

Fuzzy Cognitive Maps for Impact Assessment in Psychological Research: Case Study of Psychological Well-being

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Abstract

Assessing the impact of main factors on a given factor is important in various fields of psychological research. There are some methodological and statistical methods to tackle that problem. Recently, other methods and algorithms are being developed for this purpose. One of the methods is Fuzzy Cognitive Maps, which are recurrent neural network for modelling and simulations. The main advantage of this method is that it provides flexibility to model complex systems using causal relationships, thus allowing for what-if simulations. The key purpose of this paper is to introduce and apply this method in the Psychology field. More explicitly, this paper discusses this model in depth and applies it to a psychological well-being case study.

Key Words: Fuzzy Cognitive Map, Psychological well-being, Causality, Assessment.

1-Introduction

The Fuzzy Cognitive Map (FCM) model was introduced by Kosko in 1986 [1]. These recurrent neural networks follow a reasoning approach similar to the human reasoning and human decision-making process [2]. FCMs are a representation of a belief system in a given domain. The model is comprised of concepts (C) representing key drivers of the system, joined by directional weighted edges between the concepts. Each connection is assigned a weight (w_{ij}) quantifying the strength of the causal relationship between concepts C_i and C_j [1]. A positive weight indicates an excitatory relationship, i.e. as C_i increases C_j increases while a negative weight indicates an inhibitory relationship, i.e. as C_i increases C_j decreases. In its graphical form, an FCM provides domain knowledge as a collection of “nodes” and “arrows” that is relatively easy to visualize and manipulate. In addition, the model allows representing feedback loops, enabling its application in different domains. However, quantitative reasoning is also possible (actually, recent research efforts focus more on quantitative scenarios). As a result, FCMs have been employed to model the causal inference with relative success [3].

A methodology for developing FCMs is described in [1]. In each iteration, the activation value A_i attached to C_i is calculated by collecting–aggregating the influence of the interconnected concepts to the specific one, by using the following non-linear reasoning rule:

$$A_i^{(k+1)} = f \left(A_i^{(k)} + \sum_{j \neq i, j=1}^N A_j^{(k)} w_{ji} \right) \quad (1)$$

where $A_i^{(k+1)}$ denotes the activation value of concept C_i in the $(k+1)$ iteration, N is the number of concepts in the network and $f(\cdot)$ is a monotonic threshold function used to keep the activation values in the allowed interval. In this paper, we use the sigmoid transfer function defined as follows:

$$f(x) = \frac{1}{1 + e^{-x}} \quad (2)$$

The FCM takes different types of initial values for its concepts: real values derived from measurements, are normalized in the $[0,1]$ interval, and values that can be qualitatively or quantitatively described by domain experts or other sources such as historical data. When the FCM is initialized, its components are free to interact. This interaction of the concepts continues until the FCM model: a) reaches equilibrium at a fixed point, where the output values are stabilized at fixed numerical values, or b) exhibits limit cycle behaviour, where the output concept values are falling in a loop under a specific-time period.

2-Constructing FCM-based simulation models

Usually, a group of domain experts, who operate, monitor, supervise and know the system behaviour, are used to construct the FCM model. Based on their experience, the experts assign the main factors that describe the behaviour of the system; each of these factors is represented by one concept of the FCM. They know which elements of the systems influence other elements, thus they determine the negative or positive effect of one concept on the others, with a fuzzy degree of causation for the related concepts. In psychological research, we can use many different sources for extracting the most important factors that have impact on each other. Therefore, in psychological research there are expert-based and data-based approach for determining factors and the interconnections among them. It is important to note that the expert-based approach and the data-based approach can involve many methods and procedures. We summarize these methods as follows.

2.1-Opinion-based approach

2.1.1-Focused group discussion method

Focus group discussions (FGDs) bring 6-12 people together for a discussion on a specific health topic [2]. The participants usually have some characteristics in common, such as sex and

age, so they will feel comfortable speaking in the group. For example, an FGD on how young people discuss their puberty might be made up of girls aged 15-19, while a separate group might be made up of boys aged 15-19. It is recommended that at least two FGDs be done with each group. In this example, two FGDs with women aged 15-19 and two FGDs with men aged 15-19 are recommended. An FGD typically lasts from 1-2 hours and is led by a trained facilitator. It is useful to have another person present who takes notes but does not participate in the discussion. In addition, the FGDs should be recorded on audiotape or video cassette for later transcription and analysis [3].

2.1.2-Observation of behaviour method

In this method, an expert extracts main factors related to a specific event or trait from the observation of a real (such as observation of an aggressive child's behaviour in a playroom or an obsessive individual in the waiting room in a clinic) or fake (such as observation of people facing a fake car accident in the street or Milgram's experiment) situations and environments.

3.1.3-In –depth interview method

Using a qualitative tool like in-depth interview, the professional experts' opinions are collected. Then, the gathered data are categorized into related factors such as personal, familial, socio-cultural and biological factors causing the phenomenon being studied.

2.2. Data-driven approach

In this method, a psychological researcher tries to find the most important factors based on previous studies in papers and theses. In some psychological research, the relationship among variables is investigated in a correlational design [4]. In this method, a behavioural and social researcher can extract a final causal relationship based on real data obtaining from real sample using statistical methods such as Structural Equation Modelling, although, all researchers have no a consensus. It is important to note here causal models are constructed based on a theoretical basis extracting from reviewing the literature not only obtained data.

We can suggest applying a two-stage FCM construction in psychological research. In the first stage, a psychological researcher should review all documents that are available such as published papers, theses and books. In this stage, we determine the factors and relationships among them. We can also learn the weights automatically from historical data using a machine learning algorithm [5]. In second stage, we ask some experts in the field to update extend and tweak the relations and concepts of the model which obtained in first stage. An expert from his or her experience can add or eliminate a factor or connection. Expert's experience can be obtained from focused group discussion, observation of behaviour and in –depth interview method.

3-Psychological well-being: a case study

3-1-Constructing the FCM-based system for modelling and simulation

In this section, we construct a comprehensive FCM-based simulation model using the two-stage method described in the previous section. We have used this method for assessing the impact of personal value orientation on psychological well-being. First, we refer to the papers to find the important factors related to the main topic research. After reviewing literature [6] we extracted the most important factors related to personal value and psychological well-being having direct and indirect impacts on psychological well-being. Five important factors have been determined based on this stage (see Table1).

3-1-Reviewing the literature

Psychological well-being has an important position in psychology. Psychological well-being is about lives going well and it is the combination of feeling good and functioning effectively. Reviewing the literature related to psychological well-being indicates there are many different factors having influential impact on this concept. These factors are categorized into biological, socio-cultural and psychological factors [6]. More recent literature [7-8] indicates that one of the most important factors received increasing interest in studying health issues is basic value orientations. Basic or cultural values refer to things that individuals believe are worth desiring in life and thus guide their behaviour. Rokeach [9] believed that value orientations include cognitive, affective, and behavioural components; value orientations are cognitions of the desirable that foster emotions and motivate behaviour. These values are grouped into basic (like conformity) and cultural or modern (like hedonism) values.

Leichtentritt and Rettig [10] stated that values play an important role in human behaviour by influencing perceptions, decisions and actions, and, as a result, it impacts on the welfare of individuals, family members, and the community. Human value orientations recently received increasing attention in predicting the development and maintenance of mental disorders [11]. Conformity is a type of social influence involving a change in belief or behaviour in order to fit in with a group. It can also be defined as “yielding to group pressures” Group pressure may take different forms, for example, bullying, persuasion, teasing, criticism, etc. Conformity is also known as majority influence (or group pressure) [12]. Kahenman [13] argued that hedonism is defined well-being as the presence of positive effect and the absence negative effect.

The literature indicates that social support and resilience have a main impact on psychological well-being [14, 15]. There are many definitions on social support however; most definitions include the exchange or provision of supportive behaviours that can range from emotional to instrumental [15]. In other words, social support is operationalized as one’s perceived notion of the caring and understanding exhibited by the network According to Jenson and Fraser [16], resilience is the capacity to adapt successfully in the presence of risk and adversity. Resilience is still a relatively recent construct in psychology with slightly divergent definitions. In some of these definitions, it is congruently viewed as a construct, which includes variables like temperament and personality, in addition to specific skills (e.g. active problem-solving) that allow

individuals to cope well with life stress [17]. Benevolence is defined as preserving and enhancing the welfare of those with whom one is in Frequent personal contact in-group [18]. Health psychologists believe that benevolence is a basic personal value can influence social supports and psychological well-being [8-10]. Self-direction is a modern personal value that is defined as independent thought and action; choosing, creating, exploring [9].

Table1: Main factors related to well-being taken from the literature (Stage1)

| Identifier | Concepts |
|------------|--------------------------|
| CO | Conformity |
| HD | Hedonism |
| SS | Social Support |
| RE | Resilience |
| PW | Psychological well-being |
| BE | Benevolence |
| SD | Self-direction |
| OI | Ontological Identity |

In the second stage, the primary model was presented to the three health psychologists working on mental health and values and culture and asked to complete the model if there is a need and determine the interconnections among them (i.e., the weight matrix). The final FCM model was obtained as bellow (Fig.1).

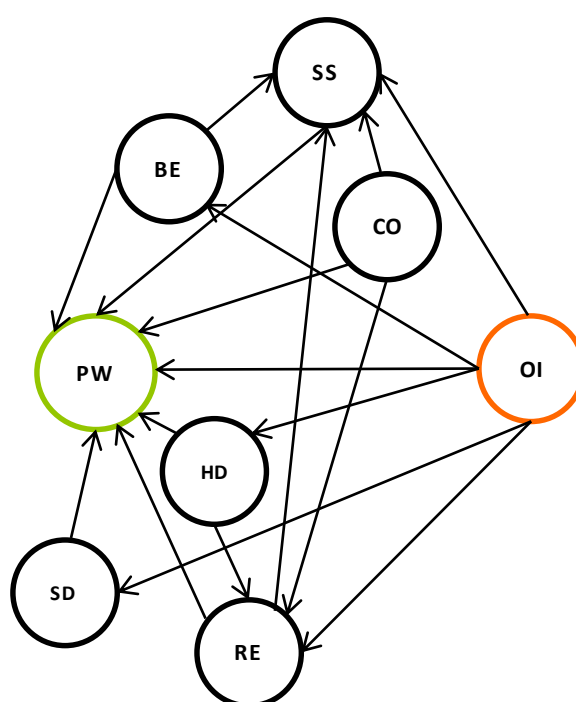


Fig.1. The comprehensive Fuzzy Cognitive Map for psychological well-being.

In this method, linguistic terms are based on these parameters existing in the literature [19],

*IF the value of concept C_i is A THEN the value of concept C_j is B
and therefore the linguistic weight w_{ij} is C .*

where A, B, C are linguistic variables taking values in the range $[0, 1]$.

The IF-THEN rule reasoning infers a fuzzy linguistic variable from a determined set, which associates the relationship between the two concepts and determines the grade of causality between the two concepts. Using linguistic variables, an expert can describe in detail the influence of one concept on another and can discern between different degrees of influence. The linguistic (symbolic) variables used in this paper are {very very low, very low, low, medium, high, very high, and very very high}. The corresponding memberships functions for these symbolic terms (depicted in Fig. 2) are $\mu_{vvl}, \mu_{vl}, \mu_l, \mu_m, \mu_h, \mu_{vh}$ and μ_{vvh} , respectively.

This linguistic terms propose by domain experts for each causal relationships should be converted to fuzzy numbers we can process to determine the crisp weights. In order to do that, the fuzzy weights are aggregated using SUM method such that we can obtain a weight with the Centre of Gravity method [20]. Hence, this process allows us to obtain numerical causal weights from qualitative representations.

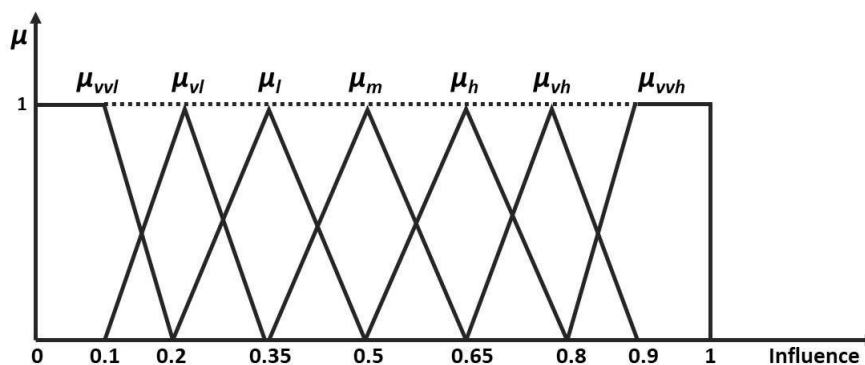


Fig.2 The seven membership functions corresponding to each one of the seven linguistic variables.

3-2-Processing the IF-THEN rules

In this section, we asked three experts in health psychologists with at least 10 years clinical and research experiences in the field to define the degree of influence among the concepts and to describe the interrelationships using an IF-Then rules. These rules are presented as follows:

1st Health psychologist

1# **IF** a very high change occurs in the value of “Conformity”, **THEN** a small change in the value of “Social support” is caused.

INFER: the influence from “Conformity” to “Social support” is positive very low.

2# **IF** a high change occurs in the value of “Benevolence”, **THEN** an average change in the value of “Social support” is caused.

INFER: the influence from “Benevolence” to “Social support” is positive medium.

3# **IF** a very high change occurs in the value of “Hedonism”, **THEN** a very small change in the value of “Resilience” is caused.

INFER: the influence from “Hedonism” to “Resilience” is positive very low.

4# **IF** a high change occurs in the value of “Self-direction”, **THEN** a small change in the value of “Resilience” is caused.

INFER: the influence from “Self-direction” to “Resilience” is positive low.

5# **IF** a very high change occurs in the value of “Social support”, **THEN** a small change in the value of “Psychological well-being” is caused.

INFER: the influence from “Social support” to “Psychological well-being” is positive medium.

6# **IF** a medium change occurs in the value of “Resilience”, **THEN** a high change in the value of “Psychological well-being” is caused.

INFER: the influence from “Resilience” to “Psychological well-being” is positive high.

7# **IF** a high change occurs in the value of “Social support”, **THEN** a small change in the value of “Resilience” is caused.

INFER: the influence from “Social support” to “Resilience” is positive low.

8# **IF** a high change occurs in the value of “Resilience”, **THEN** a medium change in the value of “Social support” is caused.

INFER: the influence from “Resilience” to “Social support” is negative medium.

9# **IF** a high change occurs in the value of “Conformity”, **THEN** a low change in the value of “Psychological well-being” is caused.

INFER: the influence from “Conformity” to “Psychological well-being” is positive low.

10# **IF** a very high change occurs in the value of “Hedonism”, **THEN** a medium change in the value of “Psychological well-being” is caused.

INFER: the influence from “Hedonism” to “Psychological well-being” is positive high.

11# **IF** a very high change occurs in the value of “Benevolence”, **THEN** a high change in the value of “Psychological well-being” is caused.

INFER: the influence from “Benevolence” to “Psychological well-being” is positive high

12# **IF** a medium change occurs in the value of “Self-direction”, **THEN** a medium change in the value of “Psychological well-being” is caused.

INFER: the influence from “Self-direction” to “Psychological well-being” is positive high

13# **IF** a high change occurs in the value of “Ontological Identity”, **THEN** a small change in the value of “Social support” is caused.

INFER: the influence from “Ontological Identity” to “Social support” is positive medium.

14# **IF** a medium change occurs in the value of “Ontological Identity”, **THEN** a high change in the value of “Benevolence” is caused.

INFER: the influence from “Ontological Identity” to “Benevolence” is positive high.

15# **IF** a medium change occurs in the value of “Ontological Identity”, **THEN** a high change in the value of “Psychological well-being” is caused.

INFER: the influence from “Ontological Identity” to “Psychological well-being” is positive high.

16# **IF** a high change occurs in the value of “Ontological Identity”, **THEN** a high change in the value of “Resilience” is caused.

INFER: the influence from “Ontological Identity” to “Resilience” is positive high.

17# **IF** a high change occurs in the value of “Ontological Identity”, **THEN** a medium change in the value of “Hedonism” is caused.

INFER: the influence from “Ontological Identity” to “Hedonism” is positive medium.

18# **IF** a very high change occurs in the value of “Ontological Identity”, **THEN** a small change in the value of “Self-direction” is caused.

INFER: the influence from “Ontological Identity” to “Self-direction” is positive medium.

2nd health psychologist

1# **IF** a high change occurs in the value of “Conformity”, **THEN** a very small change in the value of “Social support” is caused.

INFER: the influence from “Conformity” to “Social support” is positive low.

2# **IF** a high change occurs in the value of “Benevolence”, **THEN** an average change in the value of “Social support” is caused.

INFER: the influence from “Benevolence” to “Social support” is positive medium.
3# **IF** a very high change occurs in the value of “Hedonism”, **THEN** a very small change in the value of “Resilience” is caused.
INFER: the influence from “Hedonism” to “Resilience” is positive very low.
4# **IF** a very high change occurs in the value of “Self-direction”, **THEN** a medium change in the value of “Resilience” is caused.
INFER: the influence from “Self-direction” to “Resilience” is positive medium.
5# **IF** a very high change occurs in the value of “Social support”, **THEN** a small change in the value of “Psychological well-being” is caused.
INFER: the influence from “Social support” to “Psychological well-being” is positive medium.
6# **IF** a high change occurs in the value of “Resilience”, **THEN** a high change in the value of “Psychological well-being” is caused.
INFER: the influence from “Resilience” to “Psychological well-being” is positive very high.
7# **IF** a high change occurs in the value of “Social support”, **THEN** a small change in the value of “Resilience” is caused.
INFER: the influence from “Social support” to “Resilience” is positive low.
8# **IF** a high change occurs in the value of “Resilience”, **THEN** a medium change in the value of “Social support” is caused.
INFER: the influence from “Resilience” to “Social support” is negative medium.
9# **IF** a medium change occurs in the value of “Conformity”, **THEN** a very low change in the value of “Psychological well-being” is caused.
INFER: the influence from “Conformity” to “Psychological well-being” is positive very low
10# **IF** a high change occurs in the value of “Hedonism”, **THEN** a medium change in the value of “Psychological well-being” is caused.
INFER: the influence from “Hedonism” to “Psychological well-being” is positive very high.
11# **IF** a medium change occurs in the value of “Benevolence”, **THEN** a high change in the value of “Psychological well-being” is caused.
INFER: the influence from “Benevolence” to “Psychological well-being” is positive very high
12# **IF** a high change occurs in the value of “Self-direction”, **THEN** a high change in the value of “Psychological well-being” is caused.
INFER: the influence from “Self-direction” to “Psychological well-being” is positive very very high
13# **IF** a high change occurs in the value of “Ontological Identity”, **THEN** a small change in the value of “Social support” is caused.
INFER: the influence from “Ontological Identity” to “Social support” is positive medium.
14# **IF** a small change occurs in the value of “Ontological Identity”, **THEN** a high change in the value of “Benevolence” is caused.
INFER: the influence from “Ontological Identity” to “Benevolence” is positive very high.
15# **IF** a small change occurs in the value of “Ontological Identity”, **THEN** a high change in the value of “Psychological well-being” is caused.
INFER: the influence from “Ontological Identity” to “Psychological well-being” is positive very high.
16# **IF** a medium change occurs in the value of “Ontological Identity”, **THEN** a medium change in the value of “Resilience” is caused.
INFER: the influence from “Ontological Identity” to “Resilience” is positive medium.
17# **IF** a very high change occurs in the value of “Ontological Identity”, **THEN** a high change in the value of “Hedonism” is caused.
INFER: the influence from “Ontological Identity” to “Hedonism” is positive high.
18# **IF** a very high change occurs in the value of “Ontological Identity”, **THEN** a small change in the value of “Self-direction” is caused.
INFER: the influence from “Ontological Identity” to “Self-direction” is positive medium.

3rd health psychologist

1# **IF** a high change occurs in the value of “Conformity”, **THEN** a very small change in the value of “Social support” is caused.
INFER: the influence from “Conformity” to “Social support” is positive low.
2# **IF** a very high change occurs in the value of “Benevolence”, **THEN** an average change in the value of “Social support” is caused.
INFER: the influence from “Benevolence” to “Social support” is positive low.
3# **IF** a very high change occurs in the value of “Hedonism”, **THEN** a very small change in the value of “Resilience” is caused.
INFER: the influence from “Hedonism” to “Resilience” is positive very low.
4# **IF** a high change occurs in the value of “Self-direction”, **THEN** a small change in the value of “Resilience” is caused.
INFER: the influence from “Self-direction” to “Resilience” is positive low.

5# **IF** a high change occurs in the value of “Social support”, **THEN** a medium change in the value of “Psychological well-being” is caused.
INFER: the influence from “Social support” to “Psychological well-being” is positive high.

6# **IF** a medium change occurs in the value of “Resilience”, **THEN** a high change in the value of “Psychological well-being” is caused.
INFER: the influence from “Resilience” to “Psychological well-being” is positive high.

7# **IF** a high change occurs in the value of “Social support”, **THEN** a small change in the value of “Self-direction” is caused.
INFER: the influence from “Social support” to “Resilience” is positive medium.

8# **IF** a very high change occurs in the value of “Resilience”, **THEN** a medium change in the value of “Social support” is caused.
INFER: the influence from “Resilience” to “Social support” is negative low.

9# **IF** a high change occurs in the value of “Conformity”, **THEN** a low change in the value of “Psychological well-being” is caused.
INFER: the influence from “Conformity” to “Psychological well-being” is positive very low

10# **IF** a medium change occurs in the value of “Hedonism”, **THEN** a high change in the value of “Psychological well-being” is caused.
INFER: the influence from “Hedonism” to “Psychological well-being” is positive very high.

11# **IF** a small change occurs in the value of “Benevolence”, **THEN** a high change in the value of “Psychological well-being” is caused.
INFER: the influence from “Benevolence” to “Psychological well-being” is positive very very high

12# **IF** a medium change occurs in the value of “Self-direction”, **THEN** a high change in the value of “Psychological well-being” is caused.
INFER: the influence from “Self-direction” to “Psychological well-being” is positive very high

13# **IF** a high change occurs in the value of “Ontological Identity”, **THEN** a small change in the value of “Social support” is caused.
INFER: the influence from “Ontological Identity” to “Social support” is positive medium.

14# **IF** a medium change occurs in the value of “Ontological Identity”, **THEN** a medium change in the value of “Benevolence” is caused.
INFER: the influence from “Ontological Identity” to “Benevolence” is positive medium.

15# **IF** a medium change occurs in the value of “Ontological Identity”, **THEN** a high change in the value of “Psychological well-being” is caused.
INFER: the influence from “Ontological Identity” to “Psychological well-being” is positive high.

16# **IF** a high change occurs in the value of “Ontological Identity”, **THEN** a medium change in the value of “Resilience” is caused.
INFER: the influence from “Ontological Identity” to “Resilience” is positive very high.

17# **IF** a high change occurs in the value of “Ontological Identity”, **THEN** a medium change in the value of “Hedonism” is caused.
INFER: the influence from “Ontological Identity” to “Hedonism” is positive medium.

18# **IF** a very high change occurs in the value of “Ontological Identity”, **THEN** a medium change in the value of “Self-direction” is caused.
INFER: the influence from “Ontological Identity” to “Self-direction” is positive high.

In this step, the experts' linguistic variables attached to each relationship are aggregated. This procedure was done as explained in [21]. A weight matrix was produced consisting of all the weights of interconnections among the concepts. This resultant crisp weight matrix is given below:

| | <i>CO</i> | <i>HD</i> | <i>SS</i> | <i>RE</i> | <i>BE</i> | <i>SD</i> | <i>OI</i> | <i>PW</i> |
|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| <i>CO</i> | 0 | 0.0 | 0.24 | 0 | 0 | 0 | 0 | 0.20 |
| <i>HD</i> | 0 | 0 | 0 | 0.2 | 0 | 0 | 0 | 0.74 |
| <i>SS</i> | 0 | 0 | 0 | 0.42 | 0 | 0 | 0 | 0.57 |
| <i>RE</i> | 0 | 0 | -0.44 | 0 | 0 | 0 | 0 | 0.71 |
| <i>BE</i> | 0 | 0 | 0.46 | 0 | 0 | 0 | 0 | 0.74 |
| <i>SD</i> | 0 | 0 | 0 | 0.42 | 0 | 0 | 0 | 0.76 |
| <i>OI</i> | 0 | 0.58 | 0.51 | 0.66 | 0.65 | 0.55 | 0 | 0.73 |
| <i>PW</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

4-Simulation results

After construction the FCM-based simulation model, we can perform what-if simulations. For testing the scenarios, we have an initial activation vector $A^{(0)}$, representing the first value of each concept, and a final activation vector $A^{(K)}$ representing the last state after performing K iterations.

- (1) Define the initial activation vector $A^{(0)}$ to be used to initialize the concepts in the network.
- (2) Perform the neural reasoning using weight matrix (as depicted in Equation (1))
 - (2a) This new vector is considered as an initial vector in the next iteration.
 - (2b) Step 2 is repeated until $|A^{(k)} - A^{(k-1)}| < 0.01$

3-4- Inference for the case study

In this section, we analyse the simulation results. The data comes from 300 university students who answered the basic value orientations including Conformity, Hedonism and Self-direction scales [22]. Next, we perform some simulations given a certain scenario (that is to say, for a given initial state).

For this case study the confirmatory is middle ($A_1=0.53$), the hedonism is middle ($A_2= 0.47$) and the self-direction is almost low ($A_6=0.37$). Therefore, the initial vector in this case is $A^{(0)} = [A_1=0.53, A_2= 0.47, A_3=0, A_4=0, A_5=0, A_6= 0.37, A_7=0]$. The inference process for this scenario is depicted below.

$k=1$

$A^{(1)} = [\text{Conformity (1)}=0.53, \text{Hedonism (1)} = 0.47, \text{Social support (1)} =0.37, \text{Resilience (1)} =0.090, \text{Psychological well-being (1)} =0.77, \text{Self-direction (1)} =0.37, \text{Benevolence (1)} = 0]$

$k=2$

$A^{(2)} = [\text{Conformity (2)} =0.53, \text{Hedonism (2)} = 0.47, \text{Social support (2)} =0.33, \text{Resilience (2)} =0.25, \text{Psychological well-being (2)} =1, \text{Self-direction (2)} =.0.37, \text{Benevolence (2)} = 0]$

$k=3$

$A^{(3)} = [\text{Conformity (3)} = 0.53, \text{Hedonism (3)} = 0.47, \text{Social support (3)} = 0.26, \text{Resilience (3)} = 0.23, \text{Psychological well-being (3)} = 1, \text{Self-direction (3)} = 0.37, \text{Benevolence (3)} = 0]$

$k=4$

$A^{(4)} = [\text{Conformity (4)} = 0.53, \text{Hedonism (4)} = 0.47, \text{Social support (4)} = 0.27, \text{Resilience (4)} = 0.20, \text{Psychological well-being (4)} = 1, \text{Self-direction (4)} = 0.37, \text{Benevolence (1)} = 0]$

$k=5$

$A^{(5)} = [\text{Conformity (5)} = 0.53, \text{Hedonism (5)} = .47, \text{Social support (5)} = 0.29, \text{Resilience (5)} = 0.21, \text{Psychological well-being (5)} = 1, \text{Self-direction (5)} = 0.37, \text{Benevolence (5)} = 0]$

$k=6$

$A^{(6)} = [\text{Conformity (6)} = 0.53, \text{Hedonism (6)} = 0.47, \text{Social support (6)} = 0.28, \text{Resilience (6)} = 0.22, \text{Psychological well-being (6)} = 1, \text{Self-direction (6)} = 0.37, \text{Benevolence (6)} = 0]$

As $|A^{(8)} - A^{(7)}| < 0.0$, the recurrent reasoning process is finished. This means that the FCM-based simulation process converges in a steady state with the final concept vector to be: $A^{(6)} = [0.53, 0.47, 0.28, 0.22, 1, 0.37, 0]$. The final values of decision concepts are Social support = 0.28, Resilience = 0.22, Psychological well-being = 1, which denote 40%, 10% and 33.3% of the decision-making problem.

5-Discussion and concluding remarks

Causal relationships have an important position in psychological research. One of the most flexible methods to reason with causal relationships is Fuzzy Cognitive Map. This method is a knowledge-based approach to model and capture human being's cognitive process. This soft computing technique helps psychological researchers simulate and assess of psychological impacts. The modelling methodology using the FCM tool was applied as a part of decision making process. In this paper, the impact of six important variables on psychological well-being was investigated. It was shown that FCMs can be a useful tool for capturing the psychological experts' understanding of the system and incorporating the experts' knowledge and real data obtaining from a sample. The advantage of the proposed FCM tool in psychological research is the sufficient simplicity and interpretability for psychologists in the decision process, making it a convenient consulting tool in predicting the psychological well-being based on the hedonism, social support, resilience, benevolence and self-direction.

This application of FCM in psychological research can be of some new insights. In our case study, a sample of Iranian students aged 21-24 was investigated. Our research included three components of the personal value orientations including conformity, hedonism and self-direction, were used to assess social support, resilience and psychological well-being. The confirmatory and the hedonism are middle and the self-direction is low. Values or social virtues are increasingly recognized as organizing principles for human behaviours, cognitions and affect

expressions. The results have shown that social support, resilience, and psychological well-being capture 40%, 10% and 33.3%, respectively, of the decision-making problem.

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