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Does Anxiety in Science Classrooms Impair Math and Science Motivation?

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ABSTRACT

This study investigated gender differences in the experience of situational anxiety (referred to as 'state anxiety') among a sample of 268 US and 202 Finnish lower- and upper-secondary-school / high-school students (51.0% female; 177 ninth-graders, 218 tenth-graders, 37 eleventh-graders, 38 twelfth-graders, 10 unspecified grade). Three main research questions guided our study: 1) Do male and female students differ in their anxiety during science lessons if in-the-moment state measures are used?; 2) How does anxiety affect motivation in science classes?; and 3) Does the relationship of anxiety to motivation differ by gender We employed the experience sampling method (ESM), a form of time/diary instrument, to assess experiences of anxiety in the moment in which they occur, in different contexts, e.g., in and out of school and in specific science lessons. Males and females did not differ in mean levels of state anxiety with in-the-moment measures, which corroborates previous findings. Females tended to experience less positive affect and intrinsic motivation, and more negative affect and withdrawal motivation in anxious states across all their everyday life experiences. In science lessons, the only consistent finding was that females tended to experience more stress in anxious situations than males. The findings suggest that previously found gender differences in math and science anxiety might be due to biases in the applied measures (see Goetz et al., 2013), which has important theoretical and practical implications for the assessment and interpretation of gender differences in science classrooms.

KEYWORDS

State anxiety; motivation; gender differences; experience sampling method; science

Does Anxiety in Science Classrooms Impair Math and Science Motivation? Gender Differences beyond the Mean Level

INTRODUCTION

This study investigated the relationship between the experience of state anxiety and situational emotions and motivation in science lessons and in the everyday life activities of high-school students. We investigated whether students' motivation always suffers in situations in which they feel anxious, and whether male and female students differ in this regard. We applied in-the-moment measures of anxiety and motivation and disaggregated the specific STEM (= science, technology, engineering, and mathematics) contexts of mathematics, biology, and physics. This article scrutinizes simple assumptions such as "females are generally more anxious in science classrooms" by demonstrating that situation-specific and science-subject-specific measures of anxiety lead to different results, than the previously applied one-time administered subject-specific measures, and that it is insightful to consider anxiety in relation to other motivational constructs.

Motivational Experiences and their Relationship to Anxiety and Gender

The constructs of anxiety and motivation are multifaceted. Anxiety is an emotional, distressing experience that is characterized by dislike, worry, and the wish to withdraw from the anxiety-provoking stimulus. Anxiety can be disaggregated by its provoking stimulus (e.g. math anxiety: test, numerical, and abstraction anxiety, see Ma & Xu, 2004), its stability (referring to situational states versus cross-situational, trait-like dispositions) or its underlying psychological mechanism (somatic arousal versus cognitive anxiety, see Martens, Burton, Vealey, Bump & Smith, 1990). This study addresses cognitively salient and conscious aspects of state anxiety and covers only the broader science context (mathematics, biology, physics), but not the specific task or topic that might provoke anxiety. While anxiety has short-term fluctuating state and rather stable trait components, both of which influence the motivation in a given moment (Macher, Paechter, Papousek & Ruggeri, 2012), this article covers only the state aspects that fluctuate from situation to situation.

Motivation is a similarly broad term that describes people's desires and the reasons guiding their actions, and it comprises diverse constructs such as goal orientation, intrinsic and extrinsic gratification, self-competence beliefs (Eccles & Wigfield, 2002), and emotions (Fredrickson, 2004), among others. In this article we use "motivation" as an umbrella term but assess particularly the situational experiences that motivate students either to approach and engage in tasks because it feels enjoyable and manageable (which we label "intrinsic experiences/approach motivation"), or to withdraw from tasks that provoke unpleasant experiences such as stress and confusion (which we label "aversive experiences/withdrawal motivation"). In particular, we address three situational aspects of motivation that are relevant to the engagement and persistence in learning-related tasks and which prior studies found to be related to state anxiety: 1) intrinsic experiences including aspects of engagement; 2) competence beliefs and self-confidence; and 3) aversive experiences and the wish to give up on the current task. These aspects are described below.

Positive state affects are, by definition, desirable and pleasant experiences, including hedonic feelings (such as the sense of joy in doing the current activity) and the wish to approach a given stimulus or engage in a given task (such as the feelings of interest, excitement, and activation) (e.g. Watson & Clark, 1999). Both interest and joy are central aspects of the definition of intrinsic motivation, meaning the motivation to engage in a task for the mere pleasure it brings. The experience of positive emotions facilitates approach behavior and task engagement and was considered to broaden personal resources, including intellectual growth (for an overview, see Fredrickson, 2004). Although positive state emotions were found to be negatively related to state anxiety (Watson & Clark, 1999), positive trait affect was found to be unrelated to many clinical symptoms of anxiety (Watson, Clark & Carey, 1988). Frenzel, Pekrun, and Goetz (2007) reported that females tend to report fewer positive emotions (enjoyment and pride) but more anxiety, hopelessness, and shame than males in mathematics. Positive emotions and the construct of school engagement overlap in that both include feeling energetic, concentrated, and absorbed, and the feeling that "time was flying by" (Fredricks, Blumenfeld & Paris, 2004; Salmela-Aro & Upadyaya, 2012).

Further aspects of learning-related motivation that are addressed here are competence beliefs and the experience of being successful and self-confident in given learning tasks. Competence beliefs and the expectation of succeeding at a task predict an individual's likelihood of engaging and persisting in similar tasks in the future (Bandura, 1997; Eccles & Wigfield, 2002). Self-efficacy was found to be a negative predictor of math anxiety (Jain & Dowson, 2009). Competence beliefs and success expectancies are domain- and gender-specific, and many studies have found that, in science, males report generally higher competence beliefs than females (e.g., Andre, Whigham, Hendrickson & Chambers, 1999; for math competence beliefs, see Jacobs, Lanza, Osgood, Eccles & Wigfield, 2002).

Another aspect of motivation relevant to gender differences in science learning and state anxiety are negative emotions. These are unpleasant feelings such as sadness, anger, confusion, frustration, apathy, and stress (Watson & Clark, 1999), most of which motivate the individual to avoid or withdraw from a task that is perceived to cause such negative emotions. Negative state emotions were found to correlate moderately positively with state anxiety, implying that situations that elicit anxiety also tend to elicit negative emotions (Watson & Clark, 1999). Some emotion measures even include anxiety as one negative emotion. Frenzel et al. (2007) found that females reported higher levels of the negative academic emotions anxiety, hopelessness, and shame in mathematics.

Gender Differences in Anxiety Experiences at School and in Math and Science Lessons

In studies that assess anxiety with self-report questionnaires, female students generally report higher levels of anxiety about science learning than males (Mallow, 1994; Udo, Ramsey, Reynolds-Alpert & Mallow, 2001; Udo, Ramsey & Mallow, 2004). Math anxiety was found to correlate negatively with math self-efficacy (Goetz, Bieg, Lüdtke, Pekrun & Hall, 2013) and math achievement. Although some researchers discuss whether females' higher general levels of math anxiety might cause their lower motivation and achievement in science learning (Hembree, 1990), a longitudinal study found with structural equation modelling that, on the contrary, the path of prior math achievement predicting later math anxiety was stronger than the path of prior math anxiety predicting following math achievement (Ma & Xu, 2004). Preceding low mathematics achievement predicted later high math anxiety only for boys' entire junior and senior high-school careers, but for girls only at critical transition points between school levels.

Recent studies have questioned whether females really experience generally stronger anxiety in science lessons. Several studies found that gender differences in science anxiety, science self-efficacy, and performance differ by science subject and that therefore science subjects such as life science, physics, and earth science should be disaggregated (Britner, 2008; Lau & Roeser, 2002). Furthermore, a recent study found that the one-time administered anxiety questionnaires ("trait measures") used in prior studies were confounded with gender-specific competence beliefs and that gender differences in math anxiety disappeared when the more situation-specific experience sampling method (ESM; "state measures") was used (Goetz et al., 2013). Goetz and colleagues argued that females *believe* rather than *experience* that they feel more anxious in math lessons due to their generally lower math competence beliefs, and that these biases could be avoided by using situation-specific anxiety measures. In line with this argument, ESM measures were considered to be more appropriate assessments of fluctuating affective states, such as situational math anxiety, than one-time questionnaires. Hektner, Schmidt, and Csikszentmihalyi (2007) discuss the validity of repeated situational measures and argue that momentary measures avoid retrospective recall errors and activate fewer math-specific stereotypes, since they ask "Do you feel anxious *now*?", rather than "Do you feel *generally anxious in mathematics*?" Moreover, cross-situational anxiety levels can be averaged across the repeated answers by the researcher rather than being mentally aggregated by the respondents themselves, which further reduces subjective response bias.

However, Goetz et al.'s (2013) finding that males and females do not differ in state anxiety was limited to the context of math lessons, so it is unclear whether it generalizes to other science contexts. The first aim of this paper is to replicate this finding and test whether it holds true for the other science contexts of biology and physics.

The Relationship between Situational Anxiety and Learning Motivation: Gender Differences

In addition to the question of whether females experience stronger anxiety in science lessons, we investigate whether students' anxiety necessarily decreases their motivation to engage and persist in the (science-related) tasks at hand. This question is based on findings by Pekrun, Goetz, Titz, and Perry (2002), who showed that individuals differ in how much their motivation during school lessons suffers from the anxiety they experience. The authors analyzed the sample distribution of intra-individual correlations between repeated measures of anxiety and motivation (defined as intrinsic motivation meaning interest and joy, extrinsic motivation meaning motivation to learn to attain outcomes, total motivation to learn, and self-reported academic effort), and conclude:

> it turned out that daily anxiety related differently to variables of learning in different students. For example, whereas anxiety correlated negatively with motivation to learn for some students, it correlated positively with motivation for others […]. Some students may even profit motivationally from their anxieties, whereas others are handicapped. (Pekrun et al., 2002, p. 100)

These findings raise the question of which situational and personal characteristics explain why some individuals benefit while others suffer motivationally from the anxiety they perceive. Regarding situational determinants of the effect of anxiety on motivation, recent studies show, in line with that of Pekrun et al. (2002), that some states of anxiety are accompanied by positive emotions and proactive coping, whereas other states of anxiety are related to mainly negative emotions, inhibition, distraction, and psychophysiological stress reactions (Jones et al., 2009; Meijen, Jones, McCarthy, Sheffield & Allen, 2013). These authors state that anxiety results from the perception that the demands of a given task in a given situation are high. Jones et al. (2009) suggested that there are two different forms of anxiety: the beneficial, engaging, and activating anxiety in situations in which high demands are in balance with high resources ("challenge"), and stressful, inhibiting, and harmful anxiety ("threat") in situations in which the perceived demands of a given situation overwhelm the perceived resources.

Perceived resources are thus expected to moderate the relationship between anxiety and the motivation to engage and persist in a task, meaning individuals tend to feel anxious in all challenging and demanding situations, but they can nevertheless cope proactively with the demands as long as they perceive that they have the skills and resources to succeed. In contrast, if they perceive that they will not have the required skills or resources, they feel distracted, inhibited, and frustrated in addition to anxious (Jones et al., 2009; Meijen et al., 2013). Similarly, Jones, Swain, and Hardy (1993) found that high- and low-performing athletes did not differ in their mean levels of anxiety, but that high-performing athletes experienced their anxiety as more facilitating and less debilitating for their performance than low-performing athletes did. A meta-analysis of the relationship between state anxiety and sport performance found that gender moderated how much the performance of athletes suffered in anxious situations (average r_{men} = -.22; r_{women} = -.03; Woodman & Hardy, 2003).

The distinction between situations of threat and controllable challenge and their distinct effects on anxiety and motivation were earlier addressed in the Stress and Coping Model of Lazarus and Folkman (1984). Applying these authors' distinction between primary appraisals (physical and psychological threat, stress) and secondary appraisals (personal control, social support, intellectual resources), Abdullatif (2006) showed that the perception of a threatening situation positively predicts later state anxiety, while the perception of a controllable, resourceful situation negatively predicted following state anxiety, when controlling for trait anxiety and anterior state anxiety. The distinction between performance-enhancing and performance-decreasing anxiety was also described in the framework of the Yerkes–Dodson law (Yerkes & Dodson, 1908) and later elaborations (Hardy & Parfitt, 1991), which claim that individuals perform better if they experience moderate rather than low levels of anxiety, but that performance level decreases gradually (Yerkes & Dodson, 1908) or dramatically (Hardy & Parfitt, 1991) in high-anxiety situations.

Regarding the personal determinants of the effect of anxiety on motivation, it can be expected that students who generally doubt their own skills and resources feel more threatened and cope less well when feeling anxious. Since many studies have found that female students generally tend to report lower levels of competence beliefs and confidence in their abilities in math and science learning than their male classmates (e.g., Eccles, Wigfield, Harold & Blumenfeld, 1993; Goetz, Frenzel, Hall & Pekrun, 2008; Goetz et al., 2013; Hyde et al., 1990; OECD, 2007), it can be expected that they also tend to feel less confident about their competencies and resources to meet given challenges in their science courses.

In addition, given that individuals differ in how much their situational motivation suffers from their experienced state anxiety (Pekrun et al., 2002), it seems plausible that they might also differ in how their overall levels of anxiety at school are related to their overall measures of school motivation. Female students were found to suffer from higher levels of overall school-related anxiety (Lewinsohn, Gotlib, Lewinsohn, Seeley & Allen, 1998) and school burnout (Salmela-Aro & Tynkkynen, 2012), than males. In contrast, it is not known whether there are also gender differences in the effect of experienced state anxiety on school burnout. We investigate this question too in the present study. While most findings on gender differences in anxiety are based on cross-situational, overall self-report questionnaires, and, therefore, are prone to unwanted gender bias, the present study has the advantage that it applies state measures of anxiety that are supposed to be less gender-biased (Goetz et al., 2013). This allows us to tap not only the overall self-evaluation of experienced anxiety, but the individual frequency: how often a student reports feeling situational anxiety at school over the course of a school week.

Research Questions and Hypotheses

Building on the findings described above, we here investigate the following research questions:
1) Do male and female students differ in their situational anxiety? Can we replicate the findings of Goetz et al. (2013), according to which there are no gender differences in situational math anxiety if it is measured with ESM? Do these findings hold true for other science contexts (here: biology and physics)?
2) In line with the findings of Pekrun et al. (2002), we expect individuals to vary in their intra-individual correlations of anxiety with motivation (positive and negative affect, competence perceptions, engagement). We examine gender differences in this regard, and expect that females' science motivation will suffer more from the experienced anxiety than the males' motivation in the STEM contexts of mathematics, biology, and physics. In this article we disentangle four specific situational aspects of motivation (positive affect, state aspects of engagement, competence beliefs, and negative affect) and explore whether the expected gender differences vary across these motivational aspects.
3) We expect that overall anxiety level across all in-school situations is related differently to schoolwork engagement and school burnout in male and female students, assuming that males' overall level of in-school anxiety is more strongly negatively correlated with the overall level of schoolwork engagement and less strongly positively related to the level of school burnout than females' overall level of in-school anxiety.

While this study does not focus on national differences, we nevertheless checked whether our results are invariantly found in both the US and Finland, where our data were gathered.

METHODS

Sample

The sample comprised 268 US and 202 Finnish lower- and upper-secondary-school/high-school students (51.0% female; 177 ninth-graders, 218 tenth-graders, 37 eleventh-graders, 38 twelfth-graders, 10 unspecified grade). The data were collected in 2013 and 2014 in Helsinki (Finland) and town and rural areas in central Michigan (USA).

Since this study applied the experience sampling method (ESM), there were repeated measures for each individual, with eight beeps a day on seven consecutive days in a row. In total, the sample comprised 13,649 ESM beeps, with an average of 26.96 beeps per person. The Finnish students attended several different science subjects a week, whereas the US students attended mathematics and either biology or physics or chemistry courses during the week of ESM data collection. The US sample consisted of 171 biology students, 72 physics students, and 35 chemistry students. Finnish students gave on average 1.8 answers in mathematics, 2.5 in biology, 3.2 in physics, and 0.7 in chemistry. The US students who attended biology/life sciences courses answered on average 4.8 beeps in biology; those who attended physics responded on average to 4.0 beeps in this subject, and those who attended chemistry courses responded on average to 3.4 beeps. US students gave on average 2.6 answers to beeps in mathematics. Chemistry students are included in the overall analyses, but were not analyzed domain-specifically in chemistry lessons because of the small number of chemistry students and beeps. All analyses of ESM data are based on individuals who answered at least three ESM questions in the respective context.

The average number of beeps per individual and context did not differ significantly between male and female students across all situations and in the contexts of math, biology, physics, and chemistry. However, across all school beeps, females responded more often than males on average (M_{females} = 19.7, M_{males} = 15.7, p = .000, d = .33).

The data were collected in three waves: wave one in the spring of 2013, wave two in the fall of 2013, and wave three in the spring of 2014. Waves one and two were conducted simultaneously in the US and in Finland, whereas wave three consisted only of Finnish data.

Data Collection Procedures

ESM data from the Finnish–US EAGER study were used. With this procedure, we assessed which activity was being done at the moment of the ESM signal, why this activity was being done, and how it was being experienced. Among the questions about situational experiences, we assessed characteristics of situational engagement, intrinsic motivation and positive affect, current competence perceptions, and withdrawal motivation/negative affect.

Students received smartphones with applications that gave auditory signals which announced the appearance of a short ESM questionnaire on the screen, to be answered by the students. The data were stored in the smartphones and were sent later to the app's server, from where they were downloaded.

Most beeps were scheduled to occur at random times during the day, but there were also fixed-time beeps in each physics and biology lesson to make sure that the experiences were sampled in each science lesson.

In addition, the students filled out a one-time paper-and-pencil questionnaire in class, in which they were asked about demographic variables, overall experiences of schoolwork engagement and school burnout, and several other aspects of student engagement (not reported in this article).

Measures

State anxiety was assessed with the item "How are you feeling? – Anxious" and a response scale ranging from 1=*Not at all* to 4=*Very much.* The same response scale was used for all other ESM items. Likewise, all motivational correlates were assessed with ESM items. Some of these items were assessed only in a sub-sample of individuals because they had been added in the second or third wave of data collection or were dropped after the first wave. The brackets [ ] after the ESM items below indicate the wave in which the item was assessed and the number of times this item was answered.

ESM items measuring intrinsic aspects of motivation and perceived competence:

- Do you enjoy what you are doing? [1−3, *n*=12520]
- How well are you concentrating? [2−3, *n*=4994]
- How are you feeling? – Active [1-2, *n*=12374]
- How are you feeling? – Energetic [1, *n*=7538]
- How are you feeling? – Excited [2−3, *n*=4976]
- Are you succeeding? [1−3, *n*=12492]
- Do you feel competent in this activity? [1, *n*=7489]
- How are you feeling? – Self-confident [1−3, *n*=12487]

ESM items measuring aversive experiences and withdrawal motivation:

- Did you want to give up? [2−3, *n*=4999]
- How are you feeling? – Confused [1−3, *n*=12490]
- How are you feeling? – Stressed [1−3, *n*=12471]

To identify the context in the ESM assessment we asked the students, "What are you doing?" and coded their open answers.

Overall schoolwork engagement and school burnout were assessed with paper-and-pencil questionnaires that were administered once to each student. School burnout was assessed with the school burnout inventory (SBI; Salmela-Aro, Kiuru, Leskinen & Nurmi, 2009). This instrument consists of three sub-scales: exhaustion (a = .80), cynicism towards the meaning of school (a = .85), and sense of inadequacy at school (a = .62). An example item for the exhaustion sub-scale is, "I feel overwhelmed by my schoolwork". In the research on school burnout, the term "cynicism" describes an indifferent or distal attitude towards schoolwork, including the loss of interest in one's schoolwork and the perception of schoolwork as not meaningful. An example item for the cynicism scale is, "I'm continually wondering whether my schoolwork has any meaning". An example of an item tapping the feeling of inadequacy is, "I often have feelings of inadequacy in my schoolwork". The response scale for the SBI ranges from 1=*Strongly Disagree* to 6=*Strongly Agree.* The SEI main score was computed as the mean of the three sub-scales (a = .83).

School engagement was assessed by using the schoolwork engagement inventory (EDA; Salmela-Aro & Upadyaya, 2012). The EDA consists of the three sub-scales energy, absorption, and dedication. Example items are: energy sub-scale: "At school I am bursting with energy"; absorption sub-scale: "Time flies when I am studying"; and dedication sub-scale: "I find schoolwork full of meaning and purpose". The response scale taps how often the indicators of school engagement are experienced from 1=*Never* to 7=*Daily*. Salmela-Aro and Upadyaya (2012) found that all SEI items loaded on one single factor among adolescents of the same age as our sample, therefore the SEI main score was computed as the mean score of all SEI items (α = .89).

Analyses

To find out whether the findings from Goetz et al. (2013) were replicated in different science contexts, we analyzed whether male and female students differed in their ESM measures of anxiety 1) across all their experiences, 2) across all their school experiences, 3) across all their science experiences, and finally across their experiences in 4) mathematics, 5) biology, and 6) physics. For these analyses, we first computed, for each individual the average anxiety experienced across all experiences within each of the above-mentioned contexts, e.g., across all science experiences. Then, gender differences regarding these person-level averages of anxiety were analyzed using a t-test for independent samples. Effect sizes were computed using the following formula (Rosenthal & Rosnow, 1991):

$$d = 2t/\sqrt{df}$$

Second, we investigated whether the findings of Pekrun et al. (2002) were replicated in the context of science lessons, and analyzed the distribution of intra-individual correlations between state anxiety and different state measures of positive and negative affect. These analyses were run repeatedly, across all experiences, and within mathematics, biology, and physics. Then we computed, separated per gender, the inter-individual average of these intra-individual correlation coefficients to see whether anxiety was more strongly related to negative affect and less strongly to positive affect for females than for males, which was tested again with a t-test for independent samples and the above-described effect size. Variance equality was tested via Levene's test and, in cases with unequal variances, the corrected significance level was reported. Normal distribution was tested via Kolmogorov–Smirnov tests. Most variables deviated from normal distribution in at least one gender group; therefore, Mann–Whitney U-tests were computed for all variables. Their significance and effect sizes suggested similar interpretations to the t-tests.

Third, we analyzed the relationship between the individuals' mean levels of overall anxiety across all in-school situations and their overall level of school burnout and the gender differences in this regard. For this purpose, we computed the intra-individual average of anxiety across school situations and then, separated by gender, the correlations between this mean score of person-level in-school anxiety and the individual level of school burnout as measured by the SBI (Salmela-Aro et al., 2009). The coefficients of the anxiety–burnout correlation for male and female students were compared using Fisher's z-transformation and a corresponding significance test for differences between correlation coefficients (Fisher, 1915; see Upton & Cook, 2008). The correlation coefficients for females and males were first transformed into Fisher's z coefficients according to the following formula:

$$Z = \frac{1}{2} \ln \left(\frac{1 + r}{1 - r} \right)$$

z was computed based on these transformed coefficients according to the following formula, while the corresponding significance level was deduced from the table for the standard normal distribution:

$$z = 1 + \frac{Z1 - Z2}{\sqrt{\sigma^2 Z1 + \sigma^2 Z2}}$$

RESULTS

Gender Differences in State Anxiety in Different Contexts

First we analyzed whether the ESM items diminished gender differences in state anxiety, as reported by Goetz et al. (2013). Like Goetz and colleagues, we found that male and female students did not differ in their mean levels of state anxiety, assessed by ESM state measures. These findings held true across all situations, across all in-school situations, across all science lessons, in mathematics, in biology and in physics, and in both countries: neither within the US nor within Finland were there any gender differences in anxiety, across all situations and within the in-school beeps. Table 1 gives an overview of these findings.

Table 1
Descriptives: Gender Differences in Anxiety in Different Contexts

		N	*M*	*SD*	*t-Test for gender differences*	
					p(2-tailed)	*d*
Across all situations	female	239	1.73	.601	.081	-.16
	male	228	1.83	.685		
In school	female	218	1.76	.619	.255	-.11
	male	211	1.83	.700		
Mathematics	female	157	1.73	.778	.454	-.09
	male	115	1.81	.848		
Biology	female	126	1.76	.737	.471	-.09
	male	108	1.84	.764		
Physics	female	99	1.73	.777	.783	.04
	male	85	1.69	.783		
Chemistry	female	39	1.84	.678	.351	.22
	male	33	1.68	.800		

Note: Within each context, the person-level mean score (ESM) of anxiety was calculated, then the grand mean (inter-individual average of these intra-individual means) was computed separately for gender. Convention for interpreting Cohen's (1988) d: small: *d* = .2, medium: *d* = .5, large: *d* = .8.

However, within each gender, the mean levels of state anxiety differed significantly between Finland and the US, across all experiences (Females: $Mean_{US}$= 1.85;

$Mean_{Finland}$ = 1.59; p = .001; d = .45; Males: $Mean_{US}$ = 1.96; $Mean_{Finland}$ = 1.59; p = .000; d = .55), and across all in-school beeps.

Inter-Individual Differences in the Relationship between Anxiety and Motivation

After finding that male and female students did not differ in their mean levels of state anxiety in the different contexts, we investigated whether they differed in the degree to which they felt engaged, joyful, competent, or stressed in situations in which they felt anxious. For this purpose, we computed the intra-individual correlations between state anxiety and state affect/state competence perceptions, as described by Pekrun et al. (2002). As Figure 1 shows, we found a large distribution of correlation coefficients for the relationship between state anxiety and state aspects of motivation (example here: current enjoyment). Similar distributions were found in regard to all other affective and motivational variables (see Table 2). While the overall correlation between situational anxiety and situational enjoyment across all situations and individuals is r=-.02 and not significant, the range is large; the smallest observed intra-individual correlation for an individual was -.81 and the largest intra-individual correlation was .88.

This range and the distributions of the intra-individual correlations between anxiety and enjoyment imply that some individuals tend to experience positive affect at the same time as they experience anxiety, indicated by a positive intra-individual correlation between their situational experiences of anxiety and their situational experiences of enjoyment. Other individuals tend to experience less positive affect in situations in which they feel anxious, indicated by a negative intra-individual correlation between anxiety and affect/motivation. However, many individuals show very small correlations (around .0) between their experiences of situational anxiety and situational enjoyment, which suggests that they experience anxiety-provoking situations sometimes as motivating and sometimes not.

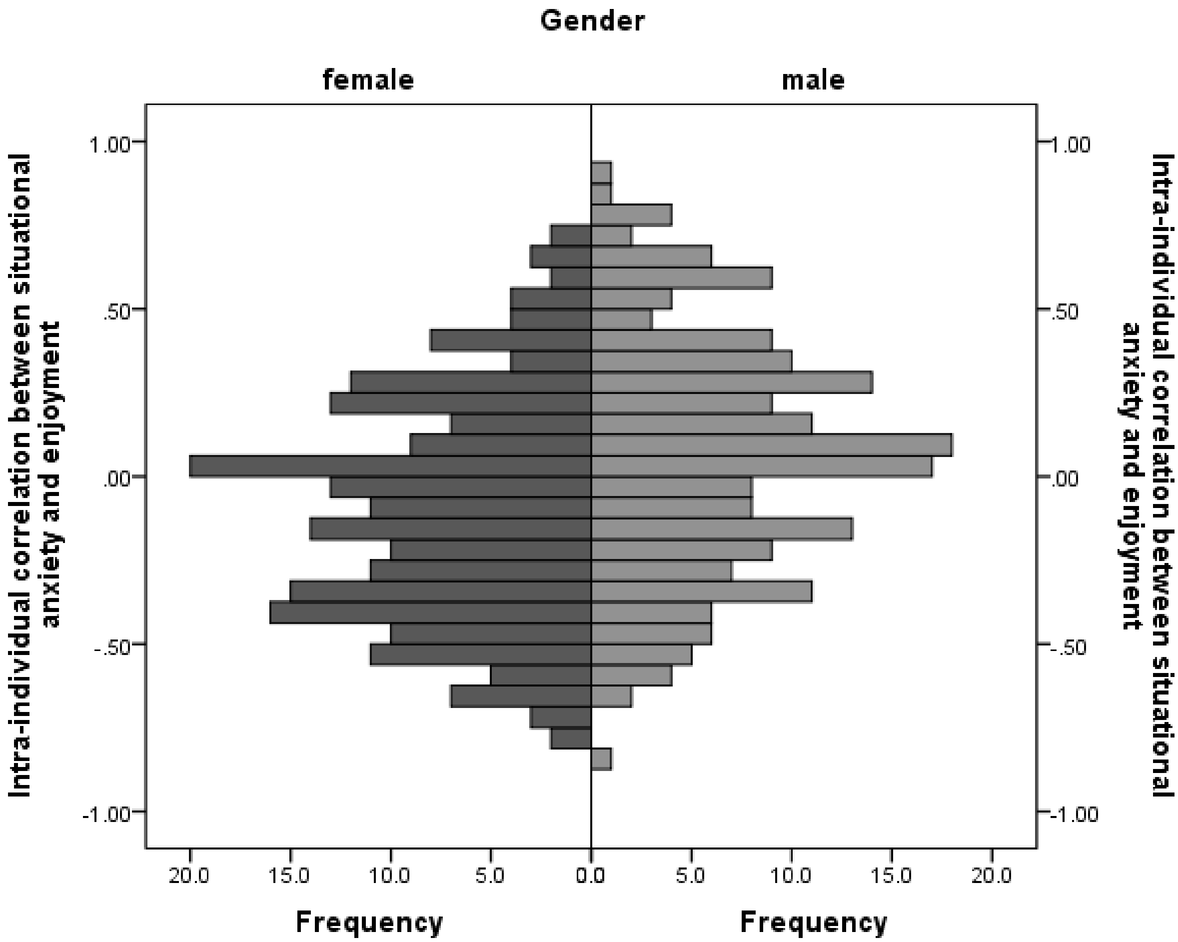

Figure 1. *Distribution of intra-individual correlations between anxiety and enjoyment), separated for females (left) and males (right), across all experienced situations.*

Gender Differences in the Intra-Individual Correlations between Anxiety and Motivation

The finding that individuals differ in how much they suffer from the anxiety they experience raises the question of which personal and contextual determinants might explain these inter-individual differences. We expected that, if we were to find gender differences, females would experience less positive affect and less intrinsic motivation than males and more negative affect and withdrawal motivation than males in situations in which they are anxious, because of their lower levels of self-confidence and motivation towards science learning (Goetz et al., 2008; Hyde et al., 1990).

Across all school and everyday life experiences, the results showed consistently that gender explained a part of the inter-individual differences in how much students suffer or benefit from anxious experiences. Females displayed significantly lower intra-individual correlations between anxiety and positive affective states (enjoyment, and feeling active, energetic, excited, successful, competent, and confident; see Table 2) than males. The effect sizes of these gender differences were small (for the correlations of anxiety to feeling active, successful, and competent) to medium (feeling enjoyment, feeling energetic, excited, and confident).

Table 2
Gender Differences in Intra-Individual Correlations between Anxiety and Motivational Aspects Across All Experiences

Correlation between anxiety and…		*N*	*Mean*	*SD*	*t-Test for gender differences* *p-value* (2-tailed)	*d*
Positive Affect / Intrinsic Motivation across all experiences						
… Enjoyment	female	212	-0.08	.363	.000	-.36
	male	189	0.05	.371		
… Concentration	female	106	0.12	.310	.351	.13
	male	103	0.08	.341		
… Active	female	200	0.04	.365	.011	-.26
	male	184	0.14	.383		
… Energetic	female	121	0.02	.388	.006	-.37
	male	104	0.17	.416		
… Excited	female	106	-0.05	.395	.000	-.50
	male	101	0.14	.366		
… Successful	female	206	-0.10	.340	.002	-.31
	male	189	0.00	.355		
… Competent	female	121	-0.07	.319	.003	-.40
	male	103	0.07	.360		
… Confident	female	204	-0.10	.371	.000	-.45
	male	186	0.07	.363		
Aversive Experiences / Withdrawal Motivation across all experiences						
… Want to give up	female	101	0.22	.369	.040	.30
	male	93	0.11	.344		
… Confused	female	206	0.31	.331	.001	.34
	male	181	0.19	.363		
… Stressed	female	207	0.40	.340	.000	.44
	male	176	0.24	.366		

Note. Includes only individuals with at least three valid ESM responses. Variance equality was tested via the Levene's-test and, in cases with unequal variances, the corrected significance level was reported. Normal distribution was tested via Kolmogorov–Smirnov tests. Most variables deviated from normal distribution in at least one gender group; therefore, Mann–Whitney U-tests were computed for all variables. Their significance and effect sizes suggested similar interpretations to the t-tests (see Table 4 in the Appendix).

No gender differences were found with regard to the correlation between anxiety and concentration. The contrary trend was found with regard to negative affect and the wish to give up on the current task, which were more strongly related to anxiety in females than in males (small effect sizes). However, this was only observed across all experiences.

Interestingly, these gender differences in the relationship between anxiety and motivational experiences were stronger and more consistent in the overall sample of everyday life activities than in the science-specific contexts of mathematics, biology, and physics (see Tables 4–7 in the Appendix). Only the correlation between anxiety and stress differed in more than one context between males and females (mathematics and physics; d_{Math}=.47, $d_{Physics}$ = .69). In math and biology, anxiety was more strongly related to males' than to females' energy (d_{Math}=.58, $d_{Biology}$ = .67), while, in physics, the wish to give up on the current task was more strongly correlated with anxiety in females than males (*d*=.93). However, the two last findings were based on small science-specific samples and require replication before they can be generalized.

Gender Differences in the Overall Correlation between In-School Anxiety and School Burnout

Having found that male and female students differed in how much their *situational* motivation was lower in moments in which they felt anxious, we analyzed whether this could also be found with *cross-situational measures*. For this purpose, we calculated the inter-individual correlations between the individuals' mean level of anxiety across all school experiences and the individual's overall schoolwork engagement and school burnout as measured by one-time administered paper-and-pencil questionnaires. Based on our prior findings, we expected that female students would display weaker negative correlations between their anxiety and schoolwork engagement and a stronger positive relationship between their overall anxiety and school burnout.

Table 3
Inter-Individual Correlations between Average In-School Anxiety with Schoolwork Engagement and School Burnout

Correlation between…		*N*	*r*	*p*
…Schoolwork engagement with in-school anxiety	female	197	-.005	.948
	male	191	-.014	.848
…School burnout with in-school anxiety	female	200	.373	.000
	male	192	.212	.002

Note: We used Fisher's z-transformation to transform Pearson correlations in z values and to test whether the gender difference between the correlation coefficients was significant. The difference between the correlation coefficient female and male for burnout is significant (*Fisher's z* = 1.73; $p_{(\text{one-tailed})}$ = .04).

We found that the overall anxiety level across all school situations was unrelated to the students' level of schoolwork engagement, but positively correlated with the overall level of symptoms of school burnout (Table 3). The correlation between overall school anxiety and school burnout was significantly stronger for girls than for boys (*Fisher's* z=1.73; $p_{(one\text{-}tailed)}$=.04).

DISCUSSION

This study investigated gender differences in situational anxiety and their influence on situational engagement, intrinsic and aversive experiences, and perceived competence in different school and science contexts. We assessed state anxiety at the moment at which it is experienced with ESM in a sample of US and Finnish comprehensive and high-school students.

The first finding of this study is that male and female students did not differ in their personal mean levels of state anxiety, but that they did differ in the implication that their anxiety had for their motivation.

In females, anxiety was more weakly correlated to positive state affect and perceived competencies than in males, and more strongly correlated to negative affect than in males. However, these gender difference effects were mostly small. The same tendency was found for the gender difference in the relationship of cross-situational anxiety in school settings and overall school burnout, which was stronger for females than for males.

Theoretical Implications

These results replicate earlier findings from Goetz et al. (2013), who reported that male and female students did not differ in their state anxiety in math if appropriate state ESM measures were used. We found that this holds true for other contexts (in-school experiences, and within mathematics, biology, and physics) in a sample of US and Finnish high-school students. Importantly, these findings contradict the frequent claim that females are generally more anxious about science learning, which was mostly based on less situation-specific measures (Mallow, 1994; Udo et al., 2001; Udo et al., 2004). In contrast to these studies, our results corroborate Goetz and colleagues' (2013) finding that ESM measures reduce gender differences in state anxiety as compared to situation-unspecific questionnaire measures, which is probably due to the fact that ESM measures are less biased by gender-specific competence beliefs (Brewer, 2000; Goetz et al., 2013; Hektner et al., 2007).

We also replicated the findings of Pekrun et al. (2002) and found that, even though state anxiety is uncorrelated or very slightly correlated with state aspects of motivation and affect, there is a wide inter-individual distribution of intra-individual correlations between these variables, meaning that some individuals benefit motivationally from their anxiety while others suffer and are less motivated in situations in which they feel anxious. Gender and science context partially explained these inter-individual differences: the relationship between anxiety and intrinsic motivation/positive affect was weaker for females, and the relationship between state anxiety and avoidance motivation/negative affect was stronger for females. These gender differences were more consistent across all experiences than within science contexts, suggesting that they might reflect other, non-science-specific mechanisms. While it looks as if females suffer more in anxious situations, they on the other hand feel less anxious in engaging situations.

Finally, we also found that the correlation between cross-situational in-school anxiety levels and overall levels of school burnout differed by gender, with a stronger –negative- correlation coefficient in females than males. This last finding corroborates and validates with paper-and-pencil questionnaires what we found before with the ESM measures.

An important theoretical implication of this study is the finding that, as suggested by Pekrun et al. (2002) and Jones, Meijen, McCarthy, and Sheffield (2009), anxiety can be beneficial or harmful for situational motivation. It remains for future research to identify further personal, contextual, and situational characteristics that determine whether students benefit or suffer from the anxiety they experience.

The practical implications of our findings regard 1) the measurement and analysis of gender differences in context- and situation-specific anxiety, and 2) students' need for support in coping with their anxiety in a way that is beneficial for their motivation to engage and persist in the tasks at hand. Regarding the first point, we assert that future studies should have a look at group differences beyond the mean level. Our findings suggest that gender might moderate the relationship between the experienced anxiety and motivational states and dispositions. The often-discussed gender mean level differences might be method artefacts that could be reduced or nullified by the use of less biased ESM measures (for a discussion, see Goetz et al., 2013; Hektner et al., 2007; and above), but that does not imply that male and female students do not differ in how they experience anxiety. It would be insightful to conduct additional moderator analyses of this question in future studies. Regarding the question of student support, we would state that anxiety cannot and does not need to be avoided in the classroom by all means, as some individuals may benefit from it. Instead, students could be supported in coping with highly challenging and demanding tasks. Several theories claim that the main difference between states of activating, engaging anxiety and states of inhibiting, stressful anxiety are the level of perceived control and perceived resources to deal with the current challenges (Jones et al., 2009; Lazarus & Folkman, 1984). This would suggest that instructions that emphasize the students' skills, resources, and perceived control might help students to deploy their anxiety in an engaging way. However, this is a hypothesis for future studies to investigate.

Limitations and Directions for Future Research

Due to the necessary shortness of ESM measures, we could not assess all facets of multidimensional phenomenon anxiety and had to focus on the situational, salient and self-reported aspects. Given that earlier studies have found different gender effects for specific sub-components of anxiety (Baloğlu & Koçak, 2006), it is desirable that future studies should differentiate between specific facets of anxiety when studying the anxiety-motivation relationship.

The relationship between anxiety and motivation might differ between types of motivation, e.g., intrinsic and extrinsic aspects. For instance, students' anxiety was negatively correlated with intrinsic motivation and with overall extrinsic motivation, but anxiety correlated positively with extrinsic avoidance motivation, i.e., motivation to invest effort to avoid failure (Pekrun et al., 2002; Pekrun & Hofmann, 1999). Therefore, it promises to be insightful to distinguish between more specific aspects of motivation and their relationship with anxiety in future studies.

One limitation of our study is that we could not analyze whether males and females differ in their anxious reactions to the same situation, due to the beeping schedule, which was different for each person. For the research on optimal instruction, it would be very interesting to learn from future studies whether and how males and females react differently to the same stimuli or teaching method when it comes to anxiety.

This article has only addressed fluctuating state aspects of anxiety and did not cover trait anxiety or other personality influences. While this may be regarded as a strength in comparison to the predominating research on stable measures of anxiety in school settings, it would be desirable to assess state and trait aspects of learning anxiety with the same approach in the future. With ESM measures like ours, stable inter-individual components can be disentangled from intra-individual variation with a multilevel approach (beeps nested in individuals). The size of our samples on both levels did not allow for such an approach, because we gathered data in many different contexts. Larger sample sizes could allow for multilevel testing if a future study sampled more beeps in one single context (e.g. math).

Although we checked that our results were invariant in the US and Finland, country differences were beyond the scope of this article. It might be insightful to examine them in detail in future studies, since we found substantial country differences, with male and female US students showing stronger anxiety than Finnish students in our samples. In addition, we found that intra-individual correlations between situational anxiety and positive and negative motivation differed by country. Bigger and more representative international samples are needed to examine these differences more in detail.

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APPENDIX

Table 4
Distributions of the Intra-Individual Correlations Across All Experiences

Intra-individual correlation between anxiety and…		*Kurtosis*	*Skew-ness*	*p-value Kolmo-gorov–Smirnov test for normality (Lilliefors corr.)*	*p-value Mann–Whitney U-test for gender difference*	*Effect size r for Mann–Whitney U-test (absolute value)*
… Enjoyment	female	-.505	.146	.200[a]	.001	.17
	male	-.609	.110	.200[a]		
… Concentration	female	-.113	-.272	.039	.360	.06
	male	-.457	-.025	.187		
… Active	female	-.424	.195	.200[a]	.008	.13
	male	-.688	-.150	.036		
… Energetic	female	-.534	.517	.010	.007	.18
	male	-1.002	-.055	.004		
… Excited	female	-.119	.477	.008	.000	.26
	male	-.225	.111	.034		
… Successful	female	-.227	.053	.200[a]	.004	.14
	male	.029	.263	.090		
… Competent	female	-.135	.030	.004	.002	.21
	male	.003	-.065	.000		
… Confident	female	-.241	.336	.078	.000	.22
	male	-.554	.129	.200[a]		
… Want to give up	female	-.495	-.098	.115	.037	.15
	male	-.369	.183	.015		
… Confused	female	-.012	-.466	.200[a]	.002	.16
	male	-.374	-.323	.041		
… Stressed	female	.777	-.899	.000	.000	.22
	male	-.567	-.355	.035		

Note. [a] = lower boundary of significance.

Table 5
Gender Differences in Intra-Individual Correlations between Anxiety and Motivational Aspects in Mathematics

Correlation between anxiety and…		*N*	*Mean*	*SD*	*t-Test for gender differences* *p-value* *(2-tailed)*	*d*
Positive Affect / Intrinsic Motivation in Mathematics						
… Enjoyment	female	67	.03	.459	.986	.00
	male	42	.02	.347		
… Concentration	female	36	.01	.249	.922	-.03
	male	27	.01	.206		
… Active	female	67	.03	.540	.715	-.07
	male	41	.06	.334		
… Energetic	female	56	-.03	.484	.009	-.58
	male	31	.25	.423		
… Excited	female	36	.01	.272	.163	-.36
	male	27	.11	.288		
… Successful	female	67	-.10	.422	.213	-.24
	male	40	.02	.512		
… Competent	female	56	-.10	.485	.979	.01
	male	32	-.10	.430		
… Confident	female	67	-.05	.621	.234	-.23
	male	42	.08	.364		
Aversive Experiences / Withdrawal Motivation in Mathematics						
… Want to give up	female	36	.08	.253	.073	.47
	male	26	-.02	.153		
… Confused	female	66	.28	.729	.168	.27
	male	41	.13	.405		
… Stressed	female	66	.38	.830	.019	.47
	male	40	.09	.394		

Note. Only individuals with at least three valid ESM responses in mathematics were included.

Table 6
Gender Differences in Intra-Individual Correlations between Anxiety and Motivational Aspects in Biology

Correlation between anxiety and…		*N*	*Mean*	*SD*	*t-Test for gender differences* *p-value* *(2-tailed)*	*d*
Positive Affect / Intrinsic Motivation in Biology						
… Enjoyment	female	39	.02	.495	.564	-.15
	male	23	.10	.458		
… Concentration	female	13	-.06	.406	.238	-.54
	male	9	.15	.370		
… Active	female	37	.00	.453	.153	-.38
	male	22	.18	.474		
… Energetic	female	31	.02	.514	.024	-.67
	male	19	.35	.411		
… Excited	female	15	.02	.377	.091	-.69
	male	13	.27	.364		
… Successful	female	34	-.11	.483	.476	-.19
	male	24	-.02	.454		
… Competent	female	30	-.10	.445	.680	.13
	male	15	-.15	.444		
… Confident	female	41	-.03	.480	.225	-.32
	male	20	.13	.473		
Aversive Experiences / Withdrawal Motivation in Biology						
… Want to give up	female	14	.17	.361	.162	.63
	male	9	-.06	.385		
… Confused	female	39	.26	.481	.708	.10
	male	23	.22	.391		
… Stressed	female	40	.35	.396	.107	.44
	male	18	.16	.448		

Note. The subject-specific tests include only individuals with at least three valid ESM responses in biology.

Table 7
Gender Differences in Intra-Individual Correlations between Anxiety and Motivational Aspects in Physics

Correlation between anxiety and…		*N*	*Mean*	*SD*	*t-Test for gender differences* *p-value* (2-tailed)	*d*
Positive Affect / Intrinsic Motivation in Physics						
… Enjoyment	female	39	-.07	.436	.301	-.25
	male	35	.03	.389		
… Concentration	female	9	.01	.336	.930	-.03
	male	21	.02	.341		
… Active	female	35	.03	.418	.206	-.31
	male	34	.17	.443		
… Energetic	female	31	.02	.477	.896	-.04
	male	17	.04	.433		
… Excited	female	9	.09	.280	.508	-.25
	male	22	.19	.414		
… Successful	female	33	-.07	.336	.528	-.15
	male	36	-.02	.367		
… Competent	female	25	-.11	.414	.455	-.24
	male	16	-.01	.409		
… Confident	female	37	-.09	.469	.068	-.44
	male	36	.10	.412		
Aversive Experiences / Withdrawal Motivation in Physics						
… Want to give up	female	8	.39	.345	.040	.93
	male	16	.03	.388		
… Confused	female	35	.33	.350	.104	.41
	male	32	.17	.410		
… Stressed	female	36	.41	.397	.007	.69
	male	33	.12	.464		

Note. The subject-specific tests include only individuals with at least three valid ESM responses in physics.