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Information Integration Cognitive Mechanisms Underlying the Face-to-Face or Online Statistics Test Anxiety Judgments of Engineering Students

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Abstract: This study examined information integration cognitive mechanisms underlying the test anxiety judgments of 474 engineering students. The experimental design considered the orthogonal combination of three factors (teaching style, exam type, and test mode), resulting in 12 experimental scenarios. During the experiments, participants were provided one scenario at a time and were asked to rate their anticipated anxiety level in the described situation. Subsequent analyses failed to reveal statistically significant differences in the anxiety levels reported by females and males. However, the factor selection and valuation female students adopted to make their anxiety judgments differed from those employed by their male peers. Cluster analysis identified three groups based on the anxiety level (low, medium, and high). The most relevant factor for all clusters was test mode, and only the medium anxiety group considered a second factor (exam type) to make their anxiety judgments, which was integrated through an additive cognitive rule. These findings suggest that participants place a higher weight on the examination context than its type when making their test anxiety judgments. Identifying these cognitive mechanisms underlying test anxiety could help regulate conditions that undermine the students' ability to cope with test anxiety.

Keywords: *Test anxiety, engineering students, online classroom, face to face classroom, Integration Information Theory.*

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Introduction

Exams are an inevitable aspect of students' life, as success or failure could have profound implications for their personal and professional development. Thus, formal evaluations can produce a wide variety of reactions among students, including working hard to obtain praise, fear immobilization, worries about meeting others' expectations (Malloy, 2016; Peleg et al., 2016; Putwain et al., 2010; Sarason & Sarason, 1990), and concerns about anticipated faults (Flett & Blankstein, 1994). These experiences, separately or together, sometimes contribute to increase the test anxiety degree.

Test anxiety is an unpleasant emotional experience that occurs before, during, or after the examination. During the evaluation, persons that are prone to test anxiety could experience worry, fear, failure, catastrophic thoughts, tension, somatic symptoms, apprehension, and physiological reactivity (Malloy, 2016; Sarason & Sarason, 1990).

High levels of test anxiety tend to interfere with academic performance, potentially resulting in procrastinate on assignments, or even difficulties in learning due to failures in information processing or difficulties in organizing and retrieving information, ultimately jeopardizing students' mental health (Cassady, 2004; Custer, 2018; Jalilian et al., 2016; Malloy, 2016; Naveh-Benjamin et al., 1987). According to the available data, approximately 18% to 50% of students experience some degree of test anxiety (Ahmad et al., 2018; Bhuvanewari, 2020; Marcue & Gonzalez, 2017; Thomas et al., 2017; Tsegay et al., 2019). However, it is particularly worrisome that nearly 7–25% of students suffer very high levels of test anxiety (Bhuvanewari, 2020; Thomas et al., 2017).

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The aforementioned discrepancies in findings yielded by extant research may stem from difficulties in defining and measuring this construct. In this regard, Howard (2020) argued that, as test anxiety is expressed on a continuum, it is difficult to create categories based on the experience's severity. In addition, there are no clear criteria to determine what is high, medium, or low anxiety.

Difficulties in identifying test anxiety levels, its prevalence, and the adverse effects it has on the students' academic life point to the need to improve or create instruments that allow identifying the severity with which students experience test anxiety and to provide more information on the psychological nature of this experience (Howard, 2020; von der Embse et al., 2013; von der Embse et al., 2018). Therefore, the purpose of this study is to introduce an alternative way to identify the test anxiety severity, to determine the relevance of factors that modulate the intensity of this experience, and to provide information on the information integration cognitive mechanisms underlying test anxiety.

Literature Review

Little more than a century has passed since the first reference to the concept of test anxiety (Folin et al., 1914), and 70 years have lapsed since this term began to be used in academic research (von der Embse et al., 2018). In the interim, numerous studies have been conducted on the test anxiety's nature and its effects on students' academic life. Their findings indicate that test anxiety can be both beneficial and detrimental for academic performance, and can also harm students' health (Hamzah et al., 2018).

Empirical evidence indicates an inverse correlation between test anxiety and academic performance in different knowledge domains, such as mathematics (Rana & Mahmood, 2010; Reyes & Castillo, 2015), medicine (Alizadeh et al., 2014; DordiNejad et al., 2011), nursing (Alizadeh et al., 2014; Shapiro, 2014), physics (Rana & Mahmood, 2010), education and languages (Trifoni & Shahini, 2011), statistics (Hunsley, 1985; Rana & Mahmood, 2010), and engineering (Vitasari et al., 2010).

The level of test anxiety can depend on students' age and gender, also on situational factors (e.g., test mode, course of study, teaching style). Studies focusing on the influence of gender on the level and effect of test anxiety do not yield consistent results, as some indicate that female students tend to experience higher test anxiety levels than male students (Lowe, 2019; Nunez-Pena et al., 2016; Sung et al., 2016), while others suggest otherwise (Safeer & Shah, 2019). Nunez-Pena et al. (2016), however, reported that, even though female university students reported a higher degree of test anxiety, their academic achievement was on par with that of their male peers.

On the other hand, the study's year in which students are enrolled affects the test anxiety levels (Casari et al., 2014; Desousa et al., 2016; Flores et al., 2016; Rana & Mahmood, 2010). The teachers' negative attitudes toward students can also play an essential role in the degree of test anxiety they experience (Putwain & Symes, 2011). However, Crisan et al. (2014) found that the general teaching style, as perceived by the students, had no bearing on their test anxiety levels.

Available data also indicate that familiarity with the exam format and the evaluation process seems to modulate test anxiety levels. For example, DordiNejad et al. (2011) found that students that were familiar with the assessment situation experienced less anxiety than those exposed to this process for the first time. According to von der Embse et al. (2018), the test's perceived difficulty, the high-risk nature of the test, and the test consequences may also contribute to elevating the anxiety. Finally, Sommer and Sommer (2009) found that students were more comfortable with closed-ended questions (multiple choice and short answer) than with open-ended questions or essays.

Deloatch et al. (2016) explored the effect of the exam mode (computerized vs. paper-based test) on the test anxiety levels reported by university students and noted no significant differences. Focusing on nursing students, Kolagari et al. (2018) reported that their anxiety scores tended to be higher in the computerized test than in the paper-based exam. However, this difference was not statistically significant. In an earlier study, Stowell and Bennett (2010) found that students experiencing high levels of anxiety prior to face-to-face exams tend to reduce their anxiety in online exams, while opposite is true for students with low test anxiety in the classroom.

As most of the extant research focused on the contextual or individual factors only, little is known about how these factors jointly contribute to elicit test anxiety. Indeed, more than two decades ago, Zeidner (1998) indicated the need to explore the interactive effect of contextual factors on test anxiety levels.

Since the people's thoughts and actions result from the joint influence of different factors (Anderson, 2013), the scientific exploration of test anxiety represents a challenge for academics. When students face an exam, their experience depends on the joint action of personal factors (such as their preparation level, their evaluation schemes, and their characteristics) and situational factors (exam type, the exam's value, and the test conditions).

Most of the research on test anxiety has been conducted from a factorial and correlational perspective, aiming to determine the components or dimensions of test anxiety (e.g., Cassady & Jonson, 2002; Driscoll, 2007; Friedman & Bendas-Jacob, 1997; Spielberger, 1980), and their interrelationships with psychological constructs such as academic self-concept, general self-efficacy, or academic motivation (e.g., Liu et al., 2005; Schwarzer & Jerusalem, 1995; Vallerand et al., 1992).

Thus, it would be beneficial to examine this phenomenon from an integrationist perspective, as this would allow identifying the cognitive processes through which people integrate information related to multiple determinants of test anxiety. This approach was adopted in the present study by using cognitive algebra experimental design to explore the simultaneous action of several factors on the test anxiety level.

Present Study

A national comorbidity survey conducted in Mexico nearly two decades ago indicated that anxiety is one of the most common mental health disorders among Mexican people (Medina-Mora et al., 2003). University students are particularly prone to developing anxiety, as they must constantly perform at a certain level to obtain an academic degree (Santillan et al., 2016). The key events that can generate these anxiety responses are exposure in class, insufficient time to complete a task, work overload, and exams (Flores et al., 2016).

Hernandez-Pozo et al. (2008) estimated that at least a quarter of Mexican students enrolled in higher education are at risk of experiencing school anxiety. According to the Mexican Ministry of Public Education (Secretary of Public Education [SEP], 2019), between 2018 and 2019, 3,943,544 students were enrolled in universities throughout the country. Thus, according to these estimates, almost one million Mexican students could potentially experience anxiety at some point in their academic journey.

However, in Mexico, there are few studies on anxiety among university students (Aragon et al., 2015; Lopez et al., 2015; Reyes et al., 2017; Santillan et al., 2016), and only a handful of these studies are related to test anxiety in students enrolled in specific courses, such as dentistry (Flores et al., 2016; Aragon et al., 2015), psychology (Hernandez-Pozo et al., 2008), education (Pedroza, 2015), and other subjects (Marcue & Gonzalez, 2017). Moreover, since the samples employed in these studies are small, the reported prevalence estimates are not necessarily representative of other student populations. Nonetheless, to the best of the authors' knowledge, these studies represent the only source of empirical information about the test anxiety prevalence and its psychological impact among Mexican university students.

In their study focusing on 87 Mexican dentistry students, Flores et al. (2016) found that the exams and job interviews produced the highest rate of evaluative anxiety. However, there were some marked gender differences in motor (and physiological) anxiety, which was reported by 74% (68.5%) of female and 39.4% (36%) of male. Moreover 44.4% of female and 30% of male felt apprehension or concerns, also 38.9% of female and 24.2% of male struggled to concentrate during the evaluative situations.

More recently, Marcue and Gonzalez (2017) applied the Self-Assessment Questionnaire for Exam Anxiety of the University of Navarra to 40 Mexican university students. Their findings indicated that 48% of the participants experienced a moderate to high level of subjective symptoms, 18% of student reported moderate to high levels of physiological symptoms, and 28% reported moderate to high levels of behavioral symptoms.

To contribute to the current body of empirical evidence about the psychological nature of test anxiety in Mexican university students, an instrument based on Norman H. Anderson's of Information Integration Theory (IIT) was employed in the present study. This cognitive theory based on experimentation is posited to explain cognitive behaviors in everyday life (Anderson, 1996). The central tenet of IIT is that psychology's unified principles underlie the modes of information processing (Gaj, 2016). According to the IIT postulates, the human mind consumes, in a systematic way, information obtained from its external and internal environment, and integrates the values assigned to different pieces of information through cognitive mechanisms known as cognitive algebraic rules.

Anderson (2013) identified three cognitive rules (addition, average, multiplication) that people use to make their judgments in different life domains (Cano et al., 2017; Gaj, 2016; Cretenet et al., 2015; Guedj et al., 2009; Lopez-Ramirez et al., 2019). These cognitive rules emerge when the person's mind integrates systematically two or more psychological factors. These information integration cognitive mechanisms can be visually represented in a two-dimensional space on the ANOVA interaction graphs obtained from the experimental results (Morales, 2012). The patterns observed in these graphs reveal the integration scheme exhibited by the studied cohort. For example a summative cognitive rule produces a linear pattern with parallel curves (Anderson, 2013), while the multiplicative one produces a linear fan pattern (Anderson, 1996).

Anderson (1996, 2008) pointed out that the ANOVA interaction graphs provide information about valuation (V), integration (I), and action (A), all of which are unobservable cognitive processes. In this context, the "V" refers to the process through which a physical stimulus is transformed into a psychological one, "I" represents the organizational process through which psychological values are combined into an internal whole (unitary internal response), and "A" is the process through which the unitary internal response is transformed into a manifest response (Anderson, 1981).

Applying the IIT principles to the educational field, it is possible to observe the information selection and integration processes in the teachers' and learners' minds that allow them to judge their circumstances and make academic decisions. For example, in Mexico, special education teachers were found to use a summative cognitive rule to judge the probability that a person with an intellectual disability (ID) would be successfully integrated into mainstream

education (Morales et al., 2014). On the other hand, they used a multiplicative cognitive rule to judge the probability that a person with ID could learn a skill through technical training (Morales et al., 2015).

Also, Mexican students have been shown to adopt a systematic thinking process, whereby they rely on summative rules to make academic self-efficacy judgments (e.g., Briones-Rodriguez et al., 2016; Villarreal-Trevino et al., 2017), and make cheating desire judgments (Morales-Martinez et al., 2019).

To continue expanding the exploration of cognitive rules in other student life domains, it is of interest to specify the cognitive mechanisms that intervene in the elaboration of test anxiety judgments in engineering students. Thus, the present study was guided by the following question:

Is there an information integration cognitive mechanism or a systematic thinking mode underlying test anxiety experienced by engineering students?

To address this question, we attempted to establish if the test anxiety level (TAL) depends linearly on the integration of specific situational (teaching style, exam mode) and test-related (exam type) variables. For this purpose, the following cognitive equation was adopted with the aim of identifying its most important factors and operators:

$$TAL = f(w_T \text{ Teaching style} \times w_E \text{ Exam type} \times w_M \text{ Test mode})$$

where TAL represents the test anxiety level predicted by the student, which is a function of the integration of the weights (w_i) pertaining to each of the three factors explored (T = teaching style, E = exam type, M = test mode).

Determining the information integration cognitive processes or mechanisms eliciting test anxiety in Mexican engineering students is important, since there are few studies on this topic at the international level (Lee et al., 2020), as well as in Mexico. Thus, the information provided by IIT studies such this one will for the first time elucidate the nature of the cognitive processes involved in the test anxiety experienced by engineering students. Moreover, it will offer evidence on the usefulness of IIT studies as an alternative means of exploring the functional aspects of test anxiety-related cognition. This information can also be used to develop instruments to measure the cognitive processing stylistics according to the severity of test anxiety.

Methodology

Research Goal

According to the IIT, the cognitive process people employ to make judgments comprises of three distinct stages. During the first stage, people's minds select pieces of information from the internal or external environment based on their relevance. Then, people psychologically represent these pieces of information and assign a value to each one (Function V). Subsequently, the mind weighs and combines these values (Function I) into an implicit response (r). Finally, the implicit response is transformed into an observable response (Function R) (Hofmans & Mullet, 2013). Based on these postulates, the goal of the present study is to determine how these three information integration cognitive mechanisms are activated during the formation of test anxiety judgments by Mexican engineering students.

The study's further goal is to demonstrate the usefulness of cognitive algebra as a methodological tool for exploring the thought modes that participate in the elaboration of exam anxiety judgments in scenarios that replicate circumstances in which actual evaluations take place.

Study Design

Three factors with their respective levels were combined in an experimental factorial design consisting of 2 teaching styles (authoritarian vs. delegator) \times 2 exam types (closed vs. open) \times 3 test modes (in site-paper test vs. in site-digital test vs. distance-online test). This resulted in 12 experimental conditions which were used for the construction of the data collection instrument.

Instruments

Each of the aforementioned 12 experimental scenarios pertained to a hypothetical evaluation situation presented to the participants in a narrative form. After reading each story, they were instructed to rate the test anxiety level they anticipate the described situation to elicit. For this purpose, they were given an 11-point response scale anchored at "Not at all" and "A lot" (see Appendix).

Sample and Data Collection

The convenience sample for this experiment included 474 engineering students (31% of whom were female and 69% male) aged 17 to 27 years ($M = 19.6$, $SD = 1.35$). They were asked to provide some background information, which revealed that 99% of the participants were single, 71% were Catholics, 10% were Christians, 14% had no religion, and the remaining 5% professed religions such as Fidencism and Adventism. All participants were volunteers.

Procedure

The study comprised of three phases, commencing with obtaining verbal informed consent from the participants. Next, participants were given task instructions and were allowed to practice by responding to some scenarios to familiarize themselves with the experimental task. In the third phase, participants read each of the 12 experimental scenarios in turn and noted the test anxiety degree that they would experience under the circumstances described in the scenario using the 11-point scale.

Analyzing of Data

The gathered data was subjected to five statistical analyses using the STATISTIC software (version 7). First, the authors observed that data had a normal distribution by using the QQ plot. After, they applied an overall ANOVA on the whole sample to explore the main effects. Next, a mixed ANOVA was carried out to examine the differences in the level of test anxiety reported by male and female participants and to identify the cognitive mechanism of information integration that underlies this phenomenon.

Subsequently, the authors used a K-means clustering to establish whether there were groups of cases with similar cognitive characteristics to elaborate on the test anxiety judgments. Hofmans and Mullet (2013) suggested using this nonhierarchical centroid-based method to analyze data from IIT studies. According to Hair et al. (2008), this type of analysis is less sensitive to atypical scores than other methods, and is also less susceptible to the type of distance measurement selected and the inclusion of irrelevant variables. Moreover, this technique can be applied to analyze extensive datasets.

The authors also applied a mixed ANOVA to observe how well the identified clusters are discriminated based on the reported test anxiety levels. Finally, the authors carried out a repeated-measures ANOVA on each cluster's data to observe each cluster's cognitive pattern in each stage of the information processing related to the test anxiety (valuation, integration, and response).

Findings / Results

Overall ANOVA

As noted in the preceding section, the analysis commenced with an overall ANOVA involving the following design: 2 (Teaching style: authoritarian vs. delegator) \times 2 (Exam type: closed vs. open) \times 3 (Test mode: in site-paper test vs. in site-digital test vs. distance-online test). This analysis revealed two principal effects related to teaching style [$F(1,473) = 57.310$, $p = .001$, $\eta^2 = .10$] and exam type [$F(1,473) = 26.534$, $p = .001$, $\eta^2 = .05$]. Absence of significant interactions among the factors suggested that the engineering students made their test anxiety judgments by using the following additive model:

$$TAL = f(w_M + w_E).$$

indicating that the level of test anxiety (TAL) is a function of the sum of test mode (w_M) and exam type (w_E). The average TAL level reported by the sample was 6.

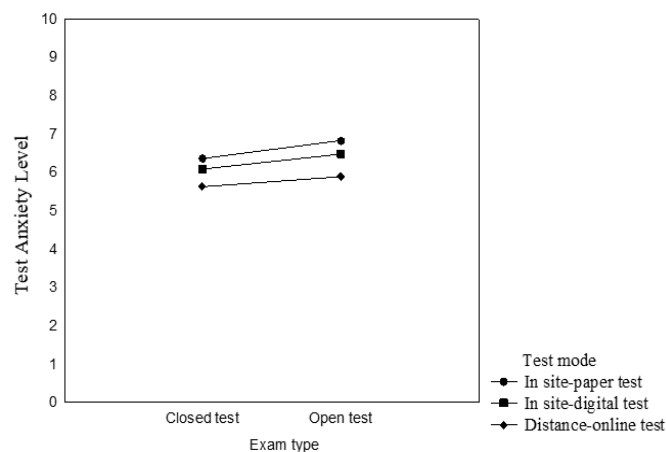


Figure 1. Interaction graph showing the integration of the test mode and exam type factors for the entire sample.

ANOVA considering the participant's *g*

Next, a mixed ANOVA was carried on the raw data considering the following design: 2 (Participant's gender: male vs. female) \times 2 (Teaching style: authoritarian vs. delegator) \times 2 (Exam type: closed vs. open) \times 3 (Test mode: in site-paper test vs. in site-digital test vs. vs. distance-online test). The level of significance was established at $p < .001$.

The analysis failed to reveal statistically significant difference in the test anxiety levels based on participant's sex [$F(1,472) = 4.104, p = .043, \eta^2 = .008$], even though women ($M = 6.5$) seemed to experience a slightly higher level of examination anxiety than men ($M = 6.0$). However, this result should be considered with caution given that 69% of participants were male. As shown in Figure 2, the most relevant factors were the test mode [$F(2,994) = 49.901, p = .001, \eta^2 = .09$] and the exam type [$F(1,472) = 35.855, p = 0.001, \eta^2 = .07$], with the latter being relevant to women ($\eta^2 = .15$) only, as men did not seem to consider this factor when making their test anxiety judgment ($\eta^2 = .02$). These results suggest that women predicted a higher level of test anxiety when the test format was open ($M = 6.8$) than when it was closed ($M = 6.1$). In contrast, men predicted very similar test anxiety levels for closed ($M = 5.9$) and open ($M = 6.1$) exams.

Figure 2 shows that the cognitive mechanism men and women use to integrate these two pieces of information is of a summative type. For female participants, this corresponds to the following model:

$$TAL = f(\text{Exam type} + \text{Test mode}).$$

For men, no rule could be established, since they selected only one factor. Nonetheless, their data pattern is included in the graph to illustrate the differences between men and women in the valuation of the aforementioned factors.

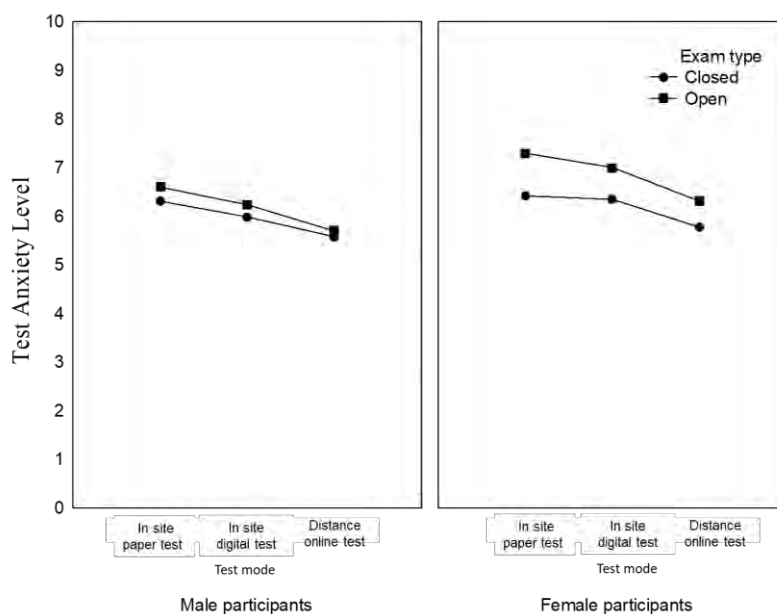


Figure 2. Interaction graph showing the integration of the exam type and test mode factors by men and women.

Since there were no significant gender-related differences in the level of anxiety, a cluster analysis was carried to determine if participants exhibited different response styles.

Cluster Analysis

Guided by the results reported by Thomas et al. (2017) and the possibility of theoretically interpreting this study's findings, the authors applied a cluster analysis (Euclidean distance, K-means) considering three sets of responses provided by the participants. At first glance, the cluster analysis indicated that 20.46% ($N = 97$) of the participants experienced a low test anxiety level ($M = 2.8$), whereas 44.51% ($N = 211$) of the participants received moderate test anxiety scores ($M = 5.8$), and the remaining 35.02% ($N = 166$) showed high anxiety ($M = 8.6$).

To determine the degree of discriminability of the three clusters, the authors applied an ANOVA involving $2 \times 2 \times 2 \times 3$ factor design, whereby the factors pertained to cluster, teaching style, exam type, and test mode. The level of significance was set at $p < .001$. The magnitude of the F value indicated that the three clusters can be clearly discriminated [$F(2, 471) = 1185.624, p = .001, \eta^2 = .83$]. Moreover, the analysis indicated that the exam type and test mode were the factors with the main effect. To see if students assigned to the three clusters used different cognitive processing modes when assessing and integrating these factors, the authors analyzed the data pertaining to each cluster separately using an ANOVA.

ANOVA for each cluster

For each cluster, a repeated-measures ANOVA involving 2 × 2 × 3 factor design was carried out whereby the factors pertained to teaching style, exam type, and test mode (Table1). The level of significance was set at $p < .001$.

To carry on the ANOVAs, the authors first satisfied the independence assumption by randomizing the presentation’s order of experimental conditions. Second, they examined the data distribution using the QQ plot, and the visual inspection showed a normal data distribution. However, the Levene’s test indicated the variances are not equal [$F(2,471) = 12.650, p < .001$]. Anderson (2008) said that the concern related to unequal variance in different conditions is unnecessary because, for randomized experiments, the most significant reason is that unequal variance indicates real treatment effects.

Table 1. ANOVA Results for each Cluster

Source	df	MS	df	MS	F	p	η^2
Cluster 1 <<Low test anxiety>>							
Teacher (T)	1	18.817	96	4.050	4.645	ns	.04
Exam (E)	1	53.694	96	7.749	6.928	ns	.06
Mode (M)	2	65.861	192	4.933	13.349	.001	.12
T*E	1	.879	96	2.706	.325	ns	.003
T*M	2	1.016	192	2.256	.450	ns	.004
E*M	2	3.361	192	2.185	1.538	ns	.01
Cluster 2 <<Moderate test anxiety>>							
Teacher (T)	1	11.280	210	3.960	2.848	ns	.01
Exam (E)	1	154.275	210	9.125	16.906	.000	.07
Mode (M)	2	342.004	420	7.902	43.278	.000	.17
T*E	1	7.630	210	3.007	2.537	ns	.01
T*M	2	4.778	420	2.537	1.883	ns	.008
E*M	2	6.560	420	3.175	2.066	ns	.009
Cluster 3 <<High test anxiety>>							
Teacher (T)	1	.002	165	1.803	.001	ns	.00
Exam (E)	1	17.367	165	3.610	4.809	ns	.02
Mode (M)	2	19.712	330	2.654	7.426	.000	.043
T*E	1	1.255	165	1.710	.733	ns	.004
T*M	2	3.050	330	1.460	2.088	ns	.01
E*M	2	1.180	330	1.466	.805	ns	.004

Note from the previous analysis that the test mode was the most relevant factor for all three clusters. In contrast, exam type was only relevant to the moderate anxiety group. Students in this cluster integrated these two factors through a summative cognitive mechanism shown in Figure 3 and described by the following equation:

$$TAL = f(\text{Test mode} + \text{Exam type}).$$

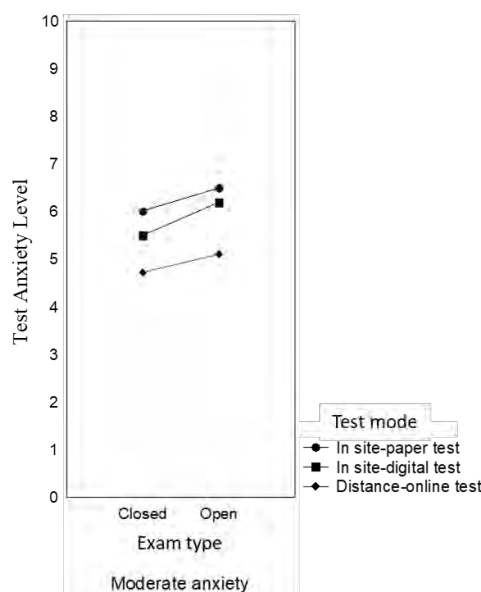


Figure 3. Interaction graph showing the information integration mechanism of the test mode and exam type factors for each cluster.

As the information integration cognitive mechanism could be established only for Cluster 2 (moderate anxiety level), Figure 3 shows the integration pattern for this cluster only. Note that in the valuation process related to test mode, the lines pattern indicates that the judgments related to the classroom-based paper test condition were more similar to those related to classroom-based digital test compared with offsite (remote) digital test.

Discussion

The study's primary intent was to determine if engineering students use a systematic thinking mode when evaluating test anxiety situations. To achieve this goal, the authors analyzed three cognitive processes or mechanisms, namely valuation function (V), integration function (I), and response function (R).

Regarding the cognitive mechanism V, the data indicated that the students considered the test mode followed by the exam type as the most relevant factors. These findings do not align with the results reported by Deloatch et al. (2016) and Kolagari et al. (2018) who found non-significant differences in the test anxiety levels produced by different test modes. Kolagari et al. (2018) nonetheless noted that the students showed greater anxiety in computerized exams. This finding is countered by the results obtained in this study, as students anticipated much greater anxiety levels when presented by face-to-face tests (whether paper or computerized) compared to those in the distance mode (online computerized test).

Since the perceived levels of control over a situation affect the persons' interpretation of threatening events, Stowell and Bennett (2010) hypothesized that the preferences toward a kind of test mode are related to the control degree over the test environment students perceive to have. Consequently, these authors posited that most students feel comfortable with the exams administered remotely because they have more opportunities to choose the most appropriate time to take the test according to their biological rhythm and personal circumstances.

On the other hand, students that took part in this study reported greater anxiety about taking paper-based face-to-face tests relative to computerized face-to-face tests. This finding may be attributed to the technological familiarity (Stowell & Bennett, 2010). Specifically, if students feel that they have no control over issues related to the software or hardware or lack requisite computer skills, they may experience greater anxiety about using the computer than about the exam itself.

Concerning the exam type, students in the present study reported being more comfortable with closed-format exams and more anxious with open-ended or essay exams. We attribute these findings to two reasons. First, as students are less familiar with open-ended or essay-based tests (e.g., Sommer & Sommer, 2009), this will increase their anxiety levels, as noted by DordiNejad et al. (2011).

On the other hand, prior experience with closed-format exams allows students to consider the available responses using basic cognitive process, such as the recognition or retrieval of small pieces of information. In other words, their answers are not evaluated with criteria dependent on external judgments, as is sometimes the case in open-ended examinations (Sommer & Sommer, 2009). These inferences can increase the perceived level of control over the evaluative situation, which would in turn decrease their anxiety levels.

Furthermore, if students realize that essay responses require cognitive processes that may not necessarily be their strength, they would estimate, implicitly or explicitly, that their academic performance will be low. This anxiety, rather than lack of knowledge, may indeed result in low performance, due to which anxiety levels before the next exam would be even higher. According to Naveh-Benjamin et al. (1987), when the anxiety levels are high, it is difficult to organize relevant information, which perpetuates the cycle of anxiety–conceptual organization difficulties–low performance anxiety. Students must also infer how to organize and structure the writing from the constraints imposed by the test itself (Sommer & Sommer, 2009), which can add one more degree of difficulty to the already complex task. In sum, the combination of a metacognitive process of becoming aware of what is needed to complete an exam correctly and what students believe about their skills (self-efficacy) may modulate their anxiety levels.

With respect to the valuation function, in line with the results reported by Crisan et al. (2014), for the current study participants, teaching style did not play a significant role in their test anxiety judgments. This finding may be attributed to the generality with which the teaching style is described in the experimental scenarios. In this regard, Putwain and Symes (2011) pointed out that particularly negative interactions among teachers and students tend to increase students' anxiety levels.

The analysis of the integration process (I) indicated that almost 50% of study participants integrated the pieces of information provided to them through a cognitive mechanism of additive information integration. According to IIT, additive laws have several conceptual implications. First, the meaning that participants with moderate anxiety level give to the test mode remains intact across all exam types, which implies that the valuation and integration are

independent processes. Furthermore, the summative rule implies that the observable response is a linear measure of the participant's judgment (Anderson, 2008).

As the current findings indicate, female participants tend to rely more on the summative cognitive rule than do male participants. It is possible that these differences arise because men and women adopt different information processing styles. However, further research is needed to confirm or refute this assumption.

Regarding the response process (R), the analyses revealed a medium level of anxiety among the participants irrespective of gender, which is in line with the available evidence (Lowe, 2019; Nunez-Pena et al., 2016; Sung et al., 2016; Tsegay et al., 2019). However, as noted before, given that male participants significantly outnumbered their female peers, any gender-related findings need to be interpreted with caution.

In the selection and valuation of factors, female participants considered exam type as the most relevant, while test mode was the most important to male participants. This may imply that women and men used different strategies to evaluate the test situation. In other words, results from this study suggest men tend to focus on context, while women emphasize the internal characteristics of the evaluation (task complexity) without ignoring the contextual factors.

On the other hand, the cluster analysis also indicated three test anxiety levels (low, medium, and high), whereby almost half of the participants reported moderate anxiety, and just over a third reported high test anxiety. Furthermore, the ANOVA interaction patterns suggested that the groups formed based on the anxiety level used different mechanisms for factor selection and valuation (V). The students assigned to high and low test anxiety groups adopted one-dimensional scheme for their test anxiety judgments whereby they considered only one factor (test mode) as relevant to estimate their level of anxiety in the hypothetical evaluative situations presented in the experiment. In contrast, the moderate test anxiety group used a two-dimensional scheme to estimate their evaluative anxiety. They selected two relevant factors (test mode and exam type) to judge the evaluative situation. The possible reasons for this type of selection were discussed at the beginning of this section.

Finally, concerning the information integration mechanism (I), the moderate anxiety cluster relied on systematic thinking for integrating the information pieces selected from the evaluation situations. These participants tended to use a summative cognitive rule. However, it was impossible to determine the cognitive rule in the low and high anxiety clusters since the participants selected only one factor. Anderson (1996) pointed out that the additive rule can shed light on many cognitive algebra problems observed across different life domains. In this regard, Hamzah et al. (2018) opined that certain anxiety levels can be beneficial for students due to activating their cognitive system, allowing them to face tests with adaptive strategies, while high levels of anxiety can subvert students' cognitive abilities, such as attention and memory. This can potentially explain why participants with a medium level of test anxiety could identify a greater number of factors that contribute to evaluative anxiety and used systematic thought modes to make a judgment.

The current study findings further suggest that a moderate level of anxiety can activate adaptive cognitive mechanisms of selection (V) and integration of information (I), while a high level of test anxiety can lead to cognitive disorganization, making it difficult to select, evaluate, and integrate information that is necessary to judge events or situations that are potentially frightening, such as academic test. This characterization is supported by the findings of other investigations indicating that difficulties in information processing can be induced by anxiety (Naveh-Benjamin et al., 1987).

Concerning the results obtained for students with low anxiety levels, it is possible that they only needed one piece of information to alert their cognitive system and direct their attention towards the test. In other words, these students deliberately chose to preserve their cognitive resources by discarding the information that does not produce uncertainty (e.g., exam type or teaching style). Hence, they focused on test mode and anticipated the issues that may potentially arise under different contexts. In general, this study's results indicate that the information processing styles related to test anxiety can be identified and explored from the functional perspective of IIT.

Conclusion

To summarize, the study results revealed that three modes of thinking underlie test anxiety and manifest differently depending on gender or anxiety level. Male and female participants differed in the mechanisms adopted for selecting and evaluating the relevant factors to elicit test anxiety. It is also noteworthy that participants with low and high test anxiety focused more on the evaluative context than on the evaluation's intrinsic demands. In contrast, students with moderate anxiety judged their test anxiety degree by considering the information pertaining to the test mode without ignoring the evaluation context's information. The participants integrated the two factors with a summative cognitive rule to form their test anxiety judgments.

The findings obtained in this research support the idea that IIT studies are a useful methodological tool for exploring the mechanisms of information selection and integration related to academic evaluation situations. Furthermore, experimental designs based on cognitive algebra also provide guidelines on the influence of latently embedded information on manipulated factors. In other words, these studies allow observing the participants' judgments about

the factors explicitly described and provide clues to interpret the utility that the participants assign to the implicit information that factors directly or indirectly contain. In sum, the IIT studies allow us to observe the implicit cognition processes that underlie the students' thinking.

Thus, by providing information on the test anxiety severity and the specific thinking mode that underlies it, cognitive algebra instruments can contribute in a practical way to the efforts to characterize the cognitive stylistics that underlie test anxiety. This information can be used for creating or modifying strategies that help students cope with their evaluative anxiety (e.g., tests, group exposure).

Recommendations

In future studies in this field, it would be beneficial to include new experimental manipulations in cognitive algebra designs to shed light on test anxiety's cognitive nature. For example, including factors related to students' goal orientation would help determine whether the integration information cognitive mechanisms involved in test anxiety could be affected by the type of student's school motivation.

It would also be useful to contrast the findings pertaining to students pursuing different majors to establish the influence that the academic context has on the information integration cognitive mechanisms that underlie test anxiety. For example, researchers could explore whether the integration mechanism observed in moderate anxiety judgments is mostly dependent on situational factors in different educational contexts.

The inclusion of innovative IIT designs would allow access to other dimensions of the test anxiety's cognitive nature. The information obtained from this perspective broadens understanding of how human cognition operates in the experience of evaluative anxiety, empowering teachers, students, and researchers with new useful information they can use to select, modify, and even create strategies to deal with potentially stressful evaluative situations.

Limitations

Although the experimental algebra design used in this study was capable of discerning differences in the information selection, evaluation, and integration cognitive mechanisms related to participants' sex, as the sample was imbalanced, in future studies, it is recommended to recruit similar number of male and female participants.

It is also worth noting a relatively small number of factors considered in ANOVA, which was a deliberate choice to prevent experimental fatigue among students. However, it would be advisable to include other factors to observe how the cognitive mechanisms explored here are affected by the inclusion of new information.

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Appendix*The Data Collection Instrument*

Imagine that, this school year, you had to take a statistics class taught by a lecturer who follows the correct agenda and objectives of the academic curriculum. As a statistics expert, the teacher always structures and assigns both the learning activities and the readings that the students must review. Furthermore, the course evaluation will be based solely on a closed test (multiple-choice, or true/false questions), which must be completed under 90 minutes. The test is given in paper format in the classroom and is supervised by the lecturer.

How anxious are you regarding your test performance?

Not at all 0---0---0---0---0---0---0---0---0---0 A lot