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# Computers & Education

journal homepage: [www.elsevier.com/locate/compedu](http://www.elsevier.com/locate/compedu)

## Internet cognitive failure affects learning progress as mediated by cognitive anxiety and flow while playing a Chinese antonym synonym game with interacting verbal–analytical and motor-control

Jon-Chao Hong<sup>a</sup>, Kai-Hsin Tai<sup>a,\*</sup>, Ming-Yueh Hwang<sup>b</sup>, Yen-Chun Kuo<sup>a</sup><sup>a</sup> Department of Industrial Education, National Taiwan Normal University, 162, Heping East Road Section 1, Taipei, Taiwan<sup>b</sup> Department of Adult and Continuing Education, National Taiwan Normal University, 162, Heping East Road Section 1, Taipei, Taiwan

### ARTICLE INFO

#### Article history:

Received 29 December 2015

Received in revised form 18 April 2016

Accepted 20 April 2016

Available online 22 April 2016

#### Keywords:

Human-computer interface

Interactive learning environments

### ABSTRACT

According to the person-artifact-task model, the process of gameplay can trigger a range of emotional responses and wide variation in students' behaviors, consequently leading to varying learning outcomes. How internet cognitive failure (ICF) can affect a game player's cognitive anxiety and flow experience, and how this interplays with learning progress was explored in this study. Ninth grade students participated in playing "Running Chinese Zodiac", a Chinese antonyms and synonyms App game, which combines interactions of verbal–analytical aspects with motor-control. The motor-control aspect required players to control a tilt mechanism by tilting the smartphone left or right to select the correct answer. Data from 149 students were collected and subjected to confirmatory factor analysis and structural equation modeling. The results revealed that ICF was positively correlated to cognitive anxiety, but it was negatively correlated to flow experience. Cognitive anxiety was negatively correlated to flow experience and learning progress; while flow experience was found to be positively correlated to learning progress. The results implied that a game with verbal–analytical and motor-control would be useful to students with a low level of ICF to learn Chinese synonyms and antonyms.

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## 1. Introduction

Finneran and Zhang (2003) proposed a person-artifact-task (PAT) model that conceptualized the main components of an individual working on a computer-related task. According to the model, the process of gameplay can trigger a range of emotional responses and wide variation in students' behaviors, consequently varying their learning outcomes (Shute et al., 2015). For example, flow experience is dependent on the interplay between the person, the task, and the artifact (Kiili, 2005). For the design of educational games, the challenge of the game should be able to maintain pace with the learners' growing abilities and their learning (Hamari et al., 2016). Previous studies have contributed to the psychological factors of challenges, skills, engagement and immersion that have been commonly believed to be characteristic of a superior game and

\* Corresponding author. P.O. Box 7-513, Taipei, Taiwan.

E-mail addresses: [tcдахong@gmail.com](mailto:tcдахong@gmail.com) (J.-C. Hong), [star99xin@gmail.com](mailto:star99xin@gmail.com) (K.-H. Tai), [t06013@ntnu.edu.tw](mailto:t06013@ntnu.edu.tw) (M.-Y. Hwang), [jekuo.ntu@gmail.com](mailto:jekuo.ntu@gmail.com) (Y.-C. Kuo).

a desirable learning experience (Hamari et al., 2016). Thus, the main contribution of the PAT model to gameplay has been to provide an approach for us to consider what actually influences one's experience in gameplay; the game itself or individual differences.

Learning is an emotional and cognitive experience (Frijda, 1986). There are two models that can be used to examine the potential causal influence of inattention on boredom and depression: attention-to-affect (Satpute, Shu, Weber, Roy, & Ochsner, 2013) and affect-to-cognition (Carpenter-Thompson, Akrofi, Schmidt, Dolcos, & Husain, 2014). In the perspective of attention-to-affect, cognitive failure can cause absent-mindedness (i.e., losing the flow experience), and increase one's anxiety to affect learning progress (Forster & Lavie, 2007; Tipper & Baylis, 1987). Regarding affect-to-cognition, emotions can also negatively or positively affect student motivation (Pekrun, Goetz, Titz, & Perry, 2002), which in turn impacts an individual's concentration on cognitive processes to ultimately influence learning progress (Giannakos, 2013). In line with above psychological views, cognitive failure may reflect a decline in efficiency of perceptual levels of Internet learning (Hong, Hwang, Liu, Ho, & Chen, 2014). Hong et al. (2014) extended cognitive failure during Internet usage to Internet cognitive failure (ICF) and focused on how it influences other affective perspectives. Despite Hong et al.'s (2014) study on the cognitive-affective learning mechanism in digital games, the uptake in a formal Chinese language learning context remains limited.

In addition to attention-to-affect theory, game-based learning environments have proven to be effective at gaining learners' attention (Bergeron, 2006). All attention is focused on relevant stimuli that generate a flow experience to reflect a state of total absorption in a demanding task with no energy remaining for distractions (Csikszentmihalyi, 1990; Kiiili, 2005). In this study, we investigated the relation among these variables, and the extent that they predict the affective factors in an educational App game. That is, we explored the extent that individual cognitive ability and cognitive anxiety are antecedents to the flow experience.

This study designed a Chinese synonyms and antonyms App game called "Running Chinese Zodiac", which combines interactions of verbal–analytical aspects with motor-control. The game requires the player to use their executive functions in a gameplay task that involves multiple vision locations coordinated with human–computer interaction (HCI) (i.e., through the gyroscope sensor, the player gently tilts the smartphone left or right to select the correct answer in the game). In a competitive game, it is expected that players' cognitive anxiety and flow experience would be raised by the changing interacting demands; this could then influence the individuals' learning outcomes (Hamari et al., 2016; Khan & Pearce, 2015). Thus, the aim of this study was to establish a research model to identify the interrelatedness among Internet cognitive failure, cognitive anxiety, flow experience, and learning progress.

## 2. Literature review

According to the mechanisms of sensory processing and motor control (Wilson, 2002), the activity of the mind is grounded in mechanisms surrounding the tilt interaction and the zodiac agent in the game. This set of abilities reflects that Chinese Running Zodiac, a Chinese antonyms and synonyms App game, could be played competitively in rule-governed manipulations of symbolic states and cognitive process under time pressure (Gomila & Calvo, 2008). There are two models that can be used to examine the potential cognitive and affective effects under time pressure: attention-to-affect (Satpute et al., 2013) and affect-to-attention (Carpenter-Thompson et al., 2014). In line with the attention-to-affect model, this study took Internet cognitive failure to explore the correlates to cognitive anxiety and flow experience. In line with the affect-to-attention model, this study took cognitive anxiety and flow experience to examine the correlates to learning progress.

### 2.1. Internet cognitive failure

Cognitive failure has been recognized as a key antecedent of behavior in particularly complex and unstructured tasks (Cohen, McClure, & Yu, 2007; Stemme, Deco, & Busch, 2007). Cognitive failure has been extended by Hong et al. (2014) to ICF to understand the interplay between cognitive and affective factors. Cognitive ability has also been recognized to be one of the most important factors for analyzing individual performance in dynamic learning systems (Laughery, Lebiere, & Archer, 2006). Cognitive failure can be defined as a mistake in performing an action that a person is normally capable of completing (e.g., Wallace, Kass, & Stanny, 2002). However, studies have seldom focused on how human cognitive systems interact with gameplay in seeking information to respond to questions that appear in an App. In accordance with this, by using a game as a dynamic learning system, this study aimed to explore how learners apply domain knowledge to interact with a game environment that has embedded verbal–analytical with motor-control mechanisms, and how this could be influenced by Internet cognitive failure.

### 2.2. Cognitive anxiety in the context of a competitive game

State anxiety (including both cognitive and somatic components) can be differentiated from personality trait anxiety (including both cognitive and somatic components) (Spielberger, 1972). Spielberger (1972) defined state anxiety as "consisting of unpleasant, consciously perceived feelings of tension and apprehension" (p. 29). The term affective state refers to emotions, attitudes, beliefs, intents, desires, and frustration moods. These states have cause and effect relations with cognitive processes (Bechara, Damasio, Tranel, & Damasio, 1997). Cognitive anxiety refers to the underlying psychological reactions to various situations (Buss, 1962). Whereas Castellar, Van Looy, Szmalec, and de Marez (2014) highlighted using games for

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