Predicting Education Science Students' Statistics Anxiety: The Role of Prior Experiences Within a Framework of Domain-Specific Motivation Constructs

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Abstract

Based on a cognitive–motivational modeling of construct relations, this study analyzed the role of prior statistics experiences within a framework of domain-specific self-concept and value variables to predict education science students' statistics anxiety. Data were analyzed from two independent samples comprising 113 and 87 participants—using the passing of a statistics exam as the experience measure in each case. In both samples, the results of three-way analyses of variance demonstrated students' statistics anxiety to be substantially explained by their negative utility value and self-concept but only to a minor extent by their prior statistics experiences. Students' statistics anxiety appeared to be dependent on value and self-concept scores across all experience levels. Though producing somewhat varying effect patterns, the findings from both samples led to similar effects, indicating the crucial role of self-belief variables. Results are discussed in terms of conceptual, methodological, and instructional implications.

Keywords: statistics anxiety; prior statistics experiences; utility value; mathematics self-concept

Introduction

In higher education settings, the learning of research methods, most notably the acquisition of statistical knowledge and competencies, can be stressful or anxiety provoking. Many undergraduate and graduate students from social science, education, psychology, and business programs struggle with statistics (Mji & Onwuegbuzie, 2004; Onwuegbuzie & Wilson, 2003). When dealing with the requirements of quantitative methods courses that are commonly compulsory for earning the degree, these students mostly suffer from strong failure expectations and frequently experience feelings of apprehension and personal threat. They perceive methodological competencies difficult to acquire and less useful for current studies and later professional development (Markle, 2017; Murtonen & Lehtinen, 2003; Murtonen, Olkinuora, Tynjälä, & Lehtinen, 2008; Zeidner, 1991). As a result, they are at risk for developing and maintaining a heightened level of anxiety in the face of statistical demands—in particular, when being confronted with statistical tasks of data gathering, processing, and interpreting (Cruise, Cash, & Bolton, 1985). Empirical analyses from diverse conceptual, methodological, and institutional backgrounds have yielded insights into the development, structure, and consequences of higher education students' statistics anxiety. These studies have established a broad-based research with the goal of clarifying and elaborating the construct (Onwuegbuzie & Wilson, 2003; Ralston, MacInnes, Crow, & Gayle, 2016).

Conceptual Perspectives on Statistics Anxiety

Structurally, emerging statistics anxiety has to be considered a multidimensional construct (Hodapp & Benson, 1997) that reflects the complex interplay of cognitive, motivational, and physiological components (Rost & Schermer, 1989; Zeidner, 1998). Based on empirical findings of test anxiety research, statistics anxiety can be defined as a domain-specific form of evaluation anxiety that manifests as worry cognitions that repeatedly occur, interfering thoughts during task completion, marked states of emotional tension, and physiological arousal (Zeidner, 1991). In particular, cognitive worries and task-irrelevant thoughts had been demonstrated to stress students' executive resources, impede their learning approach, and eventually impair their academic performance (von der Embse, Jester, Roy, & Post, 2018). This debilitating effect of worry cognitions appears to be mainly caused by their strongly biased and task-irrelevant mode of information processing (Sarason, 1984; Schwarzer, 1996). Accordingly, students experiencing a heightened level of statistics anxiety are persistently afraid they won't master a statistically loaded task or a statistical course exam (Cruise et al., 1985). They also tend to use less adaptive learning and test-taking strategies (Spada & Moneta, 2012; Virtanen, Nevgi, & Niemi, 2013; Warr & Downing, 2000). However, for the most part, previous research on statistics anxiety among university students has disregarded the cognitive components of the construct (Faber, Drexler, Stappert, & Eichhorn, 2018). Rather, relevant studies focus on its emotional and physiological components (Cruise et al., 1985; Onwuegbuzie & Wilson, 2003; Papousek et al., 2012).

Empirical Research Findings on Statistics Anxiety

Notwithstanding, numerous studies in the field have increasingly clarified the nature of statistics anxiety—in particular, with regard to its developmental antecedents, contextual references, individual determinants, and educational consequences (Cruise et al., 1985; Onwuegbuzie & Wilson, 2003; Zeidner, 1991). Several studies consistently separated university students' statistics anxiety from their general test and mathematics anxiety. Thus, relevant measures of statistics anxiety should claim construct validity to a required extent (Baloğlu, 2002; Paechter, Macher, Martskvishvili, Wimmer, & Papousek, 2017; Sesé, Jiménez, Montaño, & Palmer, 2015). Furthermore, research in the field has identified a wide variety of risk factors that can predict statistics anxiety. Across diverse designs, methodological features, and student samples, certain cognitive and motivational characteristics have consistently explained the formation of statistics anxiety—in particular, students' inadequate mathematical knowledge, lowered competence beliefs, and negative attitudes toward the value of statistical competencies (Emmioğlu & Capa-Aydin, 2012; Onwuegbuzie & Wilson, 2003).

However, as relevant multivariate analyses have repeatedly demonstrated, these antecedents and determinants operate in a complex manner. They constitute a relational pattern of direct and indirect effects, each of them specifically contributing to the development and maintenance of statistics anxiety (Chiesi & Primi, 2010; González, Rodríguez, Faílde, & Carrera, 2016; Macher et al., 2013; Nasser, 2004; Onwuegbuzie, 2003; Sesé et al., 2015; Tremblay, Gardner, & Heipel, 2000). Similarly, the level of individually experienced statistics anxiety has been shown to adversely affect students' learning approach and performance in the domain (González et al., 2016; Kesici, Baloğlu, & Deniz, 2011; Macher, Paechter, Papousek, & Ruggeri, 2012; Onwuegbuzie, 2003; Sesé et al., 2015).

Overall, research in the field indicates the students most at risk of failing a university statistics course are those who have poorer math grades at school, display inappropriate mathematical competencies, perceive their mathematical or statistical competencies as low, and value statistics as a less useful subject of study. These students experience a heightened level

of statistics anxiety (Finney & Schraw, 2003; Galli, Ciancaleoni, Chiesi, & Primi, 2008; González et al., 2016; Onwuegbuzie, 2000).

The Role of Prior Statistics Experiences

Various studies considered prior statistics experience as a relevant background variable. Seemingly, these analyses were geared toward the examination of a positive impact that familiarity with statistical procedures and course requirements should have on students' domain-specific motivation, attitudes, or performance (Carmona, Martínez, & Sánchez, 2005; Dempster & McCorry, 2009). Following the analysis of Sutarso (1992), who demonstrated significantly lower anxiety scores in the subgroup of students with more statistics courses taken before the exam, Onwuegbuzie (2003) had also substantiated a small but significant relation between prior statistics experience and self-concept. However, he did not explicitly assess the statistics anxiety variable. Instead, he had used the Computational Self-Concept subscale from the Statistical Anxiety Rating Scale instrument (Cruise et al., 1985). Although there is theoretical and empirical overlap between the self-concept and anxiety variable, they represent distinct constructs and should not be treated as interchangeable.

In another study, students' subjective rating of prior experiences did not significantly predict grades on a statistics exam (Slootmaeckers, 2012). These findings suggest that prior statistics experiences explain self-beliefs more than actual achievement in statistics. Dempster and McCorry's (2009) study supported this conclusion. Being more frequently involved with learning statistics is likely to increase confidence in typical requirements and methods (Waples, 2016) and thereby reduce apprehension and fear of failure.

As demonstrated elsewhere (Schönwetter, Clifton, & Perry, 2002), familiarity with course materials might also enhance students' perceived control. In contrast, other relevant studies (Birenbaum & Eylath, 1994; Chew & Dillon, 2012, 2014a; Schutz, Drogosz, White, & DiStefano, 1998; Townsend, Moore, Tuck, & Wilton, 1998) did not substantiate any significant impact of prior statistics experiences on students' statistics anxiety. Likewise, students with and without prior experiences appeared to not significantly differ in their valuing of statistical competencies (Hannigan, Hegarty, & McGrath, 2014; Slootmaeckers, 2012).

In sum, across various measures of prior statistics experiences, most findings do not support the assumption of positive effects. However, relevant studies suffered from conceptual and methodological limitations—the assumption of a negative relation between prior statistics learning and statistics anxiety must be considered a simplified view. That is because the impact of previously taken statistics courses should depend on students' outcome experiences (Cano, Martin, Ginns, & Berbén, 2018). Students with favorable course experiences will develop more positive competence beliefs and attitudes as well as a lowered level of statistics anxiety (Galli et al., 2008; González et al., 2016). Without controlling for the direction and magnitude of individually existing self-beliefs and attitudes, empirical analyses of prior experiences disregard the potential appearance of both positive and negative relations with students' statistics anxiety in the same sample. These studies, thus, are at risk because they omit potential moderator effects. Consequently, the relation between prior statistics experiences and statistics anxiety should be more adequately analyzed within students' cognitive–motivational system of academic self-beliefs (Stiensmeier-Pelster & Otterpohl, 2018). Specifically, empirical findings that substantiate the role of domain-specific competence beliefs and task values in predicting students' statistics anxiety and attitudes lend support to this extension of research efforts (Chiesi & Primi, 2010; González et al., 2016; Hood, Creed, & Neumann, 2012; Onwuegbuzie, 2003; Sesé et al., 2015).

Theoretical Framework and Research Hypotheses

The present study is conceptually rooted in a social–cognitive understanding of motivation processes, namely, in both the expectation-value theory of academic motivation (Wigfield & Eccles, 2000) and the control-value theory of academic emotions (Pekrun, 1988; Pekrun, Frenzel, Goetz, & Perry, 2007). The purpose of the study is to understand the effect of prior statistics experiences on students' statistics anxiety in the context of their domain-specific competence expectations and task values.

Following this conceptual perspective, the formation of statistics anxiety should be substantially affected by students' competence expectations or self-concept. As test anxiety research demonstrates, lowered academic self-concepts strongly predict test anxiety responses (Ahmed, Minnaert, Kuyper, & van der Werf, 2012; Faber, 2012; Goetz, Pekrun, Hall, & Haag, 2006). In most cases, high-anxious students reported a lowered self-concept of mathematics or statistical competencies (Bandalos, Yates, & Thorndike-Christ, 1995; Benson, 1989; González et al., 2016; Macher et al., 2012; A. Williams, 2014; Zeidner, 1991). Thus, students with lower competence beliefs will predominantly expect to fail statistical tasks and develop a higher level of apprehension and worry.

Furthermore, according to the assumption of the expectancy-value approach (Wigfield, Hoa, & Klauda, 2009), students' perceived value of statistical competencies should have a direct impact on their statistics anxiety, as well. Following relevant research findings, strong perceptions of statistics as less useful should predict a heightened level of statistics anxiety (Baloğlu, 2002; Chew & Dillon, 2014b; Chiesi & Primi, 2010; Papousek et al., 2012). Although domain-specific self-concept and utility value variables had been evidenced to correlate to some extent (Chew & Dillon, 2014b; Dempster & McCorry, 2009; Hood et al., 2012; Papousek et al., 2012), they should still uniquely contribute to the variance of the anxiety variable.

Within this framework, the role of students' prior statistics experiences needs to be considered in a more differentiated manner. In particular, the impact of prior statistics experiences will vary in some respects. Prior experiences can refer to students' successes or failures in statistics and, thus, be positive or negative in nature. In each case, the cognitive–motivational processing of anxiety formation will operate differently in the following ways.

(a) Students with prior statistics failure experiences will likely develop a negative self-concept, finding learning statistics challenging and believing they are prone to failure. Thus, they will value statistical knowledge and competencies as less useful and display a heightened level of statistics anxiety.

(b) Students with prior success experience will likely develop a positive self-concept and weak negative value beliefs and, therefore, perceive their previous statistical learning more positive. Hence, they will display a lower level of statistics anxiety. For students without prior statistics experience, the same effect of the self-concept and the value variable should be expected; however, their statistics anxiety will be more strongly affected by domain-specific beliefs, in particular, self-concept and utility value.

(c) Students without prior experience who perceive their competencies as low will mostly expect to fail in learning statistics, tend to negatively value the usefulness of statistical competencies, and will thus likely develop a heightened level of statistics anxiety.

(d) Students without prior experience who perceive their competencies as sufficient or high will most likely anticipate success in learning statistics and expect to master statistical course requirements. Therefore, they are less likely to devalue statistical competencies and will display a lower level of statistics anxiety.

Consequently, in each case, students with a lowered self-concept will report a negative utility value and statistics anxiety more than students with a heightened self-concept, whether they have gained positive or negative statistics experiences or not (Chamberlain, Hillier, & Signoretta, 2014; Galli et al., 2008).

Thus, the present study focuses on the role students' prior passing of a statistics exam will play in the formation of their statistics anxiety. In terms of a factorial research design (Field, 2013), mean differences in the anxiety variable are assumed to be explained by significant effects of the self-concept and utility value variables. However, the potential effect of prior success experiences—namely, the passing of an exam—on students' anxiety level appears less clear. The analysis of anxiety differences between students having or not having passed a statistics exam should at least consider three distinct effect patterns: Prior success experiences will (a) directly reduce students' anxiety level beyond the impact of their self-concept and utility value, (b) indirectly reduce students' anxiety level by significant interaction effects with the self-concept and utility value variables, or (c) not substantially contribute to reducing students' anxiety level. In that regard, the present study primarily addressed the impact of students' motivational characteristics to clarify the role of prior experiences—instead of (once again) merely examining their explanative value.

According to these conceptual considerations, the present study aimed to analyze the following research hypotheses:

Hypothesis 1: Across both levels of statistics experiences, students with a high mathematics self-concept will report a lower level of statistics anxiety (main effect hypothesis).

Hypothesis 2: Across both levels of statistics experiences, students with a low negative utility value of statistical competencies will report a lower level of statistics anxiety (main effect hypothesis).

Hypothesis 3: Within the subgroup displaying a high mathematics self-concept (and a low negative utility value), students with prior success experiences will report a lower level of statistics anxiety than their counterparts without prior success experiences (interaction effect hypothesis).

Hypothesis 4: Within the subgroup displaying a low mathematics self-concept (and a high negative utility value), students with prior success experiences will report a lower level of statistics anxiety than their counterparts without prior success experiences (interaction effect hypothesis).

Method

Sample and Procedure

Data from two independent samples were analyzed. In both samples, students were provided with sufficient information to make an informed decision as to whether to take part in the study. Their participation was on a voluntary basis only. To meet the institution's ethical requirements, we sought informed consent from the participants prior to data collection. Each participant's name was substituted with a pseudonym to keep the database anonymous.

Sample 1 consisted of 113 graduate students (n = 94 female, n = 19 male) from master's-level courses in educational sciences (n = 80) and special education (n = 33). They were all enrolled in a compulsory course on empirical research methods. The participation rate was sufficiently high at 82%. Seventy-five of the students had already acquired elementary statistical knowledge during their undergraduate program, whereas 38 were required to attend a course in basic descriptive and inferential statistics. Neither the subgroup with nor without statistical knowledge significantly differed with respect to gender, $\chi^2(1)$ = .043, p > .05, or age, $t(111)$ = −0.634, p > .05.

Sample 2 was thought to validate the findings from Sample 1 a year later. It consisted of 87 graduate students from the same master's-level courses: educational sciences (n = 59) and special education (n = 28). The sample was predominantly female (n = 74). Again, students were enrolled in a compulsory course on empirical research methods. The participation rate was high at 89%. Fifty of the students had acquired statistical knowledge during their undergraduate

program, whereas 37 had yet to attend an introductory statistics course. There were no subgroup differences in gender, $\chi^2(1) = .067$, $p > .05$, or in age, $t(82) = 0.790$, $p < .05$.

In both samples, all relevant data were gathered during the course's first term. A questionnaire including all items to assess students' domain-specific experiences and self-beliefs was administered. To prevent a priming effect of the self-concept items, they were presented at the end of the questionnaire (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

Measures

Prior statistics experiences. Because relevant studies had assessed students' prior statistics experiences in various ways—namely, by means of subjective ratings (Dempster & McCorry, 2009; Slootmaeckers, 2012) and the number of previously taken statistics courses (Birenbaum & Eylath, 1994; Chew & Dillon, 2012; Hannigan et al., 2014; Onwuegbuzie, 2003; Sutarso, 1992)—in the present study, an objective (formal) measure was used. In both samples, students' prior experiences with statistics referred to the successful passing of a statistics exam in their undergraduate program; passing was coded as 0 (no) or 1 (yes).

Self-concept in mathematics. Because the study samples consisted of both students with and without statistical experiences (see Table 1), their measures of domain-specific competence beliefs did not refer to their statistics but to their mathematics self-concept (González et al., 2016; Onwuegbuzie & Wilson, 2003). This was assessed using a nine-item scale addressing most recent learning experiences at school and competence beliefs with regard to meeting subject-specific demands. Most items originated from well-proven instruments, namely, the research scale for assessing learners' spelling-specific self-concept (Faber, 2012), the research scale for assessing students' subject-specific self-concepts (Möller, Streblow, Pohlmann, & Köller, 2006), and the self-concept grid for assessing students' subject-specific self-concepts (Rost, Sparfeldt, & Schilling, 2007). They were selected due to their content validity to unambiguously represent students' subject-specific competence beliefs and their psychometric properties, especially their factor loadings and item-total correlations. All items were adapted and phrased retrospectively (e.g., "I tried hard in mathematics, but I did not perform very well"). Items were summed up to create the score, with high scores indicating positive competence beliefs. In both study samples, the scale's internal consistency coefficient was very high (Cronbach's α = .93 and .94 in Samples 1 and 2, respectively).

Utility value. Utility value was measured using a five-item scale in Sample 1 that addressed the perceived utility of statistics for students' current studies and intended career. To reduce acquiescence or social desirability bias in students' responses, scale items were both positively and negatively worded (e.g., "Adequate knowledge in statistics will help me to attain better course grades"; "Statistics will not play an important role in my future professional life"). The scale's reliability was acceptable (Cronbach's α = .72). In Sample 2, to improve the instrument's content validity and reliability, an extended version with eight items was used (Faber et al., 2018). Reliability was acceptable (Cronbach's α = .75). In both samples, principal component analyses revealed the negatively worded items to load the strongest on the latent factor (a > .50) and, therefore, to determine the factor's meaning (Pituch & Stevens, 2016). High sum scores indicated students perceived statistics as being less useful for their current studies and later professional development.

Statistics anxiety. A 17-item scale was developed to measure a student's worry, avoidance, and emotionality cognitions concerning statistical demands (Faber et al., 2018). Each item was rated on a 4-point scale referring to a representative range of statistically relevant task features, course situations, and examination procedures that students would typically encounter in their undergraduate or graduate program (e.g., "It would be difficult for me to discuss statistical content adequately in my papers"). In both samples, a principal component analysis revealed a unidimensional pattern of factor loadings and, thus, led to the formation of the final scale version

including all items. A total score was computed by summing all items. High scores indicated a heightened level of students' anxiety experiences. In both samples, the scale's internal consistency coefficient was very high (Cronbach's α = .92 and .94 in Samples 1 and 2, respectively).

Data Analysis

To test research hypotheses, a 2 (Prior Statistics Experiences) $\times$ 2 (Mathematics Self-Concept) $\times$ 2 (Negative Utility Value) analysis of variance was conducted for each sample. In both samples, the self-concept and utility value variables were recoded using median split, thus creating a dichotomous variable reflecting high and low manifestations of each. The experience variable was already in a dichotomous format.

To test research Hypotheses 1 and 2, the effects of mathematics self-concept and negative utility value were analyzed. Hypotheses 3 and 4 were tested by examining the results of interaction effects of the mathematics self-concept and negative utility value variables with the prior statistics experiences variable. In view of sample size and lack of variance homogeneity, the robust Brown–Forsythe test was used for one-way analysis and post hoc difference testing (Tomarken & Serlin, 1986). For all analyses, the SPSS Version 24 was used.

In both samples, scale items had missing data (5.7% and 7.3%). They were treated as missing completely at random (MCAR; Little, 1988): $MCAR_{Sample\ 1}$, $\chi^2(276)$ = 265.37, p = .666; $MCAR_{Sample\ 2}$, $\chi^2(218)$ = 241.59, p = .131. All missing values were estimated by means of the two-step iterative expectation-maximization algorithm. Though this method appears to be at risk to underestimate the standard errors of imputed data, in view of the small amount of missing data, its use was considered justified (Graham, 2012).

Results

Descriptive information is provided in Table 1. Standardized z scores of skewness and kurtosis did not demonstrate significant deviation from the normal distribution assumption.

Table 1. *Descriptive Statistics and Reliabilities of Measures*

Variable	Range	%	*M*	*SD*	*z*S	*z*K	α
Age							
Sample 1	21–53	NA	25.65	5.05			
Sample 2	20–62	NA	25.45	4.86			
Prior statistics experiences (exam passed)							
Sample 1	1–2	66.4					
Sample 2	1–2	57.5					
Academic self-concept in mathematics							
Sample 1	10–54	NA	29.81	9.81	1.37	–2.04*	.93
Sample 2	12–53	NA	31.01	11.43	–0.33	–1.84	.94
Negative utility value of statistics							
Sample 1	5–18	NA	11.06	2.89	0.41	–1.18	.72
Sample 2	8–28	NA	16.18	3.95	0.55	–0.10	.75
Statistics anxiety							
Sample 1	17–56	NA	37.92	8.97	0.41	–1.18	.92
Sample 2	17–63	NA	40.62	10.79	–0.03	–1.66	.94

Note. NA = not applicable; *z*S = *z*-standardized skewness; *z*K = *z*-standardized kurtosis.
* *p* < .05.

Only the mathematics self-concept in Sample 1 showed a significant negative kurtosis that indicated a platykurtic distribution. Students from both samples did not significantly differ in statistics anxiety, $t(198) = -1.885$, $p > .05$, and mathematics self-concept, $t(198) = 1.708$, $p > .05$. Therefore, both samples appeared to be largely comparable. Mathematics self-concept and negative utility value are treated as independent factor measures, because they are correlated (only to a lesser extent) in Sample 1 ($r = -.27$, $p < .05$) and Sample 2 ($r = -.19$, $p > .05$).

Three-way analyses of variance revealed in Sample 1 significant main effects of negative utility value and mathematics self-concept on statistics anxiety. Likewise, there was a significant main effect of prior statistics experience (see Table 2). However, across both levels of statistics experiences, students with high negative utility value reported a considerably higher statistics anxiety than students with a low level of negative utility value. Students displaying both strong negative utility value and a low mathematics self-concept experienced higher statistics anxiety (see Figure 2). No interaction effect was statistically significant.

Table 2. *Predicting Differences in Statistics Anxiety: Analysis of Variance Results From Both Samples*

Factor variable	df	F	p	Partial η^2
Sample 1				
Prior statistics exam (PSE)	1,112	5.581	.020	.050
Mathematics self-concept (MSC)	1,112	6.731	.011	.060
Negative utility value (NUV)	1,112	21.529	.000	.170
PSE × MSC	1,112	0.816	.368	.008
PSE × NUV	1,112	0.680	.411	.006
MSC× NUV	1,112	0.108	.744	.001
PSE × MSC × NUV	1,112	0.035	.852	.000
Sample 2				
PSE	1,86	1.792	.184	.022
MSC	1,86	7.127	.009	.083
NUV	1,86	1.610	.208	.020
PSE × MSC	1,86	0.861	.356	.011
PSE × NUV	1,86	1.497	.225	.019
MSC× NUV	1,86	9.471	.003	.107
PSE × MSC × NUV	1,86	1.260	.265	.016

Furthermore, the main effect of students' prior statistics experiences especially depended on differences in the high self-concept group. Only in this group, students with a strong negative utility value reported a significantly lower level of statistics anxiety after they had already passed a statistics exam. Their counterparts who had not yet passed a statistics exam displayed a higher level of statistics anxiety (see Figure 1). Using the Brown–Forsythe procedure, this difference was statistically significant, $F(1,16) = 4.369$, $p < .05$. All other differences between students with and without an exam were not statistically significant.
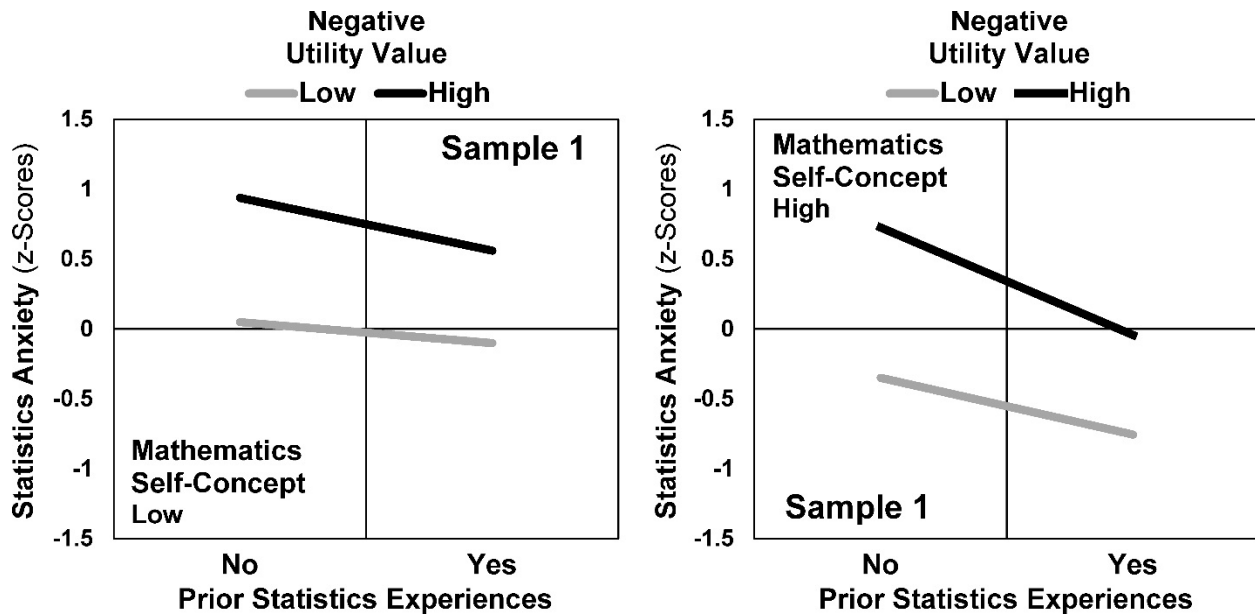
Figure 1. Statistics anxiety in Sample 1 depending on prior statistics experiences, mathematics self-concept, and negative utility value.

In Sample 2, mean statistics anxiety scores were significantly explained by an ordinal interaction effect of the mathematics self-concept and the negative utility variable (see Table 2). Students with a low mathematics self-concept tendentially valued statistics as less useful and experienced statistics anxiety to a larger extent. Notably, this interaction effect mainly manifested in the subgroup of students who reported both a low mathematics self-concept and not yet having passed a statistics exam. Only in this particular subgroup did a high negative utility value substantially predict a higher level of statistics anxiety (see Figure 2).
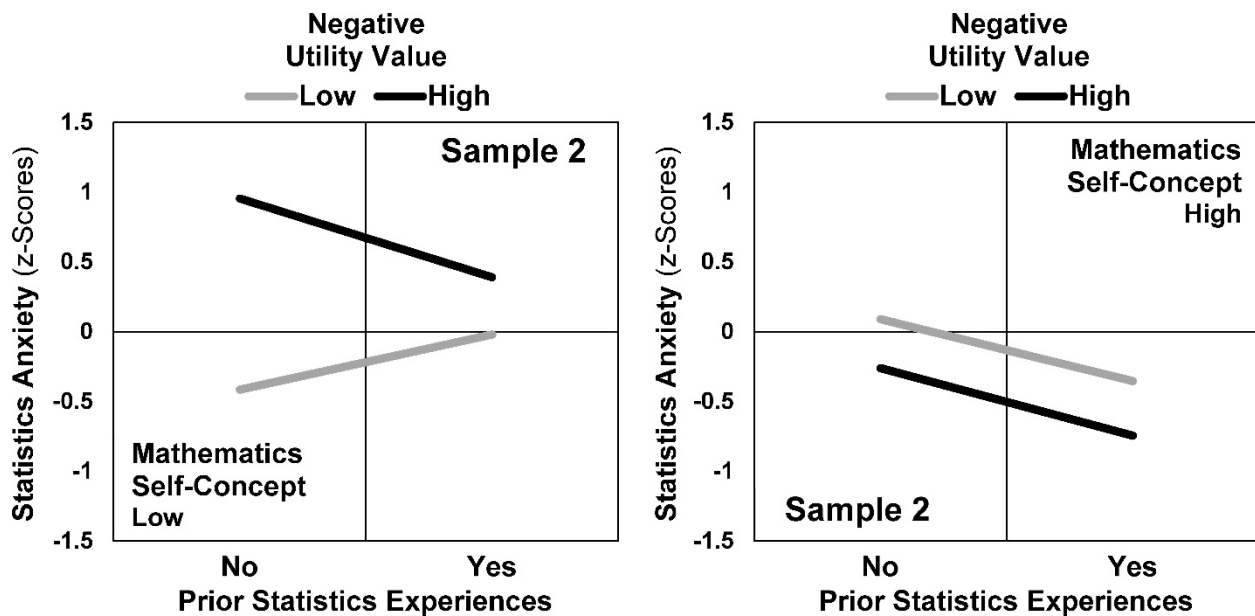

Figure 2. Statistics anxiety in Sample 2 depending on prior statistics experiences, mathematics self-concept, and negative utility value.

Using the Brown–Forsythe procedure, this difference was statistically significant, $F(1,9) =$ 11.948, $p < .01$. In the same subgroup with a prior statistics exam, this difference did not reach statistical significance, $F(1,21) = 1.330$, $p > .05$. Accordingly, only those students having developed low competence beliefs and who had not yet experienced an exam reported the highest level of negative utility value, which, in turn, was most strongly associated with a heightened level of statistics anxiety. However, the prior experience variable did not independently contribute to explaining students' anxiety level.

Discussion

Conceptually based on a cognitive–motivational perspective on construct relations, the present study aimed to analyze the role of prior statistics experiences to predict education science students' statistics anxiety in two independent samples. In particular, the present study primarily focused on the explanatory role of motivation variables to clarify the role of prior statistics experiences.

Confirming relevant research findings (Birenbaum & Eylath, 1994; Chew & Dillon, 2012, 2014a; Schutz et al., 1998; Townsend et al., 1998), the results from both samples demonstrated that prior statistics experiences predicted statistics anxiety only to a minor extent. Rather, in both samples, students' statistics anxiety appeared to be most strongly predicted by their mathematics self-concept and negative utility value. However, effect patterns evidently differed between both samples.

In Sample 1, students reporting a high negative utility value consistently displayed the highest level of statistics anxiety. Only in the high self-concept subgroup, students without statistics experiences and a high negative utility value showed a stronger level of statistics anxiety. Hence, the significant main effect of the prior experiences and self-concept variable appeared to be traced to this particular association.

In Sample 2, students reporting a low mathematics self-concept displayed a higher negative utility value, which, in turn, was associated with a higher level of statistics anxiety— whether or not they had successfully passed a statistics exam. Thus, only the combination of a low mathematics self-concept and a high negative utility value explained students' heightened statistics anxiety.

Accordingly, Hypotheses 1 and 2 were substantially supported in Sample 1 and partially supported in Sample 2. Because relevant interaction effects of the prior statistics experiences with the mathematics self-concept or negative utility value variable did not occur, Hypotheses 3 and 4 were rejected. Across both samples, the direct impact of students' mathematics self-concept on their statistics anxiety was comparable, whereas the role of their negative utility value fluctuated. Methodologically, it cannot be ruled out that the use of different scale versions to measure students' negative utility value, as well as the small size of Sample 2 and resulting limitations in the statistical power of between- and within-group comparisons (VanVoorhis & Morgan, 2007), may have contributed to these differences in effect patterns.

Apart from this, though producing varying effect patterns in detail, the findings from both samples led to similar effects indicating the crucial role of self-belief variables. Altogether, mean differences in students' statistics anxiety substantially depended on their domain-specific competence and value beliefs. In comparison, the role of students' prior statistics experiences from their undergraduate program must considered marginal. Most remarkably, students' individually existing level of statistics anxiety did not substantially decrease even when they had successfully passed a statistics exam. In line with similar results found elsewhere (Chamberlain et al., 2014; Galli et al., 2008), this finding once more indicates the relevance of students' self-beliefs in predicting their statistics anxiety.

According to relevant findings in the field (Chiesi & Primi, 2010; González et al., 2016; Papousek et al., 2012), further research efforts to analyze the development of students' statistics

anxiety should focus on motivational orientation, namely, domain-specific competence and value beliefs. In that regard, the present study's findings extend and differentiate current knowledge about the role prior statistics experiences.

Educational Implications

Completely in line with the expectancy-value and control perspective of academic self-beliefs (Wigfield & Eccles, 2000; Hood et al., 2012; Pekrun et al., 2007), in both samples, students' self-concept and utility value substantially explained their individually existing level of statistics anxiety across all experience levels. Hence, this finding indicates students' prior statistics experiences not being an effective predictor. To put it another way, even previously experienced success in learning statistics did not lessen students' negative valuing of statistical competencies. Because a strong negative utility value, in turn, provokes a heightened level of anxiety, it must be considered to bias students' statistical learning and course outcomes in a most unfavorable way (Markle, 2017; Papanastasiou & Zembylas, 2008). Therefore, this particular finding stresses the need for appropriate instructional conceptualizations and learning formats (Cybinski & Selvanathan, 2005; Schober, Wagner, Reimann, Atria, & Spiel, 2006) which should pay more attention to students' self-beliefs and, most urgently, their task values (Chiesi & Primi, 2018). Otherwise, method courses are at risk to unwantedly impede the learning of statistics and to produce insufficient learning outcomes.

Instead, beyond the teaching of statistical knowledge and procedures (Garfield & Ben-Zvi, 2007), method courses should more strongly emphasize the meaning of statistical competencies for students' professional development in relevant vocational settings (Slootmaeckers, Adriaensen, & Kerremans, 2013; Wiberg, 2009). In particular, they should offer detailed indications and practical training projects to make comprehensible how empirical analyses and quantitative procedures can help to describe, explain, and modify developmental, academic and vocational, or organizational phenomena in a certain educational setting students will probably encounter—such as concerning their professional decision of appropriate treatments, their perspectives to optimize social structures, and their supportive strategies to enhance individual or collective developments. In that regard, such teaching efforts should not only concern relevant method courses, they should also strive for a close linkage between methodological and substantive contents in other courses of a program (Adriaensen, Coremans, & Kerremans, 2014; M. Williams et al., 2016).

Limitations and Perspectives

With all that, the present study undeniably suffers from some conceptual and empirical limitations. First of all, the composition and size of both student samples do not allow for generalizing empirical findings. Instead, the findings reported here might claim a sort of local validity—all the more because their data basis referred to a certain university setting. Therefore, their external validity must be considered weak, and further analyses should attempt to replicate the findings in larger student samples in other educational science contexts. There would also be benefit to assessing prior experiences in a more differentiated way (e.g., by concurrently analyzing various indicators such as course grades, exams passed, and students' subjective appraisals of outcomes).

Furthermore, all analyses were based on cross-sectional data. Following the expectancy-value framework of motivational beliefs, the relations among constructs as hypothesized in the present study reflect a certain conceptual perspective which must be considered being dynamic over time. Principally, the relations among constructs should be reciprocal in nature (Ahmed et al., 2012; Pekrun, Lichtenfeld, Marsh, Murayama, & Goetz, 2017). Though students' self-concept and utility value undoubtedly represent important predictor variables to explain the individually

existing level of statistics anxiety, they might also operate as consequences of statistics anxiety in the long term. Therefore, prospective analyses of longitudinal data should allow for more differentiated insights into the interplay between constructs. In this respect, it would be worthwhile to investigate the role of negative utility beliefs as an individually emerged coping strategy. As relevant studies could demonstrate elsewhere, the devaluing of threatening events or competence areas might indicate students' approach to protecting their current self-system against actually experienced or mentally anticipated failure outcomes (Stephan, Caudroit, Boiché, & Sarrazin, 2012)—and, thus, constitute a certain form of motivational disengagement (Régner & Losse, 2006; Schmader, Major, & Gramzow, 2001).

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