The Role of Affective Factors in Computer-Aided Musical Learning for Non-musician Adults

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Abstract. The objective of this study is to reveal the relationship between affective factors and musical learning in computer-aided learning situation. Musical learning is a dynamic, integrated process which encompasses cognitive, psychomotor, and affective learning domains. While most studies on computer-aided musical learning tend to highlight cognitive and psychomotor factors, this study focuses on affective factors and experimentally investigates how these factors can influence visual, auditory, and audiovisual learning efficiency. This study contributes to computer-aided musical learning research by focusing on affective factors, which have been previously neglected in this field of study, proposing a new model of computer-aided musical learning systems. Additionally, by adopting affective computing methods to a platform specially optimized to create interactive sound, this study provides a new possibility of quantification of emotional changes when experiencing and learning music.

Keywords: Computer-Aided Affective Learning, Affective Computing, Musical Learning, Facial Recognition, Affective Agent.

1 Introduction

Alongside technological advance, there has been significant progress in the computer-aided instruction (CAI) field for musical learning over the last half-century. There have been numerous attempts to use computers in music education with high interdisciplinary approaches in various aspects of musical learning, which include music theories, listening skills, musical performances, and so on. A Number of studies have found that the use of computer can bring up positive effect on musical learning [1] [2] [3].

Musical learning is a dynamic, integrated process which encompasses cognitive, psychomotor, and affective learning domains. However, musical learning with computers has a tendency of highlighting cognitive and psychomotor factors, overlooking affective factors. This seems to result from the historical flow that behavioral and cognitive psychology have been major roots of music education since the 1960s [4]. In fact, development of computer-aided musical learning systems is more related with

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the advancement of music “technology”, rather than psychological consideration. The fact that CAI in music can be categorized into five generations, depending on the advent of new technology, such as personal computers, MIDI, and the internet [5] shows that CAI in the music education has been focusing more on applying new technology, rather than considering the intrinsic aspect of the human learning process.

This study aims to focus on the affective domain in computer-aided musical learning. The objective of this study is to reveal the relationship between affective factors and musical learning in computer-aided learning situation; specifically, how these factors can influence the learner’s visual, auditory learning performances. To achieve this goal, a literature review on affective computing is conducted in order to design a method that can activate the learner’s emotional state. Based on previous research, two prototypes of computer-aided music learning systems are developed on Max/MSP. An experiment is devised and carried out on how affective factors can influence auditory, visual and visual-auditory learning.

2 Affective Computing and Learning

An accelerated flow of findings in neuroscience, psychology, and cognitive science point out that the human brain is not a purely cognitive information processing system, but a system in which affective and cognitive functions are inextricably integrated. Over a decade ago, a movement to develop theories and technologies to integrate these two into computerized learning environments. The progress of affective computing area, which is referred as “computing that relates to, arises from or deliberately influences emotions [6]”, has enabled computers to recognize the learner’s emotional state and provide appropriate feedback. According to Picard [7], the major issues on affective computing and learning are 1) how to build tools and technologies that elicit, sense, communicate, measure, and respond appropriately to affective factors, 2) how to build new models and learning systems that incorporate affect, as a foundation for both new approaches to education and more effective machine learning, and 3) how to developing affectively vocative materials, things-to learn, and learning environments.

Table 1. Overall framework of computer-aided affective learning system studies

Categories	Goals	Methods
Affect Recognition	Development of Tools and Technology	Personal Preference Information
		Facial Expressions
		Physiological Data
		Speech Recognition
		Use of Questionnaire
Emotional Instruction System)	Building Systems and Models	Designing Emotional Agents
		Designing the Interface
	Evocative materials and learning	Designing Emotional Instructional Strategies

Computer-aided affective learning systems aim to enhance learning effectiveness through the activation of an emotional state, which is beneficial to learning [8]. A number of theoretical, technological, and practical studies on computer-aided affective learning systems have been carried in many different ways over the recent years. The studies of such systems can be categorized into two issues: a) how to develop tools to "recognize" the learner's affective state (Affect Recognition), and b) how to develop the system to "respond" to this emotional state to enhance the learning process (Emotional Instruction System). Table 1 shows the overall framework of the researches on learning and affective computing, based on Moridis' review [8].

3 Materials and Methods

3.1 Experimental System Design

Two prototype computer-aided music learning systems are developed: one for affective learning condition and the other for cognitive learning condition. The system is developed using MAX/MSP, developed by Cycling'74, a graphical environment optimized to create sound and multimedia interfaces. While both systems deliver learning sessions by playing sounds and enabling users to interactively play notes on an onscreen instrument, the affective system implements additional features based on affective computing studies.

Figure 1 shows the system diagram of the computer-aided affective musical learning system for the affective condition. The system has two parts: (1) course learning mechanism, which enables learners to access the course database of music theories; (2) affective learning mechanism, which is expected to enhance the learner's emotional states by emotional recognition and feedback.

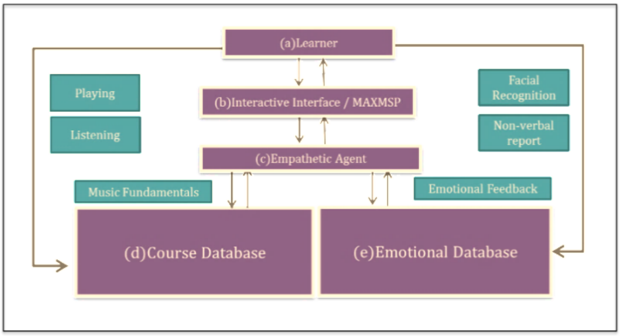


Fig. 1. System diagram for prototype of the computer-aided affective musical learning system

As discussed in chapter 2, a computer-aided affective learning system must be capable of 1) recognizing the learner's emotional states and 2) providing appropriate feedback to enhance the learning process. In order to fulfill these requirements, two different emotional methods were employed: 1) facial recognition and 2) emotional feedback through empathetic agent. For facial recognition, the idea of facial animation parameter normalization introduced by Pandzic and Forchheime [9], which can be used for 3D analysis of facial expressions with a set of facial parameters for expression with average recognition rate up to 91.3 % [10], was applied. With this approach, the implemented learning system can measure a quantified amount of emotional state by calculating ratios of learner's facial features during musical learning. The empathetic agent system is based on Moridis [11], which could be effectively used as emotional feedback to improve emotional state and brainwave activity toward learning. Figure 2 illustrates the results of the proposed and implemented system. (a) Emotional state bar is changed interactively based on learner's facial expression, while (b) the Empathetic agent provides verbal, non-verbal empathetic feedback through (c) Dialog Box during learning session. Learners can also hear the sound by clicking (d) Sound Button and playing an (e) Instrument. On the instrument, visual information is provided with different colors of the keys depending on the sound learners are currently studying.

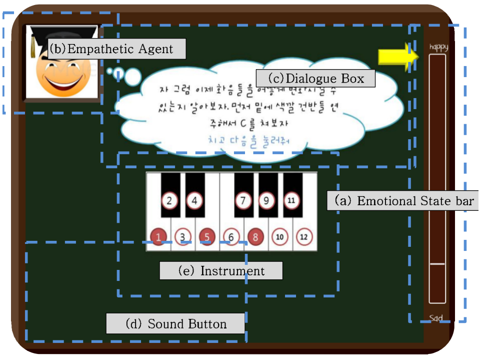


Fig. 2. System Interface

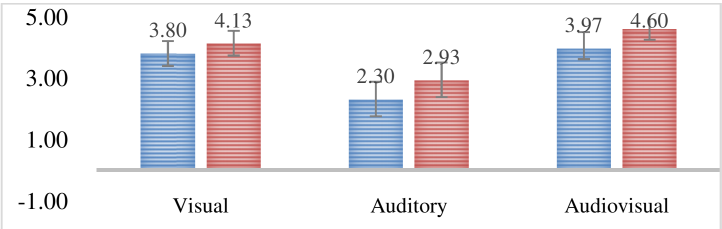
3.2 Experimental Procedure

The main purpose of the experiments was to explore how affective factors can influence learner's visual, auditory and audiovisual learning under computer-aided musical learning situation. The experiment was conducted on 32 non-musician adult participants ranging from their 20s to 40s, 17 males and 15 females. Two prototype systems, a) one using cognitive learning methods and b) another using both cognitive and affective learning methods were used for musical learning as experimental materials. During the experimental sessions, participants were asked to study two music theory chapters on interval and harmony: one chapter under affective learning condition, and the other under cognitive condition. To minimize the influence of the learning topics and tasks, participants were divided into 2 groups; 1) 'Group A' studied the topic 'interval' under affective conditions and the topic 'harmony' under cognitive conditions, and 2) 'Group B' studied the same topics under opposite conditions.

After studying for thirty minutes, participants were asked to solve tasks based on the learning materials studied during experimental session. For the tasks, participants were asked to decide which interval or chords they were looking (visual) or listening (auditory), and both looking and listening (audiovisual). To assess the effect of affective learning factors, the tasks were given in three different types. For the visual tasks, participants were not allowed to listen to the sound of the instruments, but could “see” the keys of piano to decide the answer. For the auditory test, participants couldn’t see the keys, while they could hear sound. Lastly, for audiovisual, participants could both hear and see the information to decide the answer. Each task was composed of 5 questions, 15 in total.

3.3 Results

Figure 3 illustrates the descriptive statistics of participant task scores of visual, auditory, and audiovisual tasks under affective and cognitive conditions. Accuracy is highest when participants solved the task under audiovisual conditions, and lowest when only auditory information was provided.



N=32

Task Condition	Average		Standard deviation		t-value	p-value
	Cognitive	Affective	Cognitive	Affective		
Visual	3.80	4.13	0.83	0.76	-.1589	.117
Auditory	2.30	2.93	1.16	1.06	-.2169	.034*
audiovisual	3.97	4.28	1.08	0.66	-.2692	.009*

*p<0.05

Fig. 3. Result of descriptive statistics and T-test analysis

A T-test between the scores of cognitive and affective tasks has been conducted on the three different types of study: visual, auditory, and audiovisual studies. Figure 4 summarizes the task accuracy results. In auditory and audiovisual tasks, affective learning models exhibit higher scores, and the difference is statistically significant. However, visual tasks fail to show significance. This result suggests that affective factors might be more related with auditory learning than visual learning, showing that affective factors might have a different influence level on visual, auditory learning efficiency during studying music.

4 Conclusion and Discussion

This study contributes to computer-aided musical learning research by showing the positive effects of affective factors, which have been neglected by most studies, and thereby highlighting the importance of them. The new model of computer-aided affective musical learning systems proposed in this study can provide learners an enhanced learning experience with greater learning efficiency. Additionally, by adopting affective computing methods to a platform specially optimized to create interactive sound and multimedia, this study provides a new possibility of quantification of emotional changes when especially experiencing music. We expect that this type of affective computing methods can be applied to many fields of studies: not limited to musical learning, but also musical expression and performances.

However, a challenging issue yet remains, regarding the true role of affective factors in learning. The result that affective factors can enhance auditory musical learning effectiveness has two possible explanations: 1) as auditory learning processes are not widely used compared to visual learning, affective factors might enhance learning experience when using relatively unfamiliar media, and 2) auditory learning processes benefitted from affective factors due to the audial nature of music. This question is to be verified in further studies by comparing the effect of affective factors on a) musical and non-musical learning materials, and b) musical and auditory learning processes.

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