Towards the Development of A Virtual Counselor to Tackle Students' Exam Stress

Manolya Kavakli\textsuperscript{a}\textsuperscript{*}, Manning Li\textsuperscript{b} and Tarashankar Rudra\textsuperscript{a}

\textsuperscript{a} Department of Computing, Faculty of Science, Macquarie University, Sydney, Australia
\textsuperscript{b} Northeastern University, Shenyang, Liaoning, China, 110819

Abstract Exam stress is a common predicament faced by students of all age groups and cultures. If improperly managed, it can lead to insomnia, depression, suicide and many other negative health implications for students at all levels of education. However, exam stress management gained relatively low attention from the society and academia. Stress in optimal level can stimulate students to achieve their personal best in their exams. However, excessive stress can be devastating for their well-being. Consequently, it is highly imperative that timely counselling services are made available, particularly during their exam period when there is a bursting demand to access these resources. In this study, we propose that a virtual intelligent university student advisor would be highly useful and effective in meeting this demand. We have developed an embodied conversational agent, ESCAP that simulates the facial animations and advice of a professional psychologist to support undergraduate students in stress management during their exams. In this paper, we discuss the system architecture of ESCAP as well as the practical and theoretical implications of the system. We conducted a number of pilot tests with 25 students to design the affective system and found in 200 samples that in general the voices of male advisors are considered as more pleasant and credible than female advisors\textsuperscript{*}; on the other hand, the voices of female advisors are considered as more clear, dynamic and competent than male advisors by most users. These findings have important implications on the design of virtual psychologists, especially regarding the gender of the virtual advisor. System developers should consider the gender of virtual advisors carefully to maximize their effect on users. The next stage of the project involves large scale experiments testing ESCAP’s impact on students. In these experiments, we plan to measure the stress level of students using both qualitative and quantitative measures such as heart beat and skin conductivity before and after their interactions with ESCAP.

Keywords: virtual psychologist, prototype evaluation, agent-based modelling, exam stress, coping theory

1. Introduction

Increasingly, educational stress is affecting the mental health of students from diverse age groups and educational levels (Kernan, Wheat &Lerner, 2008; Vaez & Laflamme, 2008). As the society becomes more competitive, educational institutions and parents focus more and more on students’ academic achievements. Stress is essential for effective study, since appropriate level of stress boosts our
concentration and self-disciplinary capabilities. However, it is the excessive stress and the series of related symptoms such as anxiety, worry and fear of failure that can potentially result in poor exam performance and have negative impact on student’s mental and psychical health. Exam stress has been reported to lead to depression, anxiety, substance abuse, delinquency and suicide (Lee, 2010; Yang and Shin, 2008).

According to the Australian Bureau of Statistics, during 1973–1987, suicide rates for young males (aged 15–24) increased by 66% in Australia and 127% in New Zealand. There was an increase of 51% in suicide rates in Australia between 1980–1990, and 95% in New Zealand. A study involving 1,678 Queensland university students showed that 61.5% have had some suicidal ideation or behaviour in the last 12 months, with 11% reporting having made at least one suicide attempt. In New South Wales, suicide rates are reported as 54 per 100,000 for young males and 67 per 100,000 for young females based on hospital data. Although we are not sure about the reasons for suicide attempts, these statistics demonstrate the significance of excessive stress in young population.

Improved accessibility to counselling services for at-risk students is found to be among the best intervention strategies to improve such situations (Washburn & Mandrusiak, 2010). The traditional ways of providing face-to-face counselling services have been proven to be effective in helping students to get over this particular time of difficulty. However, given the high demand of such services during exam period, it is very unlikely that those issues be addressed timely for every student. Further, quite a number of people have the perception that visiting a psychologist is equivalent to admitting that they have psychological problems. Some people fear social stigmatization and worry about being witnessed by acquaintances while visiting psychologists. These factors make it challenging to reveal a student’s emotional problems related to exam stress. Consequently, the availability of an intelligent and human-like virtual advisor would allow students to have easy access (e.g., computers or smart phones) to exam-stress related confidential advice and timely support. Such a virtual advisor is a promising way to address the aforementioned problem.

Existing virtual autonomous psychologists are either text-based or offer limited intelligence (e.g., see the avatar created by Jamie Durrant at Lionhead, using case-based reasoning technologies (Durrant, 2011)). Others require the presence of human psychologists on telephone or online (e.g., see (Loughnane, 2011)) or offer limited interactive capabilities (e.g., virtual doctor (Schueler, 2011)). There also exist voice-based artificial intelligence (AI) systems to support healthcare professionals in their diagnosis and treatment of patients (IBM 2011). However, it is not in embodied form and does not directly interact with patients. We aim at designing an avatar (Dr McQuerry) simulating a human psychologist with facial expressions and conversational intelligence. Besides, to our knowledge very few studies focus on student exam stress management through virtual counsellors. Our study intends to fill this gap in literature and advance theories on the design and evaluation of virtual psychologists in the field of information systems.

Consequently, we address the following research questions:

- Is it possible to simulate the personalized interactions between a virtual psychologist (ESCAP) and a student requiring help to manage their stress levels during exams? and, if yes,
- How to evaluate the effectiveness of this virtual psychologist (ESCAP)?

To clarify the scope of the paper, we focus on looking at how to design and evaluate an effective virtual psychologist to help students with their exam stress management. Therefore it is important to clarify that, unlike its connotation in common parlance, coping with exam stress is not equivalent to exam success – rather we focus on student’s mental and physical well-being through effective stress management. Further, we also narrow our targeted population to freshmen (first-year undergraduate students). Due to their transition into university life from high schools, first-year undergraduates may exhibit disparate stress coping taxonomies to other groups.

The rest of the paper is organized as follows: First, we explore the theoretical background related to the issue of interest, including a review of literature and applications in the virtual psychologist domain and coping theories in stress management (Section 2). Through the prototyping method, we empirically study how virtual psychologists can be designed to help students to positively cope with their exam stress.
(Section 3). Then, we present the research framework and system architecture for ESCAP (Section 4-9). In this part, we also present the results of our pilot studies regarding the credibility, competence, and attractiveness of the gender of a virtual psychologist. Finally, we discuss the implications of our current research and plans for future work (Section 10).

2. Theoretical Background

2.1. Virtual psychologists

People tend to react to avatars as if reacting to real human beings. Slater and colleagues (2006) replicated a famous yet controversial experiment (Milgram, 1963) in a virtual environment. Their findings state that in spite of the fact that all participants know that they are interacting with virtual characters and a virtual environment, they respond to the situation at the subjective, behavioural and physiological levels as if it were real. This is evidenced by concrete measures such as an increase in the participant’s heart rate (Slater et al. 2006). This finding motivates our study towards students’ exam stress management regarding the use of a virtual psychologist. There are other supporting studies suggesting that people feel more comfortable when interviewed by media-mediated electronic doctors and are more likely to release their flinched mind during the consultation process in contrast to human doctors (Yoshida et al., 2002).

Although the idea sounds promising, the current challenges for the virtual psychologist to effectively convey a feeling of social presence for its users lie in two aspects: 1) “behavioural realism” and 2) “conversational realism”. To enhance behavioural realism, scientists in the University of Southern California’s Institute for Creative Technologies managed to create virtual humans that can exhibit non-verbal human behaviours such as emotions and gestures (Rickel et al., 2002). Advancements in “Chatbot” technology, which can simulate conversations of an intelligent human being, complements the features of a virtual human stated above and make the idea of a highly-realistic virtual advisor possible. For example, a virtual advisor called “Franco”, developed by Defence Science and Technology Organisation (DSTO) at Edinburgh, South Australia, would answer questions related to military aircraft, ships and geographic information (Broughton et al., 2002). Our research aims at incorporating both of these advancements into the design of our virtual psychologist, ESCAP, using affective computing.

Affective computing refers to a future generation of flexible, learnable, and emotionally responsive user interfaces. The basic argument in affective computing is that computers cannot respond properly to the users, since they have limitations in the interpretation and evaluation of the users’ social signals. This causes a major breakdown in human computer interaction (HCI). If we want computers to be genuinely intelligent and to interact naturally, we must give computers the ability to recognize, understand, even to have and express emotions. In literature, there are attempts to develop affective agents. For example, (Cassell et al., 1999) developed technologies for sensing user affects through a variety of physiological, nonverbal and verbal channels (e.g., facial expression, postures, galvanic skin response, muscle contraction and speech.) Others developed systems for displaying affective signals using a variety of modalities (e.g., speech and facial expression (Tosa, 1994), and motion dynamics and natural language text (Hovy, 1990)). (Allbeck & Badler, 2002), (Rosis et al., 2003), and (Ball & Breese, 2000) generated affect and personality using a variety of behavioural cues including vocal cues, verbal cues, facial expressions, gestures and postural information. (Vanhala & Surakka, 2005) developed an affective system reading various physiological signals from the user’s facial muscles and heart rate, and combining these with Finnish speech synthesizers as well as a special chair to analyse users’ emotion-related body movement behavior for the production of electronic social-emotional cues for the user while interacting with digital media. Our aim in this study is using psycho-physiological feedback of the user, sensing the affective response such as facial expression, speech recognition, emotion recognition from speech, gesture recognition, and other physiological readings such as heart rate and galvanic skin response.
Creating character believability involves not only creating intelligence or realism but also providing affective connection between humans and agents. Modelling expressive agent motions that can embody distinctive personalities and engage in nonverbal communication has not been studied in detail in AI. With today’s technology, using Emotion Sensors, we can sense the emotion of the student from the statistical prosodic feature of speech by an emotion detection software. Such an emotion detection software was developed at Vox Institute, Geneva by (Zei, 2010) using PRAAT (Dutch for ‘talk’) software technology. We can also collect data about skin conductivity and heart beat. Based on the context and the sensed emotion of the student, the avatar of ESCAP (Dr McQuerry) can be emoted in real-time through dynamically generated XML from the ESCAP system database which we have developed using a behavioral markup language (BML). This technique is similar to the one in GRETA developed by (Pelachaud 2009) which is a multi-lingual embodied conversational agent.

2.2. Stress management and moping theory

Exam stress is common for students of all ages, regardless of their socio-economic, cultural and educational background. Stress is defined as a relationship between the person and the environment that is perceived as relevant to the person’s well-being and in which the person's resources failed to meet the demand (Coyne et al., 1980). An appropriate level of stress can help students to concentrate on preparing for their assessment tasks by triggering the secretion of a charged chemical called “adrenaline” in the central nervous system thus boosting our capability to cope with stress, anger or fear through increased heart rate, blood pressure, cardiac output and carbohydrate metabolism (Karavolos et al., 2008). However, too much stress will result in negative impacts on memory, exam performance, mental health and physical well-being (Lee, 2010; Yang & Shin, 2008). One common symptom of exam stress is distress or depression, which can happen even to young children (Hilsman & Garber, 1995). To proactively prevent these negative impacts from happening, stress management is essential.

Stress management, or coping, involves constantly changing cognitive or behavioral efforts to manage situations appraised as taxing or exceeding a person’s resources (Amirkhan & Auyeung, 2007). It encompasses two major forms of techniques: approach (active) coping and avoidant (passive) coping. Active coping involves a person taking active initiatives to change the situation through actions and/or cognition; it is empirically found to be more effective in mitigating stress as compared with passive coping, which refers to the person trying to ignore the stressful problem (Compas et al., 2001). Previous studies empirically show that students can be trained to handle stress better (Monkong et al., 2009). Consequently, we introduce a system for a virtual psychologist, ESCAP with the purpose of helping students to enhance their coping strategy and convert stress into efficient work.

Coping theory states that coping with stress can be considered as either a personal problem solving style, or as a problem solving process (Monkong et al., 2009). In this study, we take coping as a problem-solving process. There are three general coping processes in literature, namely avoidance, seeking support and problem-solving. We wish to explore whether and to what extent ESCAP can inspire the two relatively more positive, effective and healthier coping processes, namely seeking support and problem-solving. Consequently, two corresponding constructs namely “perceived social support” (i.e., corresponding to the acquisition of social support) and “perceived exam control” (i.e., corresponding to the feeling of having the capacity to handle the problem) become variables of interest for the study, as described in detail in Section 4 (Figure 1). Further, our ultimate goal of providing ESCAP is to reduce student’s stress level and enhance their exam stress management strategies. Thus these variables are examined in our research model as final coping outcomes. We are also interested to find out whether student’s interactions with ESCAP directly impact coping outcomes or as predicted by coping theory, going through the coping processes. Therefore, in our research model, we have also included the direct link from interactions with ESCAP to the dichotomous coping outcomes. The research framework and system development of ESCAP is detailed below.
3. Eliciting Students’ Needs through Preliminary Prototype Evaluation

To ensure our system is grounded in a thorough understanding of user requirements, semi-structured and in-depth interviews were conducted while demonstrating the preliminary prototype to potential users. Purposeful sampling was utilized. Interviewees included 14 first-year undergraduate students of a large university in Australia. 14 is deemed appropriate due to data saturation (Guest & Bunce, 2006). As justified in the Introduction Section, first-year students are the focus of our study. Respondents had diverse cultural backgrounds including Australian, European (Portuguese, English and Sweden) and Asian (Chinese, Indian, Thai and Lebanese) with ages ranging from 19 to 27 years old (nine males and five females). Each interview took approximately 30-50 minutes. Interviews were recorded and then transcribed. Open, axial and selective coding methods were used to analyze the data (Glaser & Strauss 1967). Then the various coding categories were screened, with data relevant to the research context, selected through expert review. Due to the ideal timing of this data collection, we were able to counsel students appearing for their final exams and record their perception about our system prototype without needing scenario-driven stimuli. A tranquil environment of a counseling clinic was simulated in our Virtual Reality Lab to capture genuine reactions of students in dialogue with the prototype of ESCAP. Interviews indicated that:

First, exam stress is a common and significant issue for university students that deserve more attention. This is particularly prominent for first year university students, who are more likely to feel lonely, have little sense of belonging to the new environment and need more guidance to snap out of the problem.

Second, existing university counseling services are helpful for students; however, many people hesitate to approach counselors when such need arise. This can be attributed to various reasons including self-denying of exam stress, lack of awareness of how to access the resource, inconvenience of accessing such resource, treating counseling as admitting of weakness or other negative feelings towards approaching a real psychologist. ESCAP is potentially a very promising tool to fill the gap.

Third, out of the 14 respondents, it is important to note that only three admitted that they have issues with exam stress, however their stress symptoms as indicated by their response to the common stress symptom indicators (UOM 2010) showed that they are actually not stressed. This phenomenon highlights the importance of having an easily accessible and handy system to act as a counsellor for general student use.

Finally, for the design of ESCAP, through talking to students, we understood that: Personalization is highly important for such a system. Students wish to get relevant and tailored advice for themselves; as is the sense of affection established between the user and the virtual psychologist - students wants the virtual psychologist to exhibit humane features or characteristics that they can relate to. If appropriately built, such a system would give students a better sense of control over their exams (i.e., boosted morale in coping with exam) and a sense of social support that they otherwise might find difficult to obtain in certain circumstances. For instance, for first year students who are away from family and friends, they are yet to establish their relationships with new people around them. Eventually, students perceive that such a system would significantly reduce their stress level and help them build up good habits and effective strategies in managing exam stress.

4. Research Framework and System Architecture

Born from discussions of cross-disciplinary literature and thorough analysis of user requirements in the previous sections, our research framework depicts how an effectively designed virtual psychologist, ESCAP, could help students to increase their sense of control over exams and acquire a sense of social support. Eventually this system encourages students to take more positive exam stress management
strategies and reduces students’ exam-related stress levels. This research framework serves as a guide for designing and evaluating the enhanced system prototype which will be developed based on the current system prototype (as evaluated in Section 3). Our research framework is underpinned by coping theory with emphasis on considering coping as a problem solving process in understanding this phenomenon. Note that our research model is non-exclusive, only highlighting constructs of interest in our problem context and in particular those that emerged from qualitative data analysis stage (Fig. 1).

5. Interaction with ESCAP

Students verbally interact with the highly personalized and animated virtual character of ESCAP, Dr McQuery. ESCAP is a virtual advisor, which is implemented through an embodied conversational agent (Fig. 2) with the behavioural traits of facial expressions and gestures to make the conversation more immersive. As raised by users in the interviews, we focus on two aspects in our system design: personalization and anthropomorphism. Personalization refers to providing tailored exam management advice to accommodate individual differences. Anthropomorphism (Zanbaka, Goolkasian & Hodges, 2006) refers to the extent a virtual agent resembles the appearance or behavioural attributes of a human psychologist. This aligns well with afore-mentioned design goals of having both “behavioral realism” and “conversational realism” as discussed in Section 2.1.

Fig. 3 explains the technical design of our ESCAP System that maximizes personalization and anthropomorphism. The interface between the user and the system is an avatar (Dr McQuery) that exhibits both facial and body animations. The ESCAP automatically evaluates users’ speech. The user module contains user data and associated diagnosis captured in previous or current counseling session. The intelligence and behaviour of the avatar is controlled by the context and behavioural modules of the interactive drama engine. The learning module stores vital conversation details between the user and ESCAP for reference in current and future consultation sessions. The context module sends diagnosis related questions and decisions to the behavioural module which generates the speech and gestures (action) for emoting the ESCAP. For further descriptions on technical details of ESCAP system design, please refer to (Rudra et al., 2012). We display the avatar using an immersive semi-cylindrical projection system in our Virtual Reality Lab to maximize the user experience of anthropomorphism and personalization. However, the system will be available for smart phones and tablets when the study is completed.
Fig. 2 Creating an emoted avatar using Face tracking technology.

Fig. 3 System architecture of ESCAP.

Fig. 3 illustrates the interaction between the various components of ESCAP. The interface between the user and the system is through an avatar using an artificial embodied conversational agent (Dr McQuerry). To overcome the impediments of automatic speech recognition, we simplify the language of communication by limiting the grammar and vocabulary from English and focus on providing a high quality counseling with sophisticated animation. Please note that this is a high-level architecture and is up to refinement in the later stages of the project after gathering further user feedback.

The user module stores the personal data regarding the user for more personalized diagnosis and immersive experience during the counselling session. The emotion unit captures the emotion of the user for fine tuning the inference process of the expert system and giving a human touch to the avatar of ESCAP by facilitating in generating an appropriate non-verbal expression (both facial and gesture). The diagnosis history stores the diagnosis and interactions of current and previous counseling (if any) sessions of the user with ESCAP. It is updated by the experience unit of the learning module. The information from the diagnosis history may serve as an acquaintance of ESCAP with the user and begin the process of initial dialog with reference to earlier counseling sessions. The user profile stores the data about
individual characteristics for better understanding of socio-economic and cultural background of the user to assist in diagnosis.

The intelligence and behavior of the avatar is controlled by the context and behavioral modules of the interactive drama engine respectively. The context module implements the generation of advice in the coping process outlined in our research model and consists of an expert system - the brain of ESCAP. The decisions made by the expert system during the course of the conversation is drawn from the application of inference rules on the knowledge base developed by consulting existing literature, clinical documents and experts in student psychology. The ontology provides a persona to the avatar of ESCAP and guides the reasoning process by cross checking the diagnosis history, experience from the current session and current emotion state of the user. It governs the behavior of the avatar of ESCAP during its conversation with the user.

The experience unit in the learning module stores vital conversation details between the user and ESCAP for reference in current session and future consultations. Post diagnosis, data from the experience unit is documented in the diagnosis history database for future consultation with the same user. Pragmatics governs how the avatar of ESCAP comprehends a situation and produce conversation with the user. Any new experience of the agent is stored as knowledge for updating the expert system’s knowledge base after consultation with a psychologist. The context module sends diagnosis related questions and decisions to the behavioral module which codes the speech and gesture (action) mark-up files for emoting the avatar of ESCAP. The behavioral module is the core to the realization of one of our research goals - believability to the user of the system.

To further elaborate the system design that enables ESCAP to interact with students, now we turn to a discussion of the key technologies that are involved in developing ESCAP, including the conversation interface for ESCAP, the conversation processor, grammar for conversation with ESCAP, decision support systems for ESCAP and the database design.

5.1. Conversation interface for ESCAP

An essential part of Natural Language Processor (NLP) analysis is the segmentation and classification of linguistic data into structures or phrases to determine the meaning of the sentence. For a natural language to be processed by the computer, we need efficient Natural Language Interfaces (NLI) to mediate primarily between the user and the application program (Obermeier, 1989). To accomplish this, we will use English as the language for conversation with reduced grammar and vocabulary for real time communication.

5.2. Conversation processor

According to (Holtgraves, 2002), conversational utterances are not solitary things, but occur in the context of other conversational utterances and their meaning is partially derived from their placement in a conversational context.

Our conversation processor for processing the input sentence consists of the following steps (Suereth 1997):

1) Reading the input sentence and extracting the words.
2) Looking up words in the dictionary
3) Identifying the sentence structure in the input sentence.
4) Identifying semantic items in the input sentence.
5) Generating a response.

The sequence in which words are recognized as valid phrases is depicted in Fig. 4.
5.3. Grammar for conversation with ESCAP

English Grammar has primarily four types of sentences: simple, compound, complex and compound complex; falling into the categories of declarative, interrogative, imperative and exclamative (Williams, 1999). In our proposed system, dialogue between the user and ESCAP will be through the use of simple sentences adhering to the categories of declarative, interrogative and imperative.

We have developed a Computer Pidgin Language (CPL) (Hinde & Belrose, 2010) for user conversation with our system. Although recent claims in excess of 90% accuracy in speech recognition have been made by leading voice recognition software developers (TechMediaNetwork.com 2011) for dictation, most users argue that this accuracy rate is overstated as it is highly speaker sensitive. Since our system aims to generate appropriate verbal response (not just speech to text), we need to parse the recognized spoken sentence of the user by matching and validating grammatical constructs to decipher the semantics; thus we advocate the use of short sentences by the user with simplified English grammar for real time dialogue between the user and the system.

Rudra (2008) conducted a number of experiments with nine subjects – five males and four females uttering five words from Papua New Guinea Pidgin language. The results show the accuracy of the computer to classify the emotion states of neutral and anger with 94% for males and 95% for females. His experimental results state that Papua New Guinea Pidgin words can be classified using SVM for the emotion states of neutral and anger. This result is very significant as we can make a non-player-character (NPC) reacting not only by the meaning of the utterance of the user but also his/her mood or emotional state. Using GPL (Game pidgin language), Rudra (2008) obtained a high emotion recognition rate (90%) for female speech as well.

To overcome the impediments of speech recognition systems (Hinde & Belrose, 2010), address the complexity of English grammar, and enhance the perpetuity in user conversation with our system, we have developed a CPL with a limited set of grammatical rules that can be used to form simple sentences adhering to the three categories of sentences as mentioned in the beginning of this section. The rules for interacting with ESCAP consists of 7 grammatical constraints as listed below (adapted from (Rudra, 2008))

1) The Sentence may begin with a noun or noun phrase followed by Verb.
2) A Sentence may begin with a Verb Phrase followed by a Noun.
3) An Adjective or adjective phrase is a valid sentence.
4) A Noun or noun phrase is a valid sentence.
5) A Verb Phrase is a valid Sentence.
6) A preposition phrase is a valid sentence.
7) An auxiliary verb is a valid phrase but not a valid sentence.

The goal of our grammar is not to check whether a sentence is syntactically well formed, but to ascertain whether a response can be generated from the information in the spoken text. A valid sentence is any word or phrase that satisfies any or all of the conditions mentioned above and is composed of a word or words within the ESCAP vocabulary set of the speech API (built in the operating system) and our CPL dictionary table.
There are several methods (Holtgraves, 2002), (Suerte, 1997) for checking and validating the syntax of a sentence. Due to simplicity of our grammar, we have adopted Deterministic finite state automaton (DFSA) (Mishra & Chandrasekaran, 2007) shown in Fig.4 to validate our CPL. The primary objective of the DFSA is to trigger the response generator of the system if an acceptance state is reached after parsing the input sentence.

![Sentence parsing automaton](image)

**Fig. 5 Sentence parsing automaton.**

In Fig. 5, double circles are final/acceptance states and q0 is the start state. The states q1, q2 and q3 are final states that represent noun, verb and adjective phrases respectively. The states q4, q5 and q6 are arbitrary intermediate states.

Assuming that the name of an arbitrary student is Jim, we have simulated a brief conversation between him and ESCAP. The sentence uttered by the student is parsed using the Deterministic FSA to generate a response from the system.

1. **ESCAP:** Hello, I am Dr McQuery. What is your name?
   **Student:** My name is Jim.
   **Sentence parsed by DFSA:** q0 → q1 → q2 → q1
2. **ESCAP:** Jim, what is your career objective?
   **Student:** To become an environmental scientist.
   **Sentence parsed by DFSA:** q0 → q4 → q2 → q5 → q3 → q1
3. **ESCAP:** How are you today?
   **Student:** I have severe headache.
   **Sentence parsed by DFSA:** q0 → q1 → q2 → q3 → q1
4. **ESCAP:** How do you feel?
   **Student:** Feel like throwing up.
   **Sentence parsed by DFSA:** q0 → q0 → q4 → q2
5. **ESCAP:** Are you able to study?
   **Student:** I am unable to concentrate on my study and work.
   **Sentence parsed by DFSA:** q0 → q1 → q2 → q3 → q4 → q2 → q4 → q1 → q1 → q0 → q0 → q1
6. **ESCAP:** What do you do most of the time?
Student: I lie down after taking panadol.
Sentence parsed by DFSA: \( q_0 \rightarrow q_1 \rightarrow q_2 \rightarrow q_2 \rightarrow q_4 \rightarrow q_2 \rightarrow q_1 \)

5.4. Decision support system for ESCAP

A critical part of our system development involves the creation of a comprehensive knowledge base for the expert system through existing literature, clinical documents and interviewing psychologists. The expert system for ESCAP involves complex level of verbal interactions with students to advice on techniques to cope with their exam stress. Our expert system (Weiss & Kulikowski, 1984) implements a clinical decision support system (CDSS) (Berner 2007) that incorporates all the four characteristics associated with CDSS (as suggested by Kawamoto (Kawamoto et al. 2005). The block diagram of the expert system is shown in Fig. 6.

![Expert System Model for ESCAP](image)

The steps from symptoms to advice are recursive and are repeated until the counseling session is complete.

The knowledge base of the system assists in creating a mind map (Buzan, 2010) of the student to aid the inference engine of the expert system in diagnosing stress symptoms. The input to the system is affective speech and the output is an emoted embodied conversational agent of ESCAP. We will develop our inference engine based on chained rules, adapted from causal network model developed by (Lauritzen & Spiegelhalter, 1988). A high level schematic tree depicting the flow of decision making for counselling through the inference engine is shown in Fig. 7.

![Inference Engine of ESCAP](image)
In the above equations, MB is the measure of belief, MD is the measure of disbelief, ‘P(h)’ is the probability of hypothesis (or diagnosis of illness, if any, by the system), and ‘P(e)’ is the probability of evidence (or symptom) to support the hypothesis. The calculation of MB, MD and CF is complemented by the diagnosis assistant tables in AI module of the system database presented in the subsequent Section e. and assists in creating a diagnosis of the student for future consultations report (diagnosis history of Figure 1). The probabilities for diagnosis of different mental stress symptoms are developed by consulting expert student psychologists and are stored in the ‘likelihood’ field of the ‘Symptoms_Mental’ table of the system database. From time to time, the Information collected during the course of the student-ESCAP conversation is used to calculate the certainty factor (CF) for diagnosis of stress symptoms using the above set of formulae (Castillo & Alvarez, 1991) and generate an appropriate statement of advice and empathy (if any). Interested readers are referred to (Castillo & Alvarez, 1991) and (Rudra et al., 2012) for more technical details.

The reliability of our expert system is centered on the effective implementation of the inference engine. Although research suggests that transcribing medical knowledge with inference engines underpinned by probabilities may be affected with variations in clinical judgment of experts (Bar-hillel, 1980); we will ensure that this uncertainty does not influence the final outcome of the diagnosis. We intend to customize the system to individual student requirement by segregating the inference mechanism on student’s demographic attributes by consulting expert psychologists specializing in counseling specific communities. We will also consider personality attributes of students for personalization of the system to cater for individual student category and needs.

5.5. Database design of the system

One of our important design objectives is to isolate the knowledge base from the code in the inference module and the conversation processor. The knowledge base of the expert system is derived from this database along with student characteristics and vocabulary (for speech recognition during conversation). To realize our goal, we have identified 32 tables to implement the expert knowledgebase.

5.5.1. Tables of ESCAP system

The tables along with their attributes are grouped under two broad categories and are listed below:

1) Student Module

The student module helps in creating a memory map of student. The information from this module acts as an acquaintance for the AI module to counsel the student.

i. **Student_Info** (Student_id, First_Name, Last_Name, Country_Origin, Gender, Date_of_Birth, Religion, Address, City, Post_Code) - It stores the personal details of the student.
ii. **Student_Category** (Student_Category_id, Student_id, Country_Group_id, Category_id, Student_Work_id, Study_Loan, Other_Debt) - It stores the category to which the student belongs.

iii. **Student_Personality** (Student_Personality_id, Student_id, Personality_id, Student_id, Home, Savings, Car, Date,) - It stores information on personality of the student as inferred by the system.

iv. **Student_Symptom** (Student_Symptom_id, Student_id, Symptom_Mental_id, Symptom_Physical_id, Questions_Study_id, Symptom_Valid, Date) - It stores the questions on stress symptoms that has been asked by the system.

v. **Student_Mental_State** (Student_Mental_State_id, Student_id, Mental_State_id, Date) - It stores information on mental state of the student as derived from the mental assessment questions.

vi. **Student_Diagnosis_History** (Student_Diagnosis_History_id, Student_id, Student_Mental_State_id, Student_Symptom_id, Date) - It stores the diagnosis history of the student based on valid symptoms.

vii. **Student_Support** (Student_Support_id, Student_id, Support_id1, Support_id2, Support_id, Date) - It stores information on current source of financial and social support of the student.

viii. **Student_Career_Goal** (Student_Career_Goal_id, Student_id, Career_id, Date) - It stores the career objectives and goal of the student.

ix. **Student_Work** (Student_Work_id, Student_id, Work_Type, Hours_per_Week, Significance, Can_take_Break, Date) - It stores the list of work commitments of the student.

x. **Student_Subjects** (Student_Subject_id, Student_id, Subject, Numerical, Analytical, Theoretical, Assignments, Career_Relevance, Date) - It stores the subjects enrolled by the student along with perception attributes.

NB: The tables (ii) to (x) are dynamic tables in which a new row is added every time the student logs in for a consultation session.

2) **AI Module**

The AI Module consists of the following components:

a) **Diagnosis Assistant** - The tables below stores questions for analyzing the mental state of the student for subsequent diagnosis by the expert system module of ESCAP system.

i. **Symptoms_Mental** (Symptoms_Mental_id, Symptom, Advice_Relaxation_id, Advice_life_id, Empathy_Statement_id, Pragmatics_Conversation_id, Diagnosis_id1, likelihood1, Diagnosis_id2, likelihood2, Diagnosis_id3, likelihood3, Diagnosis_id4, likelihood4, Diagnosis_id5, likelihood5) - It stores the questions concerning symptoms related to mental stress along with 5 possible diagnosis with probabilities.

ii. **Symptoms_Physical** (Symptoms_Physical_id, Symptom, Advice_Relaxation_id, Advice_life_id, Empathy_Statement_id, Pragmatics_Conversation_id) - It stores the questions concerning symptoms related to physical conditions.

iii. **Diagnosis** (Diagnosis_id, Diagnosis_Name) - It stores the list of diagnosis for stress related symptoms.

iv. **Questions_Study** (Questions_Study_id, Advice_Study_id) - It stores study related questions to balance work, life and study.

v. **Mental_Assessment_Questions** (Mental_Assessment_Question_id, Question) - It stores the questions to assess the mental state of the student and whether the intervention of a General Practitioner is required.

b) **Spoken Response** - The following set of tables store the advices to be spoken by the avatar of ESCAP during the course of counseling along with intonation tags for speech synthesis.

i. **Advice_Relaxation** (Advice_Relaxation_id, Advice, Action_Advice_id,) - It stores advice on various relaxation techniques to reduce stress.
ii. **Advice_study** (Advice_Study_id, Advice, Action_Advice_id) - It stores advice on developing strategies for effective study.

iii. **Advice_Life** (Advice_Life_id, Advice, Action_Advice_id) - It stores information to motivate students with real life examples.

iv. **Empathy_Statements** (Empathy_Statement_id, Statement, Action_Empathy_id) - It stores information to console students if they are de-motivated.

v. **Pragmatics_Conversation** (Pragmatics_Conversation_id, Pragmatics_Question, Pragmatics_Reference_id, Pragmatics_Reference_id) - It stores general statements that maintain an effective dialog with the student.

c) Behavioral Response - The tables listed below store information that animates the avatar of ESCAP.

i. **Action_Advice** (Action_Advice_id, Action_XML_Tags, Tag_Type) - It stores the action code for animating the face and gesture when ESCAP gives an advice to the student.

ii. **Action_Empathy** (Action_Empathy_id, Action_XML_Tags, Tag_Type) - It stores the action code for animating the face and gesture when ESCAP empathises with the student.

iii. **Action_Pragmatics** (Action_Pragmatics_id, Action_XML_Tags, Tag_Type) - It stores the action code for animating the face and gesture when ESCAP makes neutral conversation.

d) Reference - The following tables are used as reference for validation of user input.

i. **CPL_Dictionary** (Word_id, Meaning, Type) - It stores the list of valid words recognizable by the speech recognition system.

ii. **Category** (Category_id, Category_Name) - It stores different categories to which students fall during their enrolment in the university.

iii. **Personality** (Personality_id, Personality_Name) - It stores the list of personality traits that assists the system in inferring the personality of the student.

iv. **Career** (Career_id, Career, Career_Stream) - It stores a comprehensive list of career paths leading from different courses.

v. **Support** (Support_id, Support_From, Support_Ttype) - It stores a list of possible careers for different study streams.

vi. **Mental_State** (Mental_State_id, Mental_State_Name) - It stores the different affective states along with pitch range.

vii. **Pragmatics_Reference** (Pragmatics_Reference_id, Student_Table_Name) - It assists in populating the tables in the student module during conversation.

viii. **Country** (Country_id, Country_Name, Country_Group_id) - It stores the countries in the world as is used during conversation and personalization of the avatar of ESCAP.

e) New Knowledge - This implements the learning module of the expert system.

i. **Knowledge_referral** (Knowledge_Referral_id, Student_Response, Student_Symptom_id) - This table stores the knowledge and requires to be updated if it failed to respond to a student issue.

### 5.5.2. Relational model of the database

Fig. 8 depicts the relational database model for the database we have designed for ESCAP. Please note that due to limited space, we have shown the relationship without the attributes. The attributes for individual tables can be seen in the previous Section.
6. Moderator Variables: Individual Characteristics

Due to disparity in coping taxonomies, people with different characteristics handle stress via different ways, necessitating different coping strategies. Individual characteristics that potentially modulate the effectiveness of ESCAP include personality, age, gender, the level of maturity and attribution styles (Amirkhan & Auyeung, 2007). Understanding the influence of individual characteristics on coping
processes helps us to explore how to maximize the effectiveness of a virtual psychologist in counseling a student under stress. This is because tailored exam stress management strategies based on individual characteristics are deemed more effective for students. We use the Guilford-Zimmerman Temperament personality scale (Guilford, 1976), which had been widely used in literature and demonstrated to have good psychometric properties (Wang & Gan, 2010), to assess individual characteristics.

To increase the acceptance of the avatar for the virtual psychologist, we conducted pilot tests with potential system users 25 university students. We gave the listeners 4 different states of the same speech spoken by males and females (e.g., 10Hz, 30 Hz, fast, slow) and asked them to assess the credibility, pleasantness, dynamism, and clarity of the speech in 8 samples given on an evaluation sheet demonstrated in Fig. 9.

![Evaluation sheet](image)

**Fig. 9 Evaluation sheet used in our pilot experiments.**

In 200 samples, we found that in general the voices of male advisors are considered as more pleasant and credible than female advisors’. On the other hand, the voices of female advisors are considered as more clear, dynamic and competent than male advisors’ by most users. This gives interesting implications regarding the design of virtual psychologists, stating that we should consider the gender of the virtual advisor carefully to maximize its effect on users. Further investigations are to be carried out in this aspect. Our results are in line with Kenton (1989) who stated that “Even when men and women are objectively equal on these dimensions, receivers perceive men as being more persuasive as speakers than women.”

(Feldstein et al., 2001) conducted a set of experiments assuming that (a) listeners regard speakers whose global speech rates they judge to be similar to their own as more competent and more socially attractive than speakers whose rates are different from their own and (b) gender influences those perceptions. Their participants were 17 male and 28 female listeners; they judged each of 3 male and 3 female speakers in terms of 10 unipolar adjective scales. They used 8 of the scales to derive 2 scores describing the extent to which the listener viewed a speaker as competent and socially attractive. The 2 scores were related by trend analyses (a) to the listeners' perceptions of the speakers' speech rates as compared with their own and (b) to comparisons of the actual speech rates of the speakers and listeners. They examined trend components of the data by split-plot multiple regression analyses. In general, the results supported both hypotheses. Their findings state that the participants judged speakers with speech rates similar to their own as more competent and socially attractive than speakers with speech rates slower or faster than their own. However, the ratings of competence were significantly influenced by the gender of the listeners, and those of social attractiveness were influenced by the gender of the listeners and the speakers.
7. Coping Processes

7.1. Perceived exam control (PEC)

Prior research on college students used the perceived academic control construct to assess students’ sense of control over their academic achievements (Perry et al., 2005; Ruthig et al., 2007). In this study, based on our exam stress management context we adapted the Perceived Academic Control Scale (Perry et al., 2001) to assess PEC (Perceived Exam Control). In the PEC scale, four items are positively worded (e.g., “The more effort I put into preparing my exams, the better I do in them”) and four are negatively worded (e.g., “No matter what I do, I can’t seem to do well in my exams”), with responses ranging from 1 (Strongly disagree) to 7 (Strongly agree). Responses for negatively worded items were reversed then all item responses were summed - higher scores indicate greater PEC.

7.2. Perceived social support (PSS)

Perceived social support refers to the provision of various resources including psychological and material resources that serve as a buffer against stressful events. Such resources can be provided by 1) preventing the situation being perceived as stressful, for example through introducing continuous assessment methods or reducing the weight of exams 2) by providing a solution to a stressful problem, 3) by minimizing its perceived importance or 4) facilitating healthy behavioural responses to the event (Crockett et al., 2007). These aforementioned approaches are non-exclusive. Perceived social support comes from multiple sources, such as family, friends, class-mates and teachers. However, none of these sources of support are likely to be always immediately available when most needed. Especially given that during exam period, every student will be busy preparing for their exams, it is less likely that peer-support would be readily accessible when a student feels stressed or depressed. Professional counselors on campus are highly sought-after resources during exam time, leading to delayed appointments for some students seeking urgent professional intervention. Consequently, the availability of ESCAP would be a very handy source of support for students. The vivid representation of ESCAP as an embodied conversational agent with highly intelligent, interactive and personalized advice will enhance user’s perceived social support. This is achieved through providing tailored advices to manage stress (2nd strategy mentioned above), forming an appropriate attitude towards exam (3rd strategy) and facilitating healthy behavioural responses to better handle stress (4th strategy).

8. Coping Outcomes

We measure the stress level of students before and after their exposure to ESCAP. Both 1) objective measures including participants’ heart rate and skin conductivity, and 2) self-reported stress level measures are used. Further, we wish to find out whether the use of the system has enhanced their 3) stress management skills, as described below.

1) Objective measures: heart rate and skin conductivity

(Andreassi, 2006) states psycho-physiology as being “the study of relations between psychological manipulations and resulting physiological responses”. Psycho-physiological feedback is the measuring of subject's quantifiable physiological processes, such as heart rate, sweat, skin temperature and blood pressure. (Anttonen & Surakka, 2005) quotes Bradley, M. M. and Lang, P. J. as saying that emotions can be conceptualised by valence (level of excitement) and arousal (level of pleasure). Scientists have used heart rate for measuring valence, while heart rate variability and galvanised skin response (skin conductivity level) have been used in measuring arousal (Anttonen & Surakka, 2005; Ganglbauer et al., 2009). For example, psycho-physiological feedback has been used by NASA to measure the stress level in astronauts, with relaxation based computer games (e.g. the Wild Divine games), and for medical
related games for detecting and treating medical disorders (Dzhafarova et al., 2007). Another good example is a relaxation game (Bersak et al., 2001), where players race against each other. Each player was connected to a device measuring their galvanized skin response, which was used to calculate their levels of relaxation and subsequently to control their speed levels. Based on these insights, we use psycho-physiological feedback to measure the heart rate and skin conductivity of students to reveal whether the use of ESCAP resulted in reduction in their stress level or not.

2) Subjective measures: Perceived stress
The perceived stress construct will be measured through students’ self-reported stress level using well-established seven items from Cohen et al. (1983). In the Perceived Stress Scale (PSS), typical questions include: “During the last month, how often have you: . . . been upset because of something that happened unexpectedly; . . . felt that you were unable to control the important things in your life; . . . felt nervous and stressed; . . . found that you could not cope with all the things that you had to do; . . . been angered because of things that happened that were outside of your control; . . . found yourself thinking about things that you would have to accomplish; . . . felt difficulties were piling up so high that you could not overcome them?” Responses (1=Never; 7=Very often) are summed so that higher scores indicated greater perceived stress. Internal reliability of this shortened measure has been reported to be similar to that of the full version PSS (Cohen, Kamarck & Mermelstein, 1983; Shiovitz-Ezra et al., 2009).

3) Positive Changes in Exam Stress Management Strategy
Another important outcome of our study on student’s coping process is the identification of more active exam stress management strategies. We use the items in Amirkhan, which captures people’s intention to implement certain coping strategies, to assess whether there are any improvements in students’ coping strategy after being exposed to ESCAP (Amirkhan & Auyeung, 2007).

9. Discussion
This study forms a critical first stage development of an on-going project carried out in a well-established VR Lab by a group of interdisciplinary researchers and practitioners. In this study, we elicited user requirements to ground our work and proposed the system architecture for an intelligent student exam stress management system, ESCAP. We reviewed the social, psychological, and conversational information systems and computer graphics literature underpinning the design of this intelligent virtual advisor and demonstrated how to elicit user requirements to inform and enhance the design of innovative information systems. Further, we presented two of the three core modules, namely, a reduced grammar for conversation with ESCAP and an overview of an expert system that supports the counseling process. The third module is behavioral modeling through affective animation which will be our next area of focus. We have also developed a relational database schema consisting of thirty two tables to implement all of the three core modules of the system.

In the next stage of the project we proceed to enhancing our initial prototype of ESCAP and then move on to full-scale development. We will conduct large scale experiments to empirically verify its impact on students. In these experiments, we plan to measure the stress level of students using both qualitative and quantitative measures such as heart beat and skin conductivity before and after their interactions with ESCAP. However, it is important to note that the knowledge base for the virtual psychologist needs to be rigorously verified by domain experts to eliminate any negative impacts on students.

This novel research project aims at advancing theories in the field of information systems by studying how innovative information systems could influence people’s coping process. In particular, we examine how to utilize the strengths of virtual advisors to effectively mimic the knowledge, diagnosis and behaviour of psychologists through an intelligent agent, to help students to better cope with exam stress. Besides, the self-learning expert system for detecting symptoms and diagnosis of student stress will have significant contribution in the area of social science and psychology. Further, the agent-based behavioural
modeling of the avatar of ESCAP will have implications in the field of machine learning for human computer interaction.

In terms of contribution to practice, our project will benefit stakeholders at all levels, including the society, the university and individual students. As reflected by students during the interview process, ESCAP “has a good call” and “students really need this”. The current scope of the research is limited to student psychology but it can be further extended to the application areas of employee stress diagnosis and management, and intelligent virtual companion for people who are in need of close support. For example, the system will support people who are going through breakups or survived domestic violence, victims of post-traumatic stress disorders and people suffering from depression. Our research model and design can be applied in the above application areas with modifications to the expert system database and behavioural modeling of the avatar.

Some of the design issues that have emerged during our project are highlighted in this section to elicit further insights and discussions. First, for the design of the database, we could have used XML to represent our AI module (expert system and conversation support tables), but instead we chose the relational model since the database needs to be updated for every consultation session to generate a final report in the end for symptoms and advice. The database will complement our proposed object-oriented approach in coding the application for the modules described in Section 5.

We also intend to develop a front-end application to constantly refine the static tables in student and AI modules of the database. Our approach will facilitate an efficient update mechanism with minimum changes in the code and data redundancies. Second, we have designed a conversation processor that will work in conjunction with the speech API that ship with current operating systems. Since spoken and written English differ vastly in grammar and usage, with the difference being heavily pronounced in non-native English speakers; our focus in design is to make the conversation process robust by maximizing the response of our system even though the sentence may be syntactically ill-formed. The FSA described in Section 5 will check the basic syntax for different sentence structures and produce a response based on the semantic content. The dictionary table in the AI module will complement the speech API dictionary with missing medical terminologies and non-traditional, colloquial vocabularies. It stores meaning of all possible words expected to be used during the system-user conversation.

Second, during our pilot testing with potential system users (200 samples), we found that in general the voices of male advisors are considered as more pleasant and credible than female advisors; on the other hand, the voices of female advisors are considered as more clear, dynamic and competent than male advisors by most users. This has implications on the design of virtual psychologists. We should consider the gender of the virtual advisor carefully to maximize its effect on users. Further investigations are to be carried out in this aspect. Our results are in line with (Kenton, 1989) who stated that “Even when men and women are objectively equal on these dimensions, receivers perceive men as being more persuasive as speakers than women.”

Following (Feldstein et al., 2001) who conducted a set of experiments assuming that listeners regard speakers whose global speech rates they judge to be similar to their own as more competent and more socially attractive than speakers whose rates are different from their own, we are currently analysing the results for each gender. We assume that the ratings of competence are significantly influenced by the gender of the listeners, as well as those of social attractiveness.

Finally, we note some limitations related to the study. First, the compilation of counseling knowledge base will be an ongoing process even after implementation of the system. Therefore, it requires regular updates by knowledge experts in the domain of student psychology. Second, customization of the system remains a challenge, since we need to cater for students from different cultural, social and ethnic backgrounds.

Acknowledgement

This project has been sponsored through an Australian Research Council Discovery Grant DP0988088 (Kavakli) 2009 - 2012 titled A Gesture-Based Interface for Designing in Virtual Reality.
References


Author Biographies

**Manolya Kavakli** is an Associate Professor at the Department of Computing, Macquarie University. She gained her BSc (1987), MSc (1990) and PhD (1995) degrees from Istanbul Technical University. In 1996, she was awarded a NATO Science Fellowship in UK. In 1998, she received a Postdoctoral Fellowship from the University of Sydney, Australia. Until 1999, she worked as an Associate Professor in Design Science at Istanbul Technical University. She took an active role in establishing the first Computer Science (Games Technology) degree in Australia, at the School of Information Technology, Charles Sturt University between 2000 and 2003, as the course coordinator. Since 2003, she has been working at the Department of Computing, Macquarie University where she established a Virtual Reality (VR) Lab for fostering graphics research in 2003 and brought researchers together as a multidisciplinary and international research team with the establishment of VISOR (Visualisation, Interaction and Simulation of Reality) Research Group.

**Manning Li** is an Associate Professor in the College of information science and engineering, Northeastern University in China. Prior to this, she worked as a Lecturer (Assistant Professor) with the department of computing, Faculty of Science at Macquarie University, in Sydney Australia. She obtained her PhD in Business Information Systems from the Australian National University, Australia. Her major research interests include intelligent support systems, human-computer interaction and virtual reality.

**Tarashankar Rudra** is a Senior Research Officer at Macquarie University. He obtained his PhD in Computer Science from Macquarie University by receiving Australian Post Graduate Award in Industry (APAI). His research interest includes system design, database design, emotion in speech and AI modelling.