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Functional Measurement Applied to Engineering Students' Test Anxiety Judgment for Online and Face-to-face Tests

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Abstract: This study explored the cognitive mechanism behind information integration in the test anxiety judgments in 140 engineering students. An experiment was designed to test four factors combined (test goal orientation, test cognitive functioning level, test difficulty and test mode). The experimental task required participants to read 36 scenarios, one at a time and then estimate how much test anxiety they would experience in the evaluation situation described in each scenario. The results indicate three response styles (low, moderate, and high-test anxiety) among the participants. The orientation and difficulty of each given exam scenario were the most critical factors dictating test anxiety judgments. Only the moderate test anxiety group considered the test mode to be a third relevant factor. The integration mechanism for Cluster 1 was multiplicative, while for Clusters 2 and 3, it was summative. Furthermore, these last two clusters differed in terms of the valuation of the factors. These results suggest that programs that help students to cope with test anxiety need to take into account the valuation and integration mechanism that students use to integrate different information in specific examination contexts, since the way students assess their internal and external circumstances can influence how they deal with evaluative situations.

Keywords: *Test anxiety, engineering students, cognitive algebra, information integration theory.*

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Introduction

Learning assessment is helpful in terms of obtaining valuable information about students' academic progress. However, a considerable percentage of students report experiencing anxiety in evaluative situations (Ahmad et al., 2018; Bhuvaneswari, 2020; Marcue & Gonzalez, 2017; Thomas et al., 2017; Tsegay et al., 2019). In particular, students may experience unpleasant thoughts and feelings before, during, and after oral and written exams (Malloy, 2016; Sarason & Sarason, 1990).

Bhuvaneswari (2020) and Thomas et al. (2017) identified that 7–25% of students suffer very high-test anxiety levels. Students with high test anxiety tend to worry about failing or performing poorly on the test (Rana & Mahmood, 2010). They have intense physiological symptoms such as sweating, tension, and increased heart rates (Ringeisen & Heckel, 2019). Additionally, students with anxiety have difficulties focusing on completing the exam or evaluative task (Cassady, 2004; Furlan et al., 2014; Trifoni & Shahini, 2011). They may experience problems with the coding, organization, storage, or retrieval of information, affecting their understanding of the material read and their processing of information they have learned (Cassady, 2004; Coy et al., 2011). Students with high anxiety may also exhibit behaviors irrelevant to the test, leading to poor performance (Spielberger & Vagg, 1995). This is particularly concerning since the test anxiety score correlated negatively with the scores obtained in evaluations of a different nature such as standardized tests, university entrance exams and grade point average (von der Embse et al., 2018).

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The intensity of test anxiety felt and its effects depend on the individual or the joint action of personal, situational, and contextual factors. In this regard, a considerable number of studies have indicated that female students seem to experience higher levels of anxiety than men (Cassady & Johnson, 2002; Farooqi et al., 2012; Furlan et al., 2009; Ojediran & Oludipe, 2016; Santana & Eccius-Wellmann, 2018; Zaheri et al., 2012). However, Nunez-Pena et al. (2016) asserted that, although women report more anxiety than men, academic achievement is similar between both sexes. In contrast, Safeer and Shah (2019) observed that exam anxiety affected men's performance more than women's.

The goal approach adopted by students also seems to affect test anxiety level. Elliot and Pekrun (2007) mentioned that having a performance orientation could be related to higher test anxiety than a learning goal orientation since people's motivation is geared toward achieving success in a norm-based assessment, so their focus is primarily on avoiding failure. Various investigations have supported this premise (Eum & Rice, 2011; Jafari & Mousavi, 2014; Putwain et al., 2010; Stan & Oprea, 2015).

von der Embse et al. (2018) reviewed the research on test anxiety conducted over the past thirty years and found that students reported higher anxiety levels when faced with tests that were considered an essential part of their evaluation and had consequences. In contrast, when the exams were used as learning activities, the students' anxiety levels decreased. Putwain and Symes (2011) reported that comments that emphasize the negative consequences of not passing a test increase anxiety levels and redirect students' attention towards performance goals. Findings like these point out that extrinsic motivation seems to be positively associated with exam anxiety (von der Embse et al., 2018). In contrast, intrinsic motivation, learning goal orientation, and metacognitive learning strategies all reduce students' anxiety levels (Mohammadi et al., 2017).

In addition to personal knowledge and the self-regulation processes that are essential elements of explanatory models of anxiety, it is also necessary to include the influence of situational factors to understand the nature of the phenomenon (Putwain et al., 2010). For example, conditions associated with the exam's test mode can also influence test anxiety levels. Stowell and Bennett (2010) observed that online exams decrease test anxiety, especially when students have high anxiety in the classroom, although this is the opposite for students with low anxiety levels in the classroom. In contrast, Kolagari et al. (2018) reported that anxiety levels are not significantly different in this scenario, even though they found that the anxiety score was slightly higher for computerized tests than paper-based ones. Deloatch et al. (2016) found no significant difference in the anxiety scores of computer and engineering students due to the test mode.

Another factor that influences test anxiety level is related to the nature of the evaluation tools being used (e.g., test difficulty). von der Embse et al. (2018) identified that students experienced a higher level of test anxiety when they perceived a test to be difficult or challenging. Bonaccio and Reeve (2010) found that the degree of perceived exam difficulty increases students' anxiety levels, affecting their performance on the exam. In line with this, Chen (2012) reported that students' perceptions of exam difficulty, the consequences, and the risk type associated with the test increase the level of test anxiety experienced. When the difficulty of graduation is calibrated according to an item bank, it has a moderate and significant effect on high and moderate anxiety students. However, if item organization is based on the perceived exam difficulty level among students, the effect is also observed in low anxiety students. Tippets and Benson (1989) noted that different item arrangements could produce different levels of anxiety, which implies that unknown variables could affect the validity of an exam.

In addition to the academic effort above presented, von der Embse et al. (2018) suggested that the nature of the construct of test anxiety still needs to be further explored, in order that measuring instruments continue to be developed and improved upon. As early as the 1990s, Sarason and Sarason (1990) indicated the need for a higher number of studies on the individual and interactive nature of anxiety components (emotion, cognition, and physiology). These authors suggested that this could be achieved by characterizing exam anxiety through behavior (e.g., social withdrawal), thoughts (e.g., worries) and physiology (e.g., heart rate).

This need to explore the multifactorial and multicausal nature of psychological phenomena is universal across the various psychology domains. Information Integration Theory (IIT) proposes a way to approach this problem of multiple determination of psychological phenomena by identifying the psychological laws of information integration that govern human thoughts and actions (Anderson, 2013).

According to IIT, humans systematically process information from their internal and external environment through cognitive algebraic rules. These information-processing modes are expressed through three mathematical laws of psychological integration: averaging, adding, and multiplying (Anderson, 2008; Gaj, 2016), and these processes together make up the general cognitive algebra that underlies IIT.

Cognitive algebraic rules are present in various life domains (Anderson, 2013; Cano et al., 2017; Cretenet et al., 2015; Gaj, 2016; Guedj et al., 2009; Lopez-Ramirez et al., 2019). The cognitive rules of information processing emerge in people's minds as a systematic mechanism of cognitive integration (Morales, 2012). This cognitive mechanism develops through three cognitive processes: the valuation function (V), the integration function (I), and the action function (R). Anderson (2008, 2013) defines "V" as the transformation of physical stimulus properties to psychological values, "I" as the organization and combination of these values to produce an integrated internal response, and "A" as the process of transforming this internal response into an external one.

These three cognitive functions can be observed by scrutinizing participants' response patterns represented in ANOVA interaction graphs obtained from cognitive algebra studies (Morales, 2012). For example, parallel curve patterns suggest the use of a summative cognitive rule for information integration. On the other hand, fan linear patterns reveal the use of a multiplicative cognitive rule (Anderson, 2013).

In the field of education, the application of IIT studies has allowed us to observe the cognitive mechanisms that intervene in information processing among teachers and students, the elaboration of judgments, and decision-making within different educational contexts (special education and regular) and in domains such as school inclusion (e.g., Morales et al., 2014), training for people with disabilities (e.g., Morales-Martinez et al., 2015), academic self-efficacy (e.g., Briones-Rodriguez et al., 2016) and the desire to cheat academically among high school and higher education students.

In general, these IIT studies in the educational field have provided evidence of systematic information processing mechanisms to evaluate academic situations. However, very little is known about these mechanisms in terms of how test anxiety is elicited in college students (e.g., Moore et al., 2010). There are few studies on the information integration mechanisms underlying test anxiety among university students. This study contributes to exploring the behavior of the three cognitive mechanisms or functions (V, I, A) associated with test anxiety in learning assessment scenarios. The situational factors and exam characteristics are relevant in eliciting test anxiety. To explore the effect of factors related to the characteristics of exams (e.g., test goal orientation, test cognitive functioning level, test difficulty), the present authors designed an experiment based on the cognitive algebra paradigm to study the cognitive mechanisms underlying the test anxiety, which is described in more detail in the next section.

The present study

According to the national comorbidity survey, one of the most prevalent mental disorders among Mexicans is anxiety (Medina-Mora et al., 2003). Approximately a quarter of university students in Mexico experience school anxiety (Hernandez-Pozo et al., 2008). The Mexican Ministry of Public Education (Secretary of Public Education [SEP], 2019) reported 3,943,544 students enrolled in Mexican universities. So, close to 1,000,000 students may be at risk of experiencing school anxiety.

Not having enough time for homework, work overload, and especially exams are situations that cause school anxiety among Mexican students (Flores et al., 2016). However, the underlying psychological nature for this anxiety is little explored in this population (Aragon et al., 2015; Lopez et al., 2015; Reyes et al., 2017; Santillan et al., 2016). Specifically, there are very few scientific studies on test anxiety (Aragon et al., 2015; Flores et al., 2016; Hernandez-Pozo et al., 2008; Marcue & Gonzalez, 2017; Pedroza, 2015), and these studies have been conducted with few participants, which could mean that it is not possible to generalize their results to fully understand many aspects of the psychological nature of test anxiety. However, these studies are the only source of information on the prevalence and psychological impact of test anxiety among Mexican students to date.

Marcue and Gonzalez (2017) found that 48% of the participants in their study experienced subjective symptoms of test anxiety, 18% physiological symptoms, and 28% behavioral symptoms, and the intensity of these manifestations ranged from mild to moderate. On the other hand, Flores et al. (2016) explored the level of evaluative situations anxiety in 87 Mexican dentistry students, and he observed that job interviews and exams were the events that triggered the highest anxiety levels among the participants. Furthermore, in contrast to men, a higher percentage of women reported experiencing worry and having difficulty concentrating and experiencing motor and physiological symptoms in assessment situations.

In general, studies like the above contribute with evidence about the psychological structure of the test anxiety, also they provide information about behavioral, physiological, and emotional traits of test anxiety. Now, it is necessary uncovering the cognitive mechanisms underlying test anxiety. Specifically, the present study explored the effect of pieces of information related to the intrinsic nature of an exam on students' test anxiety judgments. With this purpose in mind, the present authors explored the following linear function to determine the algebraic cognitive pattern for each participant.

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$$TAL = f(w_{GO} \text{ Test goal orientation} * w_{CFL} \text{ Test cognitive functioning level} * w_D \text{ Test difficulty} * w_M \text{ Test mode})$$

TAL represents the test anxiety level, the estimation of which is derived from a cognitive operation (*) that combines the relevance weights (w) given to the selected factors.

So, the first question in this work is: what factors are most relevant when participants make test anxiety judgments? Further questions are as follow. What role does the test mode play in an evaluation scenario when this includes a higher number of factors associated with the evaluation's intrinsic nature? Is there a systematic rule by which participants cognitively integrate the factors they judge to be most relevant? Moreover, if there is systematic thinking, what is the cognitive rule that regulates participants' test anxiety?

In this study, the first expectation was to find a summative rule to integrate the relevant factors when students formed test anxiety judgments. Additionally, since in previous studies, the test goal orientation and difficulty were relevant factors in terms of judging self-efficacy in daily evaluative mathematics tasks (Briones-Rodriguez et al., 2016). In this study it was expected that students would perceive both these factors as relevant when evaluating an exam situation. A similar hypothesis was established for the test mode factor since this factor is central to test anxiety judgment. Regarding to test cognitive functioning factor, the authors hypothesized that test anxiety level could vary because the difficulty of cognitive process involved to resolve the test.

Methodology

Research goal

According to Hofmans and Mullet (2013), human judgments are formed in three stages. The first involves the information selection process, according to the relevance that the human viewer attaches to each piece of information selected from their internal or external environment. To do this, the person assigns a psychological value to each piece of information through the Valuation Function (V). The person's mind then generates an implicit response (r) by combining the values assigned to each piece of information using an Integration Function (I). The process ends with the implicit response being converted into an observed response through the Response Function (R). In this study, the objective is to determine the behavioral patterns related to these three information processing functions in engineering students when they face test anxiety situations.

There is little information about the cognitive functions or processes that underlie test anxiety in a functional theory such as IIT, so this study provides valuable information on the cognitive mechanisms of test anxiety from a new perspective. Furthermore, the study provides empirical evidence on the usefulness of carrying out experimental designs based on cognitive algebra.

Study design

In line with the principles of IIT, a cognitive algebra study was constructed based on the experimental design of 2 (test goal orientation: learning vs. performance) x 3 (test cognitive functioning level: knowledge vs. comprehension vs. application) x 3 (test difficulty: low vs. medium vs. high) x 2 (test mode: face-to-face vs. online) factors, generating a total of 36 experimental conditions.

Sample

The participants for this study were 140 engineering students (37 women and 103 men); their ages ranged from 17 to 30 years old (M = 20, DS = 2.1) (Table 1). Participants were chosen based on purposive sampling and they all gave verbal informed consent to participate in the experiment.

Table 1: Demographic characteristics of the participants

Characteristics	N	%
Sex		
Female	37	26.4%
Male	103	73.5%
School year		
First-year	23	16.4%
Second-year	72	51.38%
Third-year	4	2.84%
Fourth-year	27	19.1%
Fifth-year	14	9.92%

Table 1: Continued

Characteristics	N	%
Marital status		
Married	1	.71%
Single	135	96.4%
Domestic partnership	4	2.8%
Believer		
Yes	105	75%
No	35	25%
Religion		
Catholic	98	70%
Christian	19	13.5%
Other	4	2.8%
None	19	13.5%
Practicing		
Always	20	14.28%
Sometimes	83	59.28%
Never	37	26.42%

Instruments

The instruments included 36 experimental vignettes based on the experimental conditions. Each one described a hypothetical evaluation situation. Each vignette ended by asking a question about the possible test anxiety level that the participant could experience in the scenario described. The left anchor was "Not at all anxious," and the right was "Extremely anxious" (see Appendix 1).

Procedure

The first step in the study was to obtain the informed consent of students. Then, participants became familiar with the experimental task in a practice phase. Finally, the instrument was applied. The participants' task was to read 36 experimental scenarios each of which described a different academic evaluation situation. Then the students judged how much test anxiety they would experience if they faced that situation.

Analyzing the data

The authors conducted cluster analysis on the participants' raw data by using the STATISTIC software (version 7). The objective was to determine if there were different behavior patterns in terms of the cognitive functions V, I, and R. Hofmans and Mullet (2013) recommend the nonhierarchical centroid-based method for examining data from IIT studies. This type of analysis is more resistant to extreme scores, and it is also less sensitive to the inclusion of irrelevant variables and the distance measure used; this technique has also been used on large data sets (Hair et al., 2008).

In addition, a mixed ANOVA was carried out to explore the discriminability of the identified clusters given the test anxiety level. Subsequently, the authors applied a repeated-measures ANOVA to each cluster's data to analyze cognitive response patterns in each one, taking into account the three stages (V, I, R) of information processing for test anxiety situations.

Findings / Results

Cluster analysis

Keeping in mind the findings of Thomas et al. (2017) and seeking to theoretically interpret the results of the study in a feasible way, the authors applied a cluster analysis (Euclidean distance, K-means) using a three-cluster solution to find response patterns among the participants (see Table 2). It is essential to note that the authors chose three clusters, in spite of the fact that a visual inspection of the elbow graph suggested that the optimal number of clusters was four. There were two reasons underlying the decision to choose three clusters. Firstly, since the sample for the study was small, increasing the number of clusters would decrease the representativity of each cluster. Additionally, the authors decided to follow suggestions in previous research about the theoretical convenience of choosing a model of k=3 (Thomas et al., 2017). More about this solution is discussed in the recommendations.

Table 2. Demographic characteristics of the clusters

	Cluster 1 Low test anxiety M_{ta}= 2.5		Cluster 2 Moderate test anxiety M_{ta}= 5		Cluster 3 Very high test anxiety M_{ta}= 7.2		Full sample M_{ta}= 5	
	n= 44 31.42%		n= 52 37.14%		n= 44 31.42%		n= 140 100%	
Characteristics	n	%	n	%	n	%	n	%
Gender								
Female	10	23	10	19	17	39	37	26
Male	34	77	42	81	27	61	103	74
Marital status								
Single	43	98	52	100	40	91	135	96
Married	1	2	0	0	0	0	1	1
Other	0	0	0	0	4	9	4	3
School year								
First-year	8	18	11	21	4	9	23	16
Second-year	21	48	28	54	23	52	72	51
Third-year	2	4	0	0	2	5	4	3
Fourth-year	10	23	8	15	9	20	27	19
Fifth-year	3	7	5	10	6	14	14	10
Believer								
Yes	39	89	36	69	30	68	105	75
No	5	11	16	31	14	32	35	25
Religion								
Catholic	34	77	29	56	35	79	98	70
Christian	8	18	8	15	3	7	19	14
Other	0	0	4	8	0	0	4	3
None	2	5	11	21	6	14	19	13

Note: M_{ta}= mean score for test anxiety, n= number of participants

Mixed ANOVA

A mixed ANOVA involving a factor design with 3 (cluster: low vs. moderate vs. high test anxiety) x 2 (test goal orientation: learning vs. performance) x 3 (test cognitive functioning level: knowledge vs. comprehension vs. application) x 3 (test difficulty: low vs. medium vs. high) x 2 (test mode: face-to-face vs. online) factors was carried out on the data to determine the degree of discriminability among three clusters. The results of the analysis indicate statistically significant differences between the clusters [$F(2, 137) = 258.616$, $p<.001$, $\eta_p^2= .79$]. The Tukey HSD test confirmed that the mean score for the low-test anxiety condition was significantly different to the mean for the moderate anxiety group ($p = .00002$) and high anxiety group ($p = .00002$). In addition, the mean score for the moderate test anxiety group was significantly different to that for the high-test anxiety condition ($p = .00002$).

The factors that had a statistically significant main effect were test goal orientation [$F(1, 137) = 465.217$, $p< .001$], test difficulty [$F(2, 274) = 127.085$, $p< .001$], and test mode [$F(1,137) = 16.883$, $p< .001$]. To examine whether these factors were processed differently by each of the clusters, each group's data were analyzed with a repeated-measures ANOVA. This statistical analysis was carried out taking into account satisfaction of the independence assumption. The experimental conditions and the participants were randomized. The data showed a normal distribution in the QQ plot. Levene's test indicated the variances are not equal [$F(2,137) = 14.106$, $p=.000003$]. In this regard, Anderson (2008) mentions that unequal variances should not be a concern in experiments since they are generally caused by the treatment effect.

ANOVA for each cluster

A repeated-measures ANOVA of 2 (test goal orientation: learning vs. performance) x 3 (test cognitive functioning level: knowledge vs. comprehension vs. application) x 3 (test difficulty: low vs. medium vs. high) x 2 (test mode: face-to-face vs. online) factors was applied to the data for the participants in each cluster (see Table 1). The level of significance was $p <.001$.

Table 3 shows a statistically significant main effect for the goal orientation factor across all three clusters. The partial eta squared suggests that the effect size for this factor was substantial in all three groups. In addition, the difficulty factor obtained a moderately high to moderately small effect size across the clusters. The test mode only had a significant main effect in Cluster 2, and its partial eta squared suggests that the effect size was smaller compared to the effects observed for the other two factors.

Table 3. ANOVA results for each cluster

Source	df	MS.	df	MS.	F	p	η_p^2
Cluster 1 <<Low test anxiety>>							
Goal orientation (GO)	1	907.576	43	16.872	53.791*	.001	.55
Cognitive functioning level (CFL)	2	1.731	86	2.452	.706	.049	.01
Difficulty (D)	2	376.214	86	8.617	43.655*	.001	.50
Test mode (M)	1	31.960	43	8.351	3.826	.056	.08
GO * CFL	2	.341	86	1.548	.220	.802	.005
GO * D	2	43.343	86	3.023	14.337*	.001	.25
CFL * D	4	4.379	172	1.822	2.403	.051	.05
GO * M	1	1.515	43	2.245	.674	.415	.01
CFL * M	2	5.115	86	1.747	2.927	.058	.06
D * M	2	0.143	86	2.124	.067	.934	.001
Cluster 2 <<Moderate test anxiety>>							
Goal orientation (GO)	1	14802.188	51	35.865	412.712*	.001	.89
Cognitive functioning level (CFL)	2	13.237	102	2.572	5.145	.007	.09
Difficulty (D)	2	527.737	102	8.871	59.485*	.001	.53
Test mode (M)	1	72.341	51	6.509	11.113*	.001	.17
GO * CFL	2	.779	102	2.030	.383	.682	.007
GO * D	2	9.897	102	4.245	2.331	.102	.043
CFL * D	4	.752	204	2.154	.349	.844	.006
GO * M	1	.307	51	3.196	.096	.757	.001
CFL * M	2	2.378	102	2.472	.961	.385	.018
D * M	2	1.798	102	1.662	1.081	.342	.020
Cluster 3 <<High test anxiety>>							
Goal orientation (GO)	1	1435.646	43	18.491	77.638*	.001	.64
Cognitive functioning level (CFL)	2	.149	86	2.030	.073	.92	.001
Difficulty (D)	2	244.642	86	8.596	28.459*	.001	.39
Test mode (M)	1	22.790	43	6.012	3.790	.058	.08
GO * CFL	2	.099	86	2.411	.041	.959	.000
GO * D	2	2.746	86	2.368	1.159	.318	.02
CFL * D	4	4.695	172	2.274	2.064	.087	.04
GO * M	1	1.578	43	2.916	.541	.465	.01
CFL * M	2	.352	86	1.883	.187	.829	.004
D * M	2	.197	86	1.115	.177	.837	.004

Note: N= 140. ANOVA = analysis of variance; df = degree of freedom; MS = mean square; η_p^2 = partial eta squared. *$p<.001$

In short, as indicated in Table 3, test goal orientation was the most relevant factor across the three groupings, followed by test difficulty. Furthermore, a third factor (test mode) was relevant for the moderate anxiety group when assessing for the factors affecting their judgments. The observed interaction (GO x D) in the low anxiety cluster suggests that this cluster used a different cognitive rule in comparison to the moderate and high anxiety clusters. This result is illustrated in Figure 1, which shows the integration mechanism for the factors selected as relevant for each grouping.

As shown in Figure 1, Cluster 1 participants had the lowest anxiety level and used two factors to form their judgment. According to IIT, a fan pattern in the response curves indicates that the interaction is systematic; this suggests that this first group used a multiplicative cognitive rule to form their anxiety judgments between exams. The participants with low anxiety used an integration function (I) as TAL = *f*(test goal orientation x test difficulty). The test goal orientation factor multiplied the test's effect on the formation of test anxiety judgments in these participants.

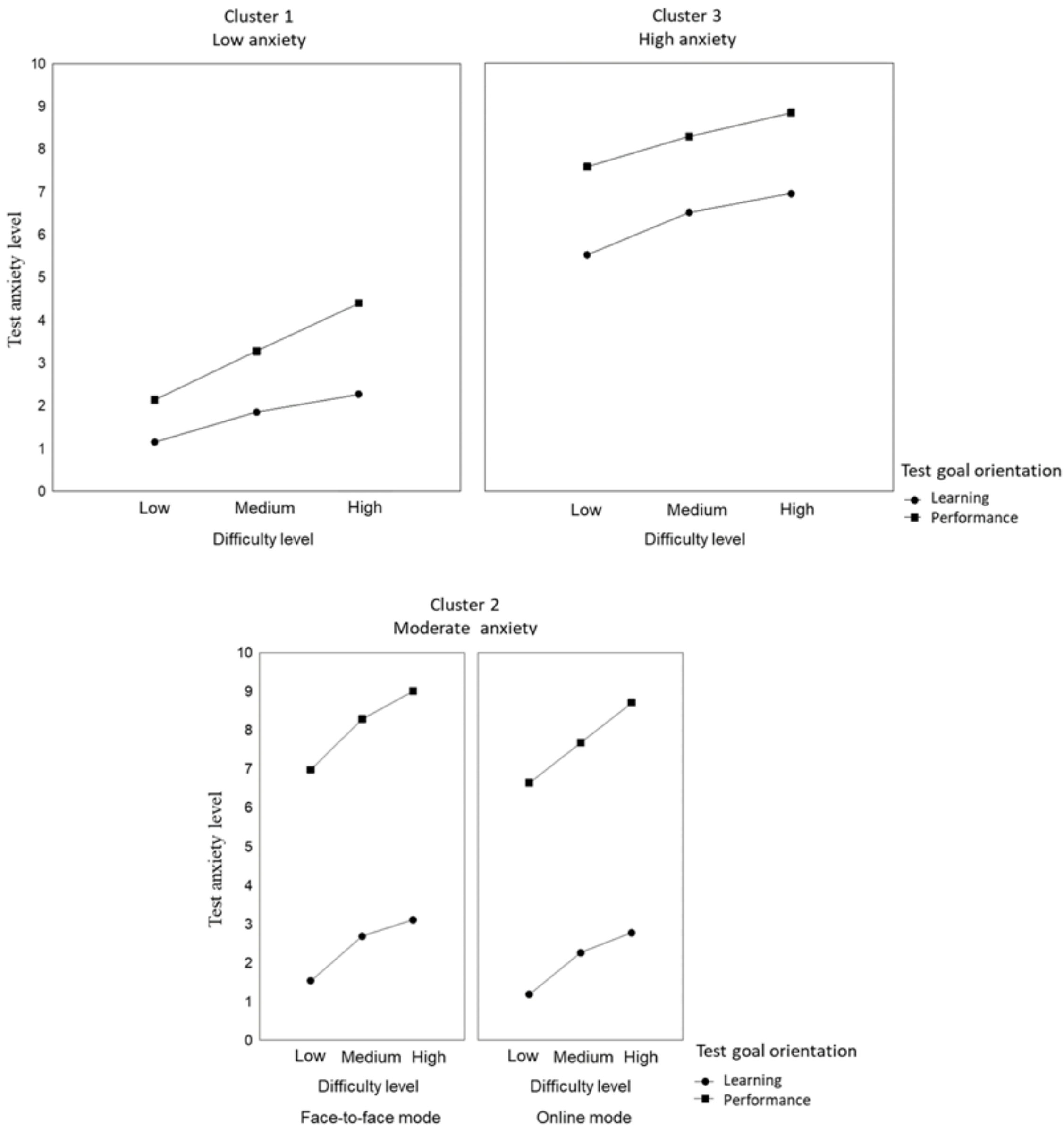

Figure 1. Interaction graph for each cluster

Cluster 2 used a three-factor model to judge the test anxiety level. The participants in this cluster demonstrated the test mode to be a third factor affecting test anxiety judgment. The pattern of curves shows parallelism; IIT proposes that this kind of pattern underlines a summative cognitive rule. Then, Cluster 2 participants used the following rule: TAL = *f*(test goal orientation + test difficulty + test mode) to generate moderate test anxiety judgment. Furthermore, this integration function suggests that the effect of the factors was constant and systematic across all experimental conditions.

Finally, Cluster 3 used a bi-factorial model to form their test anxiety judgments. This group's response curves show parallelism, so the participants in this cluster appear to have used a summative cognitive rule to integrate the values of the two factors that they considered to be the most relevant: TAL = *f*(test goal orientation + test difficulty). As in Cluster 2, this rule suggests that all factor levels had a constant effect on the amount of anxiety participants assessed that they would experience across all experimental conditions.

Discussion

Test anxiety can become a significant barrier to students' academic development. Understanding how students experience and cope with potentially frightening academic situations is relevant for decision-making and choice strategies to allow students' academic potential to be developed as fully as possible under the most favorable conditions.

This study has explored the cognitive mechanisms that allow students to integrate and use the information they receive from their academic and internal environment to generate judgments about test anxiety. Specifically, this study measured the effect of situational factors (test mode) and factors related to the nature of exams (e.g., test goal orientation, test cognitive functioning level, test difficulty) on students' anxiety levels. The data analysis identified three cognitive patterns in the manifest response (Function R) for evaluative anxiety: low, moderate, and high-test anxiety levels (see Table 2).

To answer the first question related to the valuation of information and selection mechanism, V function analysis was carried out taking into account the ANOVA data. Overall, the results indicated that test goal orientation was the most relevant factor for students (see Table 3, Figure 1). This result suggests that students considered the exam's consequences to be the central factor affecting their judgments. This result is consistent with the proposals that performance goal orientation is related to test anxiety (Elliot & Pekrun, 2007; Eum & Rice, 2011; Jafari & Mousavi, 2014; Putwain et al., 2010; Stan & Oprea, 2015).

Test difficulty was the second most critical factor affecting students' test anxiety judgments (see Table 3, Figure 1). This finding is in line with evidence that a student's perception of an exam's challenge level can influence or even increase their test anxiety level (Chen, 2012; von der Embse et al., 2018). Furthermore, the authors hypothesize that students can use the information related to the exam difficulty to calculate the success probability in each evaluative circumstance they face. This assumption could implicitly mean that students use self-efficacy schemes to anticipate their possible performance in an exam, generating states of relaxation or concern depending on their verdict on the evaluative situation they face.

To summarize the above, the cognitive patterns indicated in this study suggest that the cognitive behavior of Function V is strongly characterized by factors closely related to students' extrinsic motivations (goal orientation and exam difficulty) (see Table 3, Figure 1). This finding is in line with other research on motivational judgments among mathematics students (Briones-Rodriguez et al., 2016).

Interestingly, the first cluster, with low anxiety, also used test goal orientation and difficulty to evaluate each situation. Although this finding may seem to contradict the proposal that exam anxiety is more associated with the performance goal approach, it may indicate that participants used a metacognitive process to analyze the evaluative situation rather than generating test anxiety itself. That is, all the participants could identify the factors that can exert a possible influence on their level of test anxiety; however, the way they experience this can probably be modulated by the valuation of information and integration processes. Note that the weight of relevance given to test goal orientation is much higher in the moderate test anxiety cluster than the weight given by the low- and high-test anxiety groups (Figure 1).

Regarding the second question, related to the role that the test mode plays in the experience of test anxiety, the data indicate that this was only considered relevant by the participants with moderate anxiety (see Table 3, Figure 1). Furthermore, this factor had less weight in terms of students' anxiety judgments. This result may be because the test mode factor was framed using situations that emphasized different elements in each study. So, although the participants came from the same educational context, the valuation of test mode could have been influenced by the information emphasized in each experimental setting.

Furthermore, test cognitive functioning level was not shown to be relevant for participants in any of the clusters. This result is interesting because although students with high levels of anxiety tend to have difficulties in the recognition, organization, and understanding of information (Cassady, 2004; Coy et al., 2011), they did not consider the cognitive functioning level measured in the test's questions to be a trigger for anxiety. Alternatively, this result could suggest that the students' attention was focused more on the factors relating to each exam's consequence rather than on the learning process. That is, the students seemed to have adopted the performance goal approach more than a learning goal orientation, as can be observed in Figure 1, where participants showed a higher anxiety level for a performance goal than a learning goal. In addition, this finding suggests that although test anxiety can cause complications in the different processing levels, the cognitive functioning level measured in a test is not necessarily involved in the genesis of anxiety.

Finally, concerning the cognitive mechanisms of information integration (Function I) underlying test anxiety, the moderate and high anxiety clusters used a summative cognitive rule, while the low anxiety group used a multiplicative rule to elaborate their test anxiety judgments (Figure 1). Thus, the data do not support the assumption that the cognitive information integration mechanism underlying test anxiety is summative, at least not for all students. In this regard, the results suggested that the cognitive rule may vary according to the student's level of test anxiety (see Figure 1).

The reason for this difference in cognitive rules is not apparent to the authors of the present study. However, as we have mentioned before, a vague hypothesis could be that participants with low anxiety in certain circumstances use a multiplicative rule as a compensatory mechanism to modify their threshold of perception for the relevance of an evaluative situation. This recalibration in the perception of the factors may allow them to push their cognitive system to put in more effort and pay more attention and to exams that have implications for their grades.

Conclusion

The present study's findings indicate that, even in similar circumstances, students can be judged systematically through different cognitive mechanisms in learning assessment situations. It suggests that various cognitive processing styles may govern judgments made by engineering students about potentially frightening evaluative situations. In general, this study disclosed three types of mechanisms for selecting and integrating information related to evaluative situations. Regarding the selection process, two groups (low and high anxiety) used a bifactorial model (test goal orientation vs. test difficulty) to judge their degree of anxiety before exams. However, they differed in terms of their integration mechanism (summative vs. multiplicative), while the moderate anxiety group used three factors (test goal orientation vs. test difficulty vs. test mode), integrating them with a summative rule.

In sum, the data from the present study indicate that cognitive algebra experimental designs can provide information about the emotional-cognitive mechanisms that underlie students' experiences in assessment situations. By characterizing a student's cognitive behavior, a range of opportunities opens up in the field of educational intervention. The observation about how the information selection, evaluation, and integration mechanisms vary in the groups according to anxiety level can provide small clues about what aspects of academic evaluation can be modified to influence students' negative and positive experiences. For example, determining a student's cognitive flexibility can contribute to implementing strategies that allow non-functional evaluations to be adjusted and new pieces of information to be re-evaluated thereby allowing students to form more adaptive cognitive schemas.

Additionally, this article is an invitation to continue introducing new affective, cognitive, and contextual factors in the experimental designs based on cognitive algebra that allow us to broaden our understanding of how students experience potentially frightening academic situations they experience daily in their academic environments.

Limitations

Experimental designs based on cognitive algebra share the same limitations as factorial experimental designs. The number of factors included in an experimental design is limited because numerous factors result in copious experimental conditions, and it is challenging to maintain a participant's interest in examining all possible experimental scenarios for a long time. However, the cognitive algebra paradigm takes into account several principles that guide the selection of the most relevant factors, increasing the ecological validity of an experimental design.

Recommendations

New factors in different educational settings should be included in experimental studies based on cognitive algebra to obtain a wider depiction of the cognitive nature of test anxiety. Since this study was not able to explore the differences between men and women, given the number disparity between female and male participants, it would be useful to increase the number of female participants and compare their cognitive patterns with those of male participants. Additionally, it is necessary to increase the sample size to explore new solutions based on clusters in which the number of participants is more representative.

Additionally, including students from different fields (exact sciences vs. humanities) would allow information to be obtained about how the cognitive mechanisms diverge or converge according to an academic training profile. Broadening the exploration spectrum would contribute by offering more personalized strategies for facing test anxiety.

Authorship Contribution Statement

Hedlefs-Aguilar: Conceptualization and design of study, management of permits for the sample, writing, supervision in application of instruments. Morales-Martinez: Conceptualization and design of study, statistical analysis, writing original paper, editing and reviewing. Moreno-Rodriguez: Critical revision of manuscript. Gonzalez-Rodriguez: Management of survey platform and contact with participants via online to answers doubts.

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Appendix

Experimental scenario

This year you are enrolled in a fundamental course. You will take a test without a grade; the exam's purpose is to provide you with feedback about what you have learned. The test's questions require you to recognize or to identify certain concepts. Students, from other years, says that the test is difficult to answer. The exam will be in the classroom.

How anxious would you be about the exam?

Not at all anxious 0--0--0--0--0--0--0--0--0--0—0 Extremely anxious