VOL. 10, NO. 23, DECEMBER 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

DECISION NEUROSCIENCE MODELLING OF MOTIVATION FOR APPLICATION IN THE REHABILITATION OF PEOPLE WITH MENTAL DISABILITIES

Bin Ismail Ishak[1], Normal Mat Jusoh[2], Jasmy Yunus[2], and Abdul Kadir Abu Bakar[1]
[1]Hospital Permai R&D, JB, Johor, Malaysia
[2]Universiti Teknologi Malaysia, Skudai, Johor, Malaysia
E-Mail: normal@utm.my

ABSTRACT

Early this century, psychologists such as Linda Bartoshuk, Daniel Kahneman, Elizabeth Loftus and George Miller started to contribute to the cognitive school of psychology by delving into learning, memory and judgement. This has brought about the advancement of the field of decision neuro-science. In fact, Daniel Kahneman won the Nobel Prize in economics for his idea on psychological decision making and a system based model of psychological motivation. Thus studies on decision neuroscience was born driving a new thinking in knowledge information system and information system as a whole. Use of decision neuroscience concept is needed to solve the problem of conventional decision making theories in psychology as it has been found to be inadequate to explain human decision making process to predict selection of beliefs or a course of action. This paper proposes a decision neuroscience model (knowledge information system model) which has been named Positive Affective Cognitive Motivational State (PACMS) which can be used to predict decision making process and motivational drive of mentally ill clients. The proposed model emulates human biological system. It provides better predictive abilities and performs better than the decision making theory model first suggested by Roe, Busemeyer and Townsend [1]. Quantitative tests were carried out to investigate the outcome of the proposed decision neuroscience model using the data from mentally ill clients undergoing supported employment under the care of Hospital Permai JB Johor Malaysia. Two groups of mentally ill clients were compared. These groups were selected according to their responses of Action Decision Making Behaviour Selection (ADMBS) and Spatial Attention Target Tracking Language Understanding (SATTLU). The result has shown that motivation in any human behaviour change can be explained in terms of decision neuroscience by considering that motivation is a two part process consisting of a process of positive affective decision making followed by a cognitive process. PACMS is a system model for decision making and motivation which can be the basis of an embedded system mountable on any knowledge information system. Further work is ongoing to study how the excitation from the senses of touch, ordor, sound and vision as well as the excitation from the eye, limbs and mouth can be used to drive the Behaviour Planner which is responsible for making some form of decision.

Keywords: decision neuroscience modelling**,** positive affective cognitive motivational state, mentally Ill clients, resilience, behaviour planner, action decision making behaviour selection.

INTRODUCTION

Literature review

Positive affective cognitive motivational state (PACMS) of mentally ill clients (MI) is often referred to as "getting on with life". In most publication, this motivational state is called "resilience". Resilience is a personal quality which is not static. Instead, it is dynamic and is brought about by the interaction between vulnerability and the factors internal or external to the individual that serve to modify the effects of adversity [2 – 4]. Jun Tian *et al* [5] did a study on "Assessment of the relationship between resilience on quality of life in patients with digestive cancer". According to him, positive affective cognitive motivational state (resilience) moves from an old state to a new state when the patient is able to psychologically overcome some thresholds or tipping points as shown in Figure-1. Hence, failure can only be interpreted as a result of adaptation to cope with a problem and not as a breakdown or malfunction. Also according to Jun Tian et.al. [5], resilience is not an independent predictor of quality of life.

A mentally ill client's capacity and ability to recover is determined by his/her ability to achieve his/her psychological and physical wellbeing. Jun Tian *et al.* admitted that what influence resilience and how resilience effects quality of life will need much more research and debate. However, he did suggest that resilience is affected by (1) Positive attitude, (2) Optimism which is a positive self concept, (3) Ability to regulate emotions and manage strong impulses and feelings, (4) Ability to see failure as a feedback.

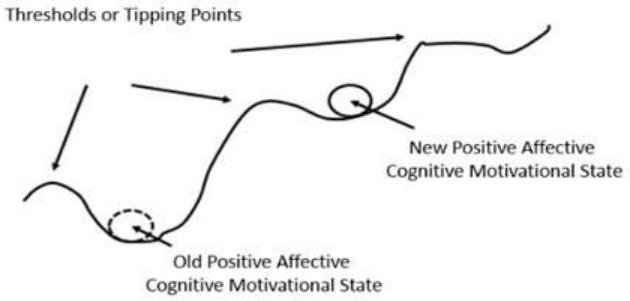

Figure-1. Positive affective cognitive motivational state (Resilience).

Hence, it is possible to treat positive affective cognitive motivational state (resilience) as a construct (dependent variable) which is affected by attitude beliefs, subjective norm which provides the social support and relationships as well as perceived behaviour control which governs the self-efficacy and proactive coping of mentally ill clients. This concept also proposes that positive affective cognitive motivational state (resilience) is a mediator to quality of life (outcome) which determines the behavior intention of mentally ill clients to be in a state of well-being which is measure of mentally ill clients' acceptance for behavioral change.

Proposed decision neuroscience model - positive affective cognitive motivational state (PACMS) and why PACMS is important

Psychological decision making and motivational models are not equipped with clear structures which can be used to predict human decision making. In many applications, it has become necessary to understand the neuroscience behind making a decision. Decision neuroscience is useful when targeting new behaviors and motivating a change from bad habits. When a person meets a car on the road and has to make the right decision so that he can avoid an accident and be safe, application of brain science behind his/her decision-making is an important life tool.

When a person has a better understanding of the neuroscience behind his/her decision-making, he/she is more likely to make decisions which can bring about positive outcomes. He/she will find that this understanding is important to avoid self-destructive choices which are everyday encounters with present day challenges relating to poisonous and addictive substance abuse and life problem coping.

Decision-making is determined by a person's ability and skill in situational control. With the right ability and skill, a person is able to break patterns of behavior simply by making better decisions. As decision making allows a person to change his/her mind and actions at any time. Even when he/she is stuck in a cycle of negative down-spiraling thinking and behavior, a change of attitude and decision-making can turn his/her life around.

In order to obtain a decision neuroscience model for MI, it is necessary to look at the overall structure associated with PACMS as in Figure-2.

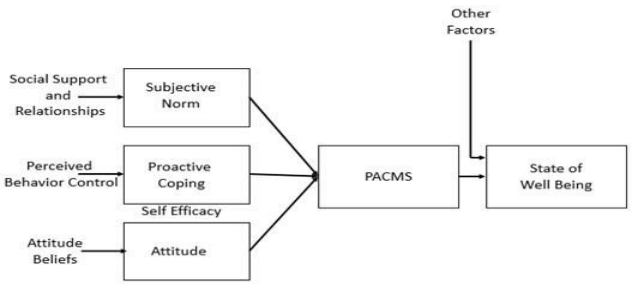

Figure-2. Overall structure associated with PACMS.

MI is able to experience this world in three ways, namely, the use of thought (cerebral), the use of the physical senses (sensate) and by the use of affective abilities (feelings). Affective abilities are driven by hormonal chemical response in the body which can lead to actions which are negative in nature (such as through sadness, resentment, hate, depression, melancholy, loneliness, etc. Affective abilities can also lead to actions which are positive in nature (for example love, trust, compassion, togetherness, friendship, etc). It is normally common to think of the feelings or emotions as positive or negative that can lead to positive or negative actions respectively. Certain negative affective abilities such as fear and aggression are important for the survival of the human species. Just as important are the positive abilities such as nuture and desire. In many varying degrees, every person is able to integrate thought and the responses from the physical senses to produce the appropriate affective abilities which bring about positive decision or negative decisions. These are the decisions to do or not to do; and to be or not to be which has been made famous by William Shakespeare in Hamlet with the evergreen quote shown below:

"To be, or not to be, that is the question:
Whether 'tis nobler in the mind to suffer
The slings and arrows of outrageous fortune,
Or to take arms against a sea of troubles
And by opposing end them …."

For MI, the manner in which the decision is made also depends on moral codes learnt since childhood and self efficacy. The power of thought, the physical senses and the affective abilities determine the decision boundary. How MI makes a decision depends on his/her perceived cost function. With positive affective consideration, there is a tendency for MI to do the positive and to be positive

PACMS is a process by which MI makes a positive decision followed by an act of cognition. Cognition has to do with how MI understands and then acts. It is associated with MI's skill and capabilities which are part and parcel of every human action. Cognitive abilities are skills worked out in the brain that is needed to perform any task from the simplest to the complex. They are associated with how MI learns, remembers and carries out problem solving. For instance, a climber who plans to climb Mount Everest has first to consider many issues from many angles before he/she decides positively. After having made the positive decision, he/she has to ascertain and work on his/her skills and resources before embarking on the act of climbing. This process taken after the positive decision is often repeated several times, causing delays in the act of climbing. As PACMS is a procedure for human motivation, it is aimed at the ultimate goal of security and success.

METHODOLOGY

The architecture of the decision neuroscience model was first designed. This architecture has three components as shown in Figure-4. The first component is the Sensory & Perception module. This module controls the somatic, auditory and visual features/precepts. The second module is the Cognitive Module. This module consists of (a)Auditory & Visual Object and Event Learning & Recognition, (b)Spatial Attention Target Tracking Language Understanding (SATTLU), (c)Spatial Navigation Adaptively Timed Learning Novelty Detection and Search – Multi Modal Information Fusion and (d)Decision Boundary Installer which is made up of Reward and Punishment Centre & Look and See Emotional Controller. The third module is the Execution Module which is made up of (a) Behaviour Planner, (b) Action Decision-Making Behaviour Selection (ADMBS) and (c) Other management/queuing units.

In order that architecture protocols can be emulated, it has been necessary to see the outcomes observed from the real living models. In this research, the real living models are MI.

As a preliminary study, it has been necessary to find out in what way Spatial Attention Target Tracking Language Understanding (SATTLU) and Action Decision-Making Behaviour Selection (ADMBS) determine the proactive coping, the getting on with life and independent functioning for MIs.

Two groups W1 and W2 of MIs were selected according to the observation of SATTLU and ADMBS as shown in Table-1a. Using the path analysis model of Figure-5a, and the technique of quantitative analysis employed by Greenglass *et al* [6], the relative abilities of group W1 and W2 in the skill of proactive coping, getting on with life and independent functioning were estimated using Smart PLS as shown in Figure-5b. Comparison were carried out using effect sizes [7].

The purpose of this test is to enable interpolation between the decision neuroscience model outputs with the emotional outcomes.

Decision making process for MI

Mental illness can make decision-making, from the perspective of MI, difficult and laborious. The ability of MI to make a decision may depend on the nature and extent of impairment at the particular time that a decision is needed and the type and complexity of decision that needs to be made. This paper describes two years of observations on MIs who had undergone satisfactory pharmacotherapy, psychotherapy, cognitive behaviour therapy and who had experienced inpatient services. Decision making process of MI can be described statistically in the following manner.

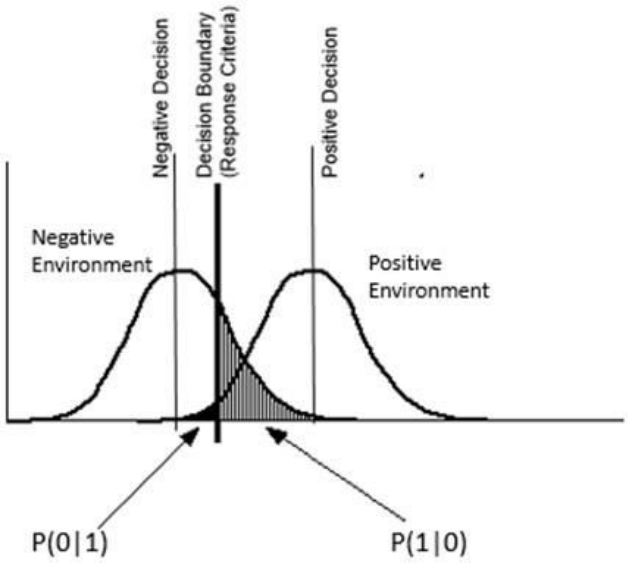

Figure-3. Probabilistic view of decision making by MI.

Referring to Figure 3, let
C_{00} be the cost of making a negative decision when the environment is negative
C_{10} be the cost of making a positive decision when the environment is negative
C_{11} be the cost of making a positive decision when the environment is positive
C_{01} be the cost of making a negative decision when the environment is positive.
Using the notation 1 to refer to positive decision and 0 to refer to negative decision,
MI's cost function

$$f = C_{00}.\, P(0|0) + C_{11}.\, P(1|1) + C_{01}.\, P(0|1) + C_{10}.\, P(1|0) \quad (1)$$

$$f = \{1 - P(1|0)\}.\, C_{00} + \{1 - P(0|1)\}.\, C_{11} + C_{01}.\, P(0|1) + C_{10}.\, P(1|0)$$

This gives

$$f = C_{00} + C_{11} + \{C_{10} - C_{00}\}\, P(1|0) + \{C_{01} - C_{11}\}\, P(0|1) \quad (2)$$

For minimum value of f,

$$\{C_{10} - C_{00}\}\, P(1|0) + \{C_{01} - C_{11}\}\, P(0|1) = 0 \quad (3)$$

Hence

$$\{P(1|0)\} / \{P(0|1)\} < \{C_{11} - C_{01}\}/\{C_{10} - C_{00}\} \quad (4)$$

In the case of Positive Affective Decision Making, C_{01} and C_{00} have zero values because they do not have any part in the decision making.

The value of C_{10} is very low because MI are rewarded if they make positive decision when the environment is negative. C_{11} is high because there is an effort to promote continuous improvement.

This statistical approach is used to describe the process of decision making of MI because there is now a

growing interest in decision neuroscience as researchers try to understand what is actually going on in the brain of MI when they are making choices. Earlier research work has shown that it would be possible to break down the thinking of MI to different parts. In this way, it would make it easier to understand how each component is linked to one another and how these components come together during the thinking and decision process. Those who partake in research work to fathom the intricacies of decision neuroscience believe that the work on neuroscience will enhance the understanding of the brain and will throw some light on the problems associated with a variety of mental illness like depression and schizophrenia. It has been known for some time now that mental patients tend to make poor decisions about many things all day long. Due to this, mental patients are unable to confront their anxieties and their other emotional states. This statistical approach is used to describe the process of decision making of MI because there is now a growing interest in decision neuroscience as researchers try to understand what is actually going on in the brain of MI

Cognitive process

PACMS consists of two processes. The first is the positive affective decision making process and the second is the cognitive process which is simplified as in Figure 4. In this paper, the layout in Figure 4 is an attempt to produce the structure of cognitive processes that imitates the brain, where there is a connection between the functions of physiology and anatomy [8-10]. The secret of the cognitive process is the integrated connection between (a) the senses such as touch, ordor, sound and vision, and (b) the physiological components such as eye/head, limbs and mouth to (c) the Behaviour Planner. This Behaviour Planner is continuously controlled by the Action Decision Making Behaviour Selection. Behaviour planner is also in direct contact to the Spatial Attention Target Tracking Language Understanding. One of the important features of the cognitive process is the feedback from the comparison between the Look & See Emotional Controller and the Reward Punishment Centre. Intermittently, the Behaviour Planner will get input from Spatial Navigation Adaptively Timed Learning Novelty Detection and Search Multi Model Information Fusion. This unit allows MI to learn any important matters that requires learning. Another type of learning is promoted by the Auditory & Visual Event Learning and Recognition. For cognitive process, adaptive timing is important because time makes any information relevant or otherwise.

Tests on the system

PACMS model was given a preliminary test to emulate its architecture protocols. It has been necessary to see the outcomes observed from real living models who were the MIs at Hospital Permai JB Johor. MI were selected on the basis of their Action Decision Making Behaviour Selection (ADMBS) according to the reaction time (slow or brisk) and also on the basis of their Spatial Attention Target Tracking Language Understanding (SATTLU) according to simple listening subjective tests (slow or OK). Group W1 has the characteristics ADMBS=Slow and SATTLU=Slow. Group W2 has the characteristics ADMBS=Brisk and SATTLU=OK. They were tested on Proactive Coping, Getting on with Life and Independent Functioning Abilities using the quantitative path analysis model of Greenglass [6] (refer to Figures 5a and 5b). For the quantitative tests, the model, questionnaires, the reliability and validity of data as carried out by Greenglass *et al* [6] were followed closely.

TEST RESULTS

Comparison was made based on effect sizes as stipulated by Keren and Lewis [7]. There is a high probability that similar effect sizes have the same strength, power or effect. The test has shown that the ability of MI with regards to Proactive Coping, Getting on With Life and Independent Functioning is as shown in Table-1.

Table-1. Relative ability of proactive coping, getting on with life and independent functioning.

Proactive Coping		Getting on With Life	
Group W1	Group W2	Group W1	Group W2
0.270	0.480	0.768	0.684

Independent Functioning	
Group W1	Group W2
0.331	0.655

Group W1 has the skills
Action Decision Making Behaviour Selection (ADMBS) =Slow
Spatial Attention Target Tracking Language Understanding (SATTLU) =Slow

Group W2 has the skills
Action Decision Making Behaviour Selection (ADMBS) =Brisk
Spatial Attention Target Tracking Language Understanding (SATTLU) =OK

The results show that MI with better Positive Affective Skills and Cognitive Skills tend to do better in Proactive Coping and Independent Functioning. There is no difference in the ability of these two groups in Getting on with Life

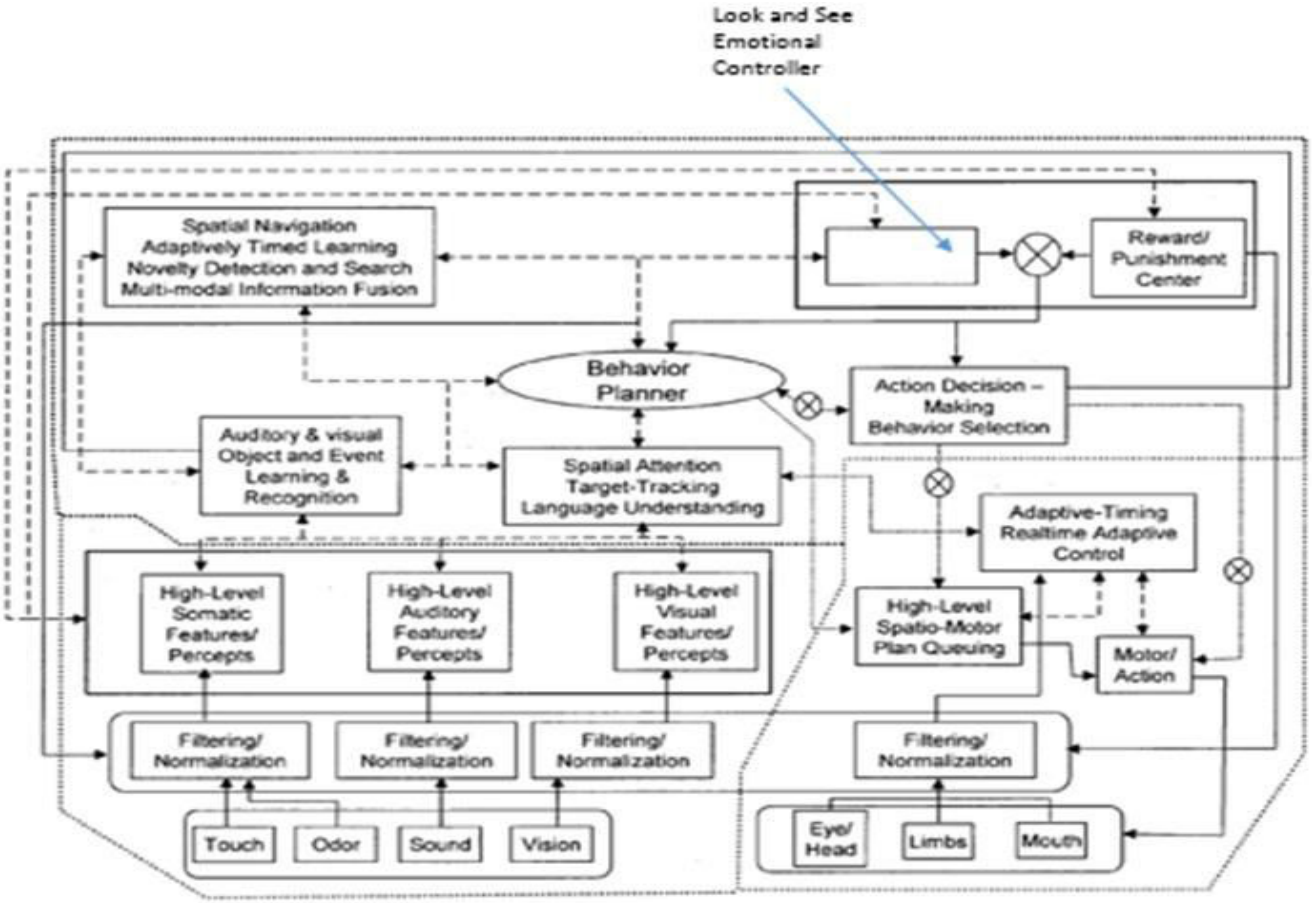

Figure-4. Proposed decision neuroscience model (Breakdown of the cognitive process).

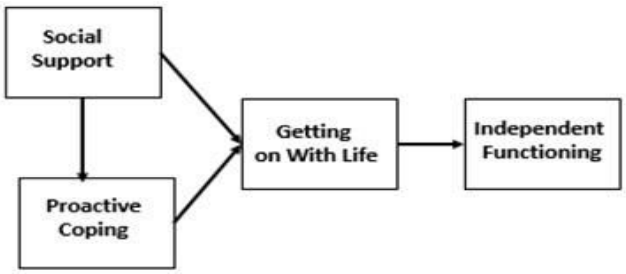

Figure-5a. Path analysis configuration used to test for PACMS.

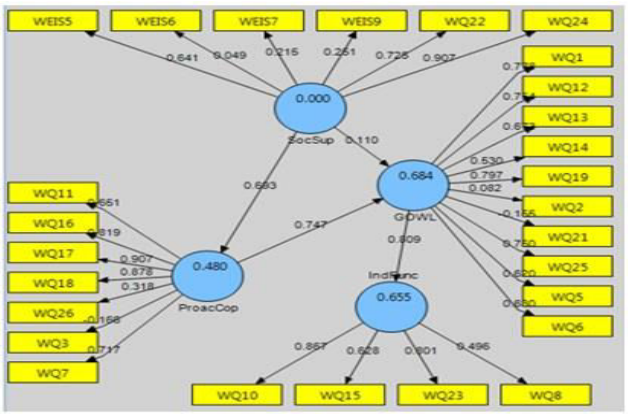

Figure-5b. Results of quantitative tests for PACMS.

CONCLUSIONS

Many researchers find it necessary to model motivation whether it be in Medical Research, in Learning Research, in Marketing Research or in Psychology Research. The idea that motivation can be modelled as a Positive Affective Process followed by Cognitive Process is about the best to date. Rough tests had shown that this concept is true for Mentally Ill Clients. Further tests have to be carried out to obtain the final model.

The decision neuroscience model research is in its preliminary stage. As the model is complex, it will take some time before an accurate working model can be made available. There is also the problem of interpolating emotional outcome with architecture output.

Tests have shown that proactive coping and independent functioning are enhanced if ADMBS and SATTLU are high. This indicates that proactive coping and independent functioning are associated with good communication abilities and good decision making skills. Decision neuroscience model proposed is a feasible information management system which can be implemented as an ASIC unit or as an embedded system. It is possible to have a working unit within the next couple of years with the current research climate in the field of preventive health care and in the field of business management.

REFERENCES

[1] Roe R.M., Busemeyer J.R. & Townsend J.T. 2001. Multi-alternative decision field theory: A dynamic connectionist model of decision making. Psychological Review, 108. 370-392

[2] Luthar S.S., Sawyer J.A. & Brown P.J. 2006. Conceptual Issues in Studies of Resilience – Past, Present and Future Research. Annals of the New York Academy of Sciences 2006, 1094. 105-115.

[3] Olsson C. A., Bond L., Burns J. M., Vella-Brodrick D. A. & Sawyer S. M. 2003). Adolescent resilience: A concept analysis. Journal of Adolescence 2003, 26. 1–11.

[4] Rutter M. 2006. Implications of Resilience Concepts for Scientific Understanding. Ann. N.Y. Acad. Sci. , 1094. 1–12 .C 2006 New York Academy of Sciences. DOI: 10.1196/annals.1376.002

[5] Jun Tian & Jin-Sheng Hong 2014. Assessment of the relationship between resilience on Quality of Life in patients with digestive cancer. World Journal Gastroenterol. 20 (48), 18439-18444. DOI: 10.3748/wig.v20.i48.18439

[6] Greenglass E.R. & Fiksenbaum L. 2009. Proactive Coping, Positive Affect, and Well-Being. Testing for Mediation Using Path Analysis. European Psychologist, 14(1).29-39.DOI 10.1027/1016-9040-14-1-29

[7] Keren G. & Lewis C. 2014. A Handbook for Data Analysis in the Behavioural Sciences, Vol 1: Methodological Issues, Vol 2: Statistical Issues. Psychology Press .584 pages. ISBN 1317759982

[8] Mishkin M. and Appenzeller T. 1987. The anatomy of memory. Scientific American, 256. 80-89

[9] Squire L.R. and Zola-Morgan S. 1991.The medial temporal lobe memory system.Science, 253. 1380-1386.

[10]Narayan Srinivasa & Deepak Khosia. 2008. Cognitive Architecture for Learning, Action and Perception, U.S. Patent No. US 20080091628A1. April 2008

[11]Burigo, M., & Knoeferle, P. 2015. Visual Attention during Spatial Language Comprehension. PLoS ONE , 10 (1), e0115758. http://doi.org/10.1371/journal.pone.0115758

[12]Kitajima, M. & Toyota, M. 2013. Decision-making and action selection in Two Minds: An analysis based on Model Human Processor with Realtime Constraints (MHP / RT). Biologically Inspired Cognitive Architectures, 5, 82-93.