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STUDY HARDER? THE RELATIONSHIP OF ACHIEVEMENT GOALS TO ATTITUDES AND SELF-REPORTED USE OF DESIRABLE DIFFICULTIES IN SELF-REGULATED LEARNING

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Abstract
We examined whether achievement goal motivations differentially relate to students' attitudes and self-reported use of desirable difficulties in personal learning. We argue that different achievement goals correspond with different levels of mental engagement, inclination to elaborate on learning content, and invested effort. We hypothesized that cognitively effortful and long-term oriented learning strategies will be preferred by students with higher intrinsic motivation for deeper processing and less avoidance of necessary effort, and by those aiming for long-term skill acquisition rather than performance objectives. In line with these new predictions, students with higher mastery goal orientation reported positive attitudes and more application of desirable difficulties. By contrast, students with avoidance goal motivations were less favorable and indicated less usage; performance approach goals were unrelated. When considering all achievement motivations simultaneously as predictors, as expected, only mastery goals remained significant. This new finding was robust despite testing against an alternative, conceptually related construct: regardless of controlling for intrinsic cognitive motivation (need for cognition), mastery goal orientation still predicted attitudes and self-reported use of desirable difficulties. Implications for (self-regulated) learning processes are discussed.

Keywords: desirable difficulties; mastery goals; achievement motivation; need for cognition; self-regulated learning

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Introduction

A subject of high interest in current research on learning and memory is *desirable difficulties* (Bjork, 1994) because they have the potential to improve both classroom teaching and personal studying alike (Bjork & Bjork, 2011; Bjork & Kroll, 2015; Bjork, Soderstrom, & Little, 2015; Roediger & Karpicke, 2006). Desirable difficulties are cognitively effortful conditions that subjectively make learning harder: Rather than mere reception or demonstration, *self-generation* of learning materials requires the active generation of content (e.g., Bertsch, Pesta, Wiscott, & McDaniel, 2007; DeWinstanley & Bjork, 2004; Ebbinghaus, 1913; McDaniel, Waddill, & Einstein, 1988), whereas *generation of predictions* calls for in-depth processing and inferences rather than repetitions of solutions (Crouch, Fagen, Callan, & Mazur, 2004). Instead of mere memorization, *self-tests* foster active memory recall (testing effect, e.g., Butler, 2010; Roediger & Karpicke, 2006). Shuffling different but related learning topics - instead of separate considerations - is referred to as *interleaved learning* (e.g., Kornell & Bjork, 2008). *Distributed learning* or *spacing* temporally separates learning into smaller units rather than mass practice (e.g., Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006; Janiszewski, Noel, & Sawyer, 2003).

Implementing difficulties to facilitate learning is seemingly counter intuitive to teachers and students: both often try to eliminate challenges based on intuitions that easier learning is more effective (Bjork, Dunlosky, & Kornell, 2013; Chew, 2005, 2007; Koriat, 2008; Schommer-Aikins & Easter, 2006). Yet, strategic challenges can improve long-term learning, despite frequent errors and slow initial increases in performance because performance needs to be distinguished from the permanent advancements targeted in learning (Soderstrom & Bjork, 2015). Although hard to believe at face value, positive effects on multiple learning outcomes of various desirable difficulties have been repeatedly confirmed (e.g., distributed learning, Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006; generation-effect, Bertsch, Pesta, Wiscott, & McDaniel, 2007; testing effect, Roediger & Karpicke, 2006). Desirable difficulties support permanent improvements in comprehension, knowledge transfer, and long-term retention. Their positive effects are (partly) based on vigorous understanding and reflection of learning content by processing new information in terms of its associations, mapping of prior knowledge, and

fostering links to broader applications (Bjork, 1994; but also retrieval-induced forgetting, cf. Anderson, Bjork, & Bjork, 1994). As such, desirable difficulties can be categorized as deep learning, in contrast to shallow learning, predominantly relying on memorization and rehearsal (cf. Ramsden, 2003).

The adoption of deep versus shallow processing is influenced by multiple factors (Ramsden, 2003). General theoretical models of self-regulated learning identify cognitive-motivational factors (Boekaerts, 1999; Pintrich, 2000) as switches for a particular learning strategy, such as motivation, ability, and time (Schmitz, Landmann, & Perels, 2007). Nevertheless, much of the research on desirable difficulties has focused on cognitive performance variables broadly investigated in laboratory settings, such as recall and retention. Research objectives did not concentrate on dispositional differences in achievement goal motivations as potential moderators for attitudes, usage, or effectivity in learning. Yet, motivational processes affect learning (Dweck, 1986). Not every student may want learning to be hard, nor be willing to work through difficulties during their personal learning, even when it is to their benefit. Therefore, the present study concerns achievement goal motivations and their relationship to attitudes and the self-reported use of desirable difficulties in self-regulated learning.

Previous research has illuminated how varying motivations influence how much mental engagement and exerted effort students put into learning, and how they organize their personal learning. For example, students, who are motivated intrinsically by interest tend to adopt deep learning; students who utilize shallow learning tend to be driven by fear of failure or by the objective of achievement (Ramsden, 2003). Similarly, a lack of self-involvement contributes to fewer mobilized cognitive resources and to a means-to-an-end learning attitude (Pintrich & Garcia, 1994; Schmeck, Geisler-Brenstein, & Cercy, 1991). This research did not concern learning with desirable difficulties. Nevertheless, it suggests that achievement motivation and cognitively effortful learning approaches are associated. In the following, we will link the concept of achievement motivations to different levels of cognitive engagement, effort, and learning styles to elucidate its relationship with desirable difficulties. We will argue specifically that mastery goal motivation best matches the requirements and learning objectives of studying with desirable difficulties: that is, deeper elaboration on learning content, increased cognitive engagement, and

more invested effort with a focus on long-term skill development rather than (short-term) performance outcomes.

Older conceptions of achievement motivation distinguish two specific goal-orientations effective in the contexts of learning and competence. These dichotomies differentiate mastery goal motivation and performance goal motivation (e.g., Ames & Archer, 1988; Elliot & Dweck, 1988). The *mastery goal motivation* reflects people's intrinsic drive to understand and master learning content to increase their capabilities. The *performance goal motivation* describes people's instrumental drive to demonstrate their competences to others. Whereas mastery motivations are tied to personal growth and inherent task incentives, performance motivations are tied to personal achievements and outcome incentives. Later accounts divided performance goal motivation into *performance approach* and *performance avoidance* goals (Elliot, 2005; Elliot & Harackiewicz, 1996); either striving toward positive competence evaluations or away from negative ability judgments. Another category added describes a *work avoidance* motivation. It captures people's general motive to keep invested effort and workload at a minimum (e.g., Archer, 1994; Nicholls, Patashnick, & Nolen, 1985). Achievement motivations are distinctive categories that allow combinations of different motivational categories to be predominant in one person (e.g., high performance motivation and high mastery orientation). Depending on situational variables, one motivation state may be more activated (Yperen, Barga, & Postmes, 2015).

These achievement motivations predict students' cognitive and personal engagement, as well as their use of deep or surface learning strategies (Greene, Miller, Crowson, Duke, & Akey, 2004; Phan, 2009; Pintrich & Schunk, 2002). Learning is inherently meaningful to students with a high mastery orientation. They are intrinsically interested and personally involved in a task (Maehr & Midgley, 1996) to promote their personal and intellectual growth (Dweck, 1986). They aspire toward comprehension of learning content (Ames & Archer, 1987) and are highly elaborative and engaged thinkers (Meece, Blumenfeld, & Hoyle, 1988). They utilize effective learning strategies that are focused on elaboration, critical thinking, and metacognitive self-regulation (Kadioglu & Kondakci, 2014). As such, mastery goal motivation leads to deep cognitive processing of learning materials and to the use of deep learning strategies (Tickle, 2001). Moreover, students with a higher mastery goal prefer difficult over easy learning tasks, invest more time and effort in learning activities

(Ames & Archer, 1988; Harackiewicz, Barron, Carter, Lehto, & Elliot, 1997), and persist when faced with difficulties (Elliot, McGregor, & Gable, 1999; Valentini & Rudisill, 2006). Therefore, we suggest that students with higher mastery goals have all the prerequisites necessary for effectively learning with desirable difficulties, and they should be most appreciative regarding the benefit of desirable difficulties for long-term knowledge acquisition and skill-advancement.

This should not be true for students with higher performance goals. Desirable difficulties can lead to learning despite the absence of immediate performance gains (Soderstrom & Bjork, 2015). This learning type likely is not a motivating means to an end they seek because they strive for performance demonstrations and desire their associated (external) rewards (e.g., grades, awards). Although students with higher performance goals are willing to put effort into a learning task, and are persistent when faced with obstacles (Elliot, McGregor, & Gable, 1999), findings on task choices are less clear (harder vs. easier; Archer 1994). This is true for processing style and learning strategies as well: sometimes finding an association with cognitive engagement and deep (Diseth & Kobbeltvedt, 2010; Howell & Watson, 2007) or surface learning (e.g., Elliot, McGregor, & Gable, 1999; Sedaghat, Abedin, Hejazi, & Hassanabadi, 2011), or both (Kong & Hau, 1996; cf. Senko, Hulleman, & Harackiewicz, 2011). Hence, we do not expect a clear relationship between performance approach goals and desirable difficulties.

Students with higher performance avoidance goals aim to avoid mistakes or task failures, but learning with desirable difficulties is error prone due to its explorative and difficult nature (Björk, 1994). Moreover, worrying about task performance can bind cognitive resources, making them unavailable for deeper processing (Hayes, Hirsch, & Mathews, 2008). Research has repeatedly supported the link between surface processing and shallow cognitive learning strategies (e.g., memorization), and task disengagement (Liem, Nau, & Nie, 2008) with performance avoidance goals (e.g., Elliot, McGregor, & Gable, 1999; Howell & Watson, 2007; Vrugt & Oort, 2008). For students with performance avoidance goals, learning with desirable difficulties is incongruent with their aim to avoid negative outcomes that unravel their *in*competence, and which are unsuited for their predominantly shallow learning style. Similarly, work-avoidance goals go along with preferences for easy tasks, less effort, less cognitive engagement, and more shallow learning strategies (Archer, 1994;

Meece, Blumenfeld, & Hoyle, 1988; Suárez Riveiro, Cabanch, & Arias, 2001). Consequently, for both the performance avoidance and work avoidance goals, the association with desirable difficulties should be negative.

Objectives

Based on the rational above, individual differences in achievement motivation are tied to students' cognitive processing styles, approaches to, and goals for personal learning. As learning with desirable difficulties targets long-term skill development rather than (short-term) performance; is challenging and error-evoking; and requires deep cognitive engagement and much learning effort, we propose the following hypotheses:

1. Higher mastery goal motivations positively relate to attitudes and self-reported utilization of desirable difficulties.
2. Approach performance goals are not linked to attitudes and reported use.
3. Both avoidance performance motivation and work avoidance motivation are negatively associated with attitudes and self-reported implementation of desirable difficulties in personal learning.
4. Compared to the other achievement motivations, mastery goal motivation demonstrates the strongest and most robust relationship to attitudes and reported use of desirable difficulties.

In order to test our hypotheses, we first created two separate scales for measuring attitudes and self-reported use of desirable difficulties. Affective and cognitive aspects of attitudes were captured (cf. Kruglanski & Stroebe, 2005). When examining our hypotheses, we also checked for simultaneous but independent relationships of the different achievement motivations on attitudes and reported use of desirable difficulties. To bolster our results, we tested against an alternative explanation by including the concept of need for cognition (NFC) into the analyses. This personality variable recently has been linked to increased mastery orientation (Day, Espejo, Kowollik, Boatman, & McEntire, 2007).

Method

Participants

Ninety-seven individuals (80 females) with an average age of 23.68 (SD=5.67) completed our study administered as an online questionnaire. The

majority were psychology students (n=65) of the University of Kassel; four were external employees. All respondents were unpaid volunteers. However, psychology students were compensated with partial course credit in exchange for their participation. Respondents were recruited via advertisement and the university's internal participant pool.

Materials and Procedure

If respondents had registered for the study, they received access to the survey via an online link. After consenting, respondents answered questions regarding their need for cognition, followed by an assessment of their general learning strategies. They further indicated their learning goal and performance motivations before completing the desirable difficulties scale and demographics questions.

Achievement goal motivation. We included a German scale on learning goal orientation and academic performance motivation (SELLMO; Spinath, Stiensmeier-Pelster, Schöne, & Dickhäuser, 2002). The scale measures students' mastery learning orientation and performance motivations that are effective for learning strategies and learning outcomes. Items presented statements on a 5-point Likert-type scale (1: *totally disagree*, 5: *totally agree*), comprising the subscales for mastery motivation (Cronbach's α=.79), approach-oriented performance motivation (Cronbach's α=.83), avoidance-oriented performance motivation (Cronbach's α=.90), and work-avoidance motivation (Cronbach's α=.92).

For example, mastery motivation items inquired about students' aims to learn interesting new content, to solve problems, or to deeply understand content (e.g., "In my studies, I really want to understand things"). Approach-oriented learning motivations covered motivations to perform better than other students, to demonstrate one's competence and knowledge, or to master content (e.g., "In my studies, I want to achieve better grades than others"). Avoidance-oriented learning motivations entailed avoiding being perceived as incompetent by others, avoiding failure, or displaying a lack of mastery (e.g., "When it comes to my studies, I don't want to embarrass myself with stupid questions or wrong answers"). Work-avoidance items targeted the tendency to avoid learning effort and difficult tasks (e.g., "When it comes to studying, I generally want to keep my work load to an absolute minimum").

Need for cognition (NFC). Participants responded to the German version of the need for cognition scale (Bless, Wänke, Bohner, Fehllhauer, & Schwarz, 1994). Assessed on a 7-point Likert-type scale, 33 items (1: *disagree*, 7: *totally agree*) were presented (Cronbach's α=.92). A sample item was, "I find it especially satisfying to complete an important task that requires a lot of thinking and mental effort".

Desirable difficulties scales. Until now, no measure capturing attitudes toward and self-reported use of desirable difficulties in self-regulated learning existed. Therefore, personal learning was assessed by 10 items on attitudes toward desirable difficulties, as well as five items on the self-reported use thereof. Measurements were made on a 7-point Likert-type scale (1: *totally disagree*, 7: *totally agree*). Both scales covered five types of desirable difficulties: self-generation of information, learning materials, and content; self-directed generation of predictions and problem solutions inferred from learning content; self-testing of learned information; distributing learning content across time rather than mass learning of material; interleaving topics rather than blocking of similar learning contents.

Sample items of *attitudes* regarding interleaved learning read: "Splitting and mixing of learning content make my exam preparation comfortable" and "I think it makes economic sense to mix several topics when it comes to learning." Items regarding attitudes toward the formulation of predictions/hypotheses were: "I enjoy predicting solutions" and "I think I remember things better if I try to deduce the solution myself." Accordingly, items of both types for self-reported use were: "When I study, I mix topics in a targeted manner" and "Prior to looking up the solution, I generate the answer myself". We separately analyzed the 10 items of the attitude scale (Cronbach's α=.75) and the five items of the scale on self-reported usage (Cronbach's α=.54).

Results

To test our hypotheses, we first computed the correlations depicted in Table 1 based on Kendal's Tau, followed by hierarchical regression analyses shown in Table 2. The regression model effect sizes are based on R^2 as a proportion of accounted variance by a computed model given the total variance of the dependent variable; the effect sizes for the unique contributions in

explained variance for each regression coefficient are represented by the squared semi-partial correlations, sr^2. Note that Kendal's Tau and the aforementioned parameters can be converted into other effect size metrics (e.g., Walker, 2003). The confidence intervals (95%) are only mentioned in the text, not in the tables.

Examining the correlation pattern yielded the following expected results: attitudes and self-reported use of desirable difficulties positively correlated with mastery goals (r=.37 resp. *r*=.26; both *p*s<.001), whereas they correlated negatively with performance avoidance (r=-.14, resp. *r*=-.18; both *p*s<.05), and work avoidance goals (r=-.25, resp. r=-.27; both *p*s<.001). These findings supported H1 and H3. Also, as predicted, performance approach motivation was unrelated to desirable difficulties (H2; r=.06, resp. r=.01, both *p*s=ns.). It is important to note that mastery goals and NFC are sizably associated (r=.41, *p*s<.001), and that NFC positively correlates with attitudes and self-reported usage of desirable difficulties (r=.27, *p*<.001, resp. r=.18, *p*<.05). Given this interrelation, NFC may represent a potent third variable that actually explains the relationship between mastery goals and desirable difficulties. To clarify and to test H4, we conducted further investigations on the standardized variables. By means of hierarchical regression analyses, we first predicted attitudes toward desirable difficulties, followed by a separate calculation for self-reported usage (*see* Table 2).

Table 1. Correlations of attitudes and use of desirable difficulties with predictor variables

Variable	1	2	3	4	5	6	M	SD
1. Attitudes	-						5.10	.81
2. Self-reported use	.61***	-					4.86	.96
3. Mastery goals	.37***	.26***	-				4.20	.49
4. Approach goals	.06	.01	-.05	-			2.95	.82
5. Avoidance goals	-.14*	-.18*	-.24**	.33***	-		2.22	.86
6. Work Avoidance	-.25***	-.27***	-.37***	.15**	.44***	-	2.00	.81
7. NFC	.27***	.18*	.41***	-.05	-.33***	-.34***	4.84	.78

Note: Desirable difficulties and NFC are measured on 7-point scales; achievement goals on 5-point scales. Bivariate correlation coefficients are based on Kendal's Tau, N=97; *p<.05; **p<01; ***p<.001 (two-tailed)

Table 2. Hierarchical regression of achievement goal motivations and NFC on Desirable Difficulty Scales

	Attitudes				Self-reported use			
Variable	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Mastery goals	.56***	.45***	.46***	.45***	.46***	.44***	.44***	.37***
NFC		.18†	.18	.17		.02	-.04	-.07
Approach goals			.11	.12			.10	.10
Avoidance goals			.00	.01			-.16	-.10
Work avoidance				-.04				-.19
R^2	.31	.33	.35	.35	.21	.21	.23	.25
Adjusted R^2	.31	.32	.32	.31	.20	.19	.19	.20
ΔF	43.33***	2.93	.97	.11	25.10***	.04	.96	2.46
ΔR^2	.31	.02	.01	.00	.21	.00	.02	.02

Note: Regression coefficients show the standardized beta values, †p <.10; *p<.05; **p<.01; ***p<.001 (two-tailed)

Attitudes toward desirable difficulties

To examine the mere effect of mastery goals on attitudes, our first model contains only mastery goal motivation. The second model is extended by NFC to test whether NFC acted as a third variable, or whether both are independent predictors. The following two models were computed to test H4; whether mastery orientation is indeed the strongest and most relevant goals motivation for desirable difficulties. Scrutinizing its robustness, we subsequently entered both performance motivations in Model 3, followed by the work-avoidance motivation in Model 4 (*see* Table 2).

As expected, higher mastery goals resulted in more favorable attitudes toward desirable difficulties, ß=.56, $t(95)=6.58$, $p<.001$, 95% CI [.39, .73], $sr^2=.31$, in Model 1 ($F(1, 95)=43.33$, $p<.001$, $R^2=.31$). This effect remained stable in Model 2 despite controlling for NFC as an alternative explanatory factor, ß=.45, $t(94)=4.35$, $p<.001$, 95% CI [.25, .66], $sr^2=.13$; $F(1, 94)=23.58$, $p<.001$, $R^2=.33$. Yet, NFC was not significant (ß=.18, $t(94)=1.71$, $p=.09$, 95% CI [-.03, .38], $sr^2=.02$). Subsequently entering both performance motivations (approach and avoidance) in Model 3 ($F(1, 92)=12.27$, $p<.001$, $R^2=.35$) did not alter the mastery goal's effect, ß=.46, $t(92)=4.40$, $p<.001$, 95% CI [.25, .67], $sr^2=.14$. Neither approach performance motivation (ß=.12, $t(92)=1.21$, $p=.23$, 95% CI [-.08, .31], $sr^2=.01$) nor avoidance motivation were significant (ß=.00, $t(92)=.08$, $p=.99$, 95% CI [-.22, .22], $sr^2=.00$). The effect of mastery goals,

ß=.46, $t(92)=3.95$, $p<.001$, 95% CI [.22, .67], $sr^2=.11$, holds even in Model 4 ($F(1, 91)=9.74$, $p<.001$, $R^2=.35$), when work-avoidance goals were taken into account (ß=-.04, $t(91)=-.32$., $p<.001$, 95% CI [-.26, .19], $sr^2=.00$). These results support H4. They indicate that mastery orientation is the clarifying factor behind attitudes toward desirable difficulties, even when statistically controlling for the other variables. As such, it is not surprising that including the aforementioned non-significant variables in the models did not improve the explained variance in attitudes, ΔR^2 = ns. In fact, 31% of the variance in attitudes toward desirable difficulties was explained by mastery goal orientation.

Self-reported use of desirable difficulties

Mirroring the prior analyses, an examination of self-reported usage yielded similar findings, again supporting H4 (*see* Table 2). Mastery goals were a significant predictor of self-reported usage, ß=.46, $t(95)=5.01$, $p<.001$, 95% CI [.28, .64], $sr^2=.21$, in Model 1 ($F(1, 95)=25.09$, $p<.001$, $R^2=21$). The variable accounted for 21% of the variance by itself. Entering NFC in Model 2 had no effect, ß=.02 $t(94)=.19$, $p=.85$, 95% CI [-.20, .25], $sr^2=.00$, whereas the positive relationship of mastery goals with usage of desirable difficulties remained strong, ß=.44, $t(94)=3.90$, $p<.001$, 95% CI [.22, .67], $sr^2=12$. This is also true in Model 3 ($F(1, 92)=6.69$, $p<.001$, $R^2=.23$), neither performance approach motivation (ß=.10, $t(92)=.92$, $p=.36$, 95% CI [-.11, .31], $sr^2=.01$) nor performance avoidance motivation (ß=-.16, $t(92)=-1.35$, $p=.18$, 95% CI [-.40, .08], $sr^2=.02$) were significant predictors, yet mastery goals positively related to use of desirable difficulties, (ß=.44, $t(92)=3.83$, $p<.001$, 95% CI [.21, .66], $sr^2=.12$). This pattern is the same in Model 4 ($F(1, 91)=5.93$, $p<.001$, $R^2=25$; $ß_{mastery}=.37$, $t(91)=3.00$, $p<.01$, 95% CI [.12, .61], $sr^2=.08$), when entering work-avoidance goals (ß=-.19, $t(91)=1.56$, $p=.12$, 95% CI [-.43, .05], $sr^2=.02$). From Model 2 to Model 4, all ΔR^2=ns. Thus, the higher respondents' mastery goals were - irrespective of other present achievement motivations - the more they reported utilizing desirable difficulties in their personal learning.

Conclusions

For the first time, we linked the concept of achievement goal motivations to desirable difficulties in self-regulated learning. Based on the

notion that individual differences in learning goal motivations relate to varying levels of personal and cognitive engagement, learning styles, and effort, we argued that a mentally challenging and error-prone learning strategy focused on long-term skill acquisition matches best with students who have a higher inclination for deeper cognitive processing, willingness to work hard, intrinsic interest in learning, and focus on personal competence development. Given this framework, we derived and supported several hypotheses.

Higher mastery goal motivations were positively linked to attitudes and self-reported use of desirable difficulties in personal learning, whereas performance approach motivations were unrelated (H1 and H2). In addition, both avoidance motivations (performance avoidance and work avoidance) negatively related to stated attitudes and to the use of desirable difficulties (H3). When simultaneously taking all achievement goals into account, mastery goal orientation was most relevant for predicting attitudes and the use of desirable difficulties. In students with multiple goal orientations, the enhancement of mastery goals is beneficial for learning with desirable difficulties. For example, increasing the mastery motivation in a student with performance avoidance may help to shift the concern over portraying one's ability instead toward personal growth and learning from errors.

Importantly, the predictive power of mastery goals was robust against a potential third variable and an alternative concept capable of confounding the relationship: need for cognition. Statistically controlling for its influences clearly showed the dominance of intrinsic learning goals over intrinsic cognitive motivation (H4). Generally, these findings show how attitudes toward desirable difficulties, such as personal learning strategy, relate to differing achievement goals. Besides, attitudes also relate to behavior - the more favorable students' attitudes, the more they indicated the use of desirable difficulties. Our findings were remarkably consistent across both attitudes and self-reported usage, speaking to the clarity of the relationship. This further suggests a sizable link between attitudes and behavior.

However, we did not record actual behavior in terms of which learning strategy students with varying achievement goals applied. This is a limitation of the current study, due to the self-report nature of the survey format. In future studies, it would be worthwhile to observe learning and learning outcomes: are desirable difficulties indeed more frequently selected by mastery goal-oriented students and less by avoidance-oriented students? How are the application of

desirable difficulties and learning performance related with respect to achievement goals? Are they more effective for one type of goal-oriented learner relative to others? Apart from answering these questions, assessing actual behavioral choices would help to strengthen and support our findings on the self-reported scale for usage of desirable difficulties. The reliability of the scale was surprisingly low. However, the scale contained only 5 items, and reliabilities improve for a higher number of items and higher intercorrelations (Lance, Butt, & Michels, 2006). Since each item reflected one type of desirable difficulty, the low alpha value may point toward a multi-dimensional factor structure. To examine this, generating more behavioral items would aid toward the goal of conducting a factor analyses (cf. Raubenheimer, 2004), and replicating the present findings.

It would be valuable to manipulate achievement goal motivations and look at their behavioral and cognitive effects on preferences, application, and outcomes of desirable difficulties. This research would be particularly relevant for practical applications in self-regulated learning and classroom learning. Instructions may have the potential to activate more beneficial learning goals according to a certain learning strategy. For example, learning with desirable difficulties may be most fruitful under mastery orientation. If instructions prior to a learning task emphasize elaboration of content, understanding, and improvement of one's abilities, than an advantageous mastery orientation could be triggered (cf. Nicholls, 1989); however, instructions emphasizing extrinsic rewards foster a performance orientation (Maehr, 1984). Nevertheless, when approach performance goals were enriched with mastery goals, they also triggered adaptive learning (Pintrich, 2000). Another interesting question would be whether students instructed to self-set a certain learning or achievement goal prior to learning choose a different type of learning strategy that matches this predetermined goal (e.g., does mastery orientation lead to more choices of desirable difficulties?). Finally, making students aware of their goals and predominant processing styles may help them to find their most suited learning strategy for their personal studies.

When implementing desirable difficulties in their teachings, practitioners may be generally advised to create a mastery-oriented learning atmosphere by framing learning goals and instructions. For example, learning could be framed as a means to personal growth instead of a (personal) grade competition, and errors as learning events instead of ability feedback.

Instructions during class may emphasize inquiry, active intellectual participation, and advancement in understanding over giving the right answers, as well as appreciating others for their input and not judging them for their questions and mistakes. Although not everyone may be accepting of desirable difficulties or receptive to goal setting interventions in the classroom, teachers nevertheless could aid self-regulated learning at home. Across the board, they may help their students to identify their personal learning goals, and inform them about appropriate learning approaches and techniques as well as how to foster learning outcomes. In doing so, teachers could support students' pursuit of goal-driven choices for learning through suitable self-regulation and study strategies.

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