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Predicting undergraduate students' learning from a lecture: The role of self-control, motivation, and mental effort

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ACADEMIC ABSTRACT

For the first time, the present study investigated the combined role of self-control, motivation, and mental effort in predicting undergraduate students' learning from a two-hour presentation-format higher education lecture. The study comprised 62 students, in a final-year BSc undergraduate Sports Coaching lecture, who completed questionnaires measuring: state self-control during the lecture; mastery approach and performance avoidance motivation towards learning the course topic; mental effort invested during the lecture; and content retention immediately after the lecture (i.e., learning). Moderated mediation analyses revealed that greater levels of state self-control (W variable) were necessary for students to transform their motivation (X variable; mastery approach or performance avoidance) into mental effort (M variable) to benefit their learning (Y variable) during the lecture. Avenues for applied interventions to motivate students and increase their self-control resources within higher education environments are discussed.

PRACTICAL ABSTRACT

The present study investigated the combined effect of various psychological factors on undergraduate students' learning from a lecture; these factors comprised self-control (i.e., their ability to override impulsive behaviours), motivation (i.e., their drive to achieve), and mental effort (i.e., how hard

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they focus/concentrate). A total of 62 students took part in a 2-hour long lecture, completed questionnaires on the aforementioned psychological factors, and completed a test immediately after the lecture to assess their learning. Statistical analyses revealed that greater levels of self-control were necessary for students to transform their motivation into mental effort to benefit their learning. Potential applied interventions to motivate students and increase their self-control resources within educational environments are discussed.

Keywords: Education, Higher Education, Lecture, Motivation, Ego-depletion, Learning, Self-control, Teaching

Self-control is suggested to be a global resource that can be utilized and depleted in tasks that require behavioral control (Baumeister, Vohs, and Tice, 2007; Baumeister, Bratslavsky, Muraven, and Tice, 1998). Although the exact psychophysiological origins of this resource are still subject to considerable debate (Kurzban, Duckworth, Kable, and Myers, 2013), low self-control resources are associated with numerous impulse-control deficient behaviors such as binge-eating, alcohol abuse, impulsive buying, and committing crime (Moffitt et al., 2011; Tangney, Baumeister, and Boone, 2008; Vohs and Faber, 2007). Within education settings, greater self-control resources generally contribute towards improved acute test performance and long-term academic achievement (Englert and Bertrams, 2017; Véronneau, Hiatt Racer, Fosco, and Dishion, 2014; Watts, Duncan, and Quan, 2018). For example, Englert and Bertrams (2017) found that students who had their state self-control resources experimentally depleted prior to a five-minute task where functions of the eye had to be memorized in a laboratory setting, recalled less functions compared to students with unaltered state self-control resources. Similarly, Véronneau et al. (2014) found that self-control at age 17 predicted future educational attainment at age 23–5. However, to our knowledge, a pertinent research lacuna remains; no prior study has investigated how state self-control resources influence acute learning over the course of a traditional higher education lecture (i.e., verbal presentation-format and approximately two hours long). Elucidating this lacuna would have important applied implications for teaching at higher education.

A factor necessary of consideration when addressing the aforementioned research lacuna is motivation; motivation may interact with self-control to

predict lecture learning. Motivation to achieve academic goals has been conceptualized into a two-dimensional framework by Elliot and McGregor (2001) comprising the following facets: mastery approach (focused on gaining task/content competence), mastery avoidance (focused on avoiding task/content incompetence), performance approach (focused on gaining competence relative to peers), and performance avoidance (focused on avoiding incompetence relative to peers). Prior research investigating the interaction between self-control and motivation (using a unidimensional measure of motivation) on cognitive tasks observed that the decremental effects of self-control depletion were attenuated by heightened motivation (Muraven and Slessareva, 2003; Vohs, Baumeister, and Schmeichel, 2012). Specifically, Muraven and Slessareva (2003) found that self-control depleted participants who had their motivation increased by being told a task would benefit them or others, performed better than self-control depleted participants who were not told this.

Aim and hypothesis

The aim of our study was to investigate how state self-control and motivation (mastery approach and performance avoidance) influence acute learning from a 'traditional' higher education lecture (i.e., presentation-format and 2 hours long). We reasoned that mastery approach motivation and performance avoidance motivation would be the most informative dimensions: given their relatively high correlation with mastery avoidance motivation and performance approach motivation respectively, and relatively low correlation with each other (Elliot and Murayama, 2008). We hypothesized a moderated mediation model a-priori, wherein greater motivation (mastery approach or performance avoidance) positively predicts lecture learning, provided students have sufficient state self-control available to convert their motivation into effort and consequently lecture learning. In essence, individuals may report a strong motivation to perform better academically (i.e., as part of a desire for mastery or normative competence) but require sufficient self-control to convert their motivation into effort that would benefit learning during a lecture.

Method

Participants

Participants comprised a convenience sample of Bangor University (North Wales, UK) final-year BSc undergraduate students attending a two-hour lecture on sport coaching practice. Participants were recruited from this lecture for sample-size purposes; it featured the largest number of bachelor's degree students in the school that year. Of the 86 students in attendance, 62 participants volunteered to take part and completed all questionnaires (M_{age}=22.350, SD_{age}=3.273; Male=42, Female=20). Our study was conducted in accordance with institutional guidelines for research involving human participants.

Procedure and measures

After giving informed consent at the beginning of the lecture, participants were asked to complete the achievement goal questionnaire-revised AGQ-R (Elliot and Murayama, 2008) and short state self-control scale (SSCS) (Ciarocco, Twenge, Muraven, and Tice, 2007) questionnaires. The AGQ-R is one of the most frequently/widely used measures of motivational achievement goals (Huang, 2011) and was used to assess participants' motivation to learn the lecture's course topic. For the purpose of the present study, the opening AGQ-R instruction was modified to read: 'Please circle the number that indicates how much each of the following statements reflect how you feel towards the Skill Acquisition module'. On a 1 (not at all) to 5 (very much) Likert scale, participants answered 12 items comprising 4 subscales (3 items per subscale): namely, mastery approach (e.g., 'My aim is to completely master the material presented in this class'), mastery avoidance (e.g., 'I strive to avoid an incomplete understanding of the course material'), performance approach (e.g., 'My goal is to perform better than the other students'), and performance avoidance (e.g., 'My aim is to avoid doing worse than other students') (the AGQ-R subscales' respective Cronbach ?s for the present dataset = .813, .757, .847, and .793). For the purpose of this study and in line with the a-prior hypothesis, only the mastery approach motivation and performance avoidance subscales were analysed and reported. To our knowledge, the SSCS is currently the only state self-control measure to have undergone validation and is

frequently used within psychological (Graham et al., 2017) and educational research (Bertrams et al., 2016); in the present investigation, it was used to assess participants' state self-control. On a 1 (not true) to 7 (very true) Likert scale, participants answered 10 items (e.g., 'I can't absorb any information') (Cronbach ? for the present dataset = .640). Participant scores on the SSCS were reversed during analysis to aid interpretation of results; higher scores reflected higher state self-control.

The lecture delivery commenced approximately 10 minutes into the two-hour session once all participants gave informed consent and completed the AGQ-R and SSCS. The lecture delivery took one hour and 30 minutes and consisted of a verbal-presentation by the lecturer accompanied by Microsoft PowerPoint slides.

Immediately after the lecture content delivery, participants remained seated in the lecture hall and completed the rating scale of mental effort (RSME) (Zijlstra, 1993), SSCS (Ciarocco et al., 2007), and a custom lecture content questionnaire. Firstly, the RSME assessed how much cognitive effort (i.e. focus) participants invested into the lecture. It comprised a 1 to 150 vertical scale with 9 anchors starting from 3 (no mental effort at all) to 114 (extreme mental effort). Secondly, the SSCS was administered again to assess participants' state self-control after the lecture (Cronbach's α for the present dataset = .708). Finally, a custom lecture content questionnaire assessed participants' immediate retention of lecture content. It comprised 10 items (e.g., 'Based on the research covered in class, which model would yield the best observational learning for a skilled male athlete?') with four options each (e.g., A, Skilled female; B, Skilled male; C, Novice male; D, Don't know). Of each set of options: one option was the correct answer to the question; two options were incorrect answers; and a final option was entitled 'don't know' to stop participants correctly guessing answers and reduce measurement error. The number of correct answers were tallied for each participant to provide a measure of immediate lecture content retention.

It was reasoned that a two-hour lecture may tax central executive functions in a similar manner to established laboratory-based ego-depleting tasks (for examples, see Muraven, Tice, and Baumeister, 1998; Muraven and Baumeister, 2000; Englert and Bertrams, 2012; Englert, Bertrams, Furley, and Oudejans, 2015): substantially reducing state self-control over a two-hour lecture. Therefore, a mean between the pre and post-lecture SSCS scores was calculated to provide an approximation of participants' self-control during the lecture (herein referred to as 'state self-control').

Mean state self-control was chosen because: pre-lecture SSCS may overestimate state self-control during the lecture; post-lecture SSCS may underestimate state self-control during the lecture; and pre-post lecture change in SSCS may not reveal how depleted participants really were during the lecture.

Analysis

All analysis was performed using SPSS Statistics 24 (IBM) and PROCESS Macro V3.2 (Hayes, 2018). Firstly, means, SDs, and zero-order two-tailed Pearson correlation coefficients were calculated for mastery approach, performance avoidance, state self-control, mental effort, and lecture content retention. Secondly, moderation analysis was performed twice either with mastery approach or performance avoidance as the predictor (X), self-control as the moderator (W) and lecture content retention as the criterion (Y). Finally, moderated mediation analysis was performed twice with either mastery approach or performance avoidance as the predictor (X), mental effort as the mediator (M), self-control as the moderator (W) on the 'a path', and lecture content retention as the criterion (Y). Parametric assumptions for these regression analyses were satisfied.

Results

Inferential statistics interpretation

The traditional use of p-values for significance testing has received ample criticism for being arbitrary, excessively dichotomous, and at risk of neglecting important hypothesized effects that do not reach the alpha threshold due to (sometimes inevitable) noise in the dataset (Greenland et al., 2016; Hazra, 2017; Ludwig, 2005; Ranstam, 2012). In essence, a p-value assumes the null hypothesis to be true and provides a measure for how likely a similar/stronger relationship between variables is via measurement error alone; thus, a smaller p-value provides further confidence to findings but should not be used as an arbitrary cutoff for the 'correctness' of obtained hypothesized effects. Therefore, during the interpretation of our results, particular emphasis is given to the data's confidence intervals and coherence with our a-priori hypothesis, rather than the attainment of

an arbitrary p-value cutoff; such an approach is in line with the recommendations of Wasserstein et al. (2019) (see also Matthews, 2019) and education-based literature utilizing similar approaches (e.g., Klinker et al., 2020).

Primary analysis: Moderated mediation

Moderated mediation analysis with mastery approach motivation as the x variable is displayed in Figure 1. In line with our hypothesis, mental effort's mediation effect on lecture content retention was moderated by state self-control. Specifically, at higher levels of state self-control, this indirect effect on lecture content retention was more positive, stronger, and did not include 0 within its confidence interval (+1 SD self-control = 90% CI[.04, .58]; 0 SD self-control = 90% CI[.12, .86]; -1 SD self-control = 90% CI[-.30, .46]).

Moderated mediation analysis with performance avoidance motivation as the x variable is displayed in Figure 2. Again, in line with our hypothesis, performance avoidance motivation's effect on lecture learning via mental effort was moderated by state self-control. At higher levels of state self-control, the indirect effect on lecture content retention was more positive and stronger (+1 SD self-control = 90% CI[-.13, .42]; 0 SD self-control = 90% CI[-.20, .11]; -1 SD self-control = 90% CI[-.42, .01]). However, contrary to mastery approach motivation, performance avoidance

Figure 1. The indirect effect of mastery approach motivation on lecture content retention via mental effort as moderated by state self-control. Mean centering for the construction of products was performed and all reported path coefficients are unstandardized regression weights. Confidence intervals are BCa bootstrapped based on 10,000 samples. ⋆p<.1, ⋆⋆p<.05, ⋆⋆⋆p<.01

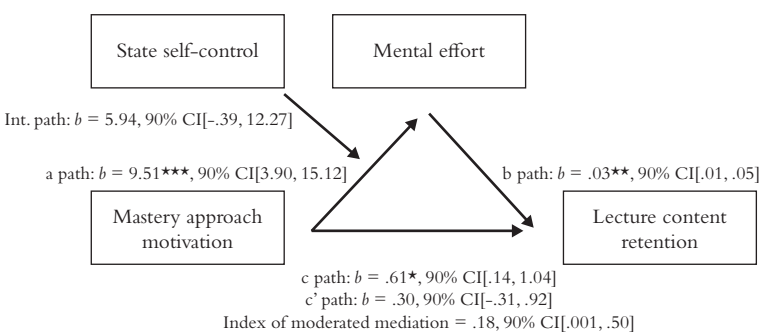
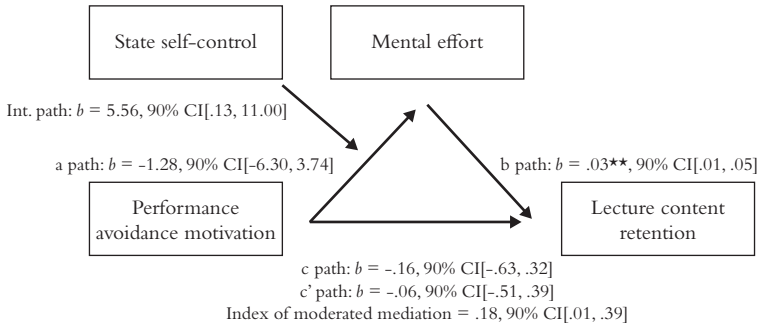


Figure 2. The indirect effect of mastery approach motivation on lecture content retention via mental effort as moderated by state self-control. Mean centering for the construction of products was performed and all reported path coefficients are unstandardized regression weights. Confidence intervals are BCa bootstrapped based on 10,000 samples. ⋆p<.1, ⋆⋆p<.05, ⋆⋆⋆p<.01



motivation's indirect effects included 0 within the confidence interval even at higher levels of self-control.

Secondary analysis: Means, SDs, and zero-order correlations

Questionnaire means, SDs, and zero-order Pearson correlation coefficients are reported in Table 1. Mastery approach motivation positively predicted mental effort and lecture content retention. Mental effort positively predicted retention of lecture content.

Discussion

We investigated the combined influence of state self-control (i.e., capacity for attention and impulse regulation), mastery approach motivation (i.e., desire to master the lecture content), and performance avoidance motivation (i.e., desire to avoid normative incompetence) on final-year BSc undergraduate students' learning during a 2hr presentation-formatted lecture. Students completed questionnaires assessing their state self-control, mastery approach, and performance avoidance immediately prior to a lecture. Immediately after the lecture, students completed questionnaires assessing: state self-control to calculate a mean amount of state self-control across the lecture (i.e. pre and post mean); mental effort invested into the

Table 1. Descriptive statistics and two-tailed zero-order Pearson correlation coefficients (R)

	1.	2.	3.	4.	5.
1. Mastery approach R					
(R 90% CI)					
2. Performance avoidance R	.18				
(R 90% CI)	(-.03, .39)				
3. State self-control R	-.01	.11			
(R 90% CI)	(-.25, .24)	(-.10, .32)			
4. Mental effort R	.36***	-.13	.16		
(R 90% CI)	(.16, .56)	(-.34, .08)	(-.05, .37)		
5. Lecture content retention R	.22*	-.07	.08	.34***	
(R 90% CI)	(.01, .42)	(-.28, .14)	(-1.31, 2.91)	(.13, .54)	
Mean (SD)	3.97 (.71)	3.99(.91)	3.49 (.97)	63.81 (19.98)	7.18 (2.00)

Note. Mastery approach motivation and performance approach motivation: AGQ-R rated from 1 to 5 (Elliot and Murayama, 2008). State self-control: mean pre and post-lecture SSCS rated from 1 to 7 (Ciarocco et al., 2007). Mental effort: RSME rated from 0 to 150 (Zijlstra, 1993). Lecture content retention: custom multiple-choice questionnaire. *p < .1, **p < .05, ***p < .01

lecture; and a multiple-choice test on the lecture content to measure learning during the lecture.

Our main analysis, moderated mediation, revealed results in line with our hypothesis. At higher levels of state self-control, mental effort more strongly/positively mediated the relationship between motivation (mastery approach and performance avoidance) and lecture content retention. This finding supports the notion that sufficient self-control (i.e., intermediate to high levels in our study) is necessary to convert motivation into effort and thus learning during a lecture. This finding was particularly strong in mastery approach motivation, wherein confidence intervals of its total effect on lecture content retention were substantially more positive and did not include 0, while the confidence intervals of the direct effect were spread more evenly around 0. This suggests moderated mediation was a key contributor to the motivation mastery approach and lecture content retention total effect. Additional analyses comprised zero-order Pearson's correlations. These revealed that, on their own, mental effort and mastery approach motivation positively predicted lecture content retention while state self-control and performance avoidance motivation did not on their own.

Overall, our findings were in line with past literature. Numerous studies have demonstrated heightened self-control's positive effects within educational settings (e.g., Englert and Bertrams, 2017; Véronneau, Hiatt Racer, K., Fosco, and Dishion, 2014; Watts, Duncan, and Quan, 2018), and demonstrated that motivation can alter self-control's effect on performance (Muraven and Slessareva 2003; Vohs, Baumeister, and Schmeichel, 2012); our study was the first to investigate self-control's influence on acute lecture learning within a real-world higher education setting and was the first to concurrently consider motivation's influence on the aforementioned. Our results suggest that higher levels of motivation and self-control may positively predict students' mental effort invested into a lecture and consequently may positively predict students' acute lecture learning. Naturally, if this finding is valid and reliable, it carries numerous applied implications.

Implications/recommendations for higher education practice

Our findings suggest increasing students' self-control resources and motivation may aid lecture learning. Knowing this offers ample applied implications. For instance, the depletion of self-control resources is

proposedly attenuated via: humor (Tice, Baumeister, Shimueli, and Muraven, 2007); autonomy (Englert and Bertrams, 2015); maintaining blood glucose levels (Gailliot and Baumeister, 2018); and opportunities to rest and relax (Englert and Bertrams, 2016). Concurrently, students' motivation towards a course/lecture can be increased via: gamification (Banfield and Wilkerson, 2014); increasing perceived content relevance (Frymier and Shulman, 1995; Newby, 1991); and attributional retraining (Parker, Perry, Hamm, Chipperfield, and Hlakyi, 2016; Perry, Hechter, Menec, and Weinberg, 1993). Education providers in Wales, and other nations, who wish to increase the effectiveness of their lectures/lessons may wish to consider implementing some of the aforementioned methods into the delivery of their content.

Limitations

The applied nature of this study made certain limitations difficult to avoid. Firstly, participants completed all questionnaires seated in the lecture theatre among their peers. This may have distracted some participants and/or made some participants rush the completion of their questionnaires to finish at the same time as their peers. Secondly, our study's sample size (N = 62) was smaller than those commonplace in correlational research (N = 100+); this was because we did not have access to a lecture featuring a larger class size. To confirm the present findings' validity, replications using larger sample sizes are encouraged (Button et al., 2013). Thirdly, the lecture content questionnaire mean scores were relatively high and standard deviations relatively low. This suggests that the questionnaire featured a ceiling effect because it was either too easy or elicited a 'test effect' wherein students paid more attention to the lecture than usual, in the knowledge that they would be tested at the end. Increased lecture content questionnaire difficulty may yield larger effects by increasing data resolution. Relatedly, the multiple-choice nature of the lecture content questionnaire meant it was not possible to assess 'deep learning' and associated critical thinking skills. Lastly, this study comprised exclusively of self-report questionnaire measures. Although this brings with it inevitable measurement error of constructs, and an inability to establish cause and effect, using self-report measures was one of the only ways to investigate the research question in an ethical and ecologically valid manner (i.e., in a real lecture featuring enrolled students).

Conclusion

Self-control, motivation, and mental effort are facilitators of lecture content retention. Students require 'sufficient' state self-control to convert their motivation into mental effort and therefore learn during a lecture. This finding yields numerous applied implications, considering presentation-format lectures generally comprise a sizable portion of contact time within traditional higher education provision. Based on the findings of the present investigation, education providers may wish to implement interventions which aim to increase students' motivation and self-control resources. We encourage future research to utilize larger sample sizes to verify the relationships observed, and directly investigate the combined effectiveness of self-control and motivation interventions at increasing students' motivation and self-control to increase effort and thus lecture learning.

Declarations of interest

Declarations of interest: none

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