Drink availability is associated with enhanced examination performance in adults

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While dehydration has negative effects on memory and attention, few studies have investigated whether drinking water can enhance cognitive performance, and none have addressed this in a real-world setting. In this study we explored the potential benefits of the availability of water for undergraduates. The exam performance of students who brought drinks in to exams was compared with those that did not for three cohorts of undergraduates (N=447). We employed earlier coursework marks as a measure of underlying ability. Students who brought water to the exam achieved better grades than students who did not. When coursework marks were covaried, this effect remained statistically significant, suggesting that this finding was not simply due to more able students being more likely to bring in water. This implies that water consumption may facilitate performance in real-world settings, and, therefore, have specific implications for the assessment of undergraduate learners under examination conditions, but further research is required to evaluate this hypothesis.

Keywords: *Hydration; cognitive performance; drinking water; education; examination performance.*

EDUCATIONAL RESEARCH has examined a variety of academic, societal, and health risk factors that contribute to underachievement – where there is a discrepancy between a student's ability and their attainment in examinations (e.g. Smith, 2003). Folk wisdom holds that performance in examinations is affected by one's hydration status, and that it is important to have water available when sitting an exam. The purpose of the present study was to evaluate this assumption by assessing whether the laboratory based finding that drink consumption enhances memory and attention translates to the real-world domain of examination performance.

Research examining the effects of dehydration on cognition in adults under controlled laboratory conditions has found that it is negatively associated with performance on tasks that assess attention (Suhr et al., 2004) and short-term memory (Cian et al., 2000; Gopinathan, Pichan & Sharma, 1988; Sharma et al., 1986; Suhr et al., 2004). Lieberman (2007) suggests a dose-response relationship between hydration status and cognitive performance with even mild dehydration of one pe cent loss in body weight being associated with poorer cognitive performance (Gopinathan et al., 1988). Hydration status is also linked to subjective feelings of alertness, concentration, and tiredness, and dehydration has been associated with increased reporting of physical symptoms such as headaches (Shirrefs et al., 2004).

Complementary to research demonstrating negative effects of dehydration on cognition, recent research has shown that having a drink of water is associated with improved cognitive performance. Researchers in this field debate whether water supplementation affects cognitive performance because it corrects subclinical or clinical dehydration, or whether it improves cognitive performance in individuals who are already well hydrated. At present, there is no evidence to discriminate between these two possibilities, but whatever the explanation there is evidence of an

effect. Five recent papers have reported that children performed better after consuming supplementary water on tasks assessing visual attention (Booth, Taylor & Edmonds, 2012; Edmonds & Burford, 2009; Edmonds & Jeffes, 2009), visual search (Edmonds & Jeffes, 2009) and visual memory (Benton & Burgess, 2009; Edmonds & Burford, 2009; Fadda et al., 2012). One study in adults has shown that water supplementation results in improved performance on a rapid visual information processing task in adults who previously reported themselves as thirsty (Rogers, Kainth & Smit, 2001), and a recent study has shown that adults supplemented with water performed better on a visual attention task (Edmonds et al., 2013). These findings would have important practical applications if found to extend to real-world settings.

If these laboratory findings are applicable to real-world settings, one would predict positive effects of water consumption in domains of real-world performance where there is a demand on cognition. Performance in exams involves, amongst other processes, memory and attention, which have been shown to be positively affected by water consumption. Folk wisdom that drinking in exams aids performance is reflected in a plethora of websites that offer advice along these lines (eHow, 2010; Student Based Services Lancaster University, 2010; Student Support Services, Canterbury Christ Church University, 2010). Bringing drinks into university exams is commonplace in the UK and the US. However, anecdotal claims that drink consumption affects exam performance have not been formally tested. The present study sought first to describe the hydration behaviour of a group of university students in terms of their tendency to bring in drinks, and the types of drinks they brought, to the exam hall. The second aim was to examine whether undergraduate students who bring drinks into exams outperform students who do not bring in drinks. We observed students in three courses in different years of study. As well as comparing performance in the exam, we also recorded marks from coursework submitted during the semester as an indicator of general ability. This was done in order to enable us to covary coursework marks so that we could test the potential explanation that any observed effects were simply explained by the more academically able students being more likely to bring drinks into the exam, while less able students were not. Given the literature on the effects of hydration status on cognition and the results of a pilot study, we predicted that students who bring drinks into exams would perform better than students who did not bring drinks in. Furthermore, we predicted that this will not simply be a function of more academically able students being more likely to bring in drinks; we expected that adding a covariate of coursework performance may weaken, but not eliminate, the effect.

Method

Participants

Data were collected from three cohorts of students attending a London-based university with an ethnically diverse student population, who were completing assessments at either Level 0 (N=71; 15 male), Level 1 (N=225; 39 male) or Level 2 (N=151; 28 male). Ages of the students at each level of study were as follows. Level 0: M=25.0, SD=7.2, Range=18–49 years; Level 1: M=25.6, SD=8.3, Range=18–61 years; Level 2: M=26.4, SD=7.9, Range=19–54 years.

Format of assessment at each level of study

The study focused on the coursework and exam performance of three different cohorts of students, each of which were at different levels of undergraduate study (Levels 0, 1 and 2). The Level 0 introductory Psychology course is taken by students in a foundation year prior to beginning formal undergraduate study. The Level 0 assessment took the form of an 60-minute, 50-item, multiple-choice exam and a group presentation was completed during the semester as

coursework. The Level 1 research methods course was taken by first-year undergraduates and comprised a 45-minute, 50-item multiple-choice exam. There were two coursework elements: a laboratory report and a portfolio of compulsory short quizzes. The Level 2 Cognitive Psychology assessment was taken by second year undergraduates and took the form of a 30-minute, 30-item multiple-choice exam and a 30-minute unseen essay (in which candidates must answer one essay question from a choice of five). This course did not have a coursework component so a coursework mark from a difference course at the same level of the degree was used as a coursework covariate; we used the mean laboratory report mark from a second year compulsory psychology research methods course.

Ethics

This study was approved by the School of Psychology ethics board. As this was an observational study of normal educational practices conducted in an educational setting, in line with guidelines from the British Psychological Society and the American Psychological Association, formal consent was not obtained.

Procedure

Students participated in their end of semester exams as usual. Candidates taking the exams within each level of study were distributed across multiple rooms. The researchers walked around the exam rooms and noted whether the student had brought a drink into the exam, and if so, what that drink was. The students were unlikely to have thought that this was different from any other exam because it is usual for invigilators to walk around the exam room in order to complete a student attendance register. Exam performance was collated from the student records system; scripts were graded in accordance with normal academic practice by assessors who were blind to whether the student had brought a drink into the exam.

The exams took place in London, in January. The average outside temperature in that period was between –3.2 degrees Celsius and 9.5 degrees Celsius (London-Weather.eu, 2010).

Statistical analysis

Exam performance for each cohort was analysed separately. The initial analyses used independent *t*-tests to compare exam performance in students who brought drinks into the exams (the drinks group) and those who did not (the no drinks group). The majority of students who brought a drink into the exams brought in water, therefore, subsequent analyses compared the no drinks group with those who brought water in to the exams, and excluded the small numbers of students who brought in other drinks. These analyses used Analysis of Covariance (ANCOVA) to consider exam performance by group whilst covarying for general ability using coursework marks. This tests the potential explanation that any effect of bringing in water on exam performance is a result of only the more able students bringing drinks into the exams. For all analyses, the alpha level was .05 and tests were non-directional.

Results

Frequency and type of drinks taken in to the exams

The behaviour of bringing in a drink into the exam was less prevalent at foundation Level 0 (27 per cent) and first-year undergraduate level (24 per cent), than at Level 2 (46 per cent), Chi Square, df=2,=21.82, p<.001. A large variety of drinks were brought in that were categorised as follows: water (still or sparkling, including varieties that were flavored or supplemented with vitamins), proprietary 'energy drinks' (e.g. Gatorade), drinks containing, or presumed to contain, caffeine (coffee, tea, colas and 'Red Bull'), and a miscellaneous 'other' category (including milk shakes, fruit juices, cordials, and non-caffeinated carbonates). Table 1 shows the frequency and type of

drinks taken in to each exam. Across the three exams, water was by far the most prevalent drink (65 per cent).

Level 0 analysis

The assessment for the foundation Level 0 cohort comprised an MCQ exam and presentation coursework. Mean marks for all modules can been seen in Table 2. Analysis of the exam performance of the 71 students sitting the exam revealed that those bringing in drinks (N=19), outperformed those that did not (N=52) by approximately 12 per cent on the MCQ test, $t(23.05)=2.74$, $p=.012$ (equal variances not assumed, Levene's test $F=9.76$, $p=.003$), Cohen's $d=0.82$. This difference remained when those candidates bringing in a drink other than water were excluded from the drink group, $t(15.9)=2.75$, $p=.014$ (equal variances not assumed, Levene's test $F=4.47$, $p=.038$), $d=0.93$.

We evaluated whether bringing a drink into the exam was associated with better coursework performance using the data for the 64 students who in addition to the exam had also taken part in the group presentation assessment. This revealed that although the mean group presentation score for the drinks group was approximately five per cent higher than that for the no drinks group, this difference was not statistically significant, $t(62)=1.49$, $p=.142$

ANCOVA was employed to assess the difference between the water group and no drink group, while statistically controlling for general ability as measured by coursework grade. This revealed that although the coursework grade covaried with the exam grade, $F(1,57)=8.26$, $p=.006$, the water group effect remained significant when this independent measure of academic ability was taken into account, with the water group performing better than the no drinks group, $F(1,57)=8.93$, $p=.004$ (Adjusted Mean difference=10.6 per cent), $\eta_p^2=0.135$.

Level 1 analysis

A similar picture emerged for the first-year undergraduate course which employed two coursework assessments (laboratory report and a portfolio of quizzes) in addition to an MCQ exam. Analysis of the full sample of exam grades (N=225), revealed that performance on the MCQ test was better in the drinks group (N=54) compared to the no drinks group (N=171) by approximately seven per cent, $t(223)=3.31$, $p<.001$, $d=0.51$. Again, this effect was maintained when those candidates bringing in a drink other than water were excluded from the drink group, $t(204)=3.47$, $p<.001$, $d=0.65$.

Analysis of the subsamples of students that submitted the report (N=194) or portfolio (N=214) in addition to the exam revealed that although the mean coursework grade for the drink group was slightly higher than that for the non drink group (Mean difference: report=2.1 per cent; portfolio=2.7 per cent) neither difference achieved statistical significance (report, $t(192)=0.942$, $p=.348$; portfolio, $t(212)=1.21$, $p=.226$).

Follow-up analyses compared the no drinks group with those who brought in water, using ANCOVA and the grades for both courseworks as covariates. This confirmed that exam performance covaried with the grades for both the report, $F(1,172)=47.7$, $p<.001$, and the portfolio, $F(1,172)=10.4$, $p=.002$. Importantly, the water only group was still found to perform better than the no drinks group, $F(1,172)=4.98$, $p=.027$ (Adjusted Mean difference=4.8 per cent), $\eta_p^2=0.028$.

Level 2 analysis

The assessment for the second-year undergraduate course comprised an exam with two components: an unseen essay in addition to an MCQ section. There was no coursework element. Therefore, the mean lab report coursework mark from a different second year course taken during the same academic year was used as a covariate for ability.

For the MCQ component, there was a tendency for the drinks group to outperform the no drinks group (Mean difference=4.3 per cent) that approached significance,

Table 1: Frequency of candidates bringing various drinks, or no drink, to the exam for three undergraduate cohorts.

					Type of Drink									
Level of Study	No drink		Any Drink		Water		Energy		Caffeine		Others		Total	
0. Introductory	52	(73%)	19	(27%)	14	(20%)	0	(0%)	3	(4%)	2	(3%)	71	(100%)
1. Research Methods	171	(76%)	54	(24%)	35	(16%)	4	(2%)	7	(3%)	8	(4%)	225	(100%)
2. Cognitive Psychology	81	(54%)	70	(46%)	47	(31%)	7	(5%)	7	(5%)	9	(6%)	151	(100%)

Note: All percentages relate to the total number of candidates sitting the exam. Frequencies for the four Type of Drink categories sum to those for 'Any Drink', but percentages may not due to rounding error.

Table 2: Mean grade (per cent) for the exam elements of three undergraduate cohorts by candidates electing to bring in either: no drink, any drink, or water only. Standard deviations are in parentheses.

Level of Study	No drink		Any Drink		Water only	
0. Introductory						
MCQ	48.0	(10.8)	60.0	(17.7)	61.3	(17.1)
1. Research Methods						
MCQ	58.1	(14.1)	65.5	(14.8)	67.3	(14.3)
2. Cognitive Psychology						
MCQ	50.4	(13.2)	54.7	(14.2)	55.4	(14.0)
Essay	35.4	(9.5)	38.3	(8.7)	38.5	(9.0)

Note: MCQ=Multiple Choice Question element.

$t(149)=1.93$, $p=.056$, $d=0.31$. This difference achieved statistical significance when those bringing in drinks other than water were excluded, $t(126)=2.03$, $p=.045$, $d=0.36$. This effect was examined further using ANCOVA, where the covariate was the lab report coursework performance. This revealed that attainment across the two courses covaried in the subsample that attempted both assessments ($N=100$; $F(1,97)=18.0$, $p<.001$). Including the covariate reduced the effect of drinks group (Adjusted Mean difference=2.2 per cent), rendering it non-significant, $F<1$, $\eta_p^2=0.007$. Attainment in the lab report covariate was found to be greater among those that brought in water ($M=56.1$ per cent) than those that did not ($M=49.7$ per cent), $t(98)=2.47$, $p=.015$.

Similarly, for the essay component, a tendency for the drinks group to outperform the no drinks group was apparent (Mean difference=2.9 per cent) that approached significance, $t(147)=1.95$, $p=.053$, $d=0.32$, when all varieties of drinks were included, and reached significance when the analysis was restricted just to water, $t(126)=2.44$, $p=.016$, $d=.034$. ANCOVA on the subsample attempting both the essay and the lab report coursework ($N=100$) confirmed that attainment covaried across these assessments, $F(1,97)=17.13$, $p<.001$, but that controlling for academic ability in this way removed the effect, $F<1$, (Adjusted Mean difference=1.9 per cent), $\eta_p^2=0.009$.

Discussion

The results presented here provide evidence that bringing drinks into exams, particularly water, is associated with enhanced exam performance in university students. Our study also showed that across the sample approximately one third of students brought drinks into the exams. Our data revealed a more mature rehydration behaviour at a higher level of study, with twice as many students at level two bringing drinks into the exams as those at Levels 0 and 1. The predominant drink taken into exams at all levels of study was water.

Our results show a positive relationship between bringing water into the exams and exam performance. By restricting the analyses to those candidates who consumed water, we have ruled out that the effect could be due to caffeine or glucose consumption. Furthermore, the majority of our covariance analyses suggest that this advantage did not occur simply as a result of the more academically able students being more likely to bring in drinks. These findings are consistent with the literature on hydration and cognition that shows that dehydration negatively affects cognitive performance (Cian et al., 2000; Gopinathan et al., 1988; Lieberman, 2007; Sharma et al., 1986; Suhr et al., 2004) and that having a drink results in improvement in cognitive performance (Benton & Burgess, 2009; Edmonds & Burford, 2009; Edmonds & Jeffes, 2009; Rogers et al., 2001).

There are at least two types of explanation for these findings, given the observational design of this study. Either: (a) bringing water into the exam, and presumably drinking it (although we did not formally measure this), played a causal role in improving performance; or (b) the behaviour of bringing in a drink such as water served as a proxy for some other factor influencing academic performance (e.g. general academic ability, organisation skills, socio-economic status, diet, etc.). For two courses (Levels 0 and 1) we found no statistically significant evidence that group membership was confounded with general ability, and robust evidence that water availability was associated with enhanced exam performance even when we covaried ability operationalised by coursework performance. For one course (Level 2) we had the converse pattern of results: there was evidence that factors linked to ability influenced the students' decision to bring in water to the exam, and there was no evidence that water had significantly affected exam performance. This pattern of results suggests that both types of explanation may be viable: in certain circumstances more academically

able students may be more likely to choose to bring in water, and in others consuming water may result in better exam attainment. Future research should tease apart these explanations and attempt to specify their condition of occurrence. Numerous questions in this regard warrant further attention, such as whether drink consumption affects all types of assessment equally, including whether they affect longer exams more than short exams.

Measurement of participants' pre-examination consumption and subjective thirst would provide additional salient data but were beyond the scope of this non-invasive observational study. Self-reported hydration status, and indeed a more detailed observation of the actual water consumed in the exam, represent important future directions for this research. However, based upon the reasonable assumption that the effects of drink availability we report were caused by water consumption, we propose several potential explanatory accounts for these findings. Water consumption may have a physiological effect that directly enhances cognitive performance that results in improved exam performance. However, there is little known about the physiological mechanism by which water consumption might affect cognition (Popkin, D'Anci & Rosenberg, 2010). Alternatively, the effects of drink availability on exam performance may be mediated by a reduction in exam-related anxiety that can negatively impinge on exam performance (Cassady & Johnson, 2002; Pekrun, Elliot & Maier, 2009). We found a stronger effect in the earlier years of study at a time at which we contend that students may be more anxious about exam performance. This account assumes that drink availability serves to reduce anxiety, perhaps via either a physiological response to water consumption, or by beliefs about the benefits of water consumption. Further research is necessary to elucidate the mechanism by which consuming water may affect cognition and exam performance.

Practical applications

The current paper is the first to provide evidence that drink availability is associated with enhanced performance in an authentic educational setting. Additional research is required to establish the role played by drink consumption, and to identify the real-world determinants of this phenomenon, before strong practical recommendations can be made. Due to ethical considerations that arise when intervening with educational practice, this research effort will probably involve the combination of controlled experiments that manipulate water availability in formative or simulated assessments and naturalistic investigations with statistical control of confounding variables (see McDaniel, Wildman & Anderson, 2012). The primary contribution of the present results is that by adopting the latter strategy they demonstrate the potential importance of drinking liquid for summative exams undertaken by students in an authentic college context.

The present findings have clear implications for psychology education, and specifically assessment design, particularly if they were to be corroborated by the results of intervention studies. At Levels 0 and 1, students that brought water into the exams outperformed their peers who did not bring in a drink by between five to 10 percentage points, when between group differences in academic ability were statistically controlled for. This difference is large, and comparable to those reported for relatively resource-intensive pedagogic enhancements, such as providing additional peer mentoring (Fox & Stevenson, 2006), online quizzes (Kibble et al., 2011), or training with assessment criteria (Payne & Brown, 2011). Numerous applied questions would warrant further attention, such as whether drink consumption affects all types of assessment equally, whether they may impact on learning of material as well as assessment, and whether certain demographics are differentially affected. Without dismissing the academic integrity and pedagogical arguments that drive examination as a chosen mode of

assessment, similar future findings may also inevitably catalyse discussions of the relative merits of examination as a form of assessment. Nonetheless, where exams are an assessment mode of choice, then the present findings raise the possibility that water supplementation may offer students and educators a simple cost-effective means of enhancing academic performance in exams.

So, how might knowledge that drink consumption enhances exam performance eventually be used by higher education institutions? We suggest that sub-optimal hydration contributes to underachievement in assessments, in the sense that there is a discrepancy between a student's ability and their performance on an assessment (Smith, 2003). As such, hydration status may ultimately become categorised by educational researchers alongside factors known to prevent students realising their potential such as anxiety (e.g. Sloboda, 1990), life difficulties (Wilding et al., 2007), and poor sleep quality (Gilbert & Weaver, 2010). In our study, it was noteworthy that the difference in exam attainment between the water and no drink groups was most robust for students at the start of their academic careers (foundation level and first year). As previously mentioned, this might be because water consumption serves to ameliorate the effects of exam anxiety, which may be supposed to be more acutely felt for the first examinations taken at college. Alternatively, these stronger effects for students toward the start of their academic careers could be accounted for by voluntary dehydration being more prevalent among young adults adapting to greater independence afforded by living/studying away from their parental home. There would be greater scope for rehydration to benefit academic performance in cohorts with a higher prevalence of dehydration. Both accounts are consistent with evidence that going to university is associated with poorer health behaviours, and psychological well-being, particularly in first years (Douglas et al., 1997; Bewick et al., 2010). These possibilities warrant further investigation and would imply that student welfare professionals designing health promotion campaigns might focus their efforts on new students' healthy hydration.

If these observational findings were supported by intervention studies, the present evidence that drink availability is associated with improved performance in adults taking exams raises the possibility that drink consumption similarly may have positive effects in other real-world domains. The present results imply that design and refurbishment of campuses, schools and workplaces may thus benefit from consideration of the need to provide adequate opportunities for students, pupils or workers to gain free access to drinks.

Conclusion

The present study provides evidence that drink availability is associated with enhanced performance in an authentic educational setting. This, to our knowledge, is the first study to assess whether the benefits of water consumption, demonstrated under controlled experimental conditions (Benton & Burgess, 2009; Edmonds & Burford, 2009; Edmonds & Jeffes, 2009; Rogers et al., 2001), extend to the real-world domain of education. These results imply that drink supplementation may be a simple, but hitherto poorly recognised, means of enhancing academic performance. However, further research is required to specify the causal mechanism for this effect, and its conditions of occurrence in real-world settings, before strong practical recommendations can be made on how best to exploit water supplementation. We hope that the present results stimulate controlled experiments and naturalistic studies to provide the convergent evidence needed to inform academic policy and practice.

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References

Benton, D. & Burgess, N. (2009). The effect of the consumption of water on the memory and attention of children. *Appetite, 53*, 143–146.

Bewick, B., Koutsopoulou, G., Miles, J., Slaa, E. & Barkham, M. (2010). Changes in undergraduate students' psychological well-being as they progress through university. *Studies in Higher Education, 35*, 633–645.

Booth, P., Taylor, B. & Edmonds, C.J. (2012). Water supplementation improves visual attention and fine motor skills in schoolchildren. *Education and Health, 30*(3), 75–79.

Cassady, J.C. & Johnson, R.E. (2002). Cognitive test anxiety and academic performance. *Contemporary Educational Psychology, 27*, 270–295.

Cian, C., Koulmann, N., Barraud, P.A., Raphel, C., Jimenez, C. & Melin, B. (2000). Influence of variations in body hydration on cognitive function: Effect of hyperhydration, heat stress, and exercise-induced dehydration. *Journal of Psychophysiology, 14*(1), 29–36.

Douglas, K., Collins, J., Warren, C., Kann, L., Gold, R., Clayton, S., Ross, J. & Kolbe, L. (1997). Results from the 1995 National College Health Risk Behaviour Survey. *Journal of American College Health, 46*, 55–67.

Edmonds, C.J., Crombie, R., Ballieux, H., Gardner, M.R. & Dawkins, L. (2013). Water consumption, not expectancies about water consumption, affects cognitive performance in adults. *Appetite, 60*, 148–153.

Edmonds, C.J. & Burford, D. (2009). Should children drink more water? The effects of drinking water on cognition in children. *Appetite, 52*, 776–779.

Edmonds, C.J. & Jeffes, B. (2009). Does having a drink help you think? 6- to 7-year-old children show improvements in cognitive performance from baseline to test after having a drink of water. *Appetite, 53*, 469–472.

eHow (2010). *How to eat properly before an exam.* Retrieved 8 December 2010, from: http://www.ehow.com/how_2189053_eat-properly-before-exam.html

Fadda, R., Rappinett, G., Grathwohl, D., Parisi, M., Fanari, R., Caio, C.M., et al. (2012). Effects of drinking supplementary water at school on cognitive performance in children. *Appetite, 59*(3), 730–737.

Fox, A. & Stevenson, L. (2006). Exploring the effectiveness of peer mentoring of accounting and finance students in higher education. *Accounting Education: An International Journal, 15*, 189–202.

Gopinathan, P., Pichan, G. & Sharma, V. (1988). Role of dehydration in heat stress-induced variations in mental performance. *Archives of Environmental Health, 43*(1), 15–17.

Gilbert, S. & Weaver, C. (2010). Sleep quality and academic performance in University students: A wake-up call for college psychologists. *Journal of College Student Psychotherapy, 24*, 295–306.

Kibble, J., Johnson, T., Khalil, M., Nelson, L., Riggs, G., Borrero, J. & Payer, A. (2011). Insights gained from the analysis of performance and participation in online formative assessment. *Teaching and Learning in Medicine: An International Journal, 23*, 125–129.

Lieberman, H.R. (2007). Hydration and cognition: A critical review and recommendations for future research. *Journal of the American College of Nutrition, 26* (suppl 5), 555S–561S.

London-Weather.eu. (2010). *Weather in South London during January 2010.* Retrieved 12 December, 2010, from: http://www.london-weather.eu/article.352.html

Lopez, N., Previc, F., Fischer, J., Heitz, R., Engle, R. (2012). Effects of sleep deprivation on cognitive performance by United States Air Force pilots. *Journal of Applied Research in Memory and Cognition, 1*, 27–33.

McDaniel, M., Wildman, K., Anderson, J. (2012). Using quizzes to enhance summative assessment performance in a web-based class: An experimental study. *Journal of Applied Research in Memory and Cognition, 1*, 18–26.

Payne, E. & Brown, G. (2011). Communication and practice with examination criteria. Does this influence performance in examinations? *Assessment & Evaluation in Higher Education, 36*, 619–626.

Pekrun, R., Elliot, A.J. & Maier, M.A. (2009). Achievement goals and achievement emotions: Testing a model of their joint relations with academic performance. *Journal of Educational Psychology, 101*(1), 115–135.

Popkin, B.M., D'Anci, K.E. & Rosenberg, I.H. (2010). Water, hydration, and health. *Nutrition Reviews, 68*(8), 439–458.

Rogers, P.J., Kainth, A. & Smit, H.J. (2001). A drink of water can improve or impair mental performance depending on small differences in thirst. *Appetite, 36*(1), 57–58.

Sharma, V. M., Sridharan, K., Pichan, G. & Panwar, M.R. (1986). Influence of heat stress-induced dehydration on mental functions. *Ergonomics, 29*(6), 791–799.

Shirrefs, S.M., Merson, S.J., Fraser, S.M. & Archer, D.T. (2004). The effects of fluid restriction on hydration status and subjective feelings in man. *British Journal of Nutrition, 91*, 951–958.

Sloboda, J.A. (1990). Combating examination stress among university students: Action research in an institutional context. *British Journal of Guidance and Counselling, 18*(2), 124–136.

Student Based Services Lancaster University (2010). *Exam Stress.* Retrieved 9 December 2010, from: http://www.lancs.ac.uk/sbs/health/examstress.htm

Student Support Services, Canterbury Christ Church University (2010). *Practical Advice – coping with exam stress.* Retrieved 8 December 2010, from: http://www.canterbury.ac.uk/support/student-support-services/students/counselling/practical-advice/exam-stress.asp

Suhr, J.A., Hall, J., Patterson, S.M. & Niinistö, R.T. (2004). The relation of hydration status to cognitive performance in healthy older adults. *International Journal of Psychophysiology, 53*(2), 121–125.