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Epistemological beliefs and epistemic strategies in self-regulated learning

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Abstract

How do epistemological attitudes and beliefs influence learning from text? We conceptualize epistemological attitudes and beliefs as components of metacognitive knowledge. As such, they serve an important function in regulating the use of epistemic strategies such as knowledge-based validation of information and checking arguments for internal consistency. We report results from two studies that investigated the effects epistemological attitudes and beliefs on the use of epistemic strategies in academic learning and the motivational states that mediate these effects. Study 1 (N=289) tested a mediation model with epistemological attitudes (separate vs. connected knowing) and textual characteristics as distal predictors, and learning goals (learning factual knowledge vs. developing an own standpoint) as mediator variables. Separate knowing had large indirect effects on the use of epistemic strategies via the goal to develop an own point of view. In addition, learners adapted their learning goals and epistemic strategies depending on objective characteristics and the perceived familiarity of the texts they read. In Study 2 (N=124), epistemological beliefs concerning the uncertainty of knowledge increased the use of epistemic strategies only when extrinsic study motivation was low. A mediated moderation model established this effect to be mediated by specific epistemic curiosity. These results illuminate the mechanisms of how epistemological attitudes and beliefs affect self-regulated learning. In contrast to other types of learning strategies, the use of epistemic strategies seems to be strongly and consistently linked to epistemological attitudes and beliefs.

Keywords: epistemic curiosity, epistemic validation, epistemological beliefs, learning strategies, self-regulated learning

Epistemological Attitudes and Beliefs in Self-regulated Learning

Epistemological beliefs are beliefs about the nature of knowledge and knowing. As such, epistemological beliefs may be regarded as the subjective counterpart of epistemology, i.e. the branch of theoretical philosophy that is concerned with characteristics, criteria, and justification conditions of knowledge (e.g., Bonjour, 2002; Bromme, 2005). Even though knowledge is a central construct in most theories of learning, it was only until recently that the epistemological beliefs of lay people and their role in knowledge acquisition have stimulated broad interest among educational psychologists (for reviews see Buehl & Alexander, 2001; Hofer, 2001; Hofer & Pintrich, 1997). This growing interest in personal epistemology stems at least partially from the finding that so called sophisticated epistemological beliefs are often related to better learning outcomes than "naïve" epistemological beliefs (e.g., Köller, 2001; Muis, 2004; Pieschl, Stahl, & Bromme, 2008; Schommer, 1993; Trautwein & Lüdtke, 2007). In this article, we focus on some of the cognitive and motivational processes by which epistemological beliefs might exert these effects. Starting from the concept of epistemological metacognition, we suggest that epistemological beliefs have an impact on the use of a special kind of learning strategies that we call epistemic strategies. We will argue that in self-regulated learning activities, the impact of epistemological beliefs is mediated by students' learning goals and their level of epistemic curiosity. We will report results from two studies that tested these assumptions for two major kinds of epistemological beliefs, the epistemological attitude of separate knowing (Belenky, Clinchy, Goldberger, & Tarule, 1986; Study 1) and beliefs in the certainty of knowledge (e.g., Hofer, 2001; Study 2).

Epistemological Metacognition and Epistemic Strategies

Despite the fact that the interest in epistemological beliefs has only recently emerged in educational psychology, the concept fits naturally in existing frameworks of self-regulated

learning: Epistemological beliefs may be regarded as an epistemological type of metacognitive knowledge (cp. Hofer, 2004; Kitchener, 1983). Comparable to other kinds of (declarative) metacognitive knowledge, epistemological beliefs are more or less coherent, complete, and adequate beliefs about knowledge and knowing. However, unlike metacognitive knowledge in the traditional sense (e.g., Flavell, 1979), epistemological beliefs are the subjective counterpart of objective theories developed in classical epistemology and the philosophy of science rather than objective theories of cognitive psychology. Thus, metacognitive knowledge in the traditional sense refers to psychological mechanisms underlying memory and learning (*psychological metacognition*). Epistemological beliefs, in contrast, refer to the nature of knowledge and the criteria that beliefs and assertions must fulfill to qualify as knowledge (*epistemological metacognition*). Note that the distinction between a psychological and an epistemological type of metacognition is solely based on the different contents of these two types of declarative metacognitive knowledge. The distinction is in no way meant to imply that epistemological metacognition does not play a role in an individual's cognitive processing.

Despite the fact that some of the earlier models of epistemological beliefs seem to confound the epistemological and the psychological types of metacognitive knowledge (e.g., by including subjective conceptions of intelligence and learning, cp. Schommer, 1990), the major theories in the field agree on drawing a sharp demarcation line between epistemological beliefs and beliefs about psychological mechanisms. The four key dimensions of epistemological beliefs that Hofer and Pintrich (1997) have identified in their landmark review of existing research are a case in point. The dimensions of certainty and simplicity deal with conceptual and normative aspects of the nature of knowledge such as whether science is capable of (ever) generating certain knowledge, whether there are absolute truths or knowledge is constantly evolving, and whether simple theories should be preferred over complex ones. Similarly, the other two dimensions

described by Hofer and Pintrich (1997), source of knowledge and justification of knowledge, refer to normative aspects of knowledge construction such as the role of expert scientists as epistemic authorities, how valid arguments should look like in science, and what kinds of evidence are admissible to support knowledge claims. Evidently, all of these questions are intensely debated in the philosophy of science but fall outside the scope of psychology. Hence, it seems reasonable to conceptualize epistemological beliefs as a special type of declarative metacognition. Both epistemological beliefs and psychological metacognition may be regarded as components of the general metacognitive endowment of learners.

Similar to metacognitive knowledge in the traditional sense, epistemological beliefs are relatively stable learner characteristics that can exert a profound influence on learning processes. This influence can be more or less direct when epistemological beliefs are used as standards against which the reliability and believability of the to-be-learned information is evaluated. For example, there is evidence that the belief in certain knowledge can result in a biased interpretation of information that downgrades its tentative character (Schommer, 1990; Kardash & Scholes, 1996). On the other hand, it is likely that epistemological beliefs exert indirect effects as well by way of regulating the use of learning strategies (e.g., Schommer, Crouse, & Rhodes, 1992). In particular, it has been suggested that more "sophisticated" epistemological beliefs are associated with less frequent use of simpler cognitive learning strategies and more frequent use of deep-processing strategies. However, the evidence for such relationships of epistemological beliefs and learning strategies is mixed. For example, while Köller, Baumert, and Neubrand (2000) reported positive correlations between the belief in certain knowledge and one type of simple learning strategies (rehearsal) in high-school students, other studies with high-school and university students did not find any evidence for this relationship (e.g., Köller, 2001; Schiefele, Streblow, Ermgassen, & Moschner, 2003). Likewise, the evidence for a relationship between the

belief in certain knowledge and the use of deep-processing strategies is far from conclusive (e.g., Bråten & Strømsø, 2005).

One likely cause for the overall inconsistent relationships found in existing studies is that cognitive learning strategies, be they simple or deep-processing strategies, represent ways how learners can exploit the functioning of the human cognitive system to optimize the encoding, storage, and integration of new information (Weinstein & Mayer, 1986). For this reason, cognitive learning strategies are closely related to psychological metacognitive knowledge, but they have little to do with epistemological metacognition. Considering the content and scope of epistemological beliefs, it seems more appropriate to assume a close relationship to strategic cognitive activities that take the epistemic status of information into account (epistemic validation, Richter, Schroeder, & Wöhrmann, in press; Schroeder, Richter, & Hoever, 2008; or epistemic judgments, Mason & Boldrin, 2008). Accordingly, such strategies may be termed "epistemic strategies".[1] We regard epistemic strategies as a special type of cognitive learning strategies that are aimed at validating the knowledge claims raised in expository or informational texts.

One primary criterion by which learners can judge the epistemic status of information presented in a text, a lecture, or in some other type of learning materials is whether the information is true or plausible given what they already know about a topic. A second, equally important criterion is whether the information is consistent with and well justified by other information presented in the learning material. Both types of epistemic validation can be pursued intentionally and strategically. Against this background, we suggest two types of epistemic learning strategies that may be called *knowledge-based validation* and *consistency checking*. Evidently, learning can benefit from epistemic learning strategies both in a direct and in an indirect manner. As a direct benefit, using these strategies can prevent learners from uncritically

encoding false or inaccurate information. As an indirect benefit, learners using these strategies activate domain-specific knowledge and actively seek for relationships of information scattered across the learning material. These activities, in turn, may be assumed to lead to a well organized and tightly integrated knowledge representation.

Epistemological Beliefs, Motivation, and Strategy Use

How is the relationship of epistemological beliefs and epistemic strategies instantiated in self-regulated learning activities? Hofer (2001) has proposed a general framework of how epistemological beliefs influence learning. According to this framework, learners' epistemological beliefs have effects on their use of strategies and their motivation. Motivation in turn influences strategy use as well. Finally, both motivation and strategy use are related to other learning processes. We regard Hofer's framework as a useful starting point for our empirical studies. However, it remains unspecific with regard to the question of which epistemological beliefs, motivational states and strategies are linked to each other. In the following, we outline two possible mediation chains that can be projected into Hofer's framework. With regard to epistemological beliefs, we focus on the dimensions of *separate knowing* (Belenky et al., 1986) and *certainty of knowledge* (e.g., King & Kitchener, 1994; Schommer, 2002). The first dimension pertains to the domain that Hofer and Pintrich (1997) call the *nature of knowing*, whereas the second one refers to one important aspect of the domain *nature of knowledge*.

The dimension of separate knowing has been introduced by Belenky et al. (1986) to characterize a well-developed epistemological position called procedural knowing. Together with the dimension of connected knowing, separate knowing represents an epistemological attitude, i.e. a habitual way of processing information with an unclear epistemic status. Separate knowing refers to an impersonal, objective, and critical way to deal with such information. It entails scrutinizing arguments for soundness and consistency. In contrast, the orthogonal dimension of

connected knowing refers to an empathic way of understanding other people's minds and communicative acts. Of these two dimensions, separate knowing may be expected to be strongly related to the epistemic strategies of knowledge-based validation and consistency checking. From the theoretical perspective advocated here, separate knowing is best described as an attitudinal component of epistemological metacognition. In terms of motivational mechanisms, it is likely to unfold its effects on the use of epistemic strategies by strengthening learning goals that require epistemic processing of information and possibly also by weakening learning goals that are best achieved by purely receptive processing. The idea that epistemological believes can exert effects on goal setting is also part of comprehensive conceptualizations of the role personal epistemology plays in self regulated learning (e.g., Muis, 2007; Muis & Franco, this issue). A generic and prototypical learning goal that necessitates epistemic processing is the goal to develop an own standpoint on the issues discussed in the learning materials. In science learning, for example, the learning goal to develop an own standpoint is important whenever students who already have achieved some basic knowledge of a domain want to gain an adequate understanding of competing scientific theories. In contrast, a generic learning goal that is best achieved by purely receptive processing is the goal to memorize the factual information conveyed by a text. The learning goal to memorize factual information is important whenever students prepare for an exam that merely requires recognizing or reproducing isolated pieces of information. For achieving this goal, the use of epistemic strategies might even be counterproductive. In sum, we propose that the effects of separate knowing on the use of epistemic strategies are mediated by the strength of learning goals, in particular the goal to develop an own standpoint on the issues covered by the learning material (Study 1).

Another core dimension of epistemological beliefs that, in one way or another, is a central part of most structural models of epistemological beliefs (e.g., Hofer, 2000; King & Kitchener,

1994; Schommer, 2002) is the perceived certainty of knowledge. Hofer (2000) conceptualizes certainty of knowledge as „[t]he degree to which one sees knowledge as fixed or more fluid“, ranging from the belief that „absolute truth exists with certainty“ to the belief that „knowledge is tentative and evolving“ (p. 380). From a motivational perspective, uncertainty can be expected to arouse specific epistemic curiosity. Specific epistemic curiosity is a motivational state that is aroused by questions and reduced by knowledge acquisition (Berlyne, 1954, 1960). In various experiments, both objective uncertainty as measured by the entropy formula (e.g., Berlyne, 1954, 1957, 1962) as well as subjective uncertainty as measured by ratings (e.g., Cancelli, Duley, & Meredith, 1980) have been found to result in specific epistemic curiosity. Although not explicitly stated by Berlyne, his use of the term “epistemic” seems to indicate that a person motivated by epistemic curiosity is not just interested in learning but in the acquisition of true or at least plausible knowledge. Epistemic curiosity should therefore lead to the use of epistemic strategies.

Of course, the epistemological belief that knowledge is uncertain cannot be expected to arouse curiosity under all circumstances. One likely boundary condition is that extrinsic motivation is sufficiently weak to allow for epistemic curiosity. This is because curiosity may be regarded as special form of intrinsic motivation (Loewenstein, 1994): A person motivated by curiosity seeks knowledge as an end in itself. A broad literature on intrinsic motivation suggests that intrinsic motivation is easily undermined by extrinsic incentives (e.g., Lepper, Greene, & Nisbett, 1973; Deci, Koestner, & Ryan, 1999). In our approach, we therefore conceptualize extrinsic motivation as moderator variable of the mediation chain from beliefs in the certainty of knowledge over epistemic curiosity to epistemic strategies. Hence, the consequences of certainty beliefs are conceptualized within a framework that encompasses both intrinsic motivation, viz. epistemic curiosity, and extrinsic motivation (Study 2).

Study 1

The primary goal of Study 1 was to test the hypothesized relationships of separate knowing, learning goals, and epistemic strategies in a naturalistic learning environment that allowed for a high degree of self-regulated learning. In an attempt to maximize these characteristics, Study 1 was a field study in which university students were asked to report on their learning goals and their use of epistemic strategies while reading a text as part of their regular studies. In addition to separate and connected knowing, we assessed the students' familiarity with the content of the text materials and characteristics of the focal text as conditions that might also play a role in determining to what extent the students would use epistemic strategies. In particular, we predicted that students' level of separate knowing would be positively related to their use of consistency checking strategies (Hypothesis 1) and to their use of knowledge-based validation strategies (Hypothesis 3), even if familiarity with the content of the text materials and the perceived amount of arguments in the text was controlled for. In terms of motivation mechanisms, we predicted that the effect of separate knowing on the use of consistency checking strategies (Hypothesis 2) and knowledge-based validation strategies (Hypothesis 4) would be mediated by the strength of the goal to develop an own standpoint on the subject matter. In addition, we also included the complementary goal to learn facts in the mediation model. Given that this goal requires merely receptive processing, it should be either unrelated or even negatively related to the use of epistemic strategies.

As a secondary goal, Study 1 also explored some of the contextual conditions that might determine to what extent university students use epistemic strategies in their everyday learning activities. We included participants' area of study, the genre of the focal text, and the extent of participants' previous studies in the respective area as potential contextual predictors of the use of epistemic strategies.

Method

Participants. Participants were 289 university students (193 women and 96 men) with a mean age of 24.9 years (*SD*=4.7). Seventy-seven participants (27%) were majoring in the social sciences or the humanities, 44 (15 %) were majoring in the natural sciences (including computer science), 61 (21%) were majoring in business and law studies, and 55 (19%) were teacher students with different majors. The majority of participants (178) took part in a web-based version of the study over the internet. These participants were recruited through postings in mailing lists of the University of Cologne and through postings on web sites for psychological on-line research (online sub-sample). The remaining 111 participants took part in a paper-pencil version of the study (paper-pencil sub-sample). These participants were recruited in courses at the University of Cologne.

Materials and procedure. The study materials consisted of one questionnaire that referred to the text participants had chosen as a typical text that they were reading for their studies, a second questionnaire that contained items assessing epistemological attitudes, and a third questionnaire asking for socio-demographic information. The text-related questionnaire asked for detailed bibliographic information on the text that participants had chosen and for the assignment of the text to one of five text genres (textbook chapter, empirical paper, theoretical paper, review paper, popular science text), for ratings of text characteristics (amount of arguments, text difficulty), and for participants' ratings of the amount and quality of their prior knowledge of the text topic. In addition, the text-based questionnaire included 13 items assessing epistemic strategies and eight items assessing participants' goals during reading on seven-point response scales. The epistemological attitudes questionnaire was presented only in the paper-pencil subsample. In this subsample, the order in which the epistemological attitudes questionnaire and the text-based questionnaire were presented was counterbalanced across participants. In the

following sections, we will describe the text-based and epistemological attitude measures used in Study 1 in more detail. Unless stated otherwise, the response scales of all items ranged from 1 (*do not agree*) to 7 (*fully agree*).

Epistemic strategies. Participants' use of two kinds of epistemic strategies while reading a typical text for their studies was assessed by the two scales *consistency checking* and *knowledge-based activation*. The use of consistency checking strategies was measured by seven items that referred to whether participants actively monitored the internal consistency of the focal text (e.g., *During reading, I looked for evidence presented for the claims made by the text*). Similarly, the six items of the scale measuring the use of knowledge-based validation strategies referred to whether participants actively used their prior knowledge to judge the plausibility of information presented in the focal text (e.g., *I asked myself whether the information presented in the text matches with my own experiences*). In the present sample, the scales reached internal consistencies (Cronbach's α) of .78 (consistency checking) and .80 (knowledge-based validation).

Processing goals. Four items were included to measure the degree to which participants followed the goal to learn factual information while reading the focal text (learning facts goal, e.g. *My goal during reading was to keep as many of the facts mentioned in the text as possible*; Cronbach's α=.90). Four additional items were included to measure the degree to which participants followed the goal to develop an own standpoint (standpoint goal, e.g., *During reading, I wanted to find out whether I should believe what the text is trying to tell me*; Cronbach's α=.75).

Further text-related questions. Participants rated the amount and quality of their prior knowledge concerning the focal text on four items (e.g., *I have solid prior knowledge about the topic of the text*; Cronbach's α=.75). They also rated the perceived difficulty of the text on six

bipolar adjective pairs (e.g., *introductory-advanced*; Cronbach's α=.75) and the amount of arguments in the text on one adjective pair (*expository-argumentative*).

Epistemological attitudes. Epistemological attitudes were assessed in the paper-pencil subsample of Study 1 with a German version of the short form of the Attitudes toward Thinking and Learning Survey (ATTLS, Galotti, Clinchy, Ainsworth, Lavin, & Mansfield, 1999). This questionnaire measures two epistemic attitudes called connected knowing (10 items, e.g., *I'm more likely to try to understand someone else's opinion than to try to evaluate it*) and separate Knowing (10 items, e.g., *I try to listen to other people's positions with a critical eye*). The items were first translated into German and retranslated into English by a native speaker of English. The retranslations were then compared to the original items for equivalence of meaning. Any inconsistencies were discussed and removed by modifications of the German items. In the present study (paper-pencil subsample), connected knowing reached an internal consistency (Cronbach's α) of .83 and separate knowing reached an internal consistency .75. In contrast to Galotti et al.'s (1999) results, connected knowing and separate knowing were not independent from each other but had a moderately positive relationship (r=.30).

Results and Discussion

We tested the predictions concerning the effects of epistemological attitudes on the use of epistemic strategies and the predictions concerning the role of processing goals as mediators of these effects by estimating a series of nested regression models (Baron & Kenny, 1986). In the first step (model with distal predictors only), epistemic attitudes (separate knowing and connected knowing) were entered as predictors into the model together with prior knowledge and amount of arguments. In the second step (model with distal predictors and mediators), standpoint goal and facts goal were entered as potential mediators. According to Baron and Kenny (1986),

an effect of a distal predictor can be said to be mediated if its effect is greatly reduced (partial mediation) or even disappears (full mediation) after introducing the mediator variable(s) into the model. As additional criterion, mediator variables themselves must have an effect on the criterion variable. However, despite its popularity, the nested regression model approach for testing mediator hypotheses has been criticized for suffering from several shortcomings (in particular, the possibility of artifactual results due to insufficient power, cp. MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). For this reason, we also estimated the hypothesized indirect effects and their standard errors and tested the indirect effects via the Sobel test (Sobel, 1982).

All significance tests reported in this article were based on a type-I error probability of .05. Descriptive statistics and intercorrelations of all variables in Study 1 are given in the upper portion of Table 1. The regression coefficients estimated in the series of nested regression models and the corresponding significance tests are provided in Table 2. We will first report results on the effects of epistemological attitudes on the use of epistemic strategies and the corresponding mediator hypotheses. Subsequently, we will report exploratory data that investigate some of the contextual factors that might guide the use of epistemic strategies in academic learning.

Consistency Checking

In line with Hypothesis 1, separate knowing had a strong positive effect on how much participants reported having used consistency checking as an epistemic strategy (Table 2, left column). In the model with processing goals as mediating variables, the direct effect of separate knowing was greatly reduced but still significant (Figure 1). However, as predicted by Hypothesis 2, the goal to develop an own standpoint exerted a strong positive effect on the use of consistency checking during reading. In addition, separate knowing had a strong positive effect on the goal to develop an own standpoint (B=0.90, SE_B=0.14, t=6.6, p<.001, ΔR^2=.22). Thus, the

criteria specified by Baron and Kenny's (1986) stepwise procedure for a partial mediation effect were fulfilled: Apparently, a large proportion of the effect of separate knowing on the use of consistency checking was mediated by the goal to develop an own standpoint, but it also had a small direct effect that was independent of participants' processing goal. We also investigated the effect predicted by Hypothesis 2 by estimating and testing the indirect effect of separate knowing through the goal to develop an own standpoint on the strategic use of consistency checking. The indirect effect was estimated as 0.37 (SE=0.09) and turned out to be significant in the Sobel test (z=4.0, p<.001).

In addition to the hypothesis-relevant results for separate knowing, the parameter estimates in the model for consistency checking revealed two further interesting patterns of results. First of all, none of the other predictors in the model exerted an effect on consistency checking. Thus, overall, the strategic use of consistency checking while studying the focal text was unrelated to participant's level of connected knowing, prior knowledge, and the amount of arguments in the text. Stated differently, separate knowing was not only a strong distal predictor but also the only one among the set of variables included in the model. Second, separate knowing, prior knowledge, and the amount of arguments in a text all had negative impact on the goal to learn facts from the focal text. However, the goal to learn facts itself was unrelated to the use of consistency checking.

Knowledge-based validation

In line with Hypothesis 3, individual differences in separate knowing had positive and independent effects on participants' use of knowledge-based validation strategies during reading the focal text (Table 2, right column). In addition to having a positive effect on the goal to develop an own standpoint, separate knowing also had a negative effect on the goal to learn facts. Furthermore, the goal to develop an own standpoint had a strong positive effect and the goal to

learn facts had a medium-sized negative effect on the use of knowledge-based validation. The effect of separate knowing on the use of knowledge-based validation strategies disappeared after including the two processing goal variables into the model. According to Baron and Kenny (1986), this pattern of effects is indicative of full mediation through the two processing goal variables. Again, we double-checked this conclusion by estimating and testing the corresponding indirect effects. The indirect effect of separate knowing on the use of knowledge-based validation through the standpoint goal was estimated as 0.43 (*SE*=0.11) and it was significant (*z*=4.1, *p*<.001). The complementary indirect effect through the learning facts goal was estimated as 0.06 (*SE*=0.10), and it was not significant (*z*=0.6). Thus, the effect of separate knowing on the use of knowledge-based validation strategies was mediated by participants' goal to develop an own standpoint while reading the focal text. In contrast, no indication was found for a mediating role of the goal to learn facts from the text.

A number of further effects in the model for the use of knowledge-based validation strategies are worth noting. One interesting finding is that not only separate knowing but also connected knowing had a positive effect on the use of knowledge-based validation strategies. This effect even grew larger after the two processing goal variables were included in the model. Apparently, the epistemic attitude of connected knowing promotes some kind of knowledge-based processing that is independent from both a receptive learning goal such as learning facts and an epistemic learning goal such as developing an own standpoint. A second notable finding was that in addition to separate knowing, prior knowledge and amount of arguments also had positive (albeit smaller) effects on the use of knowledge-based validation strategies. Similar to the effects of separate knowing, these effects were mediated by the goal to develop an own standpoint. The indirect effect of prior knowledge was estimated as 0.10 (*SE*=0.04, *z*=2.4, *p*<.05). The indirect of amount of arguments was estimated as 0.08 (*SE*=0.03, *z*=2.5, *p*<.05). One

plausible interpretation of this finding is that learners adjust their processing goals and, consequently, their use of knowledge-based validation strategies according to the perceived argumentative character of the text and according to how strong they believe their prior knowledge to be.

Contextual influences on the use of epistemic strategies

We conducted additional analyses to explore relationships of the use of epistemic strategies with contextual variables such as participants' area of study, the extent of participants' previous studies, and the text genre of the focal text.

Area of study. Both the use of consistency checking and knowledge-based validation strategies differed significantly between participants majoring in different areas of study (Figure 2a; consistency checking: $F(4,279)=9.0$, $p<.001$, $\eta^2=.12$; knowledge-based activation: $F(4,279)=4.0$, $p<.01$, $\eta^2=.12$). Post-hoc comparisons revealed that students from the Humanities reported using consistency checking strategies to a greater extent than students from all other areas of study ($p<.05$, Bonferroni correction for multiple comparisons). It seems plausible that this pattern of effects reflect differences in the methodological setup of the Humanities compared to the other areas of study. In the Humanities, the critical interpretation and examination of texts (e.g., theoretical texts, literary texts, or historical material), including checking these texts for internal consistency, are core methods and are taught to students from the first semester on. Similarly, students from the Humanities and from the Social Sciences reported using knowledge-based validation strategies more extensively than Students from the Natural Sciences or from Business and Law Studies ($p<.05$, Bonferroni-corrected). Given that students from the Humanities and the Social Sciences are often trained to use their prior knowledge (including

common-sense knowledge) for a critical evaluation of scientific texts, this pattern of effects seems to be readily interpretable.

Text genre. The use of consistency checking strategies did not differ with the text genre of the focal text, $F(4,254)=1.3$, $p=.26$, but the use of knowledge-based validation strategies did, $F(4,254)=3.9$, $p<.01$, $\eta^2=.06$ (Figure 2b). In post-hoc comparisons, only the difference between textbook chapters and theoretical papers, for which participants reported the most extensive use of knowledge-based validation strategies, was significant ($p<.05$). The average use of knowledge-based validation for the other three text genres (empirical paper, review paper, popular science text) lay between these two extremes. This pattern of results makes sense because learners often read textbook chapters for the purpose of acquiring knowledge in an area hitherto unfamiliar to them. Adequate comprehension of theoretical papers, in contrast, usually requires comparing the new theory to other pertinent theories and findings that one has knowledge of.

Extent of previous studies. In the overall sample, the use of both epistemic strategies was weakly correlated with number of semesters of participants' previous studies (consistency checking: $r=0.11$, $p<.05$, one-tailed; $r=0.21$, $p<.001$, one-tailed). Computing the correlations by subject area revealed medium-sized positive relationships only for students of the Humanities (consistency checking: $r=0.33$, $p<.05$, one-tailed; $r=0.24$, $p<.001$, one-tailed) and teacher students (consistency checking: $r=0.28$, $p<.05$, one-tailed; $r=0.44$, $p<.001$, one-tailed), whereas no significant relationships were found for students of the other subject areas. Thus, it seems possible that students majoring in the Humanities as well as teacher students are trained to use epistemic strategies in the course of their studies.

Study 2

Study 2 was designed to investigate the relationships of epistemological beliefs about the certainty of knowledge, specific epistemic curiosity, the use of epistemic strategies and extrinsic motivation. We expected a positive effect of uncertainty on the use of epistemic strategies. However, we expected this effect to be dependent on extrinsic motivation, with participants low in extrinsic motivation showing a greater tendency to employ epistemic strategies than participants high in extrinsic motivation (Hypothesis 5). The reason for this expectation is that participants low in extrinsic motivation should be more prone to develop curiosity in the face of uncertainty as well, and that curiosity should result in a more frequent use of epistemic strategies. Put otherwise, the moderation of the relationship between uncertainty and strategy by extrinsic motivation should be mediated by epistemic curiosity (Hypothesis 6).

Method

Participants. Participants were 124 university students (98 women and 26 men) with a mean age of 23.7 years (*SD*=5.6). Most of the participants (108; 87%) were majoring in the social sciences or the humanities. All of them were recruited in courses at the University of Mannheim.

Materials and procedure. Participants responded to a questionnaire containing the instruments described in the following paragraphs.

Epistemological beliefs. The perceived uncertainty of knowledge was assessed with a domain specific scale consisting of 15 items (e.g., *For most theoretical approaches in this field, there are both good arguments as well as good counterarguments*, Cronbach's $\alpha = .90$). Participants were instructed to answer these items with regard to their own field of study.

Curiosity. Specific epistemic curiosity was assessed by a 15-item scale. Each item referred to both a cognitive conflict experienced in the context of academic learning and an affective or motivational reaction (e.g., *I want to know which theory is correct in the explanation*

of a certain phenomenon, Cronbach's α = .86). To keep the item contents of this scale distinct from the item contents of the epistemic strategies scale, neither cognitive nor behavioral reactions were mentioned. The items were answered on seven-point rating scales labeled *almost never* (1), *very seldom* (2), *seldom* (3), *sometimes* (4), *often* (5), *very often* (6), *almost always* (7).

Epistemic strategies. The use of epistemic strategies was assessed with a slightly modified version of the *consistency checking* scale used in Study 1. In Study 2, this scale was altered from an instrument referring to specific texts to an instrument intended to tap the use of epistemic strategies in the broader context of academic learning (e.g., the item *During reading, I looked for evidence presented for the claims made by the text* was reworded as *I would look for evidence presented for the claims being made*). The items were presented under the lead question *How do you usually deal with the contents of your study?* They were answered on the same seven-point frequency scale as the items of the curiosity scale. In the present sample, the scale reached an internal consistency (Cronbach's α) of .82.

Extrinsic motivation. Extrinsic motivation was assessed with the scale *achievement related extrinsic motivation* (Schiefele et al., 2003). This instrument consists of four items (e.g., *I do my studies in order to come off well in the exams*). In the present sample, the scale reached an internal consistency (Cronbach's α) of .82.

Results and Discussion

Descriptive statistics and intercorrelations of all variables included in Study 2 are given in Table 3. Data were analyzed by a mediated moderation analysis (Muller, Yudd, & Yzerbyt, 2005). This approach combines moderator analysis and mediation analysis in a single model. A mediated moderation analysis is based on a mediation model such as the ones described in Study 1 (Baron & Kenny, 1986). However, in contrast to an ordinary mediation model, the effect of

both the distal and the proximal predictor is allowed to vary depending on the level of a moderator. Compared to an ordinary moderator analysis, a mediated moderation analysis has the advantage that it can inform about the process through which a moderated effect of a distal predictor is produced. For the purpose of our analysis, uncertainty was specified as distal predictor, curiosity as mediator variable, consistency checking as outcome variable, and achievement related extrinsic motivation as moderator variable. To avoid non-essential ill conditioning, all variables were *z*-standardized prior to data analysis (Aiken & West, 1991). The parameter estimates of the mediated moderation analyses are presented in Table 4 and Figure 3.

First of all, there was an overall effect of uncertainty on consistency checking. However, in line with Hypothesis 5, this effect was moderated by extrinsic motivation. To facilitate the interpretation of the moderation effect, simple slopes were calculated for the effect of uncertainty on consistency checking at different levels of the moderator (one standard deviation below the mean and one standard deviation above the mean) and tested for significance (Aiken & West, 1991). In these analyses, uncertainty was shown to exert a strong impact on consistency checking for participants with low extrinsic motivation (B=.49, SE_B=0.11, t(121)=4.29, p<.001). For participants with high extrinsic motivation, the relationship disappeared (B=.09, SE_B=0.12, t(121)= -0.79).

Second, further analyses revealed that the interaction of uncertainty and extrinsic motivation was due to the effect of uncertainty on curiosity being moderated by extrinsic motivation. There was an effect of uncertainty on curiosity (B=.29, SE_B=0.09, t(121)=3.40, p<.001, ΔR^2=.08). Similar to the effect of uncertainty on consistency checking, this effect was moderated by extrinsic motivation (B=-.17, SE_B=0.08, t(121)=-2.13, p<.05, ΔR^2=.03). Simple slope analyses demonstrated the effect to be significant only for participants with low extrinsic

motivation (one standard deviation below the mean, B=.46, SE_B=0.12, t(121)=4.00, p<.001), but not for participants with high extrinsic motivation (one standard deviation above the mean, B=.12, SE_B=0.11, t(121)=1.05). Moreover, for all participants, regardless of their extrinsic motivation, there was a strong effect of curiosity on consistency checking. This effect did not depend on participants' extrinsic motivation. Thus, in line with Hypothesis 6, the results indicate that it is the link between uncertainty and curiosity – as opposed to the link between curiosity and consistency checking – that is affected by extrinsic motivation. Indeed, the residual direct moderator effect of uncertainty and extrinsic motivation on consistency checking decreases once the mediator curiosity and its interaction with extrinsic motivation are controlled for. Given that the interaction of uncertainty and extrinsic motivation is reduced from -.29 (*SE*=0.08) to -.19 (*SE*=0.08) but still significant, the results indicate a partial mediated moderation (Muller, Yudd, & Yzerbyt, 2005). It therefore seems likely that there are other mechanisms capable to reduce the impact of uncertainty on the use of epistemic strategies besides the undermining of epistemic curiosity by extrinsic motivation (see General Discussion).

The residual main effect of uncertainty on consistency checking was not significant, indicating full mediation of this effect. As in Study 1, the indirect effect was estimated and tested for significance using the Sobel test. The effect was estimated as .16 (*SE*=.05, z=3.11, p<.01). Notice, however, that this estimation is appropriate only for participants with average extrinsic motivation. We therefore calculated indirect effects for low (one standard deviation below the mean) and high (one standard deviation above the mean) values of extrinsic motivation as well (Preacher, Rucker & Hayes, 2007). The indirect effect varied from .26 (*SE*=.08, z=3.20, p<.01) for participants with low extrinsic motivation to .07 (*SE*=.07, z=1.04, p=.15) for participants with high extrinsic motivation. This result is in line with the idea that the mediation chain from the belief in uncertain knowledge via curiosity to the use of the epistemic strategy consistency

checking does not hold for all persons alike. Rather, it seems to be typical for persons with low or average extrinsic motivation, but not for persons with high extrinsic motivation.

General Discussion

Two studies were conducted to investigate the effects of epistemological beliefs and epistemological attitudes on motivation and the use of epistemic strategies. In Study 1, the belief in separate knowing had indirect effects on strategic knowledge validation and consistency checking via the goal to develop an own point of view. In Study 2, the belief in uncertain knowledge enhanced the use of consistency checking strategies the more, the lower the participants scored in extrinsic motivation. A mediated moderation model established this effect to be mediated by specific epistemic curiosity. Of course, the results from both studies are correlational in nature and should be interpreted with caution.

In Study 1, the effect of separate knowing on consistency checking and knowledge-based validation strategies was only partially mediated by the goal to develop an own standpoint. In Study 2, the moderation of the relationship between uncertainty and consistency checking strategies by extrinsic motivation could only partially traced back to the undermining of epistemic curiosity by extrinsic motivation. These results call for an explanation that should be investigated in further research. With regard to the partial mediation in Study 1, it is conceivable that some persons high in separate knowing habitually employ epistemic strategies while reading without forming an explicit processing goal. The partial mediated moderation found in Study 2 might be explained by the fact that some students high in extrinsic motivation, albeit curious, deliberately abstain from attempts to satisfy their curiosity, but rather invest their time and effort into receptive processing. In learning contexts where epistemic processing is not instrumental for the attainment of goals (e.g., good grades), such a selective concentration on receptive processing

can be a rational strategy, since both types of processing seem to draw on the same cognitive resources (Richter, 2003).

In the research presented here we focused on certain dimensions of epistemological beliefs and certain kinds of motivational states for which relationships can be expected on theoretical grounds. Other epistemological beliefs (or configurations thereof) might affect epistemic strategies by other motivational states as well. Relativism, for example, as conceived by Kuhn (1991), might easily lead to indifference. From the perspective of a purely relativist epistemology, there is no way to evaluate the merits of a knowledge claim. Against the background such fundamental skepticism, effortful epistemic processing must seem superfluous.

A serious limitation the research reported here is that no measures of learning outcomes were included. Accordingly, both studies only traces the first part of the proposed mediational chains from epistemological beliefs to learning. Further research should complete the picture by taking effects of epistemic strategies on other kinds of learning processes and learning outcomes into account.

Moreover, future studies on the motivational and cognitive consequences of different epistemological beliefs should move from correlational analyses of self-report measures to a more process-oriented analysis. Techniques such as the think-aloud procedure can provide direct insights into the mediating motivational and cognitive processes involved when students with different subjective epistemologies are learning with texts (e.g., Hofer, 2004). In a think-aloud study, for example, a student high in separate knowledge might say something like “I really want to know whether this theory is true” (indicative for the adoption of an epistemic learning goal), followed some time later by a statement like “This argument does not fit within the rest of the text” (indicative of consistency checking). In contrast, a student low in certainty beliefs might express his or her curiosity and then show signs of epistemic strategy use. In combination with

informative measures of learning outcomes, such a process-oriented study would yield a strong test of the assumed relationships between epistemological beliefs, epistemic strategies, and learning.

References

Aiken, L.S., & West, S.G. (1991). *Multiple regression: Testing and interpreting interactions.* Newbury Park, CA: Sage.

Baron, R.M., & Kenny, D.A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*, 1173–1182.

Belenky, M.F., Clinchy, B.M., Goldberger, N.R., & Tarule, J.M. (1986). *Women's ways of knowing: The development of self, voice, and mind*. New York: Basic Books.

Berlyne, D.E. (1954). A theory of human curiosity. *British Journal of Psychology*, *45*, 256–265.

Berlyne, D.E. (1957). Conflict and information theory variables as determinants of human perceptual curiosity. *Journal of Experimental Psychology*, *53*, 399–404.

Berlyne, D.E. (1960). *Conflict, arousal, and curiosity*. New York: McGraw-Hill.

Berlyne, D.E. (1962). Uncertainty and epistemic curiosity. *British Journal of Psychology*, *53*, 27–34.

Bonjour, L. (2002). *Epistemology: Classic problems and contemporary responses*. Lanham, MD: Rowman and Littlefield.

Bråten, I., & Strømsø, H.I. (2005). The relationship between epistemological beliefs, implicit theories of intelligence, and self-regulated learning among Norwegian post-secondary students. *British Journal of Educational Psychology, 75*, 539-565.

Bromme, R. (2005). Thinking and knowing about knowledge: A plea for and critical remarks on psychological research programs on epistemological beliefs. In M. Hoffmann, J. Lenhard, & F. Seeger, (Eds.), *Activity and sign: Grounding mathematics education* (pp. 191-201). New York: Springer.

Buehl, M.M., & Alexander, P. (2001). Beliefs about academic knowledge. *Educational Psychology Review*, *13*, 325-351.

Cancelli, A.A., Duley, S.M., & Meredith, K.E. (1980). Subjective uncertainty as a predictor of specific exploration. *Journal of Psychology*, *104*, 3–9.

Deci, E.L., Koestner, R., & Ryan, R.M. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychological Bulletin*, *125*, 627–668.

Flavell, J.H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist, 34*, 906-911.

Galotti, K.M., Clinchy, B.M., Ainsworth, K.H., Lavin, B., & Mansfield, A.F. (1999). A new way for assessing ways of knowing: The Attitudes toward Thinking and Learning Survey (ATTLS). *Sex Roles, 40*, 745-766.

Hofer, B.K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology*, *25*, 378–405.

Hofer, B.K. (2001). Personal epistemology research: Implications for learning and teaching. *Journal of Educational Psychology Review*, *13*, 353–383.

Hofer, B.K. (2004). Epistemological understanding as a metacognitive process: Thinking aloud during online searching. *Educational Psychologist, 39*, 43-55.

Hofer, B.K., & Pintrich, P.R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing their relation to learning. *Review of Educational Research*, *67*, 88–140.

Kardash, C.A.M., & Scholes, R.J. (1996). Effects of preexisting beliefs, epistemological beliefs, and need for cognition on interpretation of controversial issues. *Journal of Educational Psychology*, *88*, 260–271.

King, P.M., & Kitchener, K.S. (1994). *Developing reflective judgment: Understanding and promoting intellectual growth and critical thinking in adolescents and adults*. San Francisco, CA: Jossey-Bass.

Kitchener, K.S. (1983). Cognition, metacognition and epistemic cognition. *Human Development, 26*, 222–232.

Köller, O. (2001). Mathematical world views and achievement in advanced mathematics in Germany: Findings from TIMSS population 3. *Studies in Educational Evaluation*, *27*, 65–78.

Köller, O., Baumert, J., & Neubrand, J. (2000). Epistemologische Überzeugungen und Fachverständnis im Mathematik- und Physikunterricht [Epistemological beliefs and scientific understanding in mathematics and physics instruction]. In R. Lehmann (Ed.), *TIMMS/III: Dritte internationale Mathematik- und Naturwissenschaftsstudie* (pp. 229-269). Opladen, Germany: Leske + Budrich.

Kuhn, D. (1991). *The skills of argument*. Cambridge, MA: Cambridge University Press.

Lepper, M.R. & Greene, D., & Nisbett, R.E. (1973). Undermining children's intrinsic interest with extrinsic rewards: A test of the "overjustification" hypothesis. *Journal of Personality and Social Psychology*, *28*, 129–137.

Loewenstein, G. (1994). The psychology of curiosity: A review and reinterpretation. *Psychological Bulletin*, *116*, 75–98.

MacKinnon, D.P., Lockwood, C.M., Hoffman, J.M., West, S.G., & Sheets, V. (2002). A comparison of methods to test mediation and other intervening variable effects. *Psychological Methods, 7*, 83-104.

Mason, L., & Boldrin, A. (2008). Epistemic metacognition in the context of information searching on the Web. In M. S. Khine (Ed.), *Knowing, knowledge and beliefs: Epistemological studies across diverse cultures* (pp. 377-404). New York: Springer.

Muis, K. R. (2004). Personal epistemology and mathematics: A critical review and synthesis of research. *Review of Educational Research*, *74*, 317–377.

Muis, K.R. (2007). The role of epistemic beliefs in self-regulated learning. *Educational Psychologist,* 42, 173-190.

Muller, D., Judd, C.M., & Yzerbyt, V.Y. (2005). When moderation is mediated and mediation is moderated. *Journal of Personality and Social Psychology*, *89*, 852–863.

Pieschl, S., Stahl, E., & Bromme, R. (2008). Epistemological beliefs and self-regulated learning with hypertext. *Metacognition and Learning, 3*, 17-37.

Preacher, K. J., Rucker, D. D., & Hayes, A. F. (2007). Addressing moderated mediation hypotheses: Theory, methods, and prescriptions. *Multivariate Behavioral Research*, *42*, 185–227.

Richter, T. (2003). *Epistemologische Einschätzungen beim Textverstehen* [Epistemic validation in text comprehension]. Lengerich, Germany: Pabst.

Richter, T., Schroeder, S., & Wöhrmann, B. (in press). You don't have to believe everything you read: Background knowledge permits fast and efficient validation of information. *Journal of Personality and Social Psychology*.

Schiefele, U., Streblow, L., Ermgassen, U., & Moschner, B. (2003). Lernmotivation und Lernstrategien als Bedingungen der Studienleistung: Ergebnisse einer Längsschnittstudie [Motivation to learn and learning strategies as predictors of academic achievement: results from a longitudinal study]. *Zeitschrift für Pädagogische Psychologie*, *17*, 185–198.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, *82*, 498–504.

Schommer, M. (1993). Epistemological development and academic performance among secondary students. *Journal of Educational Psychology*, *85*, 406–411.

Schommer, M. (2002). An evolving theoretical framework for an epistemological belief system. In B. K. Hofer & P. R. Pintrich (eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (S. 103–118). Mahwah, NJ: Erlbaum.

Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs in mathematical text comprehension: Believing it is simple does not make it so. *Journal of Educational Psychology*, *84*, 435–443.

Schroeder, S., Richter, T., & Hoever, I. (2008). Getting a picture that is both accurate and stable: Situation models and epistemic validation. *Journal of Memory and Language, 59*, 237-259.

Sobel, M.E. (1982). Asymptotic intervals for indirect effects in structural equations models. In S. Leinhart (Ed.), *Sociological methodology 1982* (pp.290-312). San Francisco: Jossey-Bass.

Trautwein, U., & Lüdtke, O. (2007). Epistemological beliefs, school achievement, and college major: A large-scale longitudinal study on the impact of certainty beliefs. *Contemporary Educational Psychology, 32*, 348-366.

Weinstein, C., & Mayer, R. (1986). The teaching of learning strategies. In M.C. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., pp. 315-327). New York: Macmillan.

Footnote

[1] Despite being related to epistemological beliefs, epistemic strategies per se are not part of learners' subjective epistemology. For this reason, we call these strategies "epistemic" (i.e., pertaining to knowledge) rather than "epistemological" (i.e., being part of epistemology).

Table 1:

Descriptive Statistics and Intercorrelations of All Continuous Variables in Study 1

			Correlations							
	M	*SD*	1	2	3	4	5	6	7	8
1 Connected Knowing [a]	5.11	0.83								
2 Separate Knowing [a]	4.32	0.89	.31***							
3 Prior Knowledge [b]	4.21	1.41	.00	.34***						
4 Amount of Arguments [b]	3.34	1.91	-.25**	.12	.03					
5 Standpoint Goal [b]	3.90	1.44	.01	.60***	.19***	.35				
6 Facts Goal [b]	5.30	1.55	.05	-.31***	-.17**	-.30	-.36***			
7 Consistency Checking [b]	4.77	1.13	.17*	.55***	.12*	.14	.59***	-.10*		
8 Knowledge-based Validation [b]	4.20	1.30	.21*	.35***	.29***	.22	.59***	-.36***	.41***	
9 Number of Semesters [b]	6.32	4.46	-.15	.41***	.35***	.27	.29***	-.38***	.11*	.21***

Note. [a] $n = 111$, [b] $N = 289$. *$p<.05$, ***$p<.001$ (one-tailed).

Table 2:

Summary of Hierarchical Regression Analyses (Study 1) for the Epistemic Strategies Consistency Checking and Knowledge-Based Validation with Distal Predictors (Step 1) and Distal Predictors plus Mediators (Step 2)

	Outcome variable *Consistency Checking*			Outcome variable *Knowledge-Based Validation*		
	B (SE_B)	t	ΔR^2	B (SE_B)	t	ΔR^2
Step 1						
Intercept (B_0)	1.31 (0.77)			0.40 (0.86)		
Separate Knowing	0.70 (0.13)	5.6***	.23	0.26 (0.14)	1.8*	.03
Connected Knowing	0.04 (0.13)	0.3	.00	0.28 (0.15)	1.9*	.03
Prior Knowledge	0.03 (0.07)	0.3	.00	0.26 (0.08	3.2**	.09
Amount of Arguments	0.06 (0.05)	1.2	.01	0.11 (0.06)	1.8*	.03
Model fit	R^2 =.31, F(4,105)=11.6, p<.001			R^2 =.23, F(4,105)=8.0, p<.001		
Step 2						
Intercept (B_0)	0.89 (0.91)			1.94 (0.96)		
Separate Knowing	0.34 (0.14)	2.5*	.06	-0.24 (0.14)	-1.7	.01
Connected Knowing	0.12 (0.12)	1.0	.01	0.39 (0.13)	3.0**	.05
Prior Knowledge	-0.05 (0.07)	-0.7	.00	0.12 (0.07)	1.6	.03
Amount of Arguments	0.01 (0.05)	0.2	.00	-0.01 (0.05)	-0.2	.00
Standpoint Goal	0.41 (0.08)	4.9***	.19	0.48 (0.09)	5.4***	.22
Facts Goal	0.06 (0.07)	0.8	.01	-0.19 (0.08)	-2.4*	.05
Model fit	R^2 =.44, F(6,103)=13.5, p<.001			R^2 =.46, F(6,103)=14.8, p<.001		

Note. *** p<.001, ** p<.01, * p<.05 (one-tailed).

Table 3:

Descriptive Statistics and Intercorrelations of All Variables in Study 2

			Correlations		
	M	*SD*	1	2	3
1 Uncertainty (15)	5.25	0.85	–		
2 Curiosity (15)	4.85	0.69	.31***	–	
3 Consistency Checking (7)	4.86	0.84	.22*	.60***	–
4 Extrinsic Motivation (4)	6.11	0.96	.16	.11	.13

Note. $N = 124$. *$p<.05$, ***$p<.001$ (one-tailed).

Table 4:

Summary of Hierarchical Regression Models (Study 2) for the Mediated Moderation Analysis with Belief in the Uncertainty of Knowledge as Distal Predictor, Curiosity as Mediator, Consistency Checking as Outcome Variable and Extrinsic Motivation as Moderator

	Outcome variable		
	Consistency Checking		
	B (SE_B)	t	ΔR^2
Step 1			
Intercept (B_0)	.04 (0.08)		
Uncertainty	.20 (0.08)	2.32*	.04
Extrinsic Motivation	.09 (0.09)	1.08	.00
Uncertainty × Extrinsic Motivation	-.29 (0.08)	-3.72***	.10
Model fit	R^2 =.16, F(3,120)=7.42, p<.001		
Step 2			
Intercept (B_0)	.03 (0.07)		
Uncertainty	.04 (0.08)	0.47	.00
Extrinsic Motivation	.06 (0.07)	0.83	.00
Uncertainty × Extrinsic Motivation	-.19 (0.08)	-2.54**	.03
Curiosity	.55 (0.08)	7.21***	.26
Curiosity × Extrinsic Motivation	-.01 (0.07)	-0.17	.00
Model fit	R^2 =.41, F(5,118)=16.69, p<.001		

Note. *p<.05, **p<.01, ***p<.001 (one-tailed).

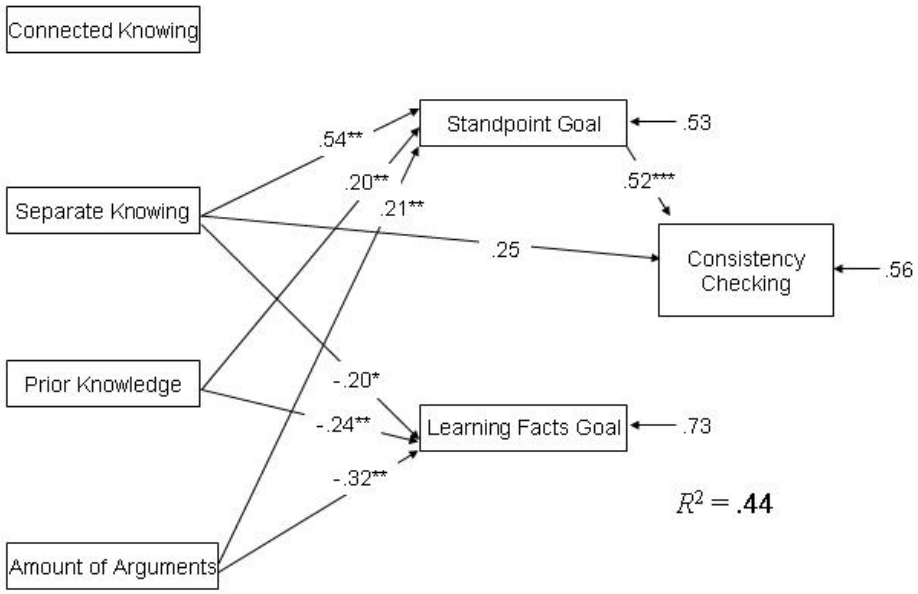
Figure captions

Figure 1. Mediation models (standardized coefficients) for the epistemic strategies consistency checking (a) and knowledge-based validation (b). Only paths with coefficients significantly different from zero are included.

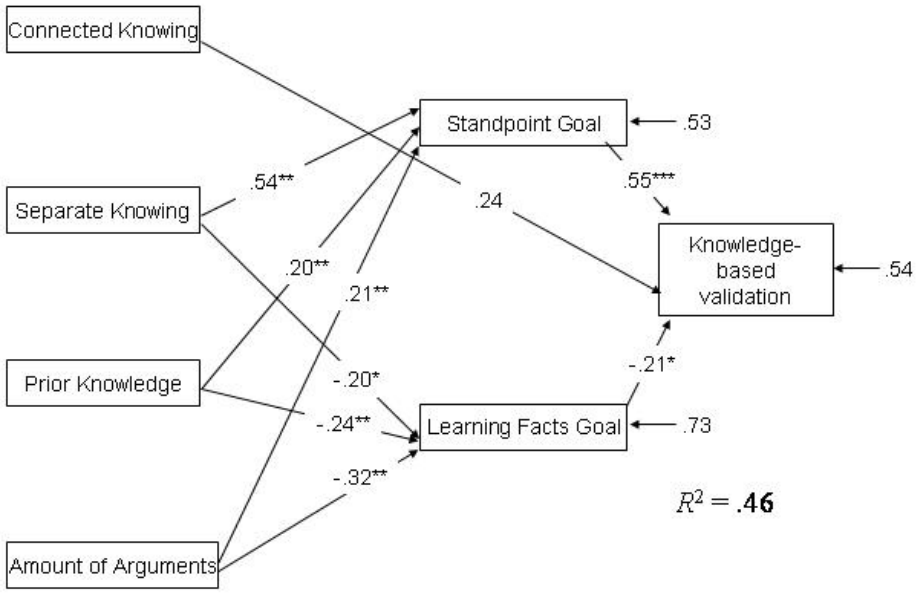
Figure 2. Use of epistemic strategies by the subject area of participants' studies (a) and by the text genre of the focal text (b).

Figure 3. Overall effect (a) and direct and indirect effects (b) in the mediated moderation model for the variables uncertainty, epistemic curiosity, consistency checking, and extrinsic motivation (standardized coefficients). Arrows pointing at other arrows indicate moderator effects.

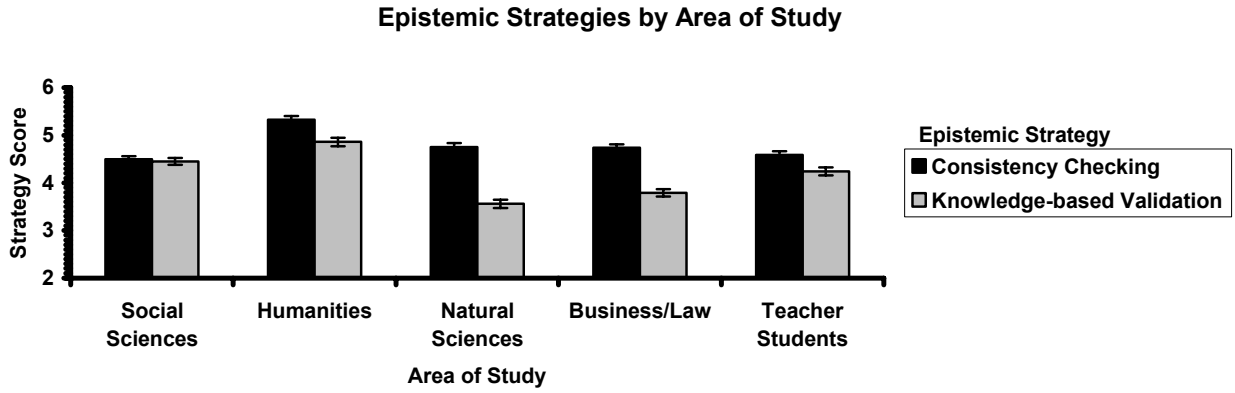
a)


Connected Knowing
Separate Knowing
Prior Knowledge
Amount of Arguments
Standpoint Goal
Learning Facts Goal
Consistency Checking
.54**
.20**
.21**
.25
-.20*
-.24**
-.32**
.53
.52***
.56
.73
$R^2 = .44$

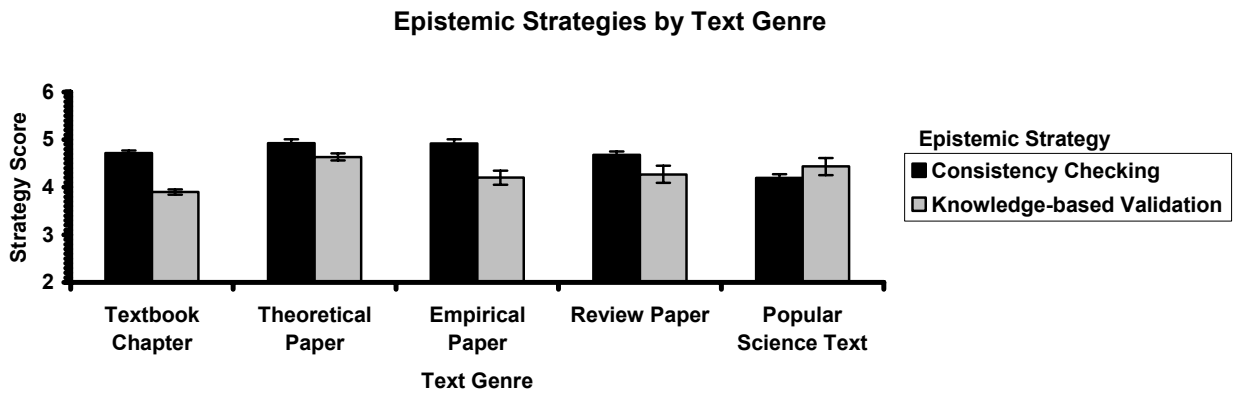
b)


Connected Knowing
Separate Knowing
Prior Knowledge
Amount of Arguments
Standpoint Goal
Learning Facts Goal
Knowledge-based validation
.54**
.20**
.21**
.24
-.20*
-.24**
-.32**
.53
.55***
-.21*
.54
.73
$R^2 = .46$

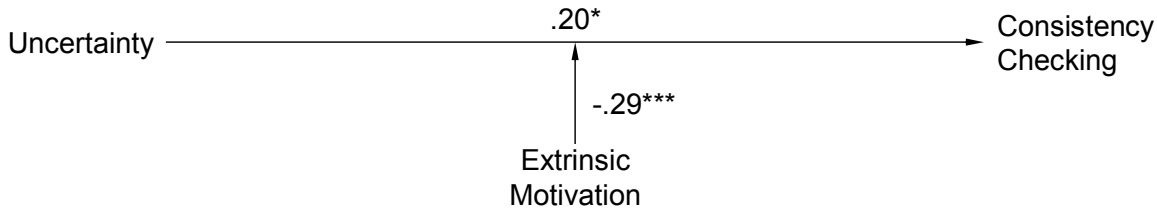
a)


Epistemic Strategies by Area of Study
Strategy Score
6
5
4
3
2
Social Sciences
Humanities
Natural Sciences
Business/Law
Teacher Students
Area of Study
Epistemic Strategy
Consistency Checking
Knowledge-based Validation

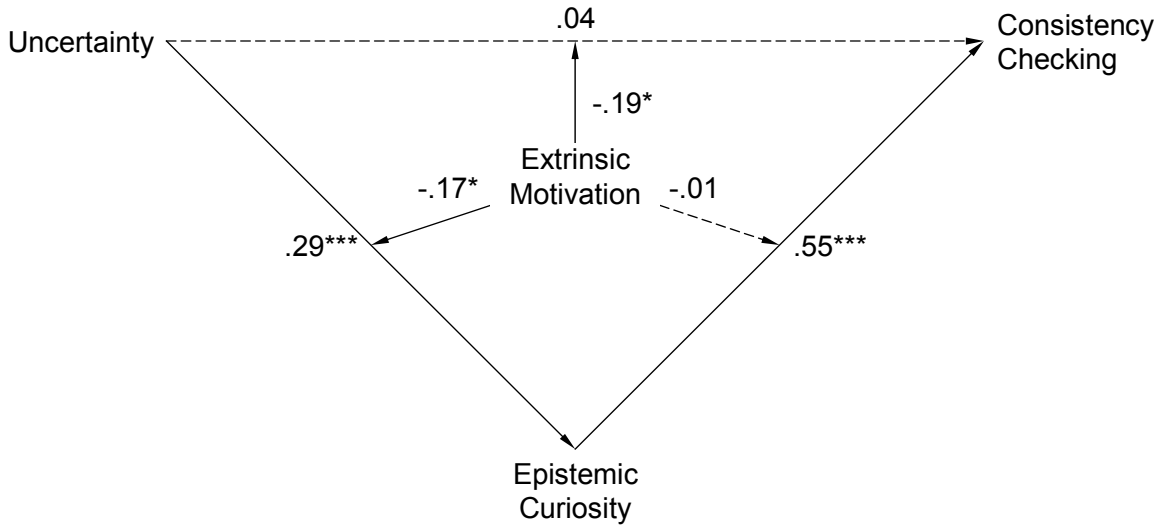
b)


Epistemic Strategies by Text Genre
Strategy Score
6
5
4
3
2
Textbook Chapter
Theoretical Paper
Empirical Paper
Review Paper
Popular Science Text
Text Genre
Epistemic Strategy
Consistency Checking
Knowledge-based Validation

a)


Uncertainty
.20*
Consistency Checking
-.29***
Extrinsic Motivation

b)


Uncertainty
.04
Consistency Checking
-.19*
Extrinsic Motivation
-.17*
-.01
.29***
.55***
Epistemic Curiosity