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Cognitive Fatigue and the Wellbeing and Academic Attainment of University Students

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Background: Effects of cognitive fatigue have been widely studied in operational settings and in working populations. Less is known about the effects of cognitive fatigue on the well-being and academic attainment of university students and the present study aimed to provide information on this topic.

Methodology: The study was carried out with the approval of the Ethics Committee, School of Psychology, Cardiff University, and with the informed consent of the volunteers. It was carried out in December and January and participants completed an online survey presented using the Qualtrics package and gave consent for access to their coursework and examination marks. Students completed an online version of the Student Well-being Process Questionnaire. This measured both positive aspects of well-being (happiness, life satisfaction and positive affect) and negative aspects (stress, anxiety, depression and negative affect). It also measured established predictors of well-being (personality, social support, stressors and coping) which were controlled for in the analyses. Grade Point Average scores were also available for the participants and again established predictors of these (previous academic attainment; conscientiousness) were also recorded. Mental fatigue was measured using a single question with a 10-point rating scale. Three hundred and thirteen students completed the study.

Results: The results showed that higher mental fatigue was associated with reduced well-being and

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lower academic performance. These results remained significant when the established predictors were included in the analyses.

Conclusion: Mental fatigue is associated with reduced wellbeing and lower academic attainment in university students. Further research is now required to identify the causes of cognitive fatigue and to evaluate methods of prevention and management.

Keywords: Cognitive fatigue; academic attainment; wellbeing; university students.

1. INTRODUCTION

There has been substantial research on the effects of cognitive fatigue on performance in the laboratory, in operational settings and at work [1,2]. Similarly, it is well established that acute fatigue can be associated with a negative mood and that chronic fatigue can lead to mental and physical health problems. In contrast to this, there has been little research on fatigue and the academic attainment and wellbeing of students. The main aim of the present study was to provide information on this topic using a multi-variate approach designed to eliminate the influence of confounding factors.

A literature search using *Pubmed* and *Psychinfo* revealed very few specific studies on fatigue and the wellbeing of university students. Many of the studies of fatigue and wellbeing focused on sleep problems [3,4,5,6]. Other research considered fatigue in a stress framework [7,8,9,10,11] and have investigated psychosocial factors such as emotional intelligence [12], social support [13], compassion [14], coping styles [11] and health-related behaviours [8,15]. The two obvious major weaknesses with all of these studies is that they failed to conceptualise wellbeing appropriately (e.g. considering both positive and negative aspects, [16]) and did not adjust for factors known to influence wellbeing [17]. The present study aimed to eliminate the problems of the prior research.

The literature research also showed that there have been few studies of fatigue and the academic attainment of university students. Again, research has focused on sleep problems and academic attainment [18,19,20] and often reported that sleep disorders impact on academic attainment. However, not all studies have found an association between fatigue and attainment; some report no effect [21,22] whereas others only report an association for certain sub-groups (e.g. females only – [23]). Other research has considered fatigue as a stressor and shown that only certain components influence attainment (e.g. poor concentration –

[24]). Studies of younger students (elementary and junior high school pupils) have shown that fatigue influences the development of cognitive functions [25]. For example, slower motor processing was associated with the prevalence of fatigue in elementary students and decreases in working memory and divided attention were positively correlated with the prevalence of fatigue in the junior high school group. The development of cognitive functions and study skills will influence attainment and the results with younger children provide a plausible mechanism for an association between fatigue and academic performance.

The present study was based on a recent conceptualisation of wellbeing (see [26], for more detail). The starting point for our approach to wellbeing has been based on the Demands-Resources-Individual Effects model [27] which has also been applied to fatigue [28,29]. The model has both positive and negative variables starting with circumstances (demands; resources), then appraisals (stress; satisfaction) and outcomes (negative affect; positive affect). The model is flexible and has established predictors but allows for the inclusion of new variables. In the present study, the established predictors of wellbeing were: stressors, social support, positive personality (optimism/self-efficacy/self-esteem) and coping. These items were measured using the student wellbeing process questionnaire [30] which is a short measuring instrument that has been validated by correlating individual questions with longer established scales [31,32,33]. A single item mental fatigue question was developed using a similar procedure and was shown to be highly correlated (0.82) with the mental fatigue scale of the multidimensional fatigue inventory [34]. The wellbeing score was based on both negative outcomes (anxiety, depression and stress) and positive outcomes (happiness, positive affect and life satisfaction). Research [26] has also investigated whether the WPQ predictors were associated with cognitive function (cognitive failures and amount of work done). Cognitive problems were predicted by high stressor and

negative coping scores, and by low scores of positive personality and conscientiousness. This suggests that these predictors may also be associated with academic attainment and perceptions of studying efficiency. Academic attainment is usually assessed using a grade point average and this was done here. Cognitions related to studying include perceptions of workload, stress related to the course and perceptions of efficiency of working. These domains were also measured in the present study.

In summary, the aim of the present study was to examine associations between mental fatigue and wellbeing/academic attainment. The study also controlled for the influence of established predictors of wellbeing and attainment by conducting multi-variate analyses.

2. MATERIALS AND METHODS

2.1 Participants

The study was carried out with the approval of the Ethics Committee, School of Psychology, Cardiff University, and with the informed consent of the volunteers. The participants were 313 first and second year undergraduate Psychology students at Cardiff University (88.7% female; mean age: 19.5 years; age range: 18-41 years) who received course credits for their participation (students from other years were not required to participate in research studies). At the end of the questionnaire volunteers were shown a debrief statement and were awarded course credits for participating. The study was carried out in December and January and participants completed an online survey presented using the Qualtrics package and gave consent for access to their coursework and examination marks.

2.2 Wellbeing

The actual questions used are shown in Appendix 1.

The established predictors (the stressor questions, measures of social support, negative coping, positive personality and conscientiousness question) are described in detail elsewhere [26], as are the wellbeing outcome measures. A single outcome score was calculated by adding scores reflecting negative wellbeing (e.g. stress, anxiety, depression etc.) and subtracting positive wellbeing scores (e.g. life satisfaction, happiness etc.). The new

question in this study was the mental fatigue question which was highly correlated with the mental fatigue score from the multi-dimensional fatigue index [34].

2.3 Academic Attainment

The academic attainment score was the grade point average (GPA) based on the coursework and examination scores for that semester. In addition, perceptions of stress caused by university work, perceived workload and efficiency of studying, were also recorded to provide an indication of study related cognitions.

3. RESULTS AND DISCUSSION

The mental fatigue scores and the established predictors were entered into regressions with the overall wellbeing score, GPA, course stress and studying efficiency as the outcomes. Participants from years 1 and 2 showed similar levels of wellbeing, attainment and similar associations with predictors. Their data are, therefore, combined in the following analyses.

3.1 Wellbeing

The output from the regression is shown in Table 1.

This analysis showed that the established predictors of wellbeing (stressors, social support and positive personality) had the usual significant effect. Mental fatigue was also associated with greater negative wellbeing and was the strongest predictor. The key feature of this analysis was that there was a significant effect of fatigue even when the established predictors were controlled.

3.2 Grade Point Average

The output from this regression is shown in Table 2.

Again, the established predictors of academic attainment (stress; conscientiousness) had a significant effect. Mental fatigue was associated with lower GPA scores and this effect was significant even when the established predictors were controlled.

3.3 Efficiency of Studying

The output from this regression is shown in Table 3.

Table 1. Regression analysis – Wellbeing scores as the dependent variable

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.	95.0% confidence interval for B	
	B	Std. error	Beta			Lower bound	Upper bound
(Constant)	12.171	3.451		3.527	.000	5.380	18.963
Stressors	.237	.040	.194	5.904	.000	.158	.317
Social support	-.184	.066	-.087	-2.808	.005	-.314	-.055
Positive Personality	-.803	.084	-.344	-9.525	.000	-.969	-.637
Negative Coping	.096	.085	.037	1.129	.260	-.071	.262
Mental Fatigue	2.855	.189	.493	15.074	.000	2.482	3.227

Table 2. Regression analysis – GPA scores as the dependent variable

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.	95.0% confidence interval for B	
	B	Std. error	Beta			Lower bound	Upper bound
(Constant)	61.863	4.368		14.161	.000	53.267	70.459
Stressors	-.162	.050	-.212	-3.278	.001	-.260	-.065
Social Support	.021	.083	.016	.255	.799	-.142	.184
Positive Personality	-.077	.103	-.053	-.749	.454	-.279	.125
Negative Coping	-.060	.105	-.037	-.565	.573	-.267	.148
Mental fatigue	.553	.232	.153	2.381	.018	.096	1.010
Conscientiousness	.717	.222	.189	3.234	.001	.281	1.153

Table 3. Regression analysis – Academic efficiency scores as the dependent variable

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.	95.0% confidence interval for B	
	B	Std. error	Beta			Lower bound	Upper bound
(Constant)	4.114	1.103		3.731	.000	1.944	6.283
Stressors	-.018	.013	-.090	-1.434	.152	-.043	.007
Social Support	-.015	.021	-.044	-.725	.469	-.056	.026
Positive Personality	.072	.026	.189	2.779	.006	.021	.123
Negative Coping	-.009	.027	-.022	-.351	.726	-.062	.043
Mental Fatigue	.012	.059	.013	.208	.836	-.104	.128
Conscientiousness	.270	.056	.273	4.827	.000	.160	.380

Table 4. Regression analysis – Academic stress as the dependent variable

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.	95.0% confidence interval for B	
	B	Std. error	Beta			Lower bound	Upper bound
1 (Constant)	3.215	.981		3.277	.001	1.284	5.146
Stressors	.042	.011	.239	3.754	.000	.020	.064
Social Support	.017	.019	.057	.923	.357	-.019	.054
Positive Personality	-.006	.023	-.019	-.281	.779	-.052	.039
Negative Coping	.042	.024	.113	1.778	.076	-.005	.089
Mental Fatigue	.083	.052	.100	1.590	.113	-.020	.185
Conscientiousness	.103	.050	.119	2.063	.040	.005	.201

Table 5. Regression analysis – Perceived workload as the dependent variable

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.	95.0% confidence interval for B	
	B	Std. error	Beta			Lower bound	Upper bound
(Constant)	5.577	.953		5.851	.000	3.702	7.453
Stressors	.013	.011	.082	1.227	.221	-.008	.035
Social support	.016	.018	.056	.872	.384	-.020	.051
Positive Personality	-.006	.022	-.019	-.258	.797	-.050	.038
Negative Coping	.006	.023	.018	.270	.787	-.039	.051
Mental fatigue	.081	.051	.106	1.601	.110	-.019	.181
Conscientiousness	.052	.048	.065	1.075	.283	-.043	.147

Positive personality (high self-efficacy, self-esteem and optimism) and conscientiousness were associated with perceptions of greater efficiency of doing academic work. Mental fatigue had no significant effect.

3.4 Academic Stress

The output from this regression is shown in Table 4.

Mental fatigue had no effect on academic stress which was predicted by stressors and conscientiousness.

3.5 Perceived Workload

The output from this regression is shown in Table 5.

None of the variables predicted perceptions of workload.

3.6 Discussion

Previous research [3-15,18-25] has investigated associations between fatigue, wellbeing and academic attainment. The major problem with these studies has been the lack of control of confounding factors. The present study was designed to control for established predictors of wellbeing and attainment. The results of the present study show that mental fatigue is associated with greater negative wellbeing. This is not too surprising as fatigue is often conceptualised as a negative outcome. The analyses showed that the association between fatigue and reduced wellbeing did not reflect established predictors such as stressors, personality or social support. These established predictors did have significant individual associations which suggests that the fatigue effects may also be robust.

Mental fatigue was also associated with poorer academic performance. This finding confirms results from the laboratory, operational settings and the workplace showing that fatigue can lead to performance impairments. Again, this effect of mental fatigue was independent of established predictors such as stressors and conscientiousness. The effects of fatigue on academic attainment were not due to differences in workload, academic stress or perceived efficiency. This suggests that students are not aware of the potential impact of fatigue and that

further education about this topic is required. Further research is now required to determine what underlies the effects of mental fatigue. The literature suggests that sleep may be the key factor and it will be important to examine key sleep parameters such as amount, quality, daytime sleepiness and the behavioural outcomes of poor sleep (e.g. missing lectures).

4. LIMITATIONS

The cross-sectional design of the survey meant that it was difficult to assign causality. Longitudinal research, preferably involving interventions, is now warranted. The sample consisted of a homogenous cohort of students and future research must study a more heterogeneous group of students.

5. CONCLUSIONS

The research described here shows that mental fatigue is associated with negative wellbeing and reduced academic attainment. These effects were significant when confounding factors were controlled for in the analyses. Further research is now required to identify the mechanisms underlying these effects of fatigue.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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APPENDIX 1

Appendix 1: The Student Wellbeing Process Questionnaire (after Williams et al., 2017)

The following questions contain a number of single-item measures of aspects of your life as a student and feelings about yourself. Many of these questions will contain examples of what thoughts/behaviours the question is referring to which are important for understanding the focus of the question, but should be regarded as guidance rather than strict criteria. Please try to be as accurate as possible, but avoid thinking too much about your answers, your first instinct is usually the best.

POSITIVE PERSONALITY

Overall, I feel that I have low self-esteem (For example: At times, I feel that I am no good at all, at times I feel useless, I am inclined to feel that I am a failure)

Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

In general, I feel optimistic about the future (For example: I usually expect the best, I expect more good things to happen to me than bad, It's easy for me to relax)

Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

I am confident in my ability to solve problems that I might face in life (For example: I can usually handle whatever comes my way, If I try hard enough I can overcome difficult problems, I can stick to my aims and accomplish my goals)

Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

Overall, I feel that I have positive self-esteem (For example: On the whole I am satisfied with myself, I am able to do things as well as most other people, I feel that I am a person of worth)

Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

NEGATIVE COPING STYLE

Blame Self

19. When I find myself in stressful situations, I blame myself (e.g. I criticize or lecture myself, I realise I brought the problem on myself).

Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

Wishful Thinking

20. When I find myself in stressful situations, I wish for things to improve (e.g. I hope a miracle will happen, I wish I could change things about myself or circumstances, I daydream about a better situation).

Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

Avoidance

21. When I find myself in stressful situations, I try to avoid the problem (e.g. I keep things to myself, I go on as if nothing has happened, I try to make myself feel better by eating/drinking/smoking).

Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

24. In general, I feel pessimistic about the future (For example: If something can go wrong for me it will, I hardly ever expect things to go my way, I rarely count on good things happening to me)

Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

CONSCIENTIOUSNESS

I feel that I am a conscientious person (For example: I am always prepared, I make plans and stick to them, I pay attention to details)

Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

STRESSORS

Please consider the following elements of student life and indicate overall to what extent they have been a part of your life over the past 6 months. Remember to use the examples as guidance rather than trying to consider each of them specifically:

Challenges to your development (e.g. important decisions about your education and future career, dissatisfaction with your written or mathematical ability, struggling to meet your own or others' academic standards).

Not at all part of my life 1 2 3 4 5 6 7 8 9 10 Very much part of my life

Time pressures (e.g. too many things to do at once, interruptions of your school work, a lot of responsibilities).

Not at all part of my life 1 2 3 4 5 6 7 8 9 10 Very much part of my life

Academic Dissatisfaction (e.g. disliking your studies, finding courses uninteresting, dissatisfaction with school).

Not at all part of my life 1 2 3 4 5 6 7 8 9 10 Very much part of my life

Romantic Problems (e.g. decisions about intimate relationships, conflicts with boyfriends'/girlfriends' family, conflicts with boyfriend/girlfriend).

Not at all part of my life 1 2 3 4 5 6 7 8 9 10 Very much part of my life

Societal Annoyances (e.g. getting ripped off or cheated in the purchase of services, social conflicts over smoking, disliking fellow students).

Not at all part of my life 1 2 3 4 5 6 7 8 9 10 Very much part of my life

Social Mistreatment (e.g. social rejection, loneliness, being taken advantage of).

Not at all part of my life 1 2 3 4 5 6 7 8 9 10 Very much part of my life

Friendship problems (e.g. conflicts with friends, being let down or disappointed by friends, having your trust betrayed by friends).

Not at all part of my life 1 2 3 4 5 6 7 8 9 10 Very much part of my life

SOCIAL SUPPORT

Please state how much you agree or disagree with the following statements:

I feel that I have the social support I need (For example: There is someone who will listen to me when I need to talk, there is someone who will give me good advice, there is someone who shows me love and affection)

Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

There is a person or people in my life who would provide tangible support for me when I need it (for example: money for tuition or books, use of their car, furniture for a new apartment).

Strongly Disagree 1 2 3 4 5 6 7 8 9 10 Strongly Agree

There is a person or people in my life who would provide me with a sense of belonging (for example: I could find someone to go to a movie with me, I often get invited to do things with other people, I regularly hang out with friends).

Strongly Disagree 1 2 3 4 5 6 7 8 9 10 Strongly Agree

There is a person or people in my life with whom I would feel perfectly comfortable discussing any problems I might have (for example: difficulties with my social life, getting along with my parents, sexual problems).

Strongly Disagree 1 2 3 4 5 6 7 8 9 10 Strongly Agree

OUTCOMES

On a scale of one to ten, how depressed would you say you are in general? (e.g. feeling 'down', no longer looking forward to things or enjoying things that you used to)

Not at all depressed 1 2 3 4 5 6 7 8 9 10 Extremely depressed

Thinking about myself and how I normally feel, in general, I mostly experience positive feelings (For example: I feel alert, inspired, determined, attentive)

Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

Thinking about myself and how I normally feel, in general, I mostly experience negative feelings (For example: I feel upset, hostile, ashamed, nervous)

Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

Overall, I feel that I am satisfied with my life (For example: In most ways my life is close to my ideal, so far I have gotten the important things I want in life)

Disagree strongly 1 2 3 4 5 6 7 8 9 10 Agree strongly

Overall, how stressful is your life?

Not at all stressful 1 2 3 4 5 6 7 8 9 10 Very Stressful

On a scale of one to ten, how anxious would you say you are in general? (e.g. feeling tense or 'wound up', unable to relax, feelings of worry or panic)

Not at all anxious 1 2 3 4 5 6 7 8 9 10 Extremely anxious

On a scale of one to ten, how happy would you say you are in general?

Extremely unhappy 1 2 3 4 5 6 7 8 9 10 Extremely happy

STUDYING COGNITIONS

How would you rate your current university workload on a scale of 1-10 (1 meaning "there is little or no workload" and 10 meaning "there is a very high workload on my course")?

How stressful do you find your course on a scale of 1-10 (1 meaning "not at all stressful" and 10 meaning "the most stressful it could possibly be")?

How efficiently do you do your university work (1=not at all efficiently, 10 = extremely efficiently)?

MENTAL FATIGUE

Overall, how often do you feel mentally fatigued?

Not at all 1 2 3 4 5 6 7 8 9 10 Very frequently

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