Proceedings of the ASME 2011 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference
IDETC/CIE 2011
August 29-31, 2011, Washington, DC, USA

DETC2011-48595

CREATIVITY AND LONG-TERM POTENTIATION: IMPLICATIONS FOR DESIGN

Gregory M. Hallihan
hallihan@mie.utoronto.ca

L.H. Shu*
*Corresponding author: shu@mie.utoronto.ca

Dept. of Mechanical and Industrial Engineering
University of Toronto, 5 King's College Road
Toronto, ON, M5S 3G8, Canada

ABSTRACT

An emerging research trend has seen concepts from cognitive psychology applied to enhance the creative design process through a more detailed understanding of the underlying cognitive mechanisms. However, the physiological processes by which the human element achieves creative solutions have only recently received significant attention. Understanding the mechanisms that allow the brain to change in response to experience may have implications for creative thought processes. Long-term potentiation (LTP) is one such mechanism, and has already been implicated in learning and memory development. This paper presents a theoretical-physiological explanation of creativity, implicating LTP as a modulator of neural networks. The proposed model is applied to explain existing creativity phenomena, including fixation, incubation, and obstacles in design-by-analogy. The model is then used to describe existing, and propose new methods for overcoming obstacles to creativity in design. The results of a study, which tested one application of the theory – the effect of physical activity on fixation, are also discussed.

1. INTRODUCTION

Creative thought is the process by which individuals and groups advance society, whether through incremental changes to existing technologies, or through innovations that change the perceived limitations of systems. Developing a better understanding of the cognitive mechanisms of creativity supports the creative process, e.g., through development of more effective tools and methods for innovation (Cagan, 2007). Furthermore, it has been argued that any credible theory of creativity must be consistent with a modern understanding of brain function (Pfenninger & Shubik, 2001). We are thus motivated towards a better understanding of the cognitive and neurological mechanisms involved in creativity.

Research from cognitive psychology, which aims to model and describe human thought processes, is clearly applicable to the design process. Cognitive theories have long been applied to develop design tools. For instance, design techniques that encourage a more distributed thought process, e.g., brainstorming or the use of random stimuli, are shaped by Mednick's (1962) theory on the associative basis of creativity. Cognitive theories have also been used to develop computer software capable of simulating creativity (Boden, 1998). In addition to cognitive psychology, we also draw from research in neuroscience, the study of the nervous system, to develop a model of creativity and explain creative phenomena.

The goals of this paper are to:

1) Establish that a theoretical-neurological model based on long-term potentiation can accurately explain creativity phenomena relevant to design.
2) Describe how this theory could be applied towards enhancing the creative design process.
3) Discuss the results of a study that tested one application of the theory, highlighting key methodological challenges.

We first outline the relevant psychological and neurological literature related to creativity, with an emphasis on long-term potentiation (LTP). LTP is an increase in the efficiency of synaptic connections between neurons, due to their repeated and synchronous firing. Next, we discuss the role of LTP in creativity and potential applications of our LTP-based model to enhance creativity.

2. LITERATURE REVIEW SCOPE

Motivating our work is an initial literature review that identified a gap in the biological explanations of creativity. While multiple biological models of creativity exist, there is little work explaining how mechanisms of neural plasticity such as LTP are involved in the generation of creative thought. However, the likely role of LTP in memory formation (Bliss & Collingridge, 1993) as well as learning (Cline, 1998; Van-Pragg et al. 1999) suggest as a logical extension, the role of LTP in creative cognition, a process that involves both.