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Christopher L. Thomas

The University of Texas at Tyler, cthomas@uttyler.edu

Savannah B. Fitch

University of Texas at Tyler

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<http://hdl.handle.net/10950/4256>

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PSYCHOLOGY AND PSYCHIATRY

NOVEL-RESULT

Handedness and test anxiety: An examination of mixed-handed and consistent-handed students

Christopher L. Thomas¹  and Savannah B. Fitch² 

¹School of Education, The University of Texas at Tyler, Tyler, USA, and ²School of Education Department of Psychology and Counseling, The University of Texas at Tyler, Tyler, USA

Corresponding author: Christopher Thomas; Email: cthomas@uttyler.edu

(Received 10 April 2023; Revised 12 June 2023; Accepted 12 June 2023)

Abstract

Test anxiety refers to maladaptive cognitive and physiological reactions that interfere with optimal performance. Self-regulatory models suggest test anxiety occurs when there is a perceived discrepancy between current functioning and mental representations of desired academic goals. Interestingly, prior investigations have demonstrated those with greater interhemispheric communication are better able to detect discrepancies between current functioning and preexisting mental representations. Thus, the current study was designed to investigate the relationship between test anxiety and handedness—a commonly used proxy variable for interhemispheric communication. Undergraduate and graduate students ($N = 277$, 85.20% female, 68.19% Caucasian, $\bar{x}_{\text{age}} = 29.88$) ($SD = 9.53$) completed the FRIEDBEN Test Anxiety Scale and Edinburgh Handedness Inventory – Short Form. A series of Mann–Whitney U tests were used to test for differences in the cognitive, physiological, and social components of test anxiety between mixed- and consistent-handers. The results indicated that mixed-handers had significantly higher levels of cognitive test anxiety than consistent-handers. We believe this information has important implications for our understanding of the role of discrepancy detection and interhemispheric communication in eliciting and maintaining test-anxious responses.

Keywords: handedness; interhemispheric communication; test anxiety

Handedness and test anxiety: An examination of mixed-handed and consistent-handed students

Research has established that test anxiety is a multidimensional construct that negatively impacts academic performance, motivational tendencies, and psychological well-being (Hembree, 1988; Steinmayr et al., 2016; von der Embse et al., 2018). A defining characteristic of test anxiety is the experience of excessive and uncontrollable thoughts and concerns surrounding evaluative events (Putwain, 2008). Specifically, test-anxious students often report excessive self-preoccupation (e.g., self-doubt, self-blame, and self-deprecation) and intrusive thoughts focused on the potential consequences of poor test performance (Cassady & Johnson, 2002). Test anxiety has also been shown to include a physiological dimension which refers to patterns of heightened physiological activity experienced during the learning-testing cycle (e.g., elevated heart rate, sweating, nausea; Liebert & Morris, 1967). Finally, contemporary theoretical frameworks suggest that concerns focused on negative social evaluations are a salient feature of test anxiety (Driesen Friedman & Bendas-Jacob, 1997). Specifically, research has demonstrated that test-anxious students often fear that important others (e.g., classmates, parents, educators) will criticize them if they perform poorly on an examination (Lowe et al., 2008).

The Self-Regulation Model of Test Anxiety (Carver & Scheier, 1984; 1988) proposes that test anxiety is the result of a self-regulatory process involving goal setting, self-monitoring, behavior modification, and performance expectations. According to this model, students must establish academic-oriented goals, identify behavioral outcomes or other standards that will signify goal attainment, and engage in goal-directed behavior to successfully navigate everyday academic challenges (Zeidner, 1998). While engaging in goal-directed behavior, students implement self-monitoring strategies where present behavior and performance are compared to the desired outcome. When a discrepancy is detected between one's current state and desired state, individuals are often motivated to adjust their subsequent behavior in a manner that supports goal attainment (Carver & Scheier, 1990). The self-regulation model further suggests that the performance difficulties observed in test-anxious students are the result of maladaptive coping and cognitive responses stemming from low self-efficacy and performance expectations. Specifically, the theoretical framework suggests that the highly test-anxious often question their ability to make satisfactory goal progress (i.e., reduce the discrepancy between current and desired states), which serves as a trigger for the cognitive, social, and physiological manifestations of the test anxiety (Zeidner, 1998). In support of these broad theoretical propositions, decades of research have demonstrated that students with low self or academic efficacy are more likely to experience elevated test anxiety than their high-efficacy peers (Flanagan et al., 2015; Roick & Ringeisen, 2017; Thomas & Cassady, 2019; von der Embse et al., 2018).

Interhemispheric communication refers to the transfer of information between the left and right hemispheres of the brain. A sizable body of empirical literature has demonstrated that the efficiency of interhemispheric information transfer influences discrepancy detection and individuals' ability and/or willingness to update existing mental representations when confronted with information that contradicts currently held beliefs. For instance, investigations have shown that those with greater interhemispheric communication rates exhibit increased attitude change following persuasive appeals (Christman et al., 2008) and experience more cognitive dissonance as a result of increased awareness of discrepancy between cognitive elements (Jasper et al., 2009; Thomas et al., 2019) than those with less efficient interhemispheric transfer. The relationship between interhemispheric communication, discrepancy detection, and belief updating is tied to the unique role the left and right hemispheres play in maintaining and updating existing mental structures. Prominent researchers suggest that one of the primary functions of the left hemisphere is to create and maintain schemas capturing individuals' knowledge of themselves and the world, as the ability to successfully navigate situational demands often requires a stable interpretation of the self and larger environmental context (Gazzaniga, 1998). The right hemisphere is believed to play a prominent role in detecting information and events inconsistent with currently held beliefs and knowledge and interfacing with the left hemisphere to update mental representations when a critical mass of contradictory information has been reached (Ramachandran & Blakeslee, 1998).

Research focused on the intricacies of neural communication has demonstrated interhemispheric communication rates are mediated by the size of the corpus callosum (van der Knaap & van der Ham, 2011). Specifically, individuals with a larger corpus callosum have increased connectivity between the two brain hemispheres and exhibit more efficient interhemispheric communication (Aboitiz et al., 1992). Interestingly, corpus callosum size and interhemispheric transfer rates have been shown to be correlated with the degree or strength of handedness. For instance, investigations have provided evidence that consistent-handed individuals (e.g., those who perform most tasks using their dominant hand) have smaller corpora callosa and slower interhemispheric transfer than mixed-handed individuals (e.g., those who perform tasks with both dominant and non-dominant hands; Luder et al., 2010; Witelson & Goldsmith, 1991). These findings have led to researchers using handedness as a proxy for interhemispheric communication in empirical investigations (Jasper et al., 2021; Lee Niebauer et al., 2004; Prichard et al., 2013; Rose et al., 2012).

We propose that increased interhemispheric communication might increase students' risk for experiencing elevated test anxiety because of the proposed role of discrepancy detection and reduction in test-anxious responses. To our knowledge, this will be one of the first studies to explore the potential contribution of interhemispheric communication to test-anxious responses. Based on our understanding

of the literature, we hypothesized that students with increased interhemispheric communication (i.e., mixed-handed) will experience higher levels of cognitive obstruction, tenseness, and social derogation than students with less efficient interhemispheric communication (i.e., consistent-handed).

Method

Participants

Participants ($N = 277$, 85.18% female, 68.1% Caucasian) included undergraduate and graduate students attending a public university in the southern United States. The mean age of the participants was 29.88 ($SD = 9.53$) years. Participants were recruited because of their involvement in a departmental research pool and received partial course credit for completing approved research studies or alternative assignments requiring equal time and effort. The materials were presented using the Qualtrics survey management platform. The study procedures were approved by the University of Texas at Tyler Institutional Review Board.

Measures

The FRIEDBEN Test Anxiety Scale (Friedman & Bendas-Jacob, 1997) is designed to assess various manifestations of test anxiety including social derogation (e.g., “I am worried that failure in tests will embarrass me socially”), cognitive obstruction (e.g., “During a test it’s hard for me to organize what’s in my head in an orderly fashion”), and physiological tenseness (e.g., “During a test my whole body is very tense”). Participants indicated how well each of the presented statements describes them using a 6-point Likert-type scale (1 = *Does not characterize me at all*, 6 = *Characterizes me most perfectly*). The cognitive obstruction (Cronbach’s $\alpha = 0.92$), social derogation (Cronbach’s $\alpha = 0.95$), and physiological tenseness (Cronbach’s $\alpha = 0.91$) subscales demonstrated excellent levels of internal consistency. This measure of test anxiety was selected over other competing alternatives because it provides estimates of the social, cognitive, and physiological dimensions of test anxiety.

We assessed participants’ handedness using the Edinburgh Handedness Inventory – Short Form (Veale, 2014). Specifically, participants were asked to indicate their hand preference when completing certain activities and interacting with specified objects (i.e., writing, throwing, holding a toothbrush, and using a spoon) using a 5-point Likert-type scale (1 = *Always right*, 2 = *Usually right*, 3 = *Both equally*, 4 = *Usually left*, 5 = *Always left*). Responses to the instrument can be used to calculate a laterality quotient (LQ) which quantifies the strength of individuals’ hand preference (-100 = strong left-handedness, $+100$ = strong right-handedness). Consistent with past work, we utilized the laterality quotient to classify participants as consistent ($LQ = -100$ to -61 & $LQ = 61$ to 100) or mixed-handers ($LQ = -60$ to $+60$; Veale, 2014). Using these cutoffs, 231 participants were classified as consistent-handed and 41 were classified as mixed-handed. Additionally, five participants were not classified due to missing data. The instrument demonstrated excellent internal consistency in the current examination (Cronbach’s $\alpha = 0.91$).

Results

A series of Mann–Whitney U non-parametric tests were used to investigate differences in cognitive obstruction, tenseness, and social derogation between mixed- and consistent-handers. Mann–Whitney U tests were used because the data for all three components violated the assumptions of an independent samples t-test. The results of our analyses indicated that mixed-handed participants reported significantly higher levels of cognitive obstruction ($\bar{X}_{\text{Rank}} = 165.09$) than consistent-handed participants ($\bar{X}_{\text{Rank}} = 130.96$), $U = 3456.50$, $p = .01$. According to Cohen’s (1992) effect size classifications, the difference in cognitive obstruction between mixed- and consistent-handed participants was small in magnitude ($r_{rb} = 0.25$). Additionally, results revealed there was not a statistically significant difference in

physiological tenseness between mixed-handed ($\bar{X}_{\text{Rank}} = 147.79$) and consistent-handed ($\bar{X}_{\text{Rank}} = 133.96$) participants, with $U = 4148.50$, $p = .30$, $r_{rb} = 0.10$. Although the effect was non-significant, the effect size estimate suggests the difference in physiological tenseness between mixed- and consistent-handed participants was small in magnitude ($r_{rb} = 0.10$). Finally, our results indicated that there was not a statistically significant difference in social derogation reported by mixed-handed ($\bar{X}_{\text{Rank}} = 143.55$) and consistent-handed ($\bar{X}_{\text{Rank}} = 134.69$) participants, with $U = 4318.00$, $p = .51$. According to Cohen's (1992) effect size classifications, the difference in social derogation reported by mixed- and consistent-handed participants was negligible ($r_{rb} = 0.07$).

Discussion

The primary aim of the current study was to investigate the relationship between handedness—a commonly used proxy for interhemispheric communication—and test anxiety. Consistent with our expectations, we found that mixed-handed students reported significantly higher levels of cognitive obstruction than consistent-handed students. This finding provides preliminary evidence that test-anxiety severity is moderated by the efficiency of interhemispheric information transfer. We believe this moderating effect is the result of the proposed role of discrepancy detection in test-anxious responses and the increased awareness of anomaly detection noted among those with more efficient interhemispheric communication. As outlined in the Self-Regulatory Model of Test Anxiety (Carver & Scheier, 1988), an important trigger for test anxiety is the realization that a discrepancy exists between an individual's current state and desired state indicating that satisfactory progress toward important academic goals has not been achieved. Given the proposed relationship between interhemispheric communication and anomaly detection (Ramachandran, 1995; Thomas et al., 2019), we propose that higher levels of interhemispheric communication increased learners' awareness of discrepancies between valued academic goals and current functioning, thereby increasing their risk for maladaptive levels of cognitive test anxiety.

Contrary to our expectations, we found no significant differences in physiological tenseness between mixed- and consistent-handed students. At first glance, this finding calls into question the role of interhemispheric communication and discrepancy detection in test-anxiety severity. However, prior work on the antecedents of test-anxious responses has suggested that the cognitive and physiological manifestations of test anxiety are triggered by distinct eliciting cues. Specifically, emotionality is triggered primarily by external cues that signal that a testing event is about to begin (e.g., testing booklets, entering testing location), while the cognitive manifestations are triggered by internal cues (e.g., efficacy appraisals, discrepancy between desired/goal states; Zeidner, 1998). Thus, it is possible there was no difference in physiological tenseness between mixed- and consistent-handers because emotionality is not directly impacted by the cognitive processes and capabilities influenced by interhemispheric communication rates (e.g., discrepancy detection).

Finally, contrary to our expectations, our results indicated that consistent- and mixed-handed students did not differ in the experience of social derogation. Once again, this non-significant finding appears to call into question the role of interhemispheric communication in test-anxious responses. However, there is disagreement in the literature regarding whether social derogation is a unique dimension of test anxiety or a factor that contributes to test-anxious responses (Putwain et al., 2020). Contemporary theoretical frameworks explaining the antecedents, nature, and outcomes of test anxiety often emphasize the role of situational appraisals in test-anxious responses (Zeidner, 1998). Specifically, test anxiety is magnified when learners engage in threat appraisals and believe situational demands have the potential to negatively impact self-worth (Lowe et al., 2008). Prior work has noted that fear of negative social evaluations most directly influences the degree to which learners view testing events as threatening (Lowe et al., 2008; Putwain, 2009). Therefore, it is reasonable that mixed- and consistent-handed students did not differ in terms of social derogation as it is likely a potential cause of test anxiety and not an indicator of the construct.

We believe there are several important limitations that must be acknowledged. Firstly, one limitation of the current work is our use of a departmental research pool to recruit participants for the investigation. Though the use of research pools and convenience sampling is common in the educational and psychological literature, it is possible our sample differed in important ways from the larger population of interest. Thus, we encourage researchers to replicate our work using sampling methods that allow them to better ensure the representativeness of the sample, such as quota sampling (Cumming, 1990). Second, although prior investigations have provided evidence linking handedness to interhemispheric communication rates (Jasper et al., 2014; 2021; Lee Niebauer et al., 2004; Prichard et al., 2013; Rose et al., 2012), our use of a self-report measure of handedness as a proxy for interhemispheric communication limits our ability to make firm conclusions regarding the relationship between the variables of interest. Therefore, we encourage future work to explore the association between interhemispheric communication rates and dimensions of test anxiety using a more objective indicator of communication efficiency, such as the Poffenberger (1912) or Banich and Belger (1990) paradigms.

Open peer review. To view the open peer review materials for this article, please visit <http://doi.org/10.1017/exp.2023.14>.

Data availability statement. The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Acknowledgments. Chatgpt (<https://chat.openai.com>) was used to proofread the manuscript.

Author contribution. C.L.T. conceived and designed the study. C.L.T. collected data. C.L.T. and S.F. performed statistical analyses. C.L.T. and S.F. wrote the article.

Competing interest. We have no known conflicts of interest.

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Cite this article: Thomas CL, Fitch SB (2023). Handedness and test anxiety: An examination of mixed-handed and consistent-handed students. *Experimental Results*, *4*, e15, 1–8. <https://doi.org/10.1017/exp.2023.14>

Peer Reviews

Reviewing editor: Dr. Teresa Ober 

University of Notre Dame, Department of Psychology, E418 Corbett Family Hall, Notre Dame, Indiana, United States, 46556

Minor revisions requested.

doi:10.1017/exp.2023.14.pr1

Review 1: Handedness and Test Anxiety: An Examination of Mixed-Handed and Consistent-Handed Students

Reviewer: Gizem Ekitli 

Date of review: 26 April 2023

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Conflict of interest statement. Reviewer declares none.

Comment

Comments to the Author: The present study provides a valuable contribution to the literature on test anxiety and its relationship to handedness and interhemispheric communication. The theoretical framework was well-designed and provided a clear rationale for the investigation of these variables. The authors employed a rigorous and well-controlled methodology, utilizing the FRIEDBEN Test Anxiety Scale to measure test anxiety in a sample of undergraduate and graduate students.

Importantly, the results of this study suggest that mixed-handed individuals report significantly higher levels of cognitive obstruction in relation to test anxiety, which provides preliminary evidence that interhemispheric communication may play a moderating role in test anxiety severity. This finding has important implications for our understanding of the mechanisms underlying test anxiety and highlights the need for further investigation into the relationship between handedness and interhemispheric communication in this context.

Overall, this study represents a significant contribution to the literature on test anxiety and provides a valuable foundation for future research in this area. The authors are commended for their careful attention to detail and their rigorous methodology, which has yielded rare results that have the potential to advance our understanding of the complex interplay between interhemispheric communication and test anxiety.

*The only potential weakness of the abstract is that it lacks sufficient detail on the sample size and brief demographic characteristics of the study participants (ie. age and education level).

**Could authors provide current empirical evidence for the self-regulation model of test anxiety, supporting the idea that test-anxious individuals may struggle with low self-efficacy and performance expectations, leading to maladaptive cognitive, social, and physiological responses? (p.4, first paragraph).

***While the FRIEDBEN's scale has been widely used in previous research on test anxiety, it was originally developed for use with high school students. I can see that using Friedben is appropriate with this sample but why authors selected this tool rather than TAI or TAQ? Is it because of the subscales? (p.6)

Score Card

Presentation



Is the article written in clear and proper English? (30%)

5/5

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5/5

Is the objective of the experiment clearly defined? (25%)

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Analysis



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Are the limitations of the experiment as well as the contributions of the experiment clearly outlined? (20%)

5/5