Self-efficacy matters: Influence of students’ perceived self-efficacy on statistics anxiety

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Abstract
Statistical knowledge is a key competency for psychologists in order to correctly interpret assessment outcomes. Importantly, when learning statistics (and its mathematical foundations), self-efficacy (defined as an individual’s belief to successfully accomplish specific performance attainments) is a central predictor of students’ motivation to learn, learning engagement, and actual achievement. Therefore, it is crucial to gain a better understanding of students’ self-efficacy for statistics and its interrelations with statistics anxiety and students’ belief in the relevance of statistics. Here, we present results showing development and validation of a self-assessment questionnaire for examining self-efficacy for statistics in psychology students (Self-Efficacy for Learning Statistics for Psychologists, SES-Psy). Upon using different methodological approaches, we demonstrate that the SES-Psy questionnaire has (1) sound psychometric properties, and within our sample of university students, (2) a robust latent structure disclosing three clearly distinctive profiles that are characterized by a complex and nonlinear interplay between perceived self-efficacy (for basic and advanced statistics), statistics anxiety, and students’ belief in the relevance of statistics. Implications for educational settings and future research are discussed.

KEYWORDS
person-centered approach, relevance of statistics, self-efficacy, statistics anxiety

INTRODUCTION
Many graduate students—particularly psychology students—report high levels of statistics anxiety, which seriously hamper students’ attainments in statistics and research methodology courses.¹-³ Statistical anxiety is a specific form of test and performance anxiety, and up to 80% of graduate students in psychology, business, behavioral, and social sciences report unmanageable levels of statistics anxiety.¹ Per definition, statistics anxiety denotes feelings of apprehension upon being confronted with statistical tasks, be it in instructional situations or evaluative contexts. Statistics anxiety is considered a habitual type of anxiety that generally persists throughout the duration of students’ statistics courses.⁴ Importantly, students with high levels of statistic anxiety are likely to show reduced motivation and learning engagement, which, in turn, yield procrastination behavior, course drop-out, and eventually low-performance levels.⁵ Upon attempting to further elucidate the previously reported relation between statistics anxiety and general trait anxiety,⁵⁷ Paechter and colleagues⁷ performed structural equation modeling on data of a large sample of psychology students and found that statistics anxiety is highly predicted by math...
Generally, self-efficacy was found to be positively related to stress (over math anxiety, $\beta = 0.855$), but only indirectly related to trait anxiety (over math anxiety, $\beta = 0.385$).

Because math and statistics anxiety are closely intertwined, and upon acknowledging that across ages and countries, females report higher levels of math anxiety (PISA, 2015), it is not surprising that gender gaps have been reported with respect to math and statistics anxiety alike.\(^9\)\(^-\)\(^11\) However, potential sex differences regarding (math and) statistics anxiety among psychology students are hardly interpretable because of the oblique gender distribution in these samples (female psychology students by far outweighing their male counterparts).\(^8\)\(^,\)\(^12\)

Because also in the present study the sample comprised more female participants, we abstained from investigating potential sex differences.

Clearly, in order to acquire statistics (and any other competency) at an advanced proficiency level, students need to have sufficient learning motivation to ascertain both learning engagement and self-regulated learning.\(^13\)\(^-\)\(^15\) While in the realm of learning mathematics, this vicious cycle has been intensively studied during the last decades,\(^15\)\(^-\)\(^20\) the scientific interest in gaining a better understanding of the intricate interplay between statistics anxiety, statistics performance, attitudes, and motivational aspects of performance attainments is somewhat younger,\(^2\)\(^,\)\(^4\)\(^-\)\(^8\)\(^,\)\(^12\) thus, leaving many open questions for future research endeavors.

The relation between self-efficacy and academic performance

According to Efklides,\(^2\)\(^1\) students’ self-regulated learning is crucially modulated by a reciprocal interplay of motivation, affect, and metacognitive experiences. Furthermore, beyond metacognitive knowledge and motivation to learn, self-efficacy has also been reported to determine students’ academic performance.\(^2\)\(^2\) The term self-efficacy denotes a person’s belief to succeed in a specific task accomplishment. Importantly, self-efficacy can be distinguished from related constructs, such as locus of control, which, in academic settings, refers to individual attribution styles of academic failure or success.\(^2\)\(^3\)\(^,\)\(^2\)\(^4\) For instance, students with an internal locus of control attribute their academic outcomes to personal investments, such as effort, while students with an external locus of control believe that their academic outcomes are beyond their own control but instead are attributable to external factors, such as luck or fate. On the contrary, academic self-efficacy refers to students’ beliefs of successful completion of course-specific academic tasks. Following social cognitive theories, self-efficacy is highly context-specific and dynamic in nature.\(^2\)\(^4\) As stated by Bandura,\(^2\)\(^3\)\(^,\)\(^2\)\(^5\) experiences of personal mastery as well as vicarious experiences of someone else (who is regarded as similar to oneself) foster the development of self-efficacy. Notably, self-efficacy is an important personality characteristic because high levels of self-efficacy promote individual accomplishments. For instance, the likelihood of actually being successful increases considerably if an individual is certain that an action can be carried out successfully. This is true even when optimistic beliefs in success do not necessarily match actual ability. Importantly, positive attitudes, such as a strong sense of self-efficacy, promote the motivation to work on new and difficult tasks and facilitate the engagement in and completion of task assignments.\(^2\)\(^6\)\(^,\)\(^2\)\(^7\)

Negative attitudes like (statistics) anxiety, on the other hand, leave people without initiative or cause them to give up prematurely.

Noteworthy, the influence of self-efficacy on performance depends on the perceived relevance of an area.\(^2\)\(^8\) For instance, psychology students who aim to become scientists are likely to consider statistics extremely important and thus, their perceived self-efficacy for statistics will have a large impact on their statistics performance. On the contrary, the influence of perceived self-efficacy for statistics performance might be low in psychology students with a major interest in psychotherapy who consider statistics not being relevant for their future work as psychotherapists.

With respect to math learning, previous findings revealed that self-efficacy—beyond being significantly related to math performance (see Refs.\(^\)\(^2\)\(^2\)\(^,\)\(^2\)\(^9\) and\(^2\)\(^9\) for similar findings in pandemic-related contexts of online learning) and students’ motivation for mathematics\(^3\)\(^0\)\(^,\)\(^3\)\(^1\)—is a much more significant predictor of academic performance than math anxiety.\(^2\)\(^6\)\(^,\)\(^2\)\(^2\)\(^6\)\(^-\)\(^2\)\(^8\) Indeed, recent findings from a large-scale study comprising 158,161 eight-graders disclosed that students self-efficacy for math had a direct and moderate effect on their math performance ($\beta = 0.260$) that was somewhat higher than the observed (direct) effect of math anxiety on math performance ($\beta = -0.212$).\(^3\)\(^3\) Likewise, there is accumulating empirical evidence that students’ self-efficacy for statistics exerts direct and significant effects on statistics performance.\(^5\)\(^,\)\(^2\)\(^7\)\(^,\)\(^3\)\(^5\)\(^,\)\(^3\)\(^6\) (reported correlation strengths being medium with $\beta = 0.45$ and an adjusted $R^2 = 0.21$;\(^3\)\(^5\) for similar findings, see Ref.\(^\)\(^3\)\(^6\)). However—and contrary to the above reported findings reflecting a direct effect of math anxiety on math performance—preliminary evidence suggests that the effect of statistics anxiety on statistics performance is an indirect one (via self-efficacy for statistics).\(^3\)\(^5\) Because the latter study might have been underpowered due to a small sample comprising 63 students only, the latter findings need to be interpreted with caution until they are replicated with larger samples.

Rationale and aims of the present study

Scales for measuring students’ self-efficacy in statistics are available in English-speaking countries.\(^3\)\(^7\)\(^,\)\(^3\)\(^8\) In terms of content, these scales concentrate on statistical performance in specific areas, such as basic statistics,\(^3\)\(^7\) and the practical application of statistics using specific software.\(^3\)\(^8\) Generally, self-efficacy was found to be positively related to students’ statistics performance.\(^3\)\(^6\)\(^,\)\(^3\)\(^7\)\(^,\)\(^3\)\(^9\) but negatively related to statistics anxiety.\(^3\)\(^9\)\(^-\)\(^4\)\(^1\) Moreover, not surprisingly, students’ statistics-related self-efficacy increased during their statistics education.\(^3\)\(^7\) However, to the best of our knowledge, existing scales for measuring students’ self-efficacy for statistics neither consider students’ familiarity with statistics (i.e., whether they attend basic or advanced statistics courses) nor do they control for potential influences of self-efficacy, perceived relevance of statistics, or emotional responses (such as statistics anxiety) to statistics learning.\(^3\)\(^7\)\(^-\)\(^3\)\(^9\) Finally,
we sought to conduct a validity check on our new assessment tool by comparing the SES-Psy to a popular questionnaire measuring competency and control beliefs (German abbreviation "FKK"). In particular, the FKK has been conceptualized to measure locus of control, which is related, but not identical, to the construct of self-efficacy addressed by the SES-Psy. Thus, the present study aimed to fill these gaps.

The main aims of the present study were threefold (at least). First, we sought to develop an economic assessment tool that is apt to evaluate psychologist’s self-efficacy for statistical competencies and to determine its psychometric properties. Therefore, we calculated the internal consistency and test-retest reliability coefficients and moreover, examined convergent and divergent validity by conducting correlation analyses between the subscales of the newly developed SES-Psy as well as between the SES-Psy subscales and a questionnaire measuring locus of control (FKK). As regards validity testing, we assume correlations between the SES-Psy and the questionnaire tapping locus of control (i.e., FKK) to be lower than the correlations observed among the subscales of the SES-Psy measuring self-efficacy for learning statistics.

Second, upon considering the current literature stressing the close interrelation between self-efficacy, motivational factors, emotional factors, and actual achievement, we chose to validate our new assessment instrument in psychology students attending basic and advanced statistic courses (i.e., second- and fourth-term students, respectively) upon including scales that—beyond testing self-efficacy for basic and advanced statistical knowledge—also tap students beliefs in the relevance of statistics and their perceived statistics anxiety.

Third, we extended our approach with a person-centered analysis using latent profile analysis (LPA) to shed further light on the relation between motivational and emotional factors as well as self-efficacy. It has been suggested that such a person-centered perspective—compared with a pure variable-centered approach—is more adequate for studying the complex structure of individuals self-regulatory processes. This allows for modeling the heterogeneity between students that may arise from the complex interaction between self-efficacy, motivation, and emotional factors.

METHODS

Participants

Overall, 290 German-speaking psychology students were tested as part of the present study (Table 1), thereof 251 students being recruited from the University of Salzburg and 39 from a private university of Hall in Tyrol. One sample consisted of 193 second-term students acquiring basic statistics upon participating in introductory-level courses. The second sample comprised 97 fourth-term students attending advanced-level statistics courses. The reason for including second- and fourth-term students as study participants was to enable us to examine whether students’ degree of self-efficacy might vary depending on difficulty level (and familiarity) of statistical contents conveyed in class. This assumption is based on the notion that self-efficacy is highly context-specific. While psychology students in second term get acquainted with basic statistical knowledge (e.g., principles of experiment planning and evaluation, simple group comparisons with parametric and nonparametric tests, descriptive statistics, and basics of methodology), students attending fourth-term statistics classes are introduced to advanced statistical knowledge (including analysis of variance, regression models, factor analysis, and other multivariate methods).

Study procedure

Students were recruited during their statistics courses. Study participation was voluntary. All students were tested in class at the midpoint of the term. Due to pragmatic reasons, we abstained from conducting the present study at the beginning or toward the end of the semester, when students are busy either with setting up their course work or exams. Testing was performed in groups at the end of a 90-min teaching unit and took between 45 and 60 min to be completed. Students willing to participate remained in class, while the others could leave the room since the teaching was already terminated. Questionnaire booklets were distributed and collected at the students’ desks with the help of student assistants. Questionnaire booklets were identified by an alphanumeric code and did not contain other personal information about individual participants other than age and sex. Participants were instructed that they could interrupt their participation at any point in time without any prejudice. The study was performed in accordance with the declaration of Helsinki.

Test and item development

Upon acknowledging that self-efficacy is highly context-specific, items tapping self-efficacy should directly address the specific situations of interest. For the purpose of the present study, 73 items were found to be eligible, some of which were adapted and translated
from an existing questionnaire, while others were new. More specifically, 14 items from the Current Statistics Self-Efficacy (CSSE) scale were found to be eligible for the purpose of the present study and translated into German. In terms of content, these items mainly covered elementary statistical knowledge, such as the distinction between population and sample parameters, when mean, mode, or median should be used as a measure of the central tendency, and so on. Because the usual training in statistics for psychologists incorporates more advanced levels of statistical knowledge than are covered by the original items of the CSSE, further 59 items were created by one of the authors (G.W.) with the help of a statistics expert (W.G.) with the intention to tap relevant advanced aspects of statistical learning (i.e., ANOVA models, correlations, and factor analyses). Thus, the first version of the newly developed SES-Psy questionnaire comprised 73 items in total (Table S1). For each item, the question “The following statement applies to me …” should be answered by using a 6-point scale (ranging from “not at all = 1” to “completely true = 6”). Subsequently, the above-described item pool has been further tested to identify the best items regarding psychometric properties.

**Item selection for the SES-Psy**

Three different methods were used for item selection: Mokken scaling,46,47,48 cluster analysis,48 and principal component analysis.49 Item groups concordant in at least two out of the three methods were considered consistent.

**Mokken scaling**

Mokken scaling is related to nonparametric item response theory models and finds an optimal combination of items maximizing parameters of one-dimensionality, local independence, latent monotonicity, and nonintersection.46,49 These principles are tested at the level of items as well as of scales. The critical value for the inclusion of an item in a scale was \( H = 0.3 \). Results disclosed very few missing values that were replaced by the mean value rounded to an integer. Seven scales were found using Mokken scaling.

**Cluster analysis**

Upon using the method of complete linkage with the cosines,48 seven clusters were found at the third level.

**Principal component analysis**

Finally, we calculated a principal component analysis with Varimax rotation. Items with a load higher than 0.3 were subjected to further analyses. Further, complex items with high loads in more than one factor were not considered.

**Questionnaire of competency and control beliefs (FKK)**

For a subsample of students recruited from the University of Salzburg \((n = 149)\), we were additionally able to assess competency and control beliefs by using the FKK.42 The FKK is a 32-item questionnaire containing four equally long subscales (internal consistency of single scales ranging from 0.70 to 0.76). All subscales of the FKK measure control beliefs but with different emphasis on perceived ability to exert control (thus tapping either internal or external locus of control attributes). In particular, internal locus of control is measured by the two subscales FKK_c (self-concept and one’s own competencies) and FKK_i (internality in the attribution of control), while external locus of control is tested by the two subscales FKK_s (social externality) and FKK_f (fatalistic externality). Importantly, the constructs of self-efficacy and locus of control (reflecting control beliefs) are related but can be kept apart.43,24 Accordingly, the FKK was used to assess the divergent validity of the SES-Psy. In order to determine the divergent validity of the construct of self-efficacy in statistics, the correlation coefficients between the subscales of the SES-Psy and the FKK were calculated. Hence, under the assumption that self-efficacy and locus of control tap distinct constructs, we expect the correlations observed among subscales of the SES-Psy to be higher than the correlations observed between the SES-Psy and the FKK.

**Profile analysis**

Finally, we conducted an LPA44 to examine individual differences and the heterogeneity of students using the scores of the four final SES-Psy scales (see the Results section below). Accordingly, this analysis allows for identifying potential subgroups of students with different profiles of statistics anxiety, perceived self-efficacy, and relevance of statistics. LPA was run using R 4.0.50 and the R package mclust,51 which is based on finite Gaussian mixture modeling. Results were visualized using the R package ggplot 2.52 We chose LPA as it offers statistical tests (BIC; BLRT)53 for determining the adequate number of clusters, which is not always the case for traditional clustering approaches.

In particular, to identify potential subgroups or latent profiles of students, we used the four subscales of the newly developed questionnaire SES-Psy as LPA indicators (see the Results section below). Prior to running the LPA, all indicators were z standardized. To identify the best model and profile solution, we utilized the Bayesian information criterion (BIC). In particular, different numbers of clusters and different classes of models (characteristics of distribution, volume, orientation, and form) were considered. With the mclust R package,51 the least negative BIC value defined the best fitting model, but also parsimony and interpretability of the model was considered.44 Finally, we used BLRT with the standard parameters (999 bootstrap replications; nonparametric bootstrapping) of the mclust R package.51 This procedure compares the model fit between models with \( k-1 \) and \( k \) clusters.
TABLE 2  Results of the reliability testing as indicated by internal consistency (indexed by Cronbach’s α) and test-retest reliability

| Variables                  | Cronbach  | Cronbach  | Test-retest* |
|---------------------------|-----------|-----------|--------------|
|                           | n = 193   | n = 97    | n = 25       |
| ANX                       | 0.79      | 0.77      | 0.68         |
| RELEV                     | 0.84      | 0.82      | 0.81         |
| SE_BASIC                  | 0.86      | 0.86      | 0.80         |
| SE_ADV                    | 0.90      | 0.88      | 0.87         |

Abbreviations: ANX, statistics anxiety; RELEV, students’ belief of statistics relevance; SE_ADV, self-efficacy for advanced statistical knowledge; SE_BASIC, self-efficacy for basic statistical knowledge.

*After an interval of 45 days.

RESULTS

Item selection yielding the final assessment instrument

From the 73 original items described above (and depicted in Table S1), 42 items were kept in the final questionnaire SES-Psy. These 42 items were divided into four scales (Tables S1 and S2), while the fifth scale—being part of the first version of the SES-Psy—did not survive the above-described item selection criteria and thus, was discarded from further analyses. The four remaining final scales were comprised of four items measuring statistics anxiety (ANX), 15 items measuring self-efficacy for basic statistics (SE_BASIC), 16 items measuring self-efficacy for advanced statistics (SE_ADV), and seven items measuring the perceived relevance of statistics (RELEV) that were consistently grouped by the three-item selection methods. Regarding the aspects of one-dimensionality, local independence, latent monotonicity, and nonintersection evaluated in the Mokken analysis, none of the items violated the four principles.

Reliability

In order to examine the scale’s reliability, we performed tests of internal consistency and test-retest reliability on different subsamples of students. As depicted in Table 2, internal consistency was assessed by calculating Cronbach’s α separately for second- (n = 193) and fourth-term (n = 97) students. The test-retest reliability check was performed on a smaller subsample comprising 25 students (all of them being second-term students) and with a time span of 45 days between the first and second testing. Notably, all coefficients were in an acceptable range (Table 2).

Construct validity

To determine the construct validity of the scale, we examined the correlations between the different subscales of the SES-Psy in the whole sample comprising 290 students and, separately, in a subsample of 149 students, the correlations between the subscales of the SES-Psy and the FKK. Notably, as depicted in Table 3A, the correlations between the subscales of the SES-Psy were satisfactory, the highest correlation coefficients being observed for the subscale SE_ADV (i.e., varying from 0.324 to 0.605). Upon recalculation these correlations for second- and fourth-term students separately, the strengths and the pattern of the correlation coefficients were found to be quite similar in the two samples. However, it needs to be noted that typically, correlations only stabilize with sample sizes close to and above n = 250. Moreover, and as depicted in Table 3B, the intercorrelations between the subscales of the SES-Psy were generally higher than those observed between subscales of the SES-Psy and the FKK, thus indicating satisfactory construct validity.

Perceived self-efficacy for basic statistics (SE_BASIC)

We conducted another 2 × 2 ANOVA with the factors sex (female vs. male) and term (second vs. fourth term) to also investigate potential differences on self-efficacy for basic statistics. The main effect for sex and term did not reach significance. However, the interactions between term and sex produced a marginal significant effect (F(1, 247) = 4.31, p = 0.039, partial eta-square = 0.02).

Perceived self-efficacy for advanced statistics (SE_ADV)

We conducted another 2 × 2 ANOVA with the factors sex and term to also investigate potential differences on self-efficacy for advanced statistics. No main- or interaction effects reached significance.

Perceived relevance of statistics (SE_REL)

Another 2 × 2 ANOVA with the factors sex and term was run to investigate potential differences on perceived relevance of statistics. No main- or interactions effect reached significance.

Latent profile analysis

Finally, we ran LPA to identify potential subgroups or profiles of students with respect to constructs assessed with the SES-Psy. Table 4 provides an overview of the three best models according to BIC values. That is, BIC values suggest a solution with two ellipsoidal profiles with equal volume and orientation. Next, we ran BLRT to determine whether adding another profile/cluster would yield a significant benefit for the model fit. In fact, BLRT indicated that the addition of one additional profile is beneficial (2 vs. 3: likelihood-ratio = 36.623, p = 0.002). A fourth profile did not improve the model fit anymore (3 vs. 4: likelihood-ratio = 13.986, p = 0.298).
TABLE 3  (A) Correlation matrix of the four SES-Psy subscales (calculated upon employing Pearson product-moment correlations on the whole sample comprising 290 students); (B) correlation matrix of the FKK subscales with the SES-Psy subscales (calculated upon employing Pearson product-moment correlations on a subsample comprising 149 students)

|       | ANX          | SE_BASIC | SE_ADV | RELEV |
|-------|--------------|----------|--------|-------|
| ANX   | 1.000        |          |        |       |
| SE_BASIC | -0.232      | 1.000    |        |       |
| SE_ADV | -0.324      | 0.605    | 1.000  |       |
| RELEV | -0.238      | 0.277    | 0.426  | 1.000 |

|       | FKK_c | FKK_i | FKK_s | FKK_f | ANX  | SE_BASIC | SE_ADV | RELEV |
|-------|-------|-------|-------|-------|------|----------|--------|-------|
| FKK_c | 1.000 |       |       |       |      |          |        |       |
| FKK_i | 0.451 | 1.000 |       |       |      |          |        |       |
| FKK_s | -0.520 | -0.275 | 1.000 |       |      |          |        |       |
| FKK_f | -0.374 | -0.213 | 0.478 | 1.000 |      |          |        |       |
| ANX   | -0.137 | -0.155 | 0.063 | 0.204 | 1.000 |          |        |       |
| SE_BASIC | 0.315 | 0.199 | -0.288 | -0.120 | -0.234 | 1.000 |          |       |
| SE_ADV | 0.311 | 0.114 | -0.267 | -0.220 | -0.241 | 0.647 | 1.000 |       |
| RELEV | 0.045 | 0.044 | -0.083 | -0.125 | -0.219 | 0.304 | 0.469 | 1.000 |

Abbreviations: ANX, statistics anxiety; FKK, German-language questionnaire measuring competency and control beliefs (Krampen, 1991); FKK_c, self-concept and one’s own competencies; FKK_f, fatalistic externality in the attribution of control; FKK_i, internality in the attribution of control; FKK_s, social externality; RELEV, perceived relevance for statistics; SE_ADV, self-efficacy for advanced statistics; SE_BASIC, self-efficacy for basic statistics.

TABLE 4  Bayesian information criterion (BIC) indices for the three best solutions of the latent profile analysis (LPA)

| Characteristics and number of clusters | EVE, 2 | EEE, 2 | VVE, 2 |
|---------------------------------------|--------|--------|--------|
| BIC                                 | -3127.45 | -3130.13 | -3132.16 |
| BIC difference                      | 0.00    | -2.68  | -4.71  |

Abbreviations: EEE, ellipsoidal, equal volume, shape, and orientation; EVE, ellipsoidal, equal volume, and orientation; VVE, ellipsoidal and equal orientation.

We decided to follow the bootstrapped results (final model: log-likelihood = −1483.042; n = 290; df = 30) as it offers a more differential view on the data but at the same time includes an additional profile with enough participants (>5% of the sample; see Nylund et al.53). Thus, the value of the additional profile as determined by BLRT was considered relevant. Further, the additional profile added in the three-profile model when compared to the two-profile model had a strong theoretical justification. That is, the students in this third group had above average levels of statistics anxiety and considered statistics to be barely relevant as compared to the rest of the students.

The z-standardized means of the final model for each LPA indicator in each profile group are shown in Table 5 and graphically illustrated in Figure 1. The identified profiles mostly differed in varying degrees of statistics anxiety and perceived relevance of statistics. In particular, students pertaining to the first profile (n = 129) exhibited the lowest levels of statistics anxiety and average to slightly above average scores regarding perceived self-efficacy for basic and advanced statistics, as well as regarding perceived relevance of statistics. That is, students in this profile can be considered confident students. This profile, with 40.3% of students attending the fourth term, descriptively has the largest proportion of fourth-term students across the three profiles. Further, similar to the other profiles, the majority of students are females. In contrast, students comprising the second profile (n = 132) reported the highest values on statistics anxiety but mainly average to slightly below average values on perceived self-efficacy for basic and advanced statistics and perceived relevance of statistics. Thus, we labeled these students anxious indifferent students. Descriptively, this profile comprised the largest proportion of female students (75.0%). Students pertaining to the third profile (n = 29) were coined anxious deniers, because they were found to exhibit high levels of statistics anxiety together with extremely low levels of perceived relevance of statistics. At the same time, students pertaining to this profile showed average perceived self-efficacy for basic statistics and below average perceived self-efficacy for advanced statistics. It is noteworthy though that the latter profile (i.e., anxious deniers) comprised the least number of students and the lowest proportion of fourth-term students (i.e., 20.7%).

DISCUSSION

The main aims of this study were (1) to describe the development and psychometric characteristics of a new scale for assessing psychology students’ self-efficacy for statistical competencies, (2) to investigate potential interrelations between students’ self-efficacy, emotional and motivational factors (i.e., statistics anxiety and perceived relevance of statistics, respectively), and finally (3) to identify
**TABLE 5**  Z-standardized mean values of all LPA indicators and number of students in each of the three profiles as well as demographic information on each of the profiles determined

| Latent profiles | Demographics | ANX | SE_BASIC | SE_ADV  | RELEV | Mean age in years (SD) | Proportion of fourth-term students |
|-----------------|--------------|-----|----------|---------|-------|------------------------|----------------------------------|
| Determined by LPA |              | 1   | 129      | -0.881  | 0.135 | 0.347                  | 0.299                           | 23.34 (6.78) | 40.31% |
| 1               |              | 2   | 132      | 0.673   | -0.112| -0.182                 | 0.038                           | 22.63 (5.67) | 29.55% |
| 2               |              | 3   | 29       | 0.543   | -0.038| -0.633                 | -1.531                          | 22.89 (4.85) | 20.70% |

Abbreviations: ANX, statistics anxiety; LPA, latent profile analysis; NA, not available; RELEV, perceived relevance of statistics; SD, standard deviation; SE_ADV, self-efficacy for advanced statistics; SE_BASIC, self-efficacy for basic statistics.

**FIGURE 1**  Z-standardized mean values of all latent profile analysis (LPA) indicators for the final model. Abbreviations: ANX, statistics anxiety; RELEV, perceived relevance of statistics; SE_ADV, self-efficacy for advanced statistics; SE_BASIC, self-efficacy for basic statistics

Potential subgroups of students that are characterized by distinct profiles regarding individual extents and interrelations of statistics anxiety, perceived self-efficacy, and beliefs in statistics relevance (upon using a person-centered approach). In the following, we discuss the findings of the present study in relation to the current literature and furthermore, propose some implications for educational settings and future research endeavors.

**Psychometric aspects of the SES-Psy**

The final version of the new assessment tool SES-Psy is comprised of 42 items grouped into the four subscales statistics anxiety (ANX), self-efficacy for basic statistics (SE_BASIC), self-efficacy for advanced statistics (SE_ADV), and perceived relevance of statistics (RELEV) (Table S1). Overall, the psychometric properties of the SES-Psy were found to be satisfactory as indicated by internal consistency (indexed by Cronbach’s α, ranging from 0.77 to 0.90) and test-retest reliability (ranging from 0.68 to 0.87; see Table 2). Likewise, validity testing yielded promising results. Such as, construct and discriminant validity were found to be satisfactory as reflected by higher intercorrelations between the subscales of the SES-Psy compared to lower correlations between subscales of the SES-Psy and a questionnaire assessing general competency and control beliefs (i.e., FKK; see Table 3). In particular, correlation coefficients between the SES-Psy subscales ranged from 0.219 to 0.647, thus indicating almost moderate to strong effect sizes. Interestingly, the only exception (from the generally lower intercorrelations observed across the subscales of the SES-Psy and the FKK) were the rather high correlations between the SES-Psy subscales assessing self-efficacy and the FFK subscale FKK_c (denoting self-concept and one’s own competencies) reaching $r = 0.315$ (SE_BASIC and FKK_c) and $r = 0.311$ (SE_ADV and FKK_c). However, upon acknowledging that the subscale FKK_c and the subscales SE_BASIC and SE_ADV tap related constructs (i.e., namely self-concept and self-efficacy), the latter finding is not very surprising.

**Content-related aspects of the SES-Psy**

Novel features of the new assessment tool SES-Psy are (1) the consideration of potential emotional and motivational moderating factors for students’ self-efficacy for statistical knowledge, and (2) the differentiation into self-efficacy for basic and advanced statistical knowledge. Notably, existing assessment tools for students’ self-efficacy do not distinguish between statistics competency levels. However, this
distinction is relevant upon acknowledging that self-efficacy is highly context-specific in nature.22,56

Furthermore, and as mentioned already above, in addition to assessing students’ extent of self-efficacy for basic and advanced statistics, the newly developed scale SES-Psy also incorporates potential moderating effects on self-efficacy stemming from emotional and motivational factors (indexed by the two SES-Psy subscales ANX and RELEV, respectively). Our rationale to include the latter two subscales is derived from previous findings reporting that (learning) motivation critically affects—and even predicts—self-efficacy8,28 (for similar findings in the realm of math anxiety, see Refs. 15 and 20), and that statistics anxiety exerts negative effects on self-efficacy.39–41 Hence, upon developing and constructing the SES-Psy that ought to measure students’ self-efficacy for statistics, we also included items tapping potential motivational and emotional moderating variables (that were grouped into the subscales ANX and RELEV; see Table S1).

Overall, the SES-Psy allows a more comprehensive evaluation of students’ self-efficacy and potentially influencing variables than already existing tools measuring self-efficacy for statistics.37,38 In the following paragraph, we provide a more elaborate discussion of the complex interrelations between self-efficacy on the one hand and emotional (i.e., statistics anxiety) and motivational factors (i.e., perceived relevance of statistics) on the other hand. For that purpose, we employed a person-centered approach (by conducting an LPA) that should enable us to identify subgroups of students with distinct parameter values on the subscales of the SES-Psy.

**Subgroups of students with different profiles of self-efficacy, statistics anxiety, and perceived relevance of statistics**

Results of the LPA disclosed three subgroups of students that are characterized by rather distinct profiles of perceived self-efficacy in relation to statistics anxiety and perceived relevance of statistics (Figure 1). As mentioned above, a unique feature of the SES-Psy is the differentiation between students perceived self-efficacy for basic and advanced statistics knowledge. Thus, we were able to investigate whether students’ self-efficacy is influenced by the difficulty level of their statistics education.

In the following, we will describe the three profile types on a descriptive level in more detail (see Figure 1, which also depicts the verbal labels of these subtypes). Students in profile 1 might be considered confident as those students report the lowest statistics anxiety and highest self-efficacy for advanced statistics knowledge (so-called confident students). In contrast, students in profile 2 have rather high statistics anxiety but also do not consider statistics to be particularly relevant and have a somewhat average self-efficacy for basic as well as advanced statistics (anxious indifferent students). Finally, profile 3 is characterized by students with high statistics anxiety that consider statistics to be barely relevant, at least compared to the opinion of the rest of the current sample (anxious deniers). Further, these students have the lowest self-efficacy for advanced statistics.

Upon having a closer look at these three subgroups of students (Table 5 and Figure 1), it becomes apparent that compared with the other two subgroups, the confident believers pertaining to profile 1 have the highest proportion of fourth-term students (i.e., students attending advanced statistics courses). Accordingly, these students were found to score highest on the SES-Psy subscale SE_ADV. Moreover, the highest scores on the subscale ANX were found in two subgroups, namely, anxious indifferent students and anxious believers (comprising profiles 2 and 3, respectively). However, while anxious indifferent students are characterized by an extreme oblique sex distribution favoring females (who comprise 75% of this subgroup) who—compared with men—generally tend to report higher levels of both trait and state anxiety,57–59 high anxiety scores of anxious believers (profile 3 students) might be partially explained by their extremely low beliefs in the relevance of statistics (Figure 1). Notably, the distinctive profile of the second subgroup (comprising a high proportion of females reporting high levels of statistics anxiety) seems to be partially caused by sample characteristics. It might reflect an accumulating effect of higher general anxiety levels found in women that are superimposed by higher context- and (subject) specific anxieties (i.e., in our case, statistics anxiety).

Despite the more comprehensive understanding we gained from the LPA, we want to stress that the results of the LPA should only be interpreted with regard to the current sample of students. Nevertheless, such person-centered analyses are not restricted to linear patterns and provided a more differential understanding of how self-efficacy, anxiety, and perceived relevance for statistics might interact. This would not have been feasible with regular variable-centered analysis approaches alone.43

**Implications for educational settings and future research endeavors**

The present study further corroborates the importance of acknowledging moderating effects of self-efficacy, motivational and emotional factors on students’ academic performance by focusing on statistics competencies. Notably, despite the fact that the SES-Psy was validated on a sample of psychology students, its use is not restricted to psychology students. Rather, we suggest that for any student taking statistics courses, the SES-Psy might be a useful measure of students’ self-efficacy for statistics. An important finding that could potentially inform educational settings is the identification of distinct subgroups of students regarding the complex and nonlinear interplay between self-efficacy, statistics anxiety, and perceived relevance of statistics. Such as, distinct subgroups of students could inform the development of more comprehensive, adaptive, and individually tailored teaching tutorials (and exercises) that encompass the fostering of students’ self-efficacy and learning motivation on the one hand and the reduction (or avoidance) of statistics anxiety on the other hand.

To conclude, future research endeavors are urgently needed to develop and test efficient measures to increase students perceived...
self-efficacy (the latter of which might be targeted at the facilitation of positive experiences, the imitation of a role model, the persuasion by a familiar model, or the regulation of one’s own psychophysiological reactions). For instance, it has been suggested that game elements, autonomy support, and scaffolding constitute potential instructional mechanisms to foster self-efficacy in students. Likewise, future research should be targeted at implementing and investigating methods to alleviate statistics anxiety and to improve attitudes in students suffering from statistics anxiety and/or low learning motivation. Such methods could include programs employing traditional counseling techniques, stress inoculation training, or systematic desensitization. Finally, future research should seek to further corroborate the validity (and persistence) of the three rather distinctive profiles characterized by a complex and nonlinear interplay between perceived self-efficacy, statistics anxiety, and students’ belief in the relevance of statistics.

Limitations of the study

Though the construct validity of the new scale SES-Psy is satisfactory (as reflected by a good model fit), its construct validity still awaits further testing (i.e., by assessing correlations between the SES-Psy and other tests of statistics anxiety). However, as mentioned above, existing tools measuring self-efficacy for statistics are restricted to basic statistics knowledge and furthermore, do not incorporate potential moderating variables.

Further potential limitations are the rather small sample size (n = 290), which should be considered when interpreting the LPA results. The oblique sex distribution favoring females might be considered another limitation.

Even so, all existing studies focusing on psychology students have a similar sample with oblique sex distribution, reflecting the fact that many more women than men study psychology. Clearly, future research endeavors are needed that systematically examine how sex differences might impact upon the interplay of self-efficacy, statistics anxiety, and related motivational factors. Moreover, future studies should collect—above and beyond age and sex—broader demographic variables related to participants’ personal characteristics, as well as previous experiences with statistics classes.

Nonetheless, despite these potential limitations, we believe that the present study significantly adds to the literature. The newly developed scale SES-Psy is novel as it is targeted at the assessment of self-efficacy for statistics in psychology students upon taking into account moderating emotional and motivational variables (i.e., statistics anxiety and perceived relevance of statistics). Another unique feature of the SES-Psy is its potential to differentiate subgroups of psychology students, who are characterized by clearly distinguishable profiles regarding the interplay between perceived self-efficacy, statistics anxiety, and perceived relevance of statistics. Overall, our findings underscore the necessity to regard self-efficacy as a highly context-specific construct that clearly impacts upon students’ emotional and motivational factors upon learning statistics and thus needs to be measured (and fostered) accordingly.

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COMPETING INTERESTS

The authors declare no competing interests.

AUTHOR CONTRIBUTIONS

L.K. collected data in Hall in Tirol, performed literature research, and wrote the manuscript. M.N. performed the latent profile analysis. G.W. translated items from the CSSE to German, created extra items, collected data in groups of students at the University of Salzburg, and performed some of the statistical analyses. Furthermore, L.K., M.N., G.W., and E.M.W critically reviewed the manuscript. All authors gave their final approval of the manuscript.

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