive dissonance theories, in particular, have provided a considerable number of conceptual models of attitude structure, formation and change. These conceptual models relied on early operational views, which provided for a formal (algebraic) modeling approach on the balanced/imbalanced states and the way humans strive to achieve consistency by attitude change (Heider, 1946; 1958).

Heider's operational model concerns cognitive states (balanced or imbalanced). Cognitive states are hold by cognitive units. A cognitive unit consists of three elements and the pairwise relationships between them. The structural elements of the cognitive unit are: (1) a Person, P, whose behavior is to be explained, another Person, P', and (3) the attitudinal Object, O. The relationships between the elements of a cognitive unit may be either positive or negative. In this model, a cognitive state is balanced or imbalanced depending on the number of signed (positive/negative) inter-elements relations only. As a cognitive state becomes imbalanced (meaning that an inconsistency between attitude and behavior occured), the Person (whose behavior has to be explained) tries to modify her own attitude and/or behavior in order to avoid inconsistency.

In spite of Heider's very influent and persistent operational model, cognitive consistency theories have shifted their interest towards operational frameworks able to describe the consistency-seeking

EQPAM Vol.2 No.3 July 2013
ISSN 2285 – 4916
ISSN-L 2285 - 4916

cognitive structures in dynamic terms, which seemed more appropriate in the context of the advent of attribution theories and reconstructive approaches to attitude change.

Interest in developing more adequate operational models of cognitive consistency has stirred the orientation of research in the direction of computational modeling.

During the mid' 90s, there has been developed the first type of computational modeling and simulation model: the connectionist model. It has been approached in various alternatives, each variant improving the modeling performances by means of (a) the type of connectionist network used for modeling, (b) the consistency-seeking mechanism, and (c) the structural and dynamic description of cognitive units and states.

6. Cognitive Theories and Connectionist Modeling

By the 1990s, cognitive theories research in Cognitive and Social Psychology have found the newly appeared Connectionist Models as a fascinating modeling instrument: it provided the means to represent conceptual structures and, most important, to use these representations for the simulation of cognitive processes.

The Parallel Distributed Processing (PDP) Model (Rumelhart & McClelland, 1986), also called Connectionist Model, consist of multiple units (nodes) and their interconnections (links). Nodes have their integrative function specified by equation(s), while the connections between nodes have coefficients of relevance (weights) assigned to them. A connectionist models operates like an integrative system: each node continuously sums up the information transmitted from all the other neighboring nodes. The information flow from one node to another is transmitted as level of activation, so that each node's activation is always constrained by the levels of activation of the neighboring nodes. The spread of activation is controlled by the connection's weights. This architecture and functionality had major implications for the kind of problems the Cognitive and Social Psychology research actually had at that time (Read and Miller, 1998). For the first time after the dyadic and tryadic paradigms have been used for representation research purposes, the connectionist models allowed for both a representation and an operational solution to the problem of representation of cognitive structures.

The fundamental characteristic of the parallel distributed processing systems is their parallel type of operation: all nodes are simultaneously active (with various degrees of activation) providing as many pieces of information as nodes are, while each piece of information has a specific relevance (weight) in the system overall architecture and functionality.

For cognitive structures, in particular, this kind of distributed system provided the means to create an overall semantics by combining the meanings conveyed by several cognitive units. The procedure is quite simple: each node provides a piece of information which is propagated as a level of activation to all neighboring nodes. The spreading of activations makes that each node is dependent on all the other nodes directly or remotely linked to it, stimulating or constraining therefore the activations of all neighboring nodes Nodes' mutual interdependency is controlled by the weights associated to each connection, such that each piece of information will get a particular degree of relevance in the overall output of the system. For cognitive consistency and consonance achieving tasks, this means that each unit in a conceptual structure will contribute to the overall consistency of the cognitive structure. As a constraint satisfaction algorithm is used, the contribution of each node to the global output will be accordingly adjusted so as the conceptual structure could achieve consistency (Read and Miller, 1994).

These characteristics and principles of operation made of the connectionist networks the ideal design tool for developing appropriate computational models for cognitive consistency-seeking theoretical

ISSN 2285 – 4916
ISSN-L 2285 - 4916

models. Actually, cognitive consistency theories have been "revitalized" (Simon, Snow and Read, 2004) and "reformulated" (Simon and Holyoak, 2002; Read and Miller, 1998) much on the conceptual background offered by the connectionist theories of cognition.

Connectionist models of cognitive consistency are usually implemented by neural networks. The type of network is however dependent on the type of problem which has to be solved. Types of neural networks include feedforward and feedback networks: each of the connectionist models described in the next section uses one of these two types of networks.

Feedforward networks have no feedback connections among nodes. The nodes have unidirectional connections and the spread of activation is transmitted from the input layer to the output layer, usually in a single processing cycle. Repeated cycles allow for the network to settle down into a stable state, which is actually meant to describe the global cognitive consonance state.

Feedback networks have feedback connections among their nodes. The nodes have bidirectional connections and the spread of activation has a special dynamics. The excitatory / inhibitory connections moderate the dynamic behavior of the nodes. The network needs many processing cycles to settle down into a stable state. Nodes' activations are updated at each cycle and, because of their feedback connections, they behave like dynamic units. If we assign each node a particular (weighted) constraint, then this kind of network operates like a parallel constraint satisfaction system, which represents the fundamental aspect for the connectionist models of cognitive consistency (Read and Miller, 1998). The constraint satisfaction algorithm provides for different levels of activation for each node (constraint), simultaneously. As bidirectional connections allow the nodes connected by excitatory links to mutually stimulate each other, the network will finally result in a set of nodes with highest activation levels, which represent the active variables in the cognitive structure. All the other nodes would have lower levels of activation, since their connections are consequently inhibited by the set of highly-active nodes (Simon and Holyoak, 2002).

Since a cognitive structure represented with this connectionist model can be associated with a person's set of beliefs, afects, knowledge and cognitive experience, the model enhances experimental settings and behavioral simulations of collections of individuals. The various contexts of such experimental settings are characterized by cognitive consistency-inconsistency, consonance-dissonance or coherence-ambiguity features.

7. The Constraint Satisfaction Modeling Paradigm of Cognitive Dissonance

Analogical mapping has been intensively studied in Cognitive Psychology and Artificial Intelligence as a means to provide the artificial mind with cognitive attributes, processes and functions (Hall, 1989; Gentner, 1983; Winston, 1984). Analogical mapping has been defined as a representation mapping from a known domain (called the source) to a new domain (called the target domain) oftenly involved in learning, problem-solving and decision making processes (Hall, 1989). As a cognitive process, analogical reasoning is based on identification and evaluative processes of the structural correspondences between source and target domains. Thus, the structural consistency and the semantic similarity of the corresponding structural elements become major requirements in an analogical reasoning model. As an analogical reasoning paradigm, constraint satisfaction has been used in modeling the analogical constraint mapping processes which require the integration in an unique overall solution of the "*interacting structural, semantic, and pragmatic constraints"* between source and target analogs (Holyoak and Thagard, 1988).

For computational modeling of cognitive consistency, the constraint satisfaction paradigm provides a practical solution to the problem of management and control of the simultaneously active relationships

EQPAM Vol.2 No.3 July 2013
ISSN 2285 – 4916
ISSN-L 2285 - 4916

among cognitive structural elements: beliefs, affects, information, and knowledge acquired from past and ongoing cognitive and behavioral experiences.

Festinger's Theory of Cognitive Dissonance actually models the human reasoning in situations in which the human agent holds opposite cognitions with respect to the same attitudinal object and experiences an unpleasant state of attitudinal imbalance, called "cognitive dissonance". Once aroused, the cognitive dissonance becomes a motivational "engine", which drives the agent towards reducing the magnitude of dissonance (Festinger, 1957). Approaching the concept of "attitudinal imbalance", this theory explains how humans strive to achieve the balance by modifying the attitude structural elements, and their relationships altogether with the goal of increasing their cognitive consistency.

A further theoretical approach of the cognitive dissonance from a human reasoning modeling perspective, the Symbolic Psycho-Logic Theory (Abelson and Rosenberg, 1958), provided a unified procedural framework for modeling the modifications of the relationships among attitudinal structural elements in the cognitive dissonance scenario.

Nevertheless, computational modeling of the cognitive dissonance started to develop only much later. Its development has been facilitated by the computational connectionist theories and models which emerged during the 1990s. What have actually bound together the cognitive dissonance theoretical modeling and the connectionist computational modeling domains were the analogical reasoning and the constraint satisfaction paradigms applied to consistency-seeking problems in attitude change models (Simon and Holyoak, 2002).

Constraint satisfaction mechanism has been intensively used in in computational models of high-level cognitive process: ACME Model of analogical mapping (Holyoak & Thagard, 1989); ECHO Model for the evaluation of competing explanations (Thagard, 1989) and SEA Model for achieving semantic coherence in concept learning (Voinea, 1991). It has been succesfully combined with the connectionist mechanism of representation and modification of large conceptual structures involved in the computational modeling of dissonace reduction systems (Read and Miller, 1994). Connectionist representation of cognitive concepts and processes has offered the possibility to model the dynamics of consistency achieving processes in attitude structural change models (Read and Miller, 1994; Read, Vanman and Miller, 1997; Read and Monroe, 2007). For cognitive dissonance research, in particular, the constraint saisfaction paradigm provided a proper means to model the dissonance reduction processes (Spellman, Ullman and Holyoak, 1993; Shultz and Lepper, 1996; Van Owervalle and Jonders, 2002).

8. Cognitive Consistency and Cognitive Dissonance Connectionist Models

This paper selects three cognitive dissonance connectionist models. These models, and some others, proved the considerable potential for the development of cognitive and social psychology modeling of the theories of cognitive dissonance. Good examples in this sense would be the computational modeling approaches on cognitive dissonance and on how it can be related to (1) the issue of personal responsibility attribution (Sakai and Andow, 1981), (2) the issue of opinion change (Sakai, 1981), and (3) the issue of cultural differences in cognitive dissonance (Hoshino-Browne et al., 2005; Sakai, 2013).

All the three approaches described bellow model cognitive dissonance reduction as a cognitive consistency-seeking problem. A comparative presentation has been possible since they either address the same experimental scenarios (i.e.:prohibition to play with toy in the settings described by Freedman, 1965) or the same dissonance-reduction paradigm (constraint satisfaction). Another common characteristics is that they all represent attitudes as memory-stored evaluations, and use localist representations of the cognitive structure (concept representation is one-to-one with respect to the nodes in the network).

European Quarterly of Political Attitudes and Mentalities EQPAM
Vol.2, No.3, July 2013

ISSN 2285 – 4916
ISSN-L 2285 - 4916

However, there are some relevant differences which provide for different performances and for a different modeling of the human cognitive dissonance processes, in general, and cognitive dissonance processes, in particular.

The dissonance-reduction paradigms are: (a) constraint satisfaction connectionis model (used by both Shultz and Lepper's Consonance Model, and Read and Monroe' RNN model for cognitive dissonance reduction), which allows the system to reduce dissonance by achieving a Gestalt-inspired global cognitive state of consistency ("consonance"); (b) attribution connectionist model (used by the Van owervalle and Jonders' AC-CD model), which allows the system to reduce dissonance by attitude change, where the attitude change results from avoinding inconsistencies by modifying the cognitive structure on a causal explanations basis.

The types of artificial network are different from one model to another: some uses feedforward (Consonance Model and AC-CD Model), while other uses feedback artificial network (Read and Monroe's RNN model for cognitive dissonance reduction).

The types of representation with artificial networks is different: some uses localist representation (Consonance Model), while another uses a combination of localis and distributed representation (Read and Monroe's RNN model for cognitive dissonance reduction).

Two of these models use learning in order to enhance attitude change by discriminating between old and new evaluative judgements with respect to the attitudinal object (Van Owervall and Jonders' AC-CD Model, and Read and Monroe's RNN model for cognitive dissonance reduction).

The simulations performed with these connectionist models are mainly based on the same experimental psychological settings: the "prohibition to play with toy" scenario, as described and explained by Freedman (1965).

8.1. The Consonance Model (Shultz & Lepper, 1996)

The Consonance Model[2] concerns the dissonance-reducing problem in the constraint satisfaction paradigm (Shultz and Lepper, 1992, p.462). The connectionist model is used for the representation of a particular cognitive structure (belief system), which is assumed to include inconsistencies between attitude and behavior with respect to a particular attitudinal object. These structural inconsistencies generate a state of cognitive dissonance which has to be processed on the basis of constraint satisfaction algorithm.

8.1.1. The Cognitive Structure

The nodes in the network represent person's cognitions (attitude, behavior, action, affect), and constraints on that person's cognitions (threat), as well as relations between cognitions (psychological implication (Shultz and Lepper, 1992, p.464)).

In this cognitive structure, the dissonance-reduction problem is approached as a consistency-seeking task: the constraints should be simultaneously satisfied (with various degrees), so that the cognitive structure could achieve a global state of balance called "consonance".

8.1.2. Cognitive Dissonance Paradigms

[2] Our description of the *Consonance Model* follows Authors' descriptions and explanations published in three papers which provide the technical references for this section: (Shultz and Lepper, 1992; 1996) and (Shultz and Lepper, 1998).

EQPAM Vol.2 No.3 July 2013
ISSN 2285 – 4916
ISSN-L 2285 - 4916

In the Consonance Model, dissonance reduction is based on the heiderian concept of balance. The constraint satisfaction mechanism is used to implement the concept of balance as cognitive consistency of the cognitive structure.

The dissonance-reduction is studied in several paradigms: insufficient justification via prohibition and free choice (Shultz and Lepper, 1992; 1996), insufficient justification via prohibition, insufficient justification via initiation, and free choice (Shultz and Lepper, 1998; Shultz, Léveillé and Lepper, 1999).

In the insufficient justification paradigm, the Actor involves in some counterattitudinal action with little justification or without justification at all. The paper presents simulations of the Freedman variant for the scenario of the nursery school children who were forbidden to play with a desirable toy in conditions of (a) non-surveillance and (b) surveillance.

8.1.3. Representation

Consonance Model uses a localist representation: each concept is associated with a node. The cognitive structure consist of cognitions (beliefs), which are representated as nodes (units), and relationships between the cognitions, which are represented as connections between the nodes. The nodes can be active or not; if active, they can have a various degree of activity between 0 and 1. Their activity is influenced by the weights associated to connections: the strength of the weights have a direct impact on each node's level of activity (**Figure 1**).

Each node (belief) is characterized by the value of its resistance to change: this parameter provides for the possibility to represent the way in which beliefs could be changed with the changing value of activation. Since nodes receive different values of activation via their weights, their resistance to change will be an important parameter of the overall consonance of the network.

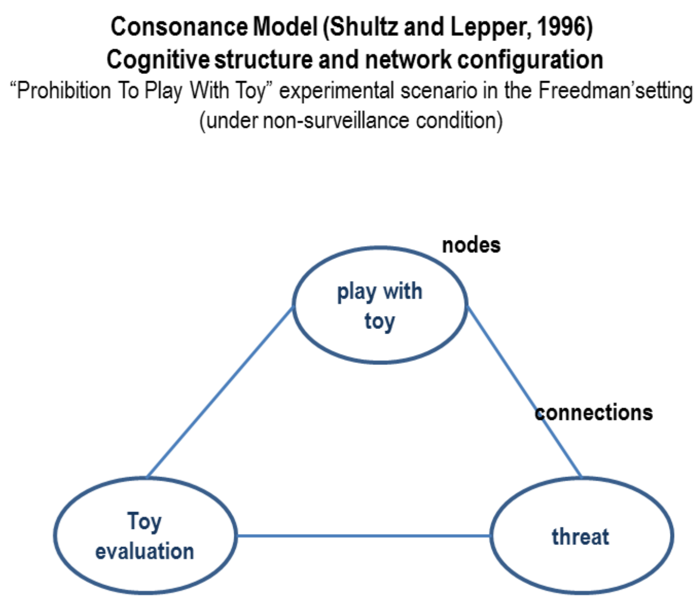

Figure 1.

ISSN 2285 – 4916
ISSN-L 2285 - 4916

Consonance Model (Shultz and Lepper, 1992). Cognitive structure.

A specific feature of the Consonance Model is that individual cognitions are represented as connections between two nodes with opposite activations: one node has a positive activation and stands for one pole of the cognition, while the other has a negative activation and stands for the other pole of the cognition. Such representations are called "dimensions". Each dimension goes on a continuum from a positive value to a negative end value (**Figure 2**). This representation also asumes that the consonance or dissonance of the nodes in the network depends on the sign of the connection beetween any two nodes: two nodes (beliefs) are consonant if the weight of their connection is positive.

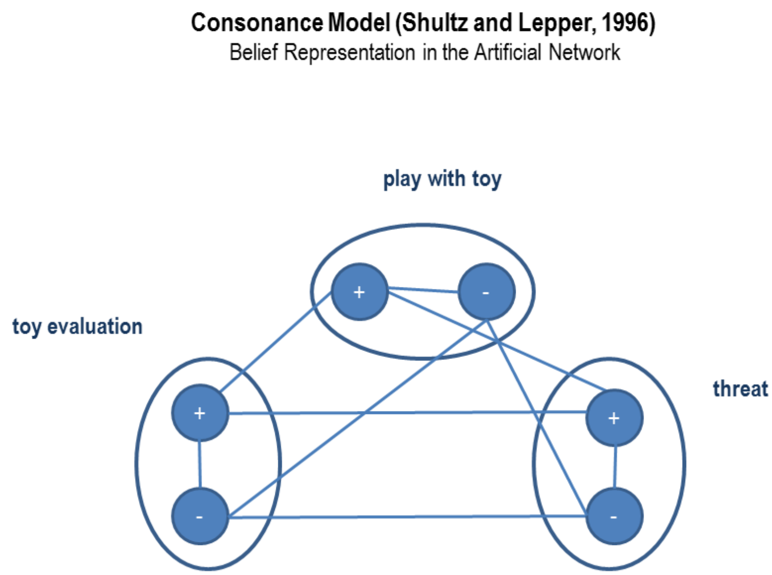

Figure 2. Consonance Model.
Adaptation of the Shultz and Lepper's Figure1 for the network for Freedman simulation (under non-surveillance condition) in: (Shultz, T. R., & Lepper, M. R., 1992; p.464).

8.1.4. Simulations

The dimension of interest in each simulation is represented by a pair of nodes (units). The connections within a pair of nodes represent the level of activation of a particular belief at any time. Connections across dimensions represent the relationships among beliefs.

At the initial moment, the nodes are characterizd by their individual resistance to change parameter value, while the weights are initialized randomly with values between 0 and 1. In a single trial, the nodes are provided a random activation level. During each simulation cycle, a number of n nodes are selected and updated according to the rules of activation spread. Dissonance reduction is approached as a constraint satisfaction problem. A dimension of interest is simultaneously subject to the influences of the

EQPAM Vol.2 No.3 July 2013
ISSN 2285 – 4916
ISSN-L 2285 - 4916

neighboring nodes by means of their connection weights. The value of the consonance is calculated taking into consideration the levels of activation for all nodes and their resistance to change values. Consonance is increased by maximizing the constraint satisfaction output.

8.2. Adaptive Connectionist Model of Cognitive Dissonance (Van Owervalle and Jordens, 2002)

The Adaptive Connectionist Model of Cognitive Dissonance[3], hereby AC-CD Model, works with an attributional approach on cognitive dissonance. As the authors describe it, the dissonance is attributed to the object, as a difference from the invoked Cooper and Fazio's approach (1984), which attributes dissonant behavior to the Actor's own responsibility (Van Owervalle and Jordens, 2002; p. 205).

An attitude is described as a relationship between an attitudinal object and behavioral affective outcomes. Cognitive dissonance is described as a difference between the expected and the real outcome (affect, behavior).

Dissonance reduction is achieved by attitude change, which is based on a learning mechanism aimed at minimizing the difference between expectations and real outcomes.

8.2.1. Cognitive Structure

The AC-CD Model concerns the dissonance-reducing problem in the attributional paradigm. The network is used for the representation of a particular cognitive structure: attitudes, behaviors, emotions. This cognitive structure is assumed to include inconsistencies between attitude and behavior with respect to the attitudinal object. These structural inconsistencies generate a state of cognitive dissonance which has to be resolved on an attributional basis: causal explanations are identified with respect to the attitudinal object so as to justify an attitude change.

The nodes in the network represent either subject's cognitions (attitude, behavior, affect) or external factors (threat). Attitudinal object, and external factors are viewed as causal factors of the differences between Subject's expectations and the real outcomes. In this cognitive structure, the dissonance-reduction problem is approached on a causal explanation basis: the discrepancies between the mental model and the real outcomes (behavior, affect) represent the cognitive dissonance. Once identified the causal explanations for these discrepancies, they provide the reasons for attitude change, which help in dissonance reduction.

8.2.2. Cognitive Dissonance Paradigms

While the Consonance Model is based on the concept of balance, the AC-CD Model is based on the concepts of causality and causal explanation: instead of consistency-seeking mechanism, a causal explanation is searched within the cognitive structure (knowledge, past experience) so as to provide reasons for dissonance reduction.

Dissonance reduction is based on attitude change which, in turn, relies on a causal explanation of the difference between mental model and real outcome of behavior ((Van Owervalle and Jordens, 2002; p. 205).

---

[3] Our description of the *Adaptive Connectionist Model of Cognitive Dissonance* follows Authors' descriptions and explanations published in the paper which provide the technical references for this section: (Van Owervalle and Jordens, 2002).

ISSN 2285 – 4916
ISSN-L 2285 - 4916

8.2.3. Representation

The AC-CD Model works on distributed representation of cognitions: an attitude representation uses multiple nodes in the network.

The type of network used by the AC-CD Model is a standard feedforward network. The model includes new features with respect to Shultz and Lepper's Consonance Model: representation of affect, and learning.

Representation of dissonant cognitions, behaviors and affect is based on the "Affect-Behavior-Cognitive" structure of attitudes inspired by the work of Rosenberg and Hovland (1960). An attitude is a memory-stored relationship between beliefs about the attitudinal object and two classes of responses: (1) behavior towards the attitudinal object and (2) affective outcomes of the interactions with the attitudinal object. The weights associated to the connections in the network represent the attitude'strength ((Van Owervalle and Jordens, 2002; p. 205).

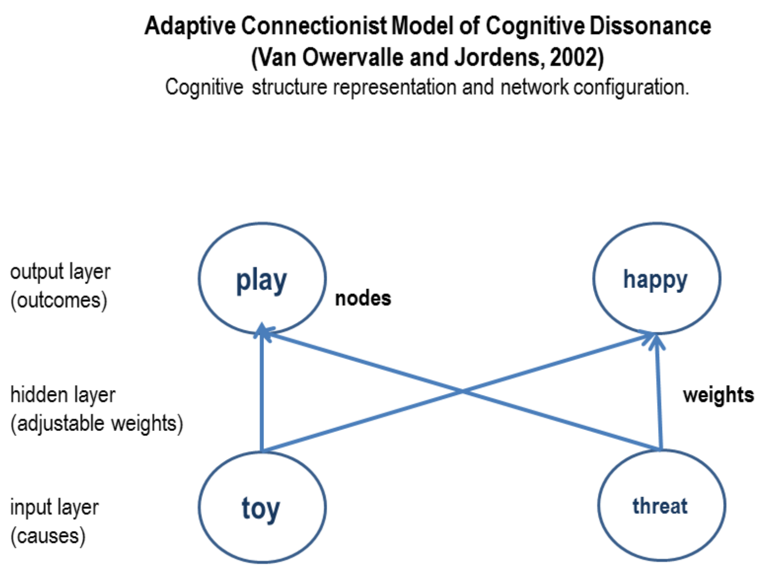

Figure 3.
Adaptive Connectionist Model of Cognitive Dissoance (Van Owervalle and Jordens, 2002).
(Adaptation of Van Owervalle and Jordens' Figure1 for the specifications of the feedforward network model, in : Van Owervalle and Jordens, 2002, p.207).

The nodes in the network are representations of causes and outcomes. The causes include the attitude object and the external factors (like, threat). The outcomes include behavior and affect. Outcomes could have multiple causes.

Since the network is of feedforward type, the connections work unidirectional and represent causal explanations of the outcomes. Their associated weights represent strength of causal influence or intensity of attitude ((Van Owervalle and Jordens, 2002; p.207).

EQPAM Vol.2 No.3 July 2013
ISSN 2285 – 4916
ISSN-L 2285 - 4916

8.2.4. Simulations

The cognitive dissonance is expressed by the difference between what is expected as outcome of an action choice with regard to an object (behavior) and the actual outcome (affect). Cognitive dissonance is therefore reduced by minimizing this difference by means of attitude change. This attitude change is achieved by weights adjustement (learning process).

The AC-CD Model is used to simulate the same cognitive dissonance paradigms like in Shultz and Lepper, 1996. Comparative analysis shows that the AC-CD Model achieves better performances due to the learning feature.

In the prohibition scenario, the network receive comparable input activation at both threat node (causal factor) and the toy node (object). Since the summed activation is approaching a zero value, the network indicates no attitude change. In the other two scenarios, the network receives (1) mild threat activation and (2) severe threat activation, the network output indicates an attitude change in the first case, and small or no attitude change in the second one. These results confirm the results described in the Freedman paradigm (1960).

8.3. The RNN Model for long-term attitude change resulting from cognitive dissonance reduction (Read and Monroe, 2007)

Read and Monroe (2007) developed a connectionist model based on a recurrent neural network which provides for attitude change as a result of cognitive dissonance reduction[4]. In contrast with the AC-CD Model approach on dissonance reduction, Read and Monroe's model approaches this problem in the old Gestaltian paradigm of cognitive balance.

Read and Monroes' connectionist model for cognitive dissonance tries to give solutions to the aspect remained unsolved by the previous models: the capacity of the network to achieve long-term attitude change by means of learning. To this purpose, the model (i) returns to the constraint satisfaction model in order to implement a dissonance-reduction model based on the Gestalt-inspired concept of consistency and (ii) uses a feeedback network able to learn evaluations and changes in evaluations, and therefore, provide for long-term attitude change.

Like the AC-CD Model, this model also uses a learning algorithm. The differences from the AC-CD Model reside in (1) the type of network and in (2) the type of the learning mechanism.

8.3.1. Cognitive structure

The nodes in the Read and Monroe's connectionist model are representations of beliefs, attitudes, behavioral outcomes/alternatives, evaluative task, objects and instrumental/contextual factors (i.e.:payment in the Festinger and Carlsmith's scenario of counter-attitudinal advocacy, (Festinger and Carlsmith, 1959) (**Figure 4**).

The cognitive structure has a flexible structure: it allows for adjustement of beliefs (attitudes) as the behavioral outcomes are or are not those expected.

The flexibility of the cognitive structure is provided by the learning mechanism: the network is initially instructed with evaluations of the object and later on it is able to adjust those evaluations on new

[4] Our description of the *Recurrent Neural Network Model for long-term attitude change resulting from cognitive dissonance reduction* follows Authors' descriptions and explanations published in the paper which provide the technical references for this section: (Read and Monroe, 2007).

European Quarterly of Political Attitudes and Mentalities EQPAM
Vol.2, No.3, July 2013
ISSN 2285 – 4916
ISSN-L 2285 - 4916

criteria which follow from the evaluations of behavioral alternatives. This evaluation follows a constraint satisfaction model.

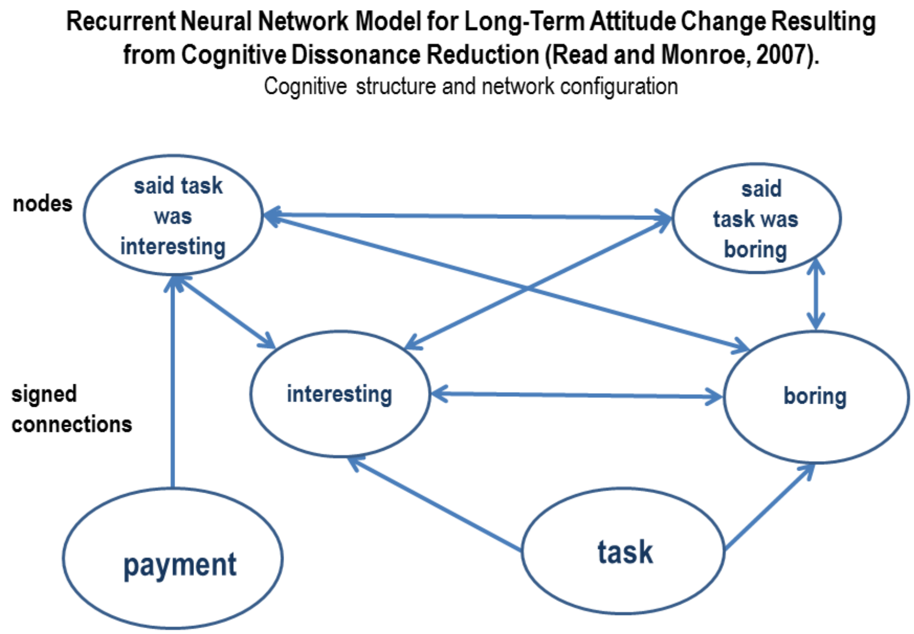

Figure 4.
Read and Monroe's Recurrent Neural Network Model for Long-Term Attitude Change Resulting from Cognitive Dissonance Reduction (2007).
(Adaptation of Read and Monroe's Figure 2 on Network for Festinger and Carlsmith (1959) in: Read and Monroe, 2007, p.589).

8.3.2. Cognitive Dissonance Paradigm

The constraint satisfaction paradigm is used for achieving consistency amongst different evaluations of the same object. The different evaluations result from comparing expectations with the outcomes of different behavioral alternatives. After repeated learning sessions, the network is able to discriminate between old and new evaluations, and to adjust the differences between evaluations as a dissonance reduction task.

8.3.3. Representation

The nodes representing the cognitive structure in the network have associated weights which take values in a continuum between -1 and +1 from positive to negative values, which allows for a mechanism of mutual inhibition between evaluative nodes.

The pair of evaluative nodes is a technique used also in the Consonance Model, where it merely denotes a bipolar type of evaluation, while in the Read and Monroe's model, it denotes a possibility to get separate independent evaluations (positive or negative) of the attitudinal object. This mechanism enhances

EQPAM Vol.2 No.3 July 2013
ISSN 2285 – 4916
ISSN-L 2285 - 4916

the capacity of the network to distinguish between behavioral alternatives and between old and new evaluations of the attitudinal object.

This adaptive technique enhances the discrimination between different outcomes of behavioral alternatives and modification of the cognitive structure by introducing new evaluations.

8.3.4. Simulation

While the Delta Learning algorithm in the AC Model mainly adjusts the weights so as to capture instructor's own evaluation changes with respect to the attitudinal object, the Contrastive Hebbian Learning (CHL) algorithm used by Read and Monroe is able to capture the evaluation changes by itself, which is a real improvement: in the AC-CD Model, the instructor "tells" the network how the evaluation changed, while in this model, the network itself is able to detect the evaluation changes. It thus provides for the attitude change by modifying the very cognitive structure (reflexive feature). Modifications of the cognitive structure then determine the dissonance reduction in a balance or consistency-seeking paradigm (Read and Monroe, 2007; p. 588).

9. Conclusions

The paper presents three relevant connectionist models of cognitive dissonance. Although they have much in common, each model uses a different type of connectionist network, and a different paradigm of cognitive dissonance reduction mechanism. The persistent interest in the Cognitive Dissonance Theory and the advent of Computational Modeling explain the renewed evaluations and appreciation of dissonance research.

Soon after the "boom" of connectionist models, cognitive dissonance research has extended its reach so as to uncover cultural approaches on cognitive dissonance. This allowed for a revision of the theories on social role which address cognitive dissonance issues. Part 2 of this work is dedicated to a comparative analysis of this and other types of approaches on cultural issues and social role.

References

1. Abelson R.P., Rosenberg M. J, 1958. Symbolic psycho-logic: A model of attitudinal cognition, Behavioral Science No. 3, pp. 1-13.
2. Abelson R.P., Aronson, E., McGuire, W. J., Newcomb, T. M., Rosenberg, M. J., & Tannenbaum, P. H. (Eds.), *Theories of cognitive consistency: A source book.* Chigago: Rand Mcnally (1968).
3. Aronson, E. 1969. A theory of cognitive dissonance: A current perspective. In L.Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 4, pp. 1-34). New York: Academic Press
4. Aronson, E. 1992. *The return of repressed: Dissonance theory makes a comeback*. Psychological Inquiry, No. 3, pp. 303-311.
5. Aronson, E. 1997. *The theory of cognitive dissonance: The evolution and vicissitudes of an idea*, in: C. McGarty & S. A. Haslam (Eds.), *The message of social psychology* (pp. 20-36). Blackwell Publishers: Oxford.
6. Bartlett C.F. 1932. *Remembering. A Study in Experimental and Social Psychology*, Cambridge University Press.
7. Cohen, J. B. and Americus Reed II, 2005, *A Multiple Pathway Anchoring and Adjustment (MPAA) Model of Attitude Generation and Recruitment,* Journal of Consumer Research, Vol. 33, No.1, pp.1–15.
8. Cooper, J., & Fazio, R. H. (1984). A new look at dissonance theory. In L. Berkowitz (Ed.) *Advances in experimental social psychology* (Vol. 17, pp. 229–266). New York: Academic.
9. Cooper, J., & Fazio, R. H. 1984. *A new look at dissonance theory*. In L. Berkowitz (Ed.), *Advances in experimental social psychology,* Vol. 17, pp.229-266), Orlando, FL: Academic Press.
10. Cooper, J., 2007, *Cognitive Dissonance: Fifty Years of a Classic Theory*, London/Los Angeles, Sage Publications.

ISSN 2285 – 4916
ISSN-L 2285 - 4916

11. Festinger L. 1957. A Theory of Cognitive Dissonance, Evanston: Row, Peterson.
12. Festinger, L., & Carlsmith, J. M. (1959). *Cognitive consequences of forced compliance*. Journal of Abnormal and Social Psychology, No. 58, pp. 203–210.
13. Freedman, J.L. 1965. Long-term behavioral effects of cognitive dissonance, Journal of Experimental Social Psychology No.1, pp.145-155.
14. Gentner, D. 1983. *Structure-mapping: A theoretical framework for analogy*, Cognitive Science No. 7, pp. 155-170.
15. Gentner, D.1987. *Analogical inference and analogical access*, in: A. Priedilis (Ed.), *Analogica: The first Workshop on Analogical Reasoning,* Pitman, London.
16. Hall R. 1989. *Computational Approaches to Analogical Mapping: A Comparative Analysis*, *Artificial Intelligence* 39, pp.39-120.
17. Harmon-Jones E. and C. 2003. *Whatever Happened to Cognitive Dissonance Theory?,* The General Psychologist, vol.38, no.2, pp. 28-33.
18. Heider F. 1946. *Attitudes and Cognitive Organization*, The Journal of Psychology, No. 21, pp. 107-112.
19. Heider, F. 1958. *The Psychology of Interpersonal Relations*.New York, NY: John Wiley & Sons.
20. Higgins E.T. 1989. *Self-discrepancy theory: What patterns of self-beliefs cause people to suffer?,* in: Berkowitz L. (ed.) Advances in Experimental soacial Psychology, San Diego, CA: Academic, Vol. 22, pp. 93-136.
21. Holyoak, K. J., & Simon, D. 1999. *Bidirectional reasoning in decision making by constraint satisfaction*. Journal of Experimental Psychology: General, No. 128, pp. 3-31.
22. Holyoak, K. J., & Thagard, P. 1989. *Analogical mapping by constraint satisfaction*. Cognitive Science, 13, 295-355.
23. Hoshino-Browne E., Zanna A.S., Spencer S.J., Zanna M.P., Kitayama S., Lackenbauer S. 2005., *On the Cultural Guises of Cognitive Dissonance: The Case of Easterners and Westerners,* Journal of Personality and Social Psychology, Vol. 89, No.3, pp.294-310.
24. Lepper. M. R., & Shultz, T. R. (1999). Dissonance theory. In R. A. Wilson & F. C. Keil (Eds.), MIT Encyclopedia of the cognitive sciences (pp. 233-234). Cambridge, MA: MIT Press.
25. Lord, C. G., & Lepper, M. R. 1999. *Attitude representation theory*. In M. P. Zanna (Ed.), Advances in experimental social psychology, Vol. 31, pp. 265-343, San Diego: Academic Press.
26. Monroe, B. M., & Read, S. J. 2008. A General Connectionist Model of Attitudes and Attitude Change: The ACS (Attitudes as Constraint Satisfaction) Model. *Psychological Review, 115*, 733–759.
27. Newcomb, T. M. 1953. *An approach to the study of communicative acts*, Psychological Review No. 60, pp.393–404.
28. Osgood, C. E., & Tannenbaum, P. H. 1955. *The principle of congruity in the prediction of attitude change*, Psychological Review, No. 62, pp. 42-55.
29. Read S.J., Miller L.C. 1994. *Dissonance and balance in belief systems: The promise of parallel constraint satisfaction processes and connectionist modelling approaches*, in: Schank R.C. and Langer E. (Eds.), Belief, Reasoning, and Decision Making: Psycho-logic in Honor of Bob Abelson. Hillsdale, NJ: Erlbaum, pp.209-235.
30. Read, S. J., & Monroe, B. M. 2007. *Modeling Cognitive Dissonance using A Recurrent Neural Network Model with Learning.* In D. McNamara and Greg Trafton (Eds). *Twenty-Ninth Annual Conference of the Cognitive Science Society*, pp. 587-592, Austin, TX: Cognitive Science Society.
31. Read, S. J., Vanman, E. J., & Miller, L. C. 1997. *Connectionism, parallel constraint satisfaction processes, and gestalt principles: (Re)introducing cognitive dynamics to social psychology*, Personality and Social Psychology Review, No.1, pp. 26-53.
32. Rosenberg M.J. and Hovland C. I. 1960. *Cognitive, Affective and Behavioral Components of Attitudes*, in: M. J. Rosenberg, C. I. Hovland (eds.), Attitude Organization and Change: An Analysis of Consistency Among Attitude Components. New Haven: Yale University Press.
33. Rosenberg, M. J. 1960. An analysis of affective–cognitive consistency, in: M. J. Rosenberg, C. I. Hovland, W. J. McGuire, R. P. Abelson, &J. W. Brehm (Eds.), *Attitude organization and change: An analysis of consistency among attitude components,* New Haven, CT:Yale University Press, pp. 15–64.
34. Rumelhart D.E., McClelland (Eds.). 1986. *Parallel distributed processing: Explorations in the microstructure of cognition,* Cambridge, MA, MIT Press.
35. Sakai, H., Andow, K. 1980. *Attribution of personal responsibility and dissonance reduction*, Japanese Psychological Research No.22, pp.32–41.
36. Sakai, H. 1981. *Induced compliance and opinion change*, Japanese Psychological Research No.23, pp.1–8.
37. Sakai H. 2013. *"A Recurrent Network Model of Cognitive Consistency: How Balance and Dissonance Theories Could Be Unified",* The Sapporo University Journal, no.35, pp.43-55.
38. Shultz T.R., Lepper M.R. ??. *Computer Simulation of Cognitive Dissonance Reduction*, Chapter 10, pp.235-265.

39. Shultz T.R., Lepper M.R. 1996. *"Cognitive dissonance reduction as constraint satisfaction",* Psychological Review, No.103, pp.219-240.
40. Shultz T.R., Lepper M.R. 1998. *"The consonance model of dissonance reduction",* in: S.J. Read and L.C. Miller (Eds.), Connectionist models of social reasoning and social behavior (pp.211-244), Hillsdale, NJ:Erlbaum.
41. Shultz T.R., Lepper M.R. 2005. Cognitive dissonance reduction as constraint satisfaction. Pers Soc Psychol Rev. Vol.9, No.3, pp.231-274.
42. Shultz T.R., Léveillé E., Lepper M.R. 1999. *Free-choice and cognitive dissonance revisited: Choosing "lesser evils" vs. "greater goods".* Personality and Social Psychology Bulletin No. 25, pp. 40-48.
43. Shultz, T. R., & Lepper, M. R. (1992). A constraint satisfaction model of cognitive dissonance phenomena. *Proceedings of the Fourteenth Annual Conference of the Cognitive Science Society* (pp. 462-467). Hillsdale, NJ: Erlbaum. - Preliminary conference version of Shultz & Lepper (1996).
44. Shultz, T. R., & Lepper, M. R. (1999). Computer simulation of cognitive dissonance reduction. In E. Harmon-Jones & Mills, J. (Eds.), *Cognitive dissonance: Progress on a pivotal theory in social psychology* (pp. 235-265). Washington, DC: American Psychological Association.
45. Shultz, T. R., & Lepper, M. R. (2000). Simulation of self-affirmation phenomena in cognitive dissonance. *Proceedings of the Twenty-second Annual Conference of the Cognitive Science Society* (pp. 464-468). Mahwah, NJ: Erlbaum.
46. Shultz, T. R., & Lepper, M. R. 1998. A constraint-satisfaction model of Machiavellianism effects in cognitive dissonance. *Proceedings of the Twentieth Annual Conference of the Cognitive Science Society* (pp. 957-962). Mahwah, NJ: Erlbaum. - The consonance constraint-satisfaction model is applied to Machiavellianism self-concept effects, covering human findings that classical dissonance theory does not.
47. Shultz, T. R., &Lepper, M. R. (1996). *Cognitive dissonance reduction as constraint satisfaction*. PsychologicalReview, 103, pp. 219-240.
48. Shultz, T. R., Leveille, E., & Lepper, M. R. (1999). *Free-choice and cognitive dissonance revisited.* Personality and Social Psychology Bulletin, 25, pp. 40-48.
49. Simon & Holyoak. 2002. *Structural Dynamics of Cognition: From Consistency Theories to Constraint Satisfaction"*
50. Simon D., Snow C.J., Read S.J. 2004. *The Redux of Cognitive Consistency Theories: Evidence Judgements by Constraint Satisfaction,* Journal of Personality and Social psychology, Vol. 86, No.6, pp. 814-837.
51. *social psychology,* San Diego, CA: Academic, Vol. 21, pp. 261–302.
52. Spellman, B. A., Ullman, J. B., & Holyoak, K. J. 1993. *A coherence model of cognitive consistency: Dynamics of attitude change during the Persian Gulf War.* Journal of Social Issues, 49, 147-165.
53. Steele, C. M. (1988). The psychology of self-affirmation: Sustaining the integrity of the self. In L. Berkowitz (Ed.), *Advances in experimental*
54. Tesser A. 1988. *Toward a self-evaluation maintenance model of social behavior,* in: Advances in experimental social psychology, New Academic Press, NY, Vol. 21, pp. 181-227.
55. Thagard P. 1989. *Explanatory coherence*, Behavioral and Brain Sciences *, No. 12* , pp. 435-467.
56. Vallacher R.R., Wegner D.M. 1987. *What do people think they're doing? Action identification and human behavior,* Psychological Review, No. 94, pp.3-15.
57. van Overwalle F., Jordens K. 2002. *An Adaptive Connectionist Model of Cognitive Dissonance*, Personality and Social Psychology Review, August 2002 vol. 6 no. 3, pp. 204-231.
58. Voinea, C. 1991. "*Principles of Semantic Coherence in Concept Learning*", în: Graham I.M. şi Milne R.W. (Eds.), "Research and Development in Expert Systems VIII", Proceedings of Expert Systems 91, The Eleventh Annual Technical Conference of the British Computer Society Specialist Group on Expert Systems, Cambridge University Press, London, pp. 127-139.
59. Voinea, C.F. 2012. *Political Attitudes. In Search for Measure*, University of Bucharest-Ars Docendi Press, Bucharest, Romania.
60. Wicklund R.A., Gollwitzer P.M. 1982. *Symbolic self-completion*, Hillsdale: Lawrence Erlbaum, NJ.
61. Wilson T. D. and Hodges S.D. 1992. *Attitudes as Temporary Constructions*, in: *The Construction of Social Judgments*, Martin L.L. and Tesser A. (Eds.), Hillsdale, NJ: Erlbaum, pp. 37-65.
62. Wilson T.D., Lindsey S. and Schooler T.Y. 2000. *A Model of Dual Attitudes*, Psychological Review, Vol. 107 No. 1, pp. 101-26.
63. Winston, P.M. 1984. *Artificial Intelligence,* Addison-Wesley.
64. Zajonc R.A. 1968. *Cognitive Theories in Social Psychology,* in: Handbook of Social Psychology, Lindzey G. and Aronson E. (Eds.), 2nd edition, Vol.1, Addison-Wesley, New York.