A SENSOR-LITE ANXIETY DETECTOR FOR FOREIGN LANGUAGE LEARNING

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ABSTRACT

Foreign language learners face cognitive and emotional interference which reduces their learning acquisition. Foreign language anxiety (FLA) is one of the impediments to learning a new language. It hinders cognitive processes, interferes with attention, and reduces working memory capacity. Detecting foreign language anxiety is the first step toward reducing and eventually overcoming it. Here we present a novel design to detect foreign language anxiety in the context of an e-learning system using sensor-free and sensor-lite metrics. By adopting the Foreign Language Classroom Anxiety Scale (FLCAS) as a pre-test along with language difficulty self-report, system difficulty self-report, and score, we are predicting the current anxiety level of the learner when learning English as a second language using an e-learning system. We found that some components of the FLCAS can effectively predict FLA for listening and speaking exercises. Additionally, FLCAS plus the self-reports and the score are effective in detecting the learner's current anxiety level for all exercise types.

KEYWORDS

Foreign Language Anxiety, Emotion, Affect, Sensor-Free, Sensor-Lite

1. INTRODUCTION

Learning and emotions are strongly connected. Positive emotions such as engagement increase learning, while negative emotions such as anxiety obstruct learning. Foreign language anxiety (FLA) can appear in all learning environments such as classrooms and when using an e-learning system. Researchers are interested in understanding the reasons, impacts, and processes for overcoming anxiety.

Previous research has described the impacts of emotional state on learning and the effects of learning on emotional state (Bigdeli, 2010). Learners may feel not confident speaking a new language (Lu, Chang and Chen, 2007; Lai and Wen, 2012). Learners may feel anxious about reading, listening or writing a second language (Lin, Chao and Huang, 2015), which reduces their achievement (Shao, Yu and Ji, 2013; Huang and Huang, 2015) and impacts learner performance, production and retention (Rafada and Madini, 2017a).

Understanding fundamental aspects that produce anxiety within the context of foreign language learning could help to reduce it. (Horwitz, Horwitz and Cope, 1986) classified causes of FLA into three main categories: fear of negative evaluation, communication apprehension, and test anxiety. Other researchers have linked additional factors to FLA including task complexity (Chen and Lee, 2011; Levitt, 2015), native language proficiency (Gregersen, 2006; Liu, 2013), and lack of emotion intelligence (Shao, Yu and Ji, 2013).

Researchers are studying FLA because it affects learner performance (Liu, 2006; Bigdeli, 2010; Liu and Huang, 2011; Huang, 2018; Sparks *et al.*, 2018), reduces acquisition (Dewaele, Petrides and Furnham, 2008), and produces unwillingness to communicate in the foreign language (Liu, 2006; Liu and Jackson, 2008). FLA reduces motivation to learn (Liu and Huang, 2011), divides attention between emotion and cognition making performance less efficient (Kralova and Petrova, 2017), and moderates interest in learning a foreign language (Liu, 2006). According to the Yerkes-Dodson Law, moderate anxiety improves performance, but high levels of anxiety are disruptive. Furthermore, very low levels of anxiety are associated with a lack of desire to learn (Bigdeli, 2010; Levitt, 2015).

The Foreign Language Classroom Anxiety Scale (FLCAS) is a well-validated, reliable instrument which is widely used to measure foreign language anxiety within classroom contexts. It was initially designed by (Horwitz, Horwitz and Cope, 1986) for English speakers studying Spanish as a foreign language. It was used since 1986 to detect anxiety no matter what is the foreign language. FLCAS has been translated into many native languages to measure anxiety levels in various foreign language classes. The scale has 33 questions in three sections which correspond to the three categories or components of FLA. The first section has 11 questions dealing with communication apprehension, i.e., the respondent's feelings about listening and speaking a foreign language. The second section has 15 questions focused on test anxiety. For example, it asks learners about their emotions in a foreign language classroom: do they tremble in the class, do they fear to fail the class, or do they feel pressure in the class? The last section has 7 questions and about fear of negative evaluation. This part focuses on worries about peer or teacher judgments. The FLCAS has been used as a pre-test in some experiments (Chen and Lee, 2011; Alemi, Meghdari and Ghazisaedy, 2014; Lin, Chao and Huang, 2015; Ismail and Hastings, 2019) or as a standalone measure for examining different aspects that affect FLA (Shao, Yu and Ji, 2013; Rafada and Madini, 2017a). Some researchers have argued that self-report is unreliable because people may unintentionally lie to hide their emotions (American Psychiatric Association, 2013; Imani and Montazer, 2019), while within the context of e-learning systems, self-reports have been shown to be effective (Lopatovska and Arapakis, 2011; Imani and Montazer, 2019; Ismail and Hastings, 2019). There are several mechanisms for collecting self-reports related to anxiety such as Likert scales (Luo *et al.*, 2018), self-explanation texts (Lin, Chao and Huang, 2015), or sliders with emojis (Ismail and Hastings, 2019).

Various researchers have studied the relationship between FLCAS components and aspects of FLA. Some studied listening comprehension and found that anxiety impedes communication in a foreign language (Atasheneh and Izadi, 2012). (Mufidah, 2016) found that grammar comprises a large portion of the English proficiency test and more anxious students get worse scores in the grammar section of the test. Foreign language speaking anxiety is related to fear of unpleasant feedback (Rafada and Madini, 2017b) and lack of communication techniques (Balemir, 2009). With respect to vocabulary, (Chen, 2015) found that vocabulary anxiety can slightly predict foreign language achievement. At the same time, they mentioned that foreign language vocabulary is correlated with test anxiety and fear of negative evaluation. The previous study by (Ismail and Hastings, 2019) showed that using language difficulty self-report, system difficulty self-report, and the exercise score provides a significant moderate prediction for FLA.

Through this study, we want to discover how to detect FLA within an e-learning system using sensor-free and sensor-lite methods. Sensor-free means detecting anxiety using interaction patterns without using physical sensors. Sensor-lite methods use minimal sensors such as self-report (D'Mello and Graesser, 2014). Using level of anxiety self-report as the ground truth data of participants' emotional state, we posed the following research questions to determine if we could effectively identify anxiety without using explicit level of anxiety self-report, using instead their answers to components of the FLCAS:

1. Does communication apprehension predict the learner's anxiety level in listening exercises?
2. Does test anxiety predict the learner's anxiety level in grammar exercises?
3. Do fear of negative evaluation and communication apprehension predict the learner's anxiety level in speaking exercises?
4. Do test anxiety and fear of negative evaluation predict the learner's anxiety level in vocabulary exercises?
5. Can we predict the learner's anxiety level within an e-learning system using initial answers to the FLCAS plus language difficulty self-report, system difficulty self-report, and the score?

According to (Horwitz, Horwitz and Cope, 1986) foreign language anxiety could be related to three main reasons: communication apprehension, test anxiety and fear of negative evaluation. Communication apprehension is related to listening to native speakers and oral communication. Thus for question 1, we hypothesized that the communication apprehension questions on the FLCAS would effectively predict the anxiety level for listening exercises. Other questions on the FLCAS measure test anxiety. The grammar exercises of the system evaluate participants on their ability to use adverbs of quantity and prepositions, and generate indirect questions. For Question 2, our hypothesis was that the test anxiety component of the FLCAS would effectively predict the current anxiety level for grammar exercises. Speaking could be affected by both communication apprehension and fear of negative evaluation. Anxious individuals would have trouble communicating in a foreign language. Moreover, they are afraid of being judged by their peers, teachers or any native speaker. For Question 3, we hypothesized that fear of negative evaluation and

communication apprehension would predict FLA in speaking exercises. Foreign language instruction often includes assessments that produce test anxiety and fear of negative evaluation. Learners may be concerned about the consequences of failing in the class, they may feel afraid that the teacher would correct their mistakes or their peers would laugh at them. For these reasons, for Question 4, we hypothesized that test anxiety and fear of negative evaluation can predict FLA in vocabulary exercises. Based on (Ismail and Hastings, 2019) and the previous research questions, we would like to address the anxiety level in an e-learning system regardless of the type of exercise. The eventual goal of this project is to develop means of mitigating anxiety when it occurs. Thus for Question 5, our hypothesis was that using the FLCAS, language difficulty self-report, system difficulty self-report, and the score of the exercise is effective to predict the anxiety level within an e-learning system.

We propose a novel design to detect FLA within the context of an e-learning system for English as a foreign language using sensor-free and sensor-lite measures. Our design uses FLCAS components (Horwitz, Horwitz and Cope, 1986) administered as a pre-test along with self-reports of language difficulty and system difficulty and the score on the current exercise (Ismail and Hastings, 2019).
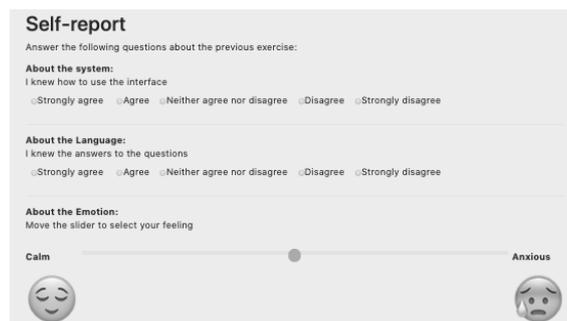
2. METHOD

2.1 Participants

We recorded 30 participants who are non-native English speakers between the age of 18-54 years old. Their English proficiency language level was 17% beginner, 53% intermediate and 30% advanced. We conducted an observational study at software observation and usability lab. We paid $20 compensation for each participant.

2.2 Procedure

Each participant completed the FLCAS as a pre-test. Then they completed 27 exercises with the English E-learning System (EES). The exercises focused on listening, grammar, speaking, and vocabulary. After each exercise, the participants completed a brief self-report about their current level of anxiety as shown in Figure 1. The FLCAS and the self-report questions were presented in the participant's native language (Arabic, Chinese, Spanish, and Thai). The figure presents the English version of the self-report just for the purpose of this paper.

Figure 1. Level of anxiety self-report

2.3 Analyzing the Data

We did statistical analyses to understand the relationship between the FLCAS and the learner's current level of anxiety when using the e-learning system. We combined the FLCAS responses from the three main components: communication apprehension, fear of negative evaluation and test anxiety (Horwitz, Horwitz

and Cope, 1986). We averaged the answers for each group (reversing scores where appropriate) and compared the results with the learner's current level of anxiety. Level of anxiety self-report, language difficulty, and system difficulty were coded from the participants' Likert scale responses. The score for each exercise for each participant was calculated as the percentage of correct answers. After that, we did regression, then we split the dataset into 80% trained and 20% tested data to check any overfitting.

3. RESULTS

3.1 FLA in Listening Exercises

To test our hypothesis that communication apprehension as measured by the FLCAS predicts anxiety level in a listening exercise, we did a linear regression with the average communication apprehension as the independent variable and level of anxiety self-report as the dependent variable. We used linear regression because we measure anxiety in a scale ratio from zero to hundred. The model provided a moderately good fit, R = 0.355. This predictor accounts for about 13% of the variation in anxiety, $R^2 = 12.6\%$, and $R^2(adj)=12.1\%$. The regression equation indicated that the model was a significant predictor of anxiety, $F(1, 179) = 25.647, p < 0.001$.
To evaluate the generalizability of the prediction we split the data into 80% training and 20% testing sets, and performed cross-validation by doing a Pearson correlation between the datasets and the dependent variable. We found a significant moderate positive correlation between the training dataset and the level of anxiety self-report, $p<0.001, r=0.370$. We found a significant moderate positive correlation between the test-set and the level of anxiety self-report, $p<0.013, r=0.395$.

3.2 FLA in Grammar Exercises

For our second research question, we hypothesized that average test anxiety would predict FLA in grammar exercises. To test the hypothesis, we did a linear regression with FLCAS test anxiety scores as the independent variable and level of anxiety self-report as the dependent variable. The model provided a good fit, $R = 0.423$. This predictor accounts for about 18% of the variation in the level of anxiety, $R^2 = 17.9\%$, and $R^2(adj)=17.3\%$. The regression equation indicated that the model was a significant predictor of anxiety, $F(1, 149) = 32.278, p < 0.001$.
To evaluate the generalization of this prediction we again did cross-validation using the 80/20 split mentioned above. We found a significant moderate positive correlation between the training data and the level of anxiety self-report $p<0.001, r=0.491$. However, we found no significant correlation between the test-set and the level of anxiety self-report $p<0.137, r=0.236$.

3.3 FLA in Speaking Exercises

For the third research question, we hypothesized that the average fear of negative evaluation and the average communication apprehension would predict FLA in speaking exercises. We did a multiple regression analysis with the average fear of negative evaluation and the average communication apprehension as the independent variables level of anxiety self-report as the dependent variable. The model provided a good fit, $R = .459$. These predictors account for about 21% of the variation in anxiety, $R^2 = 21.1\%$, and $R^2(adj)=20.3\%$. The regression equation indicated that the model was a significant predictor of anxiety, $F(2, 209) = 27.682, p < 0.001$.
On the 80/20 cross-validation split, we found a significant moderate positive correlation between the training set and the level of anxiety self-report, $p=0.001, r=0.466$. There was a significant moderate positive correlation between the test-set and the level of anxiety self-report, $p=0.008, r=0.436$.

3.4 FLA in Vocabulary Exercises

To predict the anxiety level when the learners do vocabulary exercises, we hypothesized that the average test anxiety and average fear of negative evaluation would be effective. We did a multiple regression analysis with the average test anxiety and the average fear of negative evaluation as the independent variables and the level of anxiety self-report as the dependent variable. The model provided a good fit, R = 0.502. This predictor accounts for about 25% of the variation in anxiety, $R^2 = 25.2\%$, and $R^2(adj)=22.6\%$. The regression equation indicated that the model was a significant predictor of anxiety, $F(2, 59) = 9.595, p < 0.001$.

To assess the generalization of the prediction, we again did a Pearson correlation between the training set, test-set and the level of anxiety self-report. We found a significant moderate positive correlation between the training set and the level of anxiety self-report $p=0.001, r=0.516$, but there was no significant correlation between the test-set and the level of anxiety self-report, $p=0.132, r=0.407$.

3.5 FLA in an E-learning System

To predict the anxiety level regardless of the type of exercise, we used the level of anxiety self-report as dependent variable and the FLCAS components as independent variable. We found that this predictor account for about 20% of the variation in anxiety. Thus for overall FLA within an e-learning system, we hypothesized that using FLCAS, language difficulty self-report, system difficulty self-report, and the exercise score would be effective predictors regardless of the type of exercise. We did multiple regression with those items as the independent variables and level of anxiety self-report as the dependent variable. The model provided a good fit, $R = 0.653$. These predictors account for about 43% of the variation in anxiety, $R^2 = 42.7\%$, and $R^2(adj)=42.2\%$. The regression equation, which indicated that the model was a significant predictor of anxiety $F(5, 599) = 88.404, p < 0.001$ is shown in Table 1. Average test anxiety was excluded because the tolerance was 0 which meant that the variance in predictor level of anxiety self-report was already contained in, or redundant with, the other predictors.

Table 1. FLCAS to predict FLA within an e-learning system

Term	Unstandardized Coefficients			
	B	Std. Error	t-value	p-value
Constant	-30.746	3.476	-8.844	<0.001
Fear of negative evaluation	7.853	1.102	7.125	<0.001
Communication apprehension	0.899	1.43	0.629	0.53
Language difficulty	11.331	1.01	11.223	<0.001
System difficulty	3.959	1.168	3.388	<0.001
Score	-0.453	0.232	-1.956	0.051

We split the dataset into trained and tested data. We did cross-validation to evaluate the prediction and prevent any overfitting. Then we did a Pearson correlation and found a significant moderate positive correlation between the trained data and the level of anxiety self-report, $p<0.001, r=0.66$. We found a significant moderate positive correlation between the test data and the level of anxiety self-report, $p=0.001, r=0.628$.

4. DISCUSSION

Through this study, we detected foreign language anxiety in the context of an e-learning system. We used the FLCAS as the main medium for predicting the learner's current level of anxiety. The FLCAS has been shown to be a reliable measure for foreign language in the *classroom* (Horwitz, Horwitz and Cope, 1986) but in this study we have demonstrated that it can be used to predict anxiety in an e-learning context as well.

For the first research question, we hypothesized that the average communication apprehension questions would give us a prediction about the learner's anxiety level in the listening exercise. Our hypothesis was supported, confirming (Horwitz, Horwitz and Cope, 1986; Atasheneh and Izadi, 2012) which indicated that listening is a factor of the communication apprehension. This provides an indication that regardless of the

medium for learning --- in a classroom or through an e-learning system --- anxiety production would be the same.

Based on (Bodie and Villaume, 2003) people are less apprehensive when they communicate in an interpersonal situation and they become more anxious in public. This would explain the moderate correlation between the training and test data with the level of anxiety self-report. The listening exercise is within an e-learning system so the learner interacts with a computer without any connections with other people. The effect of communication apprehension is based on the habituation of previous listening exercises in class. Consequently, modeling FLA within a listening exercise can be effectively done using communication apprehension answers from the FLCAS. Using grammar in a foreign language is a complex task which frequently causes frustration for the learner in foreign language classroom (Mufidah, 2016). Research has identified grammar as the most difficult aspect of the English proficiency test (Mufidah, 2016). We hypothesized that average test anxiety from the FLCAS would predict the anxiety level in a grammar exercise. The analysis partially supported our hypotheses. The regression model was promising with moderate prediction. Nevertheless, the test data did not show a significant correlation with the level of anxiety self-report. We are using only one predictor which may require more variables to increase the prediction. Moreover, the questions in the test anxiety section are focused on worrying about the consequences of failure, forgetting known material, and getting more confused the more the learner studies. These items do not apply to the grammar exercises within the e-learning system because there is no effect of this study on failing, and there is no studying related to these exercises. There are two directions to take regarding predicting the FLA within a grammar exercise: either getting more data then check the prediction or add more predictors.

Foreign language speaking anxiety is a common topic discussed by researchers. Communication apprehension and fear of negative evaluation are the main speaking anxiety producers (Rafada and Madini, 2017b). Researchers found that a major source of FLA is the lack of automaticity (Balemir, 2009). Other aspect that affects speaking anxiety are communication and sociolinguistic competence (Balemir, 2009). Negative feedback from the teacher or the peer induces anxiety and prevents the learner from speaking in class (Rafada and Madini, 2017b). In our study, we hypothesized that fear of negative evaluation and communication apprehension is effective for predicting speaking anxiety in the context of an e-learning system. Our results supported the hypotheses and confirmed the previous research (Horwitz, Horwitz and Cope, 1986; Balemir, 2009; Rafada and Madini, 2017b) about the relationship of foreign language speaking anxiety, fear of negative evaluation and communication apprehension. We chose these two predictors because feeling worried about negative feedback would produce unwillingness to communicate which could prevent the learner from engaging in social activities (Rafada and Madini, 2017b).

(Chen, 2015) found that test anxiety and fear of negative evaluation is significantly correlated with vocabulary anxiety. To address the anxiety level in a vocabulary exercise, we hypothesized that average test anxiety and average fear of negative evaluation would be effective predictors. The results partially support the hypotheses. The training data showed a moderate positive correlation with the level of anxiety self-report while the test data did not show significance. We believe the results may be due to the small size of the dataset. There are only two vocabulary exercises and 30 participants so the total size of the dataset may not be sufficient. We need to investigate these predictors with more data to figure out if the amount of data is the problem or the predictors are not effective.

Our last research question was predicting the anxiety level in an e-learning system regardless of the type of exercise. Based on (McIntyre and Garder, 1994), when a participant is anxious in one situation, they are likely to be anxious in a similar context. (Ismail and Hastings, 2019) found that language difficulty self-report, system difficulty self-report, and the exercise score were effective for measuring anxiety in an e-learning system. Thus, we hypothesized that combination of FLCAS, language difficulty self-report, system difficulty self-report, and exercise score would be effective for predicting FLA. The hypothesis was supported because the training data and the test data were positively correlated with level of anxiety self-report.

We plan to use these indicators in the future to build an intelligent tutoring system for English as a second language that can predict anxiety level and work to remediate it. We propose to use animated pedagogical agent that provides emotional support to reduce FLA.

5. CONCLUSION AND FUTURE WORK

Foreign language anxiety hinders language learning. It produces a negative effect even after the stressor is gone. In this research, we studied indicators from different components of the FLCAS of learner anxiety level. Using multiple regression, we found that FLCAS components could provide a sensor-free predictor for foreign language anxiety within listening and speaking exercises. We found a sensor-lite predictor for FLA regardless of the type of exercise by including self-report of language difficulty, system difficulty, and the score of the exercise in addition to the FLCAS components. We suggest giving the FLCAS as a pre-test and using it to predict the anxiety level in the context of an e-learning system.

The main limitation of this work is that it does not include writing and reading exercises which are primary components in ESL teaching. But we believe that a sensor-lite method could predict FLA for these types of exercises as well. The dataset was rather small for some of the exercises which may have kept the test data from giving significant predictions.

For future work, we will build an intelligent tutoring system that detects FLA using sensor-free and sensor-lite anxiety indicators. This system will be able to recognize learner anxiety and change its behavior to overcome and eventually eliminate FLA.

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