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Development of the Oldenburg Epistemic Beliefs Questionnaire (OLEQ), a German Questionnaire based on the Epistemic Belief Inventory (EBI)

Manuela Paechter [a], Karin Rebmann [b], Tobias Schloemer [b], Bjoern Mokwinski [b], Yvonne Hanekamp [b], and Martin Arendasy [a]

Karl-Franzens-University, Graz [a]
Carl von Ossietzky University, Oldenburg [b]

The present research describes the development of a German questionnaire for measurement of domain-general epistemic beliefs. Pre-studies on the psychometric properties of a German version of the Epistemic Beliefs Inventory (EBI) had emphasized the necessity to develop an instrument that is especially constructed for German-speaking samples. The new questionnaire, the Oldenburg Epistemic Beliefs Questionnaire (OLEQ), is based on the Epistemic Beliefs Inventory and includes original EBI items as well as newly developed ones. The investigation of the psychometric properties of the questionnaire in a German-speaking sample showed a factor solution in which nearly all items loaded on the theoretically assumed dimensions. The stability of the factor solution could be confirmed by means of confirmatory factor analysis in another sample. Retest reliabilities of the different questionnaire dimensions were satisfactory. The dimensions of the new instrument correlated significantly, yet to a moderate to weak degree, to the use of learning strategies.

Keywords: epistemic beliefs; psychometric properties of the Oldenburg Epistemic Beliefs Questionnaire (OLEQ); learning strategies.

Epistemic beliefs are personal beliefs about knowledge and the acquisition of knowledge. As subjective theories of an individual, they have the function of directing and controlling actions. Therefore, they are linked to numerous aspects of academic learning, how students approach learning processes, which learning strategies they use, or how they view their role as learners (Bråten & Strømsø, 2005; Bråten, Strømsø, & Britt, 2011; Bromme, Kienhues, & Porsch, 2010; Buehl, 2003; Buehl & Alexander, 2005; Cavallo, Rozman, Blickenstaff, & Walker, 2003; Hofer & Pintrich, 1997; Hogan, 2000; Paulsen & Feldman, 2005; Schommer-Aikins, 2002; Strømsø & Bråten, 2009).

Schommer (1990, 1993a, 1993b; Schommer-Aikins, 2002) developed a concept of epistemic beliefs that consists of five independent dimensions: (1) structure of knowledge, (2) stability of knowledge, (3) source of knowledge, (4) control, and (5) speed of knowledge acquisition. Each of these dimensions describes a continuum from a naïve to a sophisticated, well-developed belief, which illustrates the assumed process of development (Duell & Schommer-Aikins, 2001). Within these dimensions complex as well recursive developments are possible.

The dimension “structure of knowledge” ranges from a naïve position that knowledge is simply structured and consists of isolated components to a sophisticated position that knowledge is complex and interrelated. The dimension, “stability of knowledge,” can be characterized by a position that knowledge is absolute and stable over time on the one side and by a position that knowledge is subject to a constant process of development on the other side. The dimension, “source of knowledge,” ranges from the position that there is an omniscient authority to impart knowledge to a position that knowledge is acquired through individual experiences. The dimension, “control of learning processes,” describes a continuum ranging from the view that the ability to learn is fixed at birth to the view that the ability to learn is acquired through experience. The dimension, “speed of knowledge acquisition,“ extends from the view that learning is a process which succeeds on an ad-hoc basis or not at all to the view that learning is a gradual process.

The five dimensions can be ordered into two categories: into beliefs that refer to the nature of knowledge (structure, stability, and source of knowledge) and into beliefs that refer to learning processes and the acquisition of knowledge (control of learning processes and speed of knowledge acquisition) (Bråten et al., 2011; Schommer-Aikins, 2002). While most models of epistemic beliefs would agree on the first three dimensions as core dimensions of epistemic beliefs there is lower consensus whether beliefs on the acquisition of knowledge should be included (Greene, Azevedo, & Torney-Purta, 2008; Hofer, 2001; Hofer & Pintrich, 1997). Yet, when individuals are concerned with the nature of knowledge they very likely also activate cognitions on the nature of learning (Pintrich, 2002). Especially, when epistemic beliefs are investigated in the context of learning and teaching it seems reasonable to include beliefs on knowledge as well as beliefs on the acquisition of knowledge. Elby and Hammer (2010) advocate the inclusion of both categories because:

> what we see students doing in class… almost always involves aspects of both. Because we are ultimately interested in how students approach knowledge and learning in situations such as these, it serves us to treat knowledge and learning together as part of epistemic cognition. (p. 421)

Especially in the context of education and learning it seems worth to measure both categories. However, when analyzing and interpreting research results one should keep in mind that the categories describe distinct concepts and they should not be treated as if they were one construct.

Schommer (1990) developed a standardized questionnaire, the Schommer Epistemological Questionnaire (SEQ), with 63 items for the measurement of the above five dimensions of epistemic beliefs. In her questionnaire, individuals rate on a 5-point Likert scale the degree to which they agree or disagree with certain views on knowledge and knowing. However, investigations of the internal structure of the SEQ showed various inconsistencies. Several studies could not verify the assumed 5-factor structure of the set of 63 items but yielded a 4-factor solution with the dimensions “structure”, “stability”, “control”, and “speed of knowledge acquisition” (without the dimension “source”) (Schommer, 1990; Schommer, Crouse, & Rhodes, 1992; Schommer & Dunnell, 1994). Internal consistencies, Cronbach’s α coefficients, reported in two of these studies ranged from .51 to .78 and from .63 to .85 respectively (Schommer, 1993b; Schommer, Calvert, Gariglietti, & Bajaj, 1997). Also, Schommer’s methodological approach can be called into question because she carried out factor analyses on 12 a-priori defined subsets of the 63 items and not on the 63 items themselves; the aggregation of items into subsets was based on experts’ evaluations (Bråten & Strømsø, 2005; Schommer, 1990, 1993a).

Several studies attempted to analyze the factor structure of the 63 items themselves but found inconsistent factor solutions. Quian and Alverman (1995) found a 3-factor solution with the factors “speed of knowledge acquisition”, “structure”, and “control of knowledge.” Bråten and Strømsø (2005) found a similar solution plus the factor “certainty of knowledge.” Schraw, Bendixen, and Dunkle (2002) found a solution with two of Schommer’s original factors and three additional factors.

Schraw et al. (2002) note that one of the main problems to investigate epistemic beliefs lies in the lack of reliable and valid measurement instruments. They aimed to develop a questionnaire that would measure all five dimensions of epistemic beliefs described by Schommer but that would be shorter than the SEQ and show better psychometric properties. Their first version of the Epistemic Beliefs Inventory (EBI) consisted of 28 items with statements on knowledge and learning which are rated on a 5-point Likert scale ranging from strongly disagree (1) to strongly agree (5). Higher scores indicate more sophisticated epistemic beliefs while lower scores indicate less sophisticated beliefs. The final EBI version includes 15 items with five subscales based upon the factors outlined by Schommer (1990): omniscient authority (the dimension “source” in Schommer’s concept), simple knowledge (structure), certain knowledge (stability/certainty), fixed/innate ability to learn (control), and quick learning (speed). In a validation study, Schraw et al. (2002) could confirm these five dimensions by means of exploratory factor analysis with orthogonal as well as with oblique rotation. In a variety of subsequent studies the assumed 5-factorial structure of the EBI could be confirmed (Bendixen, Schraw, & Dunkle, 1998; Hardre, Crowson, Ly, & Xie, 2007; Nietfeld & Enders, 2003; Ravindran, Greene, & DeBacker, 2005; Teo & Chai, 2011). In these studies, the EBI showed similar internal consistencies as did the SEQ, e.g., ranging from .54 to .78 (Ravindran et al., 2005), from .53 to .80 (Nietfeld & Enders, 2003), or from .50 to .76 (Hardre et al., 2007). While in these studies the initial factorial structure could be confirmed, there are also some studies in which the 5-factorial structure could not be confirmed (Bell, 2006; DeBacker, Crowson, Beesley, Thoma, & Hestevold, 2008; Nussbaum & Bendixen, 2003).

Problems with reliability and validity may arise when questionnaires on epistemic beliefs are transferred into another language and/or educational background. Up to now, only few attempts have been made to develop a questionnaire for the measurement of epistemic beliefs in German-speaking samples. In a survey on German instruments for the measurement of epistemic beliefs, Priemer (2006) describes only four instruments for adult populations. Three of them are based on the SEQ by Schommer (Moschner & Gruber, 2005; Moschner & Schiefele, 2003; Rehrl, Gruber, & Renkl, 2003). One is based on the Epistemological Beliefs Instrument by Jacobson and Jeng (Pieschl, Stahl, & Bromme, 2006). All instruments are only broadly outlined in abstracts in conference proceedings. The instruments face the same test-theoretical difficulties as their English counterparts.

In a series of preliminary studies, Rebmann and her research group translated the EBI into German and investigated its internal structure in several samples of German-speaking students. In these studies, the translated EBI version partly showed unsatisfactory psychometric properties such as inconsistent factor solutions in different samples or varying and often small amounts of explained variance. Table 1 shows six of the studies conducted with the translated EBI version. In the studies, 3-factorial, 4-factorial, as well as 5-factor solutions were found. In some studies, items that belonged to different factors in the original English EBI version were grouped into one factor. Besides, the factor "certainty of knowledge" consistently did not show in the factor analyses. The preliminary studies reached an explained variance of 34.87% up to 62.72%. Cronbach's α coefficients ranged from .41 to .88 for the single factors.

Table 1
Studies with a Translated Version of the Epistemic Beliefs Inventory (EBI, 28 Items) and Results of the Original EBI

Author(s), Year	Participants (*N*)	Items[a]		Factors[b]	Reliability	Variance in %
Bünnemeyer (2009)	154	14	4	Sp, C/S, Str, S	$.41 < \alpha < .69$	42.20
Hanekamp, Mokwinski, & Rebmann (2010)	157	21	4	Sp, C, Str, S	$.56 < \alpha < .73$	42.56
Kuhlmann (2009)	154	18	5	Sp, C, S/C, St/Str, Str/S	$.45 < \alpha < .68$	47.18
Mokwinski (2011)	314	18	3	Sp, Str, S	$.50 < \alpha < .88$	44.30
Müller, Rebmann, & Liebsch (2008)	52	16	4	Sp, C, St/Str, S	$.61 < \alpha < .88$	62.72
Wortmann (2009)	158	14	4	C, Str/Sp, S, S/Sp	$.43 < \alpha < .68$	34.87
Original EBI (Schraw et al., 2002)	160	15	5	Sp, C, S, St, Str	$.58 < \alpha < .68$	60.00
Original EBI (Bendixen et al., 1998)	154	15	5	Sp, C, S, St, Str	$.67 < \alpha < .87$	54.00

[a] Number of items remaining in factor solution
[b] Speed (Sp), Control (C), Source (S), Stability (St), Structure (Str)

Altogether, the results of these studies advise the development of a new German instrument. Three studies were carried out in the process of the development of the questionnaire: Firstly, an initial questionnaire version with partly new items was developed and its psychometric properties (item difficulties, factorial structure, and retest reliability) were investigated. Secondly, it was investigated whether the factorial structure can be confirmed in other samples. Lastly, the relationship between the factors of the new questionnaire and the application of learning strategies was investigated.

Development of a German Questionnaire for the Measurement of Epistemic Beliefs and Test of its Psychometric Properties (Study 1)

Item Development

As a first step in the development of a German questionnaire based on the EBI, it had to be decided which of the original EBI items were to be included into the new questionnaire. After an analysis of their psychometric properties in the six preliminary studies (see Table 1), 14 out of the 28 original EBI items were adopted. These items had shown satisfactory item difficulties and high item-to-factor loadings in each of the preliminary studies.

In a second step, new items were developed in an empirical study with qualitative interviews. A repertory grid technique was used to interview students on their views on knowledge and knowing (Fromm, 1987; Kelly, 1955). The interviewees were to imagine successful, average, and unsuccessful students in terms of academic achievement and grades. The interviewees were to describe in which constructs students who differ with regard to their academic success might differ from each other and in which constructs students in the group of successful respectively average respectively unsuccessful students might resemble each other. Altogether, 30 students were interviewed. To summarize and to categorize students' answers, a computer-assisted content analysis was carried out on all statements. Altogether, 160 statements that referred to epistemic beliefs were sampled. Two coders allocated the statements to the dimensions of epistemic beliefs. Of the 160 statements, 30 were allocated to the dimension "source", 15 to the dimension "structure", 38 to the dimension "control", and 72 to the dimension "speed". Hardly any statements (n = 5) were allocated to the dimension "stability of knowledge." In a next step, within each dimension statements that describe the same aspect were grouped together by the coders. New items were developed on the basis of these groupings.

Based on the results of the content analysis and on the preliminary studies on the original EBI, a revised German version of the EBI was developed. It consisted of 14 items of the original questionnaire and 11 new items (altogether 25 items). The items refer to four dimensions of epistemic beliefs, namely "source", "structure", "control", and "speed." Each factor is described by six items, except the factor "speed" which is described by seven items. Participants are asked to indicate the extent to which each of them is true using a scale ranging from 1 (strongly agree) to 5 (strongly disagree). Items are scored such that a high value on a particular subscale indicates a more sophisticated epistemic belief. The new questionnaire was called Oldenburg Epistemic Beliefs Questionnaire (OLEQ).

Investigation of the Item Properties, the Factorial Structure, and the Retest Reliability of the OLEQ

Participants and measurements. Psychometric properties and the factorial structure of the revised EBI were investigated in a sample of 471 university students from social sciences and economics at the universities of Oldenburg and Kassel (Germany). The sample included 210 males (44.6%) and 261 females (55.4%). Their mean age was 24.32 years (SD = 3.55). Excluding one missing case most of the students were undergraduates (414, 88.0%), 12.0% (56) were graduates. All students spoke German as a first language. Participation in the study was voluntary and all participants were assured that the information they provided would be confidential.

A subsample of 163 students filled in the OLEQ again one month after the first testing. This subsample included 81 males (49.7%) and 82 females (50.3%). The mean age was 26.06 years (SD = 3.40). Excluding one missing case most of the participants (111, 68.5%) were undergraduates, 31.5% (51) were graduates.

Results. All items showed satisfactory item difficulties between 0.20 and 0.80. Orthogonal exploratory factor analysis with Varimax rotation was carried out to uncover the underlying structure of the variables. As a criterion factor loadings above the .30 level were defined as significant (see Table 2). Bühner (2011) as well as Bortz (1999) consider sufficient sample size as an important requirement for conduction of factor analysis. A sample size of n = 471 as in the present study can be regarded as a "very good" pre-condition for conduction of factor analysis (Bühner, 2011, p. 343).

The factor analysis showed a solution with 20 out of 25 items and four factors with eigenvalues greater than 1, ranging from 1.27 to 3.80: speed (nine items), control (four items), structure (four items), and source (three items). The factors explained 40.74% of the total sample variation.

For the calculation of the internal consistency of the four factors, Cronbach's α as well as Guttmann's $\lambda 4$ coefficients were calculated (Osburn, 2000; Raykov, 1997a, 1997b).

Factor labels, item-to-factor loadings, eigenvalues, Cronbach's α, and Guttmann's $\lambda 4$ coefficients for each of the four factors are shown in Table 2. Cronbach's α coefficients for the data associated

Table 2
Factor Structure of the OLEQ, Items and Factor Loadings (N = 471)

	Structure	Speed	Control	Source
Too many theories just complicate things.[a]	.640			
Instructors should focus on facts instead of theories.[a]	.632			
The best ideas are often the most simple.[a]	.584			
Things are simpler than most professors would have you believe.[a]	.554			
If you haven't understood a chapter the first time through, going back over it won't help.[a]		.699		
If you don't learn something quickly, you won't ever learn it.[a]		.595		
Even if you learn slowly, you can understand the essence of a topic.[b]		.659		
Working on a problem with no quick solution is a waste of time.[a]		.605		
If two people are arguing about something, at least one of them must be wrong.[a]		.559		
You learn things better when you can relate them to your own experiences.[b, c]		.566		
I would feel uncomfortable if I rely on only one source of information when preparing a presentation.[b, c]		.525		
The ability to learn is a skill that can be developed.[b, c]		.516		
If two people are arguing about something, one of them quickly agrees with the other.[b]		.459		
Smart people are born that way.[a]			.764	
People's intellectual potential is fixed at birth.[a]			.715	
How well you do in school depends on how smart you are.[a]			.541	
Really smart students don't have to work as hard to do well in their course.[a]			.405	
Usually you can rely on the knowledge of instructors.[b]				.772
Most things in textbooks are trustworthy.[b]				.690
When someone in authority tells me what to do, I usually do it.[a]				.580
Eigenvalue	1.53	3.81	2.27	1.27
Guttmann's λ_4	.65	.77	.66	.51
Cronbach's α	.56	.76	.57	.50

[a] paraphrased/translated from Schraw et al. (2002)
[b] developed by content analysis of 30 repertory grid interviews
[c] raters had allocated the item to the dimensions source and control

Table 3
Descriptive Statistics of the OLEQ and the LIST for Studies 1, 2, and 3

	Sample Study 1 (*N* = 471)		Retest sample (*n* = 163)		Sample Study 2 (*N* = 364)		Sample Study 3 (*N* = 835)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
OLEQ factors								
Structure	2.72	.58	2.77	.58	2.91	.63	2.80	.61
Speed	4.15	.50	4.10	.49	3.60	.82	3.91	.71
Control	3.43	.96	3.32	.74	3.25	.74	3.30	.70
Source	2.86	.63	2.89	.63	2.88	.73	2.87	.67
LIST factors								
Memorization							3.90	.93
Elaboration							3.86	.86
Critical Thinking							3.22	.89

with the factors ranged from .51 to .77; Guttmann's λ4 coefficients were .65 for the factor "structure", .77 for "speed", .65 for "control", and .51 for "source".

Test-retest correlations were $r = .50$ ($p < .01$) for the factor "speed", $r = .80$ ($p < .01$) for the factor "control", $r = .70$ ($p < .01$) for the factor "structure", and $r = .62$ ($p < .01$) for the factor "source" ($n = 163$).

Table 3 shows the descriptive statistics for the four factors for the initial sample and the sample in which retest reliability was measured.

Discussion

Three parameters for assessing the quality of the new questionnaire had been calculated, item difficulties, factorial structure, and internal consistency. Factor analysis of the new questionnaire revealed four factors. Out of 25 items, four items had to be excluded due to insufficient factor loadings, another item had to be excluded in order to increase the respective factor's internal consistency.

All remaining items, but three, loaded on the factors for which they had been originally developed. These three items had been allocated to the factors "source" and "control" by two raters but in the empirical investigation they loaded on the factor "speed" (Table 2). The (empirical) judgment of the participants of the study is comprehensible because all three items are related to the question whether learning is a slow, gradual process that needs time and effort or whether learning occurs immediately. Altogether, the OLEQ shows a factor structure that fits to the theoretical concept of the dimensions of epistemic beliefs.

Cronbach's α coefficients for the four factors of the OLEQ ranged from satisfactory ($\alpha = .77$ for speed) to low coefficients ($\alpha = .51$ for source) (see Table 2). Cronbach's α coefficient, however, assumes tau-equivalent measurements, i.e., approximately equal factor loadings for all items (Osburn, 2000; Raykov, 1997a, 1997b). Especially for factors with a smaller number of items violations of this assumption lead to an underestimation of the internal consistency. Therefore, Guttman's λ4 coefficients were calculated. Simulation studies showed that they are more robust against violations of tau equivalence. However, similar to Cronbach's α, the size of Guttman's λ4 depends on the mean inter-item correlations and on the number of items belonging to a scale (Osburn, 2000).

By choice of a more appropriate coefficient the internal consistency of the factors "structure" and "control" could be increased. Yet, Guttman's λ4 value for the scale "source" still reflects the small number of items belonging to the factor. Lower internal consistency coefficients may also point at the heterogeneity of a factor and the aspects measured. For future revisions of the scale "source" it is advised to increase the number of items. All in all, internal consistency coefficients resemble those reported in studies on the original English EBI version (Hardre et al., 2007; Nietfeld & Enders, 2003; Ravindran et al., 2005).

Retest reliability was recorded because one would expect that changes in general epistemic beliefs occur gradually over the course of learning experiences and as a result of an individual's interactions with learning content, instructors, and/or other learners (Ferguson, Bråten, & Strømsø, 2012). On the other hand, epistemic beliefs can be changed by instructional interventions. Tsai (2008) could show that high school students' epistemic beliefs changed to an at least moderate degree after a month-long intervention of an inquiry-teaching program in science. In the present study retest reliability was measured one month after the first testing. Retest reliability was high for the factors "control" and "structure". Lower, but still acceptable reliabilities were found for the factors "speed" and "source". The coefficients partly exceed the retest reliability coefficients found by Schraw et al. (2002) for the English EBI version (coefficients between r = .62 to r = .66 for the factors "structure", "speed", "control", and "source").

Replication of the Factorial Structure in Another Sample (Study 2)

Participants and Measurements

In Study 2, it was investigated whether the factorial structure of the OLEQ found in Study 1 can be replicated in another sample. The stability of the factor structure was investigated in a German-speaking sample of 364 students at the University of Graz (Austria) from different majors from social sciences and economics. The sample included 70 males (19.2%) and 294 females (80.8%). Their mean age was 24.34 years (SD = 4.33). All participants spoke German as a first language. Excluding 89 missing cases most of them were graduates (252, 91.6%), 23 (8.4%) were undergraduates.

Results

Confirmatory factor analysis was used to test the model fit of the factorial structure found in Study 1. Calculations were carried out with Plus Mplus 5.21 (Muthen & Muthen, 2009). The maximum likelihood estimation method was used. Confirmatory factor analysis showed the following model fit indices: RMSEA = .05, CFI = .96 and SRMR = .067. Generally, values of RMSEA < .05, CFI ≥ .95, and SRMR ≤ .11 can be considered indicators for acceptable fit (Hu & Bentler, 1999; Schermelleh-Engel, Moosbrugger, & Mueller, 2003; Tinsely & Brown 2000). The items measuring the dimension "structure" loaded with weights between .319 and .620, the items measuring "speed" loaded with weights between .513 and .916 on this factor, the items measuring the dimension "control" loaded with weights between .093 and .802, and the items measuring the dimension "source" loaded with weights between .524 and .687 (see Table 4; see descriptive statistics in Table 3).

Discussion

Confirmatory factor analysis was calculated to test the stability of the factorial structure in another sample. Global fit indices were in the proposed range and speak for the tested model (see Hu & Bentler, 1998).

For the factor "structure" the initial solution from exploratory factor analysis can be confirmed with four items loading on the factor (all original EBI items, see Table 3). A closer view to the items suggests two facets of beliefs on the structure of knowledge, "complexity of knowledge resulting from multiple theories" and "meaning of simplicity and probability of a simple truth." The last two items of the factor seem to tap into the latter facet. In the initial exploratory factor analysis (study 1) these items had received high factor loadings (see Table 2). The items show lower but still significant weights in the confirmatory factor analysis (p < .01 for "the best ideas are often the most simple" and p < .05 for "things are simpler than most professors would have you believe"). Due to their weights in exploratory factor analyses and the significance of the loadings in confirmatory factor analysis the items were retained in the factor solution.

The structure of the factor "speed" remained unchanged with nine items (all significant weights above .50). As in exploratory factor analysis, four items (all original EBI items) load on the factor "control". The last item ("really smart students don't have to work as hard to do well in their course") had an acceptable factor loading of .405 in the exploratory analysis but obtained a very low loading of .093 in the confirmatory factor analysis. However, a confirmatory factor analysis without the item showed lower fit indices indicating that the item contributes to global fit. A closer view to the content of the items suggests two facets of beliefs on the control of knowledge acquisition: beliefs whether ability is innate and beliefs whether individuals with high ability nevertheless need to work hard for success. Of the four items, only the last one taps into the latter belief. In future investigations, it is advised to enlarge the item pool by further items that reflect this facet and by exchanging the last item.

The item pool of the factor "source" should be also enlarged. Even though the initial composition of

Table 4
Standardized Factor Loadings for the 4-Factor Model Tested by Confirmatory Factor Analysis (N = 364)

	Structure	Speed	Control	Source
Too many theories just complicate things.	.620			
Instructors should focus on facts instead of theories.	.617			
The best ideas are often the most simple.	.328			
Things are simpler than most professors would have you believe.	.319			
If you haven't understood a chapter the first time through, going back over it won't help.		.938		
If you don't learn something quickly, you won't ever learn it.		.885		
Even if you learn slowly, you can understand the essence of a topic.		.916		
Working on a problem with no quick solution is a waste of time.		.815		
If two people are arguing about something, at least one of them must be wrong.		.839		
You learn things better when you can relate them to your own experiences.		.843		
I would feel uncomfortable if I rely on only one source of information when preparing a presentation.		.640		
The ability to learn is a skill that can be developed.		.854		
If two people are arguing about something, one of them quickly agrees with the other.		.513		
Smart people are born that way.			.802	
People's intellectual potential is fixed at birth.			.757	
How well you do at university depends on how smart you are.			.498	
Really smart students don't have to work as hard to do well in their course.			.093	
Usually you can rely on the knowledge of instructors.				.687
Most things in textbooks are trustworthy.				.656
When someone in authority tells me what to do, I usually do it.				.524

items to the factor has been confirmed by the confirmatory factor analysis and factor loadings are adequate it is advised to supplement the three items of the factor by new items. It can be concluded, that the confirmatory factor analysis mainly confirmed the structure found in study 1 (with the exception of one item belonging to "control"). This is an important result because in former studies on the EBI and in studies on the translated EBI version the inconsistency of factorial structures was a test-theoretical problem (Bråten & Strømsø, 2005; Qian & Alvermann, 1995; Schraw et al., 2002; Tsai, Ho, Lian, & Lin, 2011).

Relationship between the Dimensions of the OLEQ and the Application of Learning Strategies (Study 3)

Current concepts of validity (e.g., Borsboom, Mellenberg, & van Heerden, 2004) distinguish different strategies to investigate the validity of measurements, including construct and criterion validity. Distinguishing between construct validity in terms of the nomothetic span of a measure and criterion validity can often be conceptually complex, particularly if the model allows researchers to deduce the structural relations between criterion measures and predictor variables on theoretical grounds. In the present study, the validity of the OLEQ was assessed by criterion validity due to the following reasons: (1) the structural relations between criterion measures such as the ones used in the present study and epistemic beliefs have already been evaluated in the literature, (2) the theoretical model allowed to deduce structural relations between criterion and predictor measures; thereby allowing to evaluate aspects of the validity of the newly constructed measure, (3) evaluating construct validity in terms of nomothetic span would require simultaneous convergent and discriminate measures, i.e. comparisons with measures that assess the same construct versus comparisons with measures that asses a construct not related to epistemic beliefs (see Borsboom et al., 2004). Since no measure of epistemic beliefs is available in German-speaking countries thus far, a more theory-based evaluation of the criterion validity was chosen.

Various researchers point at a relationship of epistemic beliefs with students' learning behaviors (Bråten & Strømsø, 2005; Hofer, 2002; Hofer & Pintrich, 1997). Epistemic beliefs may function as implicit theories that can give rise to goals for learning and guide the selection of self-regulatory strategies (Hofer & Pintrich, 1997; Pintrich, 2002). In the context of learning at university it might be especially interesting how students process learning material and which learning strategies they prefer.

Rodriguez and Cano (2006) showed linkages between different dimensions of epistemic beliefs and the application of deep-level and surface-level learning strategies. More simplistic and naïve beliefs were related to more reproduction-oriented, i.e. surface learning strategies while more sophisticated epistemic beliefs were related to more meaning-oriented, i.e., deep-level strategies. This result was partly confirmed by Schommer (1993b) who found that the more students believe in quick learning (dimension "speed") the less they attempt to monitor their learning processes. Other studies point at linkages between the dimension "structure" and surface-level learning strategies. Pupils and students who advocated positions such as "knowledge is seen as best characterized by isolated facts" preferred surface-level strategies such as memorizing facts over more complex strategies in which information is integrated (Koeller, 2001; Schommer et al., 1992). Research has mainly found evidence for relationships of the dimensions "speed," "structure," "source" with the application of surface-level or deep-level learning strategies (Koeller, 2001; Rodriguez & Cano, 2007; Schommer, 1993b; Schommer et al., 1992). Studies on the relationship between "control" and learning strategies often showed ambiguous results. Students with sophisticated beliefs on the dimension "control" rather employ a wide range of different strategies and do not rely on only a few strategies or a single strategy (Dweck & Leggett, 1988; Rodriguez & Cano, 2007; Schommer, 1993b).

While the aforementioned literature assumed a direct relationship between epistemic beliefs and the application of learning strategies, other research implies that the relationship between these two concepts is moderated by conceptions and views of learning (Tsai et al., 2011) or metacognitive knowledge on types of tasks and learning strategies (Bromme, Pieschl, & Stahl, 2010). Yet, all of these studies would agree that at least to a certain degree epistemic beliefs may function as a lens through which a student may interpret learning material and learning demands imposed upon her or him and that therefore epistemic beliefs are related to the use of learning strategies. Due to these deliberations, it was investigated to which degree the four dimensions of the OLEQ are related to students' application of deep-level and surface-level learning strategies in their studies.

Participants and Measurements

The relationship between the dimensions of the OLEQ and the use of learning strategies was investigated in a combined sample of Study 1 and 2. It included 835 students who had filled in the OLEQ and a questionnaire on the use of learning strategies. The sample included 280 males (33.5%) and 555 females (66.5%) with 437 undergraduate students (58.5%) and 309 graduates students (41.5%) (missing cases $n = 89$). The participants' mean age was 24.33 years ($SD = 3.91$).

The participants' epistemic beliefs were measured by the four dimensions of the OLEQ. The application of learning strategies was measured by the questionnaire "Lernstrategien im Studium" (LIST [learning strategies in academic studies]; Wild, 2000), a German adaptation of a selection of MSLQ scales

(Motivated Strategies for Learning Questionnaire; Pintrich, Smith, Garcia, & McKeachie, 1991). In several studies, the instrument showed satisfactory reliability measures (Cronbach's α) and a stable factorial structure (Boerner, Seeber, Keller, & Beinborn, 2005; Schiefele, Streblow, Ermgassen, & Moschner, 2003; Wild, 2000; Wild & Schiefele, 1994). The scales of the instrument are modular and can be selected according to specific research purposes. In Study 3, measurement focused on the application of surface- and deep-level cognitive strategies. Students were asked to indicate on 5-point Likert scales ranging from "very seldom" (1) to "very often" (5) how often they apply specific learning strategies.

As a surface-level strategy, memorization was measured by seven items (example item: "I learn rules, technical terms, or formulas by heart"). The internal consistency (Cronbach's α) of this scale was .76.

Deep-level strategies were measured by the scales "elaboration" and "critical thinking." Elaboration strategies describe cognitive processes in which learners relate new information to already known information, in which they pull together information from different sources, or draw connections between different sources of information (Mayer, 1996; Pintrich, 1999). The scale "elaboration" consisted of eight items (example item: "I try to find links between new concepts or theories and those I already know"). Internal consistency (Cronbach's α) of this scale was .84.

Critical thinking strategies describe cognitive processes in which students try to evaluate or to challenge ideas or conclusions, e.g., by questioning the ideas in a text book, by finding evidence for or against an argument, or by reflecting from different perspectives. The scale consisted of eight items (example item: "I develop my own ideas, based on the study materials I am actually working on"). The internal consistency (Cronbach's α) of this scale was .87.

Results

Students' epistemic beliefs contributing to the application of learning strategies were investigated. A multiple regression analysis was carried out with the four dimensions of epistemic beliefs as independent variables and three learning strategies as dependent variables (see descriptive statistics for these variables in Table 3, summary of multiple regression analysis in Table 5). A linear relation between independent (predictor) and dependent (criterion) variables was assumed meaning that increases in one variable should be related to increases or decreases in another one. Mplus 4.21 was used for the multiple regression analyses because it supports the investigation of the relationship between a set of independent and dependent variables in one single regression analysis (Muthen & Muthen, 2009).

Table 5

Summary of Multiple Regression Analysis for Learning Strategies Regressed on Students' Epistemic Beliefs (N = 835)

	Use of:								
Epistemic	Elaboration			Critical thinking			Memorization		
beliefs:	*B*	*SE B*	*β*	*B*	*SE B*	*B*	*B*	*SE B*	*β*
Speed	0.08	0.04	.08	0.10	0.03	.09	.10	.03	.10
Control	0.05	0.03	.05						
Structure	0.12	0.03	.12	0.10	0.03	.11	-.10	.03	-.10
Source				0.15	-0.03	.11	-.15	.03	-.15
R^2		.03			.07			.06	

Note: All reported regression coefficients are significantly different from zero ($p < .05$).

As expected, the dimension "structure" is positively related to both deep-level learning strategies, elaboration (β = .12, $p < .01$) and critical thinking (β = .11, $p < .01$), and it is negatively related to the surface learning strategy of memorization (β = -.10, $p < .01$). The dimension "speed" contributes positively to all learning strategies, the use of elaboration (β = .08, $p < .05$), the use of critical thinking (β = .09, $p < .01$), and the use of memorization strategies (β = .10, $p < .01$). The dimension "control" contributes with a low but significant positive weight to elaboration (β = .05, $p < .05$). The dimension "source" is mainly negatively related to the application of the surface-level learning strategy "memorization" (β = -.15, $p < .01$) and positively related to the use of critical thinking (β = .11, $p < .01$). For all three types of learning strategies only smaller amounts of variance can be explained by the four dimensions of epistemic beliefs (R2 between .03 and.07, see Table 5).

Discussion

In order to assess criterion-related validity the relationship between the dimensions of the OLEQ and the use of learning strategies was investigated. All four dimensions of epistemic beliefs showed significant regression weights for the application of learning strategies. For the dimensions "source", "structure", and "control" more sophisticated epistemic beliefs were related to the use of deep-level learning strategies whereas more naïve beliefs were related to the use of surface-level learning strategies. Also, the dimension speed was positively related to the use of deep-level learning strategies. This dimension, however, was also positively related to the more frequent use of memorization strategies and it probably can be characterized by a wide use of all learning strategies.

For the dimension "control" only a weak relationship to the application of elaboration strategies could be found. Items belonging to this dimension refer to the belief whether individuals can improve their capacity to learn or whether the capacity to learn is rather innate and cannot be changed. The connection between these items and learning strategies is also less obvious. It is possible that this dimension is more strongly related to aspects such as effort and motivation.

When interpreting the results of Study 3 one also has to consider that epistemic beliefs explain a significant, yet a small amount of the variance (R2 = 0.03 to R2 = 0.07). Then again, similar results are reported by Tsai et al. (2011) who found significant but moderate to low relationships between epistemic beliefs and conceptions of learning such as viewing learning as a memorization process as opposed to viewing learning as making sense of information. Epistemic beliefs seem to be one variable in a variety of others that may influence the application of learning strategies. For future studies, the relationships between the dimensions of the OLEQ and learner characteristics such as metacognitive knowledge (Bromme et al., 2010), self-efficacy (Tsai et al., 2011), or motivation and goal orientation (Paulsen & Feldman, 2005) should be included. It also might be a methodological problem that students only had to describe how they generally learn for their studies. Relationships between these two concepts might have been higher if students had been asked to describe their learning behavior in a more concrete situation (e.g. for a certain subject or in a specific time interval). Also, studies in which actual behavior is recorded, e.g., by observing students' processing of learning materials, are to be recommended.

General Discussion and Conclusion

Research on test adaptation indicates that the construct validity of an adapted (e.g., translated) version of a questionnaire cannot be taken at face value and therefore additional research examining its psychometric characteristics is needed (for an overview: Hambleton, Merenda, & Spielberger, 2006). In a series of preliminary validation studies by Rebmann and her workgroup it was not possible to obtain satisfactory psychometric properties of a merely translated form of the Epistemic Beliefs Inventory (EBI) (Schraw et al., 2002). Therefore, a new version for measurement of epistemic beliefs in German-speaking samples of university students was developed, the Oldenburg Epistemic Beliefs Questionnaire (OLEQ). Of the original EBI, 13 items could be retained; seven new items had to be developed, especially for measurement of the dimensions "source" and "speed".

The new instrument, the OLEQ, showed several advantages over the EBI version that had been translated into German. The main problem of the translated version had been the inconsistency of the factorial structure in different samples. Inconsistencies had occurred with regard to the number of factors as well as with regard to the composition of items into factors (see Table 1). In contrast, the OLEQ showed a stable factorial structure in a cross-validation approach with two samples from different universities.

In several instances, the OLEQ showed advantages over or was at least comparable to the original (English) EBI. The new instrument exceeded the translated EBI version somewhat with regard to its internal consistency measures. However, for both instruments internal consistency still should be improved. Retest reliability of the OLEQ was satisfactory and comparable to that of the EBI. For some scales retest reliability was higher than for the corresponding EBI scale (e.g., control r = .80), for some scales it was somewhat lower.

However, it was not possible to completely replicate the original factor structure of the EBI. Neither in the present studies on the development of the OLEQ nor in preliminary studies with a translated EBI version a factor/dimension "stability" could be confirmed. This dimension describes beliefs whether knowledge remains stable over time or whether knowledge is subject to a constant process of change and development. Failure in proving this factor might be due to characteristics of the investigated student samples (predominantly students from studies in economics and social sciences such as education, psychology), their learning experiences, and the structure of their studies. In fields such as education, psychology, or economics, students (should) learn how scientific theories are related to each other, evolve of each other, and are subject to a constant change. Thus, students in the here-mentioned investigations might have taken it for granted that knowledge is changeable over time and the investigated samples might have been too homogeneous with respect to their beliefs on this dimension. Then again, researchers such as Greene et al. (2008) generally question the existence of a separate dimension "stability" and argue against a fine-grained distinction of the dimensions "stability" and "structure". In their view, both dimensions belong together as both concern the ontology of knowledge. For a thorough investigation of the breadth of epistemic dimensions it seems necessary to carry out further studies. As a first step, the empirical basis should be enlarged by students from other fields of science.

It can be concluded, that with the OLEQ, a step forward in the development of an instrument for measurement of epistemic beliefs in German-speaking samples has been taken. The new instrument is partly based on the EBI (Schraw et al., 2002) but also includes new items. Investigation of the psychometric properties of the instrument showed a stable factorial structure and satisfactory retest reliabilities. However, the instrument should be improved with regard to internal consistency of certain scales by developing further items and thus enlarging the number of items in each factor.

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Author Notes

Manuela Paechter
Department of Psychology, Educational Psychology Unit, Karl-Franzens-University, Graz, Austria
Universitaetsplatz 2, 8010 Graz, Austria
manuela.paechter@uni-graz.at

Manuela Paechter is a full professor of Educational Psychology at Karl-Franzens University of Graz. Her primary research interests focus on individual traits and attitudes relevant for learning (anxiety, self-concept, beliefs), on learning with digital media, and on competence development and modelling. Correspondence concerning this article should be addressed to Manuela Paechter.

Karin Rebmann
Department of Business Administration, Economics, and Law, Carl von Ossietzky University, Oldenburg
Ammerlaender Heerstraße 114-118, 26129 Oldenburg, Germany
karin.rebmann@uni-oldenburg.de

Karin Rebmann is a full professor at the Institute of Vocational Training and Business Education at Carl von Ossietzky University in Oldenburg. Her primary research interests center around epistemic beliefs of learners and teachers/instructors, learning in vocational contexts, didactics of business education, vocational education for sustainable development, and competence development and modelling.

Tobias Schloemer
Department of Business Administration, Economics, and Law, Carl von Ossietzky University, Oldenburg
Ammerlaender Heerstraße 114-118, 26129 Oldenburg, Germany
tobias.schloemer@uni-oldenburg.de

Tobias Schloemer is an assistant professor at the Institute of Vocational Training and Business Education at Carl von Ossietzky University in Oldenburg. His primary research interests center around epistemic beliefs of learners and teachers/instructors, learning in vocational contexts, didactics of business education, vocational education for sustainable development, and competence development and modelling.

Bjoern Mokwinski
Department of Business Administration, Economics, and Law, Carl von Ossietzky University, Oldenburg
Ammerlaender Heerstraße 114-118, 26129 Oldenburg, Germany
bjoern.mokwinski@uni-oldenburg.de

Bjoern Mokwinski is a post-doc lecturer and researcher at the Institute of Vocational Training and Business Education at Carl von Ossietzky University in Oldenburg. His primary research interests focus on epistemic beliefs and motivational tendencies of learners.

Yvonne Hanekamp
Department of Business Administration, Economics, and Law, Carl von Ossietzky University, Oldenburg
Ammerlaender Heerstraße 114-118, 26129 Oldenburg, Germany
yvonne.hanekamp@uni-oldenburg.de

Yvonne Hanekamp is a doctoral student at the Institute of Vocational Training and Business Education at Carl von Ossietzky University in Oldenburg. Her primary research interests center around epistemic beliefs of teachers and instructors in vocational education and training.

Martin Arendasy
Department of Psychology, Psychological Methodology and Computer-Based Modeling Unit, Karl-Franzens-University, Graz, Austria
Universitaetsplatz 2, 8010 Graz, Austria
martin.arendasy@uni-graz.at

Martin Arendasy is a full professor of Psychological Methodology and Computer-Based Modelling at Karl-Franzens-University, Graz. His primary research interests focus on automatic item generation and cognitive modelling by item-response theory.

Current Issues in Education
Mary Lou Fulton Teachers College • Arizona State University
PO Box 37100, Phoenix, AZ 85069, USA

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