SPi	Journal Code				Article ID				Dispatch: 14.05.13	CE: Crystal Gayle M. Sarming
	S	M	I		2	4	9	6	No. of Pages: 7	ME:

RESEARCH ARTICLE

The Multitasking Framework: The Effects of Increasing Workload on Acute Psychobiological Stress Reactivity

Mark A. Wetherell*† & Kirsty Carter

Health in Action: Stress Research Group, Department of Psychology, Northumbria University, Newcastle upon Tyne, UK

Abstract

A variety of techniques exist for eliciting acute psychological stress in the laboratory; however, they vary in terms of their ease of use, reliability to elicit consistent responses and the extent to which they represent the stressors encountered in everyday life. There is, therefore, a need to develop simple laboratory techniques that reliably elicit psychobiological stress reactivity that are representative of the types of stressors encountered in everyday life. The multitasking framework is a performance-based, cognitively demanding stressor, representative of environments where individuals are required to attend and respond to several different stimuli simultaneously with varying levels of workload. Psychological (mood and perceived workload) and physiological (heart rate and blood pressure) stress reactivity was observed in response to a 15-min period of multitasking at different levels of workload intensity in a sample of 20 healthy participants. Multitasking stress elicited increases in heart rate and blood pressure, and increased workload intensity elicited dose–response increases in levels of perceived workload and mood. As individuals rarely attend to single tasks in real life, the multitasking framework provides an alternative technique for modelling acute stress and workload in the laboratory. Copyright © 2013 John Wiley & Sons, Ltd.

Received 14 August 2012; Revised 23 April 2013; Accepted 24 April 2013

Keywords

stress; multitasking framework; psychobiological stress reactivity; workload demand; mood; cardiovascular reactivity

***Correspondence**

Mark A. Wetherell, Health in Action: Stress Research Group, Department of Psychology, Northumbria University, Newcastle upon Tyne NE1 8ST, UK.

†Email: mark.wetherell@unn.ac.uk

Published online in Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/smi.2496

Introduction

Exposure to psychological stress, especially long-term enduring stress, is known to increase the likelihood of health-compromising behaviours and alter the functioning of key physiological systems (Steptoe, Lipsey, & Wardle, 1998; McKewen, 1998). These stress-related alterations result in increased vulnerability to new diseases and more rapid progression of existing illnesses (Kiecolt-Glaser & Glaser, 2002). To assess the pathways by which stress leads to deleterious outcomes in terms of health and well-being, it is necessary to observe individuals while they are experiencing stress. Observations of individuals during real-life extended stressors (e.g. examination periods, care giving) offer an ecologically valid method for assessing these pathways; however, they can be costly, complex and burdensome for the participants (Saxbe, 2008). In contrast, laboratory stressors allow for greater manipulation of stimuli and control of confounding factors and, therefore, more specific consideration of the causal factors involved in the responses that may lead to deleterious outcomes (Brotman, Golden, & Wittstein, 2007). Furthermore, variations in psychobiological stress reactivity, that is, how and the extent to which individuals respond to stressful stimuli, may account for why some individuals are more susceptible to the deleterious effects of psychological stress than others (Schlotz, Yim, Zoccola et al., 2011). Q1

A variety of techniques exist for eliciting acute psychological stress in controlled settings; however, they vary in terms of their level of ecological validity, that is, the degree to which they represent the types of stressors encountered in real world settings. Effective laboratory stressors should provide a snapshot of how an individual would respond to a stressor encountered in real life (Wetherell et al., 2006). In support, Kudielka and WÜst (2010) recently highlighted the lack of studies investigating the ecological validity of psychological stress protocols and urged the development of alternative stress protocols, particularly, protocols suitable for repeated administration in the same participants.

Regarding ecological validity, in their review of chronic psychosocial factors and acute physiological stress reactivity, Chida and Hamer (2008) identified a wide range of experimental stressors (duration less than 1 h). These stressors comprised cognitive challenge, public speaking, emotion induction and/or interpersonal stress; however, reflecting the stressors typically employed in laboratory stress research, the stressors included in the review served no function outside of the laboratory setting. It is generally the case, therefore, that acute stressors employed to observe stress mechanisms in the laboratory, rarely represent situations that would be experienced in the real world. This is especially the case for single tasks such as mirror tracing (Sawada, Nagano, & Tanaka, 2002) or mental arithmetic (Willemsen et al., 1998), which have low ecological validity (Pattyn, Migeotte, Neyt, van den Nest, & Cluydts, 2010). Individuals are rarely confronted by single stressors in everyday activities but instead are exposed to multiple stressors from different sources (Chida & Hamer, 2008). Laboratory techniques that reflect these multiple inputs are, therefore, more representative of demanding situations encountered in everyday life.

The multitasking framework comprises a set of eight generic cognitive tasks and elicits acute stress through the manipulation of workload intensity by increasing the number of tasks a user must attend to or by increasing the individual difficulty of those tasks. The multitasking framework does not simulate any specific working environment; however, it comprises tasks that are typically required in many working environments, for example, calculating values, the continuous monitoring of displays and auditory information inputs and the need to react to specific stimuli whilst ignoring less relevant information. Moreover, the framework necessitates the completion of self-paced tasks, whilst attending to and responding as appropriate, to the demands of time-limited tasks as and when they occur. As such, the framework provides an analogue for generic working environments that require individuals to simultaneously attend and respond to several stimuli that differ in terms of process and required response.

Many laboratory stressors are subject to habituation of psychobiological responses as a consequence of the stressor becoming more familiar and, therefore, less challenging (Kudielka & WÜst, 2010), and this can be problematic for protocols that require repeated administrations in the same individual. The framework, however, is not subject to such levels of habituation for two reasons. Firstly, as participants are instructed to achieve as high a score as possible, they will in normal circumstances, attempt to perform to the best of their ability at every session. This creates their own level of workload resulting in equivalent psychological and biological stress reactivity following repeated multitasking exposures (Wetherell, Hyland, & Harris, 2004). Secondly, drawing on a set of eight tasks, the framework can present up to four individual tasks simultaneously; if a researcher is interested in the effects of multitasking, rather than the specific effects of particular cognitive tasks, then a different combination of tasks can be presented in protocols requiring repeated administrations in the same individual (Scholey et al., 2009).

Several studies have utilized the framework for its performance-based stress inducing capabilities. The focus of these studies, however, has been to assess the efficacy of non-pharmaceuticals as potential anxiolytics. That is, they have compared performance on and reactivity to the framework following acute administration of *Melissa officinalis* (Kennedy, Little, & Scholey, 2004), *Salvia officinalis* (Kennedy, Little et al., 2006), *Valeriana officinalis* (Kennedy, Pace et al., 2006), chewing gum (Scholey et al., 2009; Johnson, Jenks, Miles, Albert, & Cox, 2011) and multi-vitamin supplements (Haskell et al., 2010), with responses following a placebo administration. The placebo/control arms of the studies typically demonstrate consistent effects of multitasking stress on mood, specifically, increased reports in feelings of alertness and state anxiety and reductions in feelings of calmness and contentment. Only one study has explicitly assessed the effects of the multitasking framework on psychobiological parameters. Wetherell and Sidgreaves (2005) assessed the effects of increasing workload intensity (5-min duration) on perceived workload demands, mood and secretory immunoglobulin A, an immune parameter responsive to acute stress. The framework elicited patterns of secretory immunoglobulin A reactivity typical of similar acute stressors, for example, a mental arithmetic task (Willemsen et al., 1998). Furthermore, increases in objective workload intensity were met with concomitant increases in perceived mental and temporal demand, effort, frustration and self-reported stress. This pattern of responses is typical of stressors that elicit an active coping response, that is, tasks that require continued engagement and effort on the part of the user (Uchino, Berntson, Holt-Lunstad, & Cacioppo, 2001).

Given the recent call for the development of new stressor paradigms (Kudielka & WÜst, 2010), and the increasing number of studies utilizing the framework for its stress-inducing properties, it is important to establish the effects of multitasking on psychobiological stress reactivity. Specifically, the current study assessed the effects of multitasking (15 min) at increasing workload intensities, on mood, perceived workload demands and cardiovascular (heart rate and blood pressure) parameters. It was hypothesized that increases in workload intensity would be met with dose-response changes in mood and perceived workload. Furthermore, as engagement with the tasks requires active coping, it was expected that multitasking stress would elicit the cardiovascular reactivity typical of active coping stressors, in this case, increases in heart rate and blood pressure.

Methods

Participants

The recruitment of participants and the study protocol were approved by the Departmental Ethics Committee.

The sample comprised of 21 healthy adults (male = 11 and female = 10). Interested participants were screened on the basis of the following exclusion criteria: current or previous anxiety or stress-related disorder, hypertension, pregnancy, current medication apart from over-the-counter analgesia and the contraceptive pill. Eligible participants gave written informed consent and were asked to refrain from smoking, eating and drinking, apart from water, for 1 h prior to each testing session. One participant (male) failed to attend all testing sessions, so analyses are conducted on 20 participants (M_{age} = 28.1 years and standard deviation = 10.4) who provided complete data.

Materials

The multitasking framework (Purple Research Solutions, UK) is a platform for the presentation of performance-driven and cognitively demanding tasks. The framework comprises eight tasks each of which can be presented singularly or in combination, up to a maximum of four tasks, where each task occupies a quadrant of the screen. Levels of workload stress can be manipulated either by increasing the number of tasks a user must attend to, or by altering the difficulty/workload of the tasks. All tasks are performance related and points are awarded for correct responses and deducted for incorrect or missed responses. A running total is presented in the middle of the screen and respondents are instructed to achieve as high a score as they can by being as fast and accurate on all of the tasks as possible. The current study used a combination of four tasks: mental arithmetic, auditory monitoring, visual monitoring and a Stroop task presented at low, medium and high workload intensity. These tasks were chosen as they require a number of cognitive processes including perceptual, attentional, psychomotor and memory abilities, which are typically employed in everyday functioning (for a full description of tasks see Wetherell & Sidgreaves, 2005).

Blood pressure and heart rate were recorded at predefined time points using an inflatable cuff attached to a semi-automatic blood pressure device (Omron M3 IntelliSense).

Questionnaires

Q2 Perceived workload demands and mood were assessed using the National Aeronautics and Space Administration-task load index (NASA-TLX) (Hart & Staveland, 1988) and Bond-Lader Visual Analogue Mood Scales (Bond & Lader, 1974), respectively. Both of these instruments comprise visual analogue scales, whereby participants are asked to mark a series of lines (100 mm) at the point that corresponds with their feelings at that time. The NASA-TLX comprises a set of six scales anchored with 'low' and 'high' at the extreme points. The scores for each scale are used to provide measures of six workload domains, three of which reflect the demand placed upon the respondent by the task (mental demand, physical demand and temporal demand) and three reflect the interaction between the respondent and the task (effort, perceived performance and frustration), where higher scores reflect greater levels of each perceived workload domain. The Bond-Lader comprises 16 scales with bipolar antonyms (e.g. lethargic–energetic, troubled–tranquil, tense–relaxed) which are used to produce three mood domains: alert (nine items, Cronbach's $\alpha = 0.88$), content (five items, Cronbach's $\alpha = 0.81$) and calmness (two items, Cronbach's $\alpha = 0.46$), where higher scores reflect greater state feelings related to each mood state.

Procedure

Participants attended the laboratory at the same time of day for three consecutive days. All participants completed low, medium and high workload intensity sessions (15-min duration), the order of which was counterbalanced using a Latin square. At the first session, participants were seated for several minutes before an initial measurement of blood pressure was recorded to familiarize them with the procedure. During testing, the cuff was kept on the non-dominant arm enabling measurements whilst participants completed the tasks. Participants were given a 2-min demonstration of the framework and prior to commencement, informed that they must obtain as high a score as possible whilst being as fast and accurate on all of the tasks as they can. To further encourage respondents to engage in all of the tasks, they were informed that their level of multitasking is assessed (i.e. attendance and response to all of the tasks) and that their data could only be included if multitasking is evident. At each session, participants completed the Bond-Lader immediately before and after the framework and in addition, the NASA-TLX was completed following framework cessation. Heart rate and blood pressure were recorded immediately before, 5 and 10 min during and immediately upon cessation of the framework.

Treatment of results

To account for individual differences in cardiovascular reactivity, pre-stress values were compared with maximal (peak) values during the task and post-task values for each individual for heart rate, systolic and diastolic blood pressure (Kaye et al., 2004; Hruschka, Kohrt, & Worthman, 2005; Wetherell et al., 2006) and were assessed across the three workload intensities using two way (low, medium, high intensity X pre, peak, post value) repeated measures analysis of variance. Pre–post differences in mood parameters were assessed across the three workload intensities using two-way (low, medium and high intensity X pre–post stress) repeated measures analysis of variance. An alpha of 5% was used for all statistical analyses, with post-hoc analyses as appropriate. *F*-values, degrees of freedom and effect size (ε) are reported. All analyses were conducted using ~~PASW Statistic v18~~. Q3

Results

Cardiovascular reactivity

There were no main effects of workload intensity; however, significant main effects of time were observed for heart rate ($F(2,18)$ 3.99, $p = 0037$, $\varepsilon = 0.31$), systolic blood pressure ($F(2,18)$ 10.40, $p = 0.001$, $\varepsilon = 0.54$) and diastolic blood pressure ($F(2,18)$ 4.50, $p = 0.026$, $\varepsilon = 0.33$). Post hoc analyses demonstrated significant multitasking induced increases between pre-stress and peak response in heart rate ($p = 0.031$), systolic blood pressure ($p = 0.009$) and diastolic blood pressure ($p = 0.01$) and subsequent recovery from peak response to post-stress for heart rate ($p = 0.042$) and systolic blood pressure ($p = 0.001$). Table I presents the mean standard error (SE) values for cardiovascular parameters at pre-stress, 5 and 10 min during task, post-stress[1] and peak responses at low, medium and high intensity workload.

Mood

Analyses demonstrated significant pre to post increases in feelings of alertness ($F(1,19)$ 8.41, $p = 0.009$, $\varepsilon = 0.31$), and decreases in feelings of calmness ($F(1,19)$ 5.61, $p = 0.03$, $\varepsilon = 0.23$). The interactions between pre to post change and intensity approached significance for feelings of contentment ($p = 0.08$, $\varepsilon = 0.25$) and calmness ($p = 0.07$, $\varepsilon = 0.26$). For contentment, this represented post-stress increases following low and medium intensities but a decrease following high intensity. For calmness, this represented greater post-stress reductions concomitant with increases in workload intensity. Mean (SE) pre and post scores for each mood domain at low, medium and high intensity workload are presented in Table I.

Perceived workload

Increasing workload intensity led to significant increases in mental demand ($F(2,18)$ 35.1, $p < 0.001$, $\varepsilon = 0.80$), physical demand ($F(2,18)$ 4.89, $p = 0.02$, $\varepsilon = 0.35$), temporal demand ($F(2,18)$ 24.75, $p < 0.001$, $\varepsilon = 0.73$), effort ($F(2,18)$ 31.27, $p < 0.001$, $\varepsilon = 0.78$) and frustration ($F(2,18)$ 6.92, $p = 0.006$, $\varepsilon = 0.44$). In contrast, as workload intensity increased, perceived performance significantly decreased ($F(2,18)$ 5.05, $p = 0.02$, $\varepsilon = 0.36$). Mean (SE) perceived workload demands following low, medium and high intensity workload and significant post-hoc analyses are presented in Figure 1.

Discussion

This study assessed the effects of increasing workload intensity on mood, perceptions of workload and

[1]Analyses of the four measurement periods (pre-stress, 5 and 10 min during task and post) across low, medium and high intensities yielded no significant effects of time or intensity for heart rate, systolic or diastolic blood pressure.

Table I. Mean (SE) pre-stress, 5 and 10 min during task, post-stress and individual peak response values for cardiovascular parameters and pre-stress and post-stress values for mood parameters at low, medium and high workload intensities

	Low					Medium					High				
	Pre-stress	5 min	10 min	Post-stress	Peak	Pre-stress	5 min	10 min	Post-stress	Peak	Pre-stress	5 min	10 min	Post-stress	Peak
Cardiovascular parameters															
Heart rate (bpm)	74.2 (2.5)	74.6 (2.5)	73.9 (2.3)	74.3 (2.5)	76.3 (2.4)	75.9 (3.3)	76.2 (2.9)	77.2 (3.0)	77.7 (2.9)	78.9 (3.1)	75.3 (3.2)	75.5 (2.4)	75.2 (2.6)	75.1 (2.3)	77.3 (2.4)
Systolic blood pressure (mm Hg)	119.0 (3.6)	119.6 (3.8)	118.1 (4.0)	119.5 (3.7)	121.0 (3.9)	121.4 (4.1)	122.8 (3.7)	123.9 (3.1)	120.4 (4.1)	125.7 (3.2)	121.0 (3.1)	120.5 (3.5)	120.9 (3.4)	119.6 (2.7)	123.9 (3.5)
Diastolic blood pressure (mm Hg)	74.2 (3.1)	73.6 (2.9)	72.4 (3.1)	73.3 (2.9)	77.2 (2.9)	75.4 (2.8)	74.9 (2.5)	78.2 (3.1)	78.3 (3.3)	79.8 (3.2)	72.3 (2.6)	73.8 (2.7)	75.3 (3.1)	75.6 (3.2)	77.5 (3.2)
Mood															
Alert	58.8 (3.4)			63.5 (3.9)		57.6 (4.0)			66.3 (3.2)		58.5 (4.2)			64.2 (3.7)	
Content	64.5 (3.7)			65.8 (4.3)		61.2 (3.6)			66.9 (3.60		62.5 (4.0)			60.3 (4.1)	
Calm	59.3 (5.1)			56.7 (5.1)		59.6 (4.4)			48.2 (5.4)		58.5 (4.2)			44.7 (4.5)	

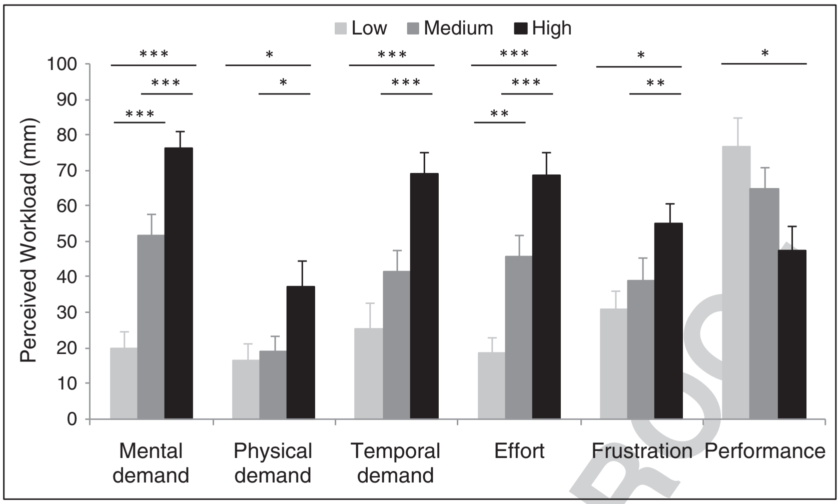


Figure 1. Perceived workload demands following low, medium and high workload intensity. $***p < 0.001$, $**p = 0.01$, $*p < 0.05$

cardiovascular parameters using the multitasking framework. Multitasking, for a period of 15 min, elicited changes in a range of psychobiological stress responses, the magnitude of which was dependent upon the intensity of objective workload. Regarding psychological responses, increases in workload intensity were met with dose response changes in all facets of perceived workload, specifically, participants reported the tasks to be more demanding and frustrating and requiring more effort. Regarding mood, all framework intensities elicited increased feelings of alertness and decreased feelings of calmness.

Given the nature of the framework, these psychological responses are not surprising; participants are instructed to obtain as high a score as possible by attending to all of the tasks as quickly and accurately as they can, the tasks, therefore, require engagement and this leads to increased alertness. However, the tasks are also cognitively demanding leading to reductions in feelings of calmness and concomitant increases in perceived demand, effort required and subsequent frustration. These mood effects are in line with the previous uses of the framework at low and medium intensities (Kennedy et al., 2004; Scholey et al., 2009; Haskell et al., 2010). Furthermore, the dose response increases in perceived workload support previous work demonstrating the same effects following a 5-min period of multitasking at low, medium and high intensity (Wetherell & Sidgreaves, 2005).

Multitasking stress led to significant cardiovascular activation as evidenced by increases in heart rate, systolic and diastolic blood pressure. The observed cardiovascular responses are analogous to other laboratory tasks that elicit cardiovascular reactivity, for example, reaction time and mental arithmetic tasks (Sosnowski et al., 2010) that required active engagement for successful completion (Uchino et al., 2001). It should be noted that as individuals may demonstrate their greatest cardiovascular reactivity at different time points during the task, individual peak responses were compared with pre-stress and post-stress measures. Individual differences in stress reactivity may account for variations in susceptibility to stress-related ill health (Schlotz, Yim, Zoccola et al., 2011), specifically, dysfunctional cardiovascular reactivity to acute psychological stress is associated with increased risk of cardiovascular disease (e.g. Phillips, 2011). As such, the framework could provide a useful tool for assessing individual differences in cardiovascular responses to everyday stressors.

The current study should be evaluated in the context of its limitations. Firstly, cardiovascular monitoring was limited to a pre-multitasking measure, specific time points during multitasking and immediately post-stress. Although the pre-multitasking measure was taken following a period of seated rest, this does not represent a true baseline period but instead is a pre-stress measure, which may also be subject to anticipation of forthcoming tasks. Secondly, alternative methods of analysis, for example, comparison of pre-stress values with either an aggregation of task values or individual values during the task could have been employed to assess cardiovascular stress reactivity. The use of individual peak responses, where the maximal observed value at 5 or 10 min was compared with the pre-stress and post-stress measures at each intensity, was, however, considered appropriate for reasons pertaining to statistical power and individual differences. As greater samples sizes are typically required to ensure sufficient power to detect differences at individual time points, single reactivity measures can be employed to minimize type one error (Carlson, Dikecligil, Greenberg, & Mujica-Parodi, 2012). Given the relatively small sample size in the current study, a single measure of reactivity for each of the cardiovascular variables was, therefore, calculated. Individual peak responses are also considered appropriate as they allow for the interpretation of within-individual variation in stress responding (Hruschka et al., 2005). This is especially important given the capacity for individual differences in responding to the multitasking framework, where demand may not be consistent throughout a session. That is, because of differences in response rates to the tasks, demand may transiently increase and recede. For example, in the current configuration, the visual monitoring task may require a cursor reset at the same time as a high tone is sounded whilst the participant is trying to complete a mental arithmetic task. The calculation of individual peak responses, therefore, allows for the maximal period of reactivity to be used as a measure of representative reactivity during that session. A number of other studies have used individual peak values to assess similar indices (e.g. Kaye et al., 2004; Kudielka, Buske-Kirschbaum, Hellhammer, & Kirschbaum, 2004; Hendrawan, Yamakawa, Kimura, Murakami, & Ohira, 2012) and highlight the importance of maximizing individual responses (e.g. Ramsay & Lewis, 2003). A greater sampling frequency, coupled with an increased sample size would, however, allow for the use of alternative methods of assessing cardiovascular reactivity that compare mean tasks levels with levels at baseline. Now that acute cardiovascular reactivity has been established during multitasking, future studies could usefully employ continuous assessments to provide more sensitive indices of cardiovascular reactivity and recovery in relation to objective and perceived changes in workload.

Q6

Notwithstanding these limitations, the current findings demonstrate that the multitasking framework provides an easy to administer, reliable tool for investigating the effects of workload stress on psychological (i.e. mood and perceived workload demands) and biological (i.e. heart rate and blood pressure) parameters within the laboratory. Furthermore, these responses are analogous to other laboratory stressors requiring active coping, that is, the tasks require motivated performance and continuous user engagement for successful completion. The framework, however, has several advantages over other single task stressors typically used in the laboratory. Firstly, repeated multitasking does not lead to the levels of habituation typically seen with other acute stressors (Wetherell et al., 2004), and the framework is, therefore, suitable for repeated testing of the same participants (Scholey et al., 2009). Secondly, the framework comprises reliable manipulations of workload intensity, which are met with concomitant increases in levels of perceived workload and increases in negative mood. Finally, as individuals are rarely faced with single stressful stimuli in real life, the framework provides a controlled laboratory analogue for everyday tasks that require multitasking. The multitasking framework, therefore, provides an alternative laboratory technique for inducing stress through the manipulation of workload intensity.

REFERENCES

Bond, A., & Lader, M. (1974). The use of analogue scales in rating subjective feelings. *British Journal of Psychology*, *47*, 211–218.

Q7 ~~Bosch, J. A., De Geuss, E. J. C., Kelder, A., Veerman, E. C. I., Hoogstraten, J., & Nieuw Amerongen, A. V. (2001). Differential effects of active versus passive coping on secretory immunity. *Psychophysiology*, *38*, 836–846.~~

Brotman, D. J., Golden, S. H., & Wittstein, I. S. (2007). The cardiovascular toll of stress. *Lancet*, *370*, 1089–1100.

Carlson, J. M., Dikecligil, G. N., Greenberg, T., & Mujica-Parodi, L. R. (2012). Trait reappraisal is associated with resilience to acute psychological stress. *Journal of Research in Personality*, *46*, 609–613. Q8

Chida, Y., & Hamer, M. (2008). Chronic psychosocial factors and acute physiological responses to laboratory-induced stress in healthy populations: A quantitative review of 30 years of investigation. *Psychological Bulletin*, *134*(6), 829–885.

Q9 ~~Dickerson, S. S., & Kemeny, M. E. (2004). Acute stressors and cortisol responses: A theoretical integration and synthesis of laboratory research. *Psychological Bulletin*, *130*(3), 355–391.~~

Hart, S. G., & Staveland, L. E. (1988). Development of a multi-dimensional workload rating scale: Results of empirical and theoretical research. In P. A. Hancock, & N. Meshkati (Eds.), Human Mental Workload. Amsterdam. The Netherlands: Elsevier.

Haskell, C. F., Robertson, B. C., Jones, E., Forster, J., Jones, R., Wilde, A., … Kennedy, D. O. (2010). Effects of a multi-vitamin/mineral supplement on cognitive function and fatigue during extended multitasking. *Human Psychopharmacology*, *25*, 448–461.

Hendrawan, D., Yamakawa, K., Kimura, M., Murakami, H., & Ohira, H. (2012). Executive functioning performance predicts subjective and physiological acute stress reactivity: Preliminary results. *International Journal of Psychophysiology*, *84*, 277–283.

Hruschka, D. J., Kohrt, B. A., & Worthman, C. M. (2005). Estimating between- and within individual variation in cortisol levels using multilevel models. *Psychoneuroendocrinology*, *30*, 698–714.

Johnson, A. J., Jenks, R., Miles, C., Albert, M., & Cox, M. (2011). Chewing gum moderates multi-task induced shifts in stress, mood, and alertness. *Appetite*, *56*, 408–411.

Kaye, J., Buchanan, F., Kendrick, A., Johnson, P., Lowry, C., Bailey, J., … Lightman, S. (2004). Acute carbon dioxide exposure in healthy adults: Evaluation of a novel means of investigating the stress response. *Journal of Neuroendocrinology*, *16*(3), 256–264.

Kennedy, D. O., Little, W., Haskell, C. F., & Scholey, A. B. (2006). Anxiolytic effects of a combination of Melissa officinalia and Valeriana officinalis during laboratory induced stress. *Phytotherapy Research*, *20*, 96–102.

Kennedy, D. O., Little, W., & Scholey, A. B. (2004). Attenuation of laboratory induced stress in humans following acute administration of Melissa officinalis (Lemon Balm). *Psychosomatic Medicine*, *66*, 607–613.

Kennedy, D. O., Pace, S., Haskell, C., Okello, E. J., Milne, A., & Scholey, A. B. (2006). Effects of cholinesterase inhibiting sage (Salvia officinalis) on mood, anxiety and performance on a psychological stressor battery. *Neuropsychopharmacology*, *31*(4), 845–852.

Kiecolt-Glaser, J. K., & Glaser, R. (2002). Depression and immune function – central pathways to morbidity and mortality. *Journal of Psychosomatic Research*, *53*, 873–876.

~~Kirschbaum, C., Pirke, K. M., & Hellhammer, D. H. (1993). The 'Trier social stress test' – a tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology*, *28*, 76–81.~~ Q10

Kudielka, B. M., & Wüst, S. (2010). Human models in acute and chronic stress: Assessing determinants of individual hypothalamus-pituitary-adrenal axis activity and reactivity. *Stress*, *13*(1), 1–14.

Kudielka, B. M., Buske-Kirschbaum, A., Hellhammer, D. H., & Kirschbaum, C. (2004). Differential heart rate reactivity and recovery after psychosocial stress (TSST) in healthy children, younger adults and elderly adults: The impact of age and gender. *International Journal of Behavioral Medicine*, *11*(2), 116–121.

McKewen, B. S. (1998). Protective and damaging effects of stress mediators. *The New England Journal of Medicine*, *338*, 171–179.

Pattyn, N., Migeotte, P.-F., Neyt, X., van den Nest, A., & Cluydts, R. (2010). Comparing real-life and laboratory-induced stress reactivity on cardio-respiratory parameters: Differentiation of a tonic and a phasic component. *Physiology & Behavior*, *101*, 218–223.

Phillips, A. (2011). Blunted as well as exaggerated cardiovascular reactivity to stress is associated with negative health outcomes. *Japanese Psychological Research*, *53*(2), 177–192.

Ramsay, D., & Lewis, M. (2003). Reactivity and regulation in cortisol and behavioural responses to stress. *Child Development*, *74*, 456–464.

Sawada, Y., Nagano, Y., & Tanaka, G. (2002). Mirror tracing and the provocation of vascular-dominant reaction pattern through heightened attention. *Journal of Psychophysiology*, *16*, 201–210.

Saxbe, D. E. (2008). A field (researcher's) guide to cortisol: Tracking HPA axis functioning in everyday life. *Health Psychology Review*, *2:2*, 163–190.

Scholey, A., Haskell, H., Robertson, B., Kennedy, D., Milne, A., & Wetherell, M. (2009). Chewing gum alleviates negative mood and reduces cortisol during acute laboratory psychological stress. *Physiology & Behaviour*, *97*, 304–312.

Sosnowski, T., Bala, A., & Rynkiewicz, A. (2010). Mental task demands and cardiovascular response patterns. *Biological Psychology*, *84*, 264–271.

Steptoe, A., Lipsey, Z., & Wardle, J. (1998). Stress, hassles and variations in alcohol consumption, food choice and physical exercise: A diary study. *British Journal of Health Psychology*, *3*, 51–64.

Uchino, B. N., Berntson, G. G., Holt-Lunstad, J., & Cacioppo, J. T. (2001). Stress-induced autonomic and immunologic reactivity. In R. Ader, D. L. Felten, & N. Cohen (Eds.), Psychoneuroimmunology (pp. 317–333). San Diego: Academic Press.

Wetherell, M. A., & Sidgreaves, M. C. (2005). Secretory immunoglobulin A reactivity following increases in workload intensity using the defined intensity stress simulator. *Stress and Health*, *21*, 99–106.

Wetherell M. A., Crown A. L., Lightman, S. L., Miles, P. J., Kaye, J., & Vedhara, K. (2006). The four dimensional stress test: Psychological, sympathetic-adrenal-medullary, parasympathetic and hypothalamic-pituitary-adrenal responses following inhalation of 35% C02. *Psychoneuroendocrinology*, *31*, 736–747.

Wetherell, M. A., Hyland, M. E., & Harris, J. E. (2004). Secretory immunoglobulin-A reactivity to acute and cumulative acute multitasking stress: relationships between reactivity and perceived workload. *Biological Psychology*, *66*, 257–270.

Willemsen, G., Ring, C., Carroll, D., Evans, P., Clow, A., & Hucklebridge, F. (1998). Secretory immunoglobulin A and cardiovascular reactions to mental arithmetic and cold pressor. *Psychophysiology*, *35*, 252–259.

Author Query Form

Journal: Stress and Health

Article: smi_2496

Dear Author,

During the copyediting of your paper, the following queries arose. Please respond to these by annotating your proofs with the necessary changes/additions.

- If you intend to annotate your proof electronically, please refer to the E-annotation guidelines.
- If you intend to annotate your proof by means of hard-copy mark-up, please refer to the proof mark-up symbols guidelines. If manually writing corrections on your proof and returning it by fax, do not write too close to the edge of the paper. Please remember that illegible mark-ups may delay publication.

Whether you opt for hard-copy or electronic annotation of your proofs, we recommend that you provide additional clarification of answers to queries by entering your answers on the query sheet, in addition to the text mark-up.

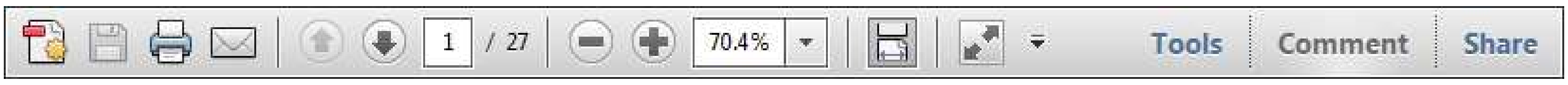
Query No.	Query	Remark
Q1	AUTHOR: "Schlotz, Yim, Zoccola et al., 2011" is cited in throughout the text but not given in the reference list. Please provide details in the list or delete the citation from the text.	
Q2	AUTHOR: National Aeronautics and Space Administration-task load index. Is this the correct definition for NASA-TLX? Please change if this is incorrect.	
Q3	AUTHOR: Please give manufacturer information for this product: company name, town, state (if USA), and country.	
Q4	AUTHOR: Table 2 has been changed to Table 1. Please check if appropriate.	
Q5	AUTHOR: Figure 2 citation has been changed to Figure 1, please check.	
Q6	AUTHOR: The citation "Ramsay et al., 2003" (original) has been changed to "Ramsay and Lewis, 2003". Please check if appropriate.	
Q7	AUTHOR: Reference "Bosch et al. (2001)" is not cited in the text. Please indicate where it should be cited; or delete from the reference list.	
Q8	AUTHOR: Please check authors name in ref. Carlson J.M et al. 2012 if captured correctly.	
Q9	AUTHOR: Reference "Dickerson & Kemeny (2004)" is not cited in the text. Please indicate where it should be cited; or delete from the reference list.	
Q10	AUTHOR: Reference "Kirschbaum et al. (1993)" is not cited in the text. Please indicate where it should be cited; or delete from the reference list.	

WILEY-BLACKWELL

USING e-ANNOTATION TOOLS FOR ELECTRONIC PROOF CORRECTION

Required software to e-Annotate PDFs: Adobe Acrobat Professional or Adobe Reader (version 7.0 or above). (Note that this document uses screenshots from Adobe Reader X)
The latest version of Acrobat Reader can be downloaded for free at: http://get.adobe.com/uk/reader/

Once you have Acrobat Reader open on your computer, click on the Comment tab at the right of the toolbar:



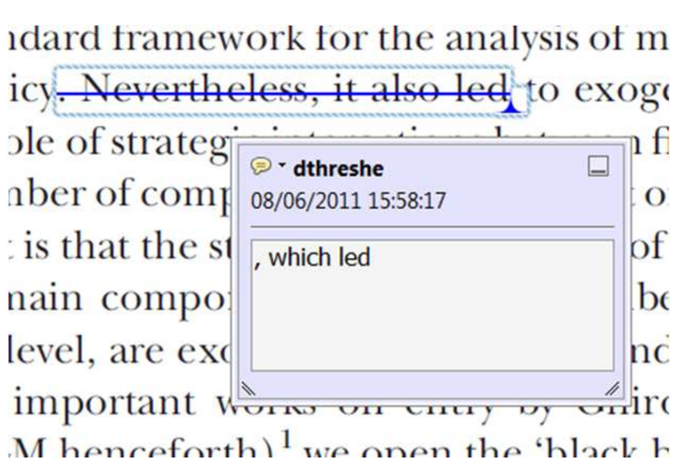
This will open up a panel down the right side of the document. The majority of tools you will use for annotating your proof will be in the Annotations section, pictured opposite. We've picked out some of these tools below:

1. Replace (Ins) Tool – for replacing text.

Strikes a line through text and opens up a text box where replacement text can be entered.

How to use it

- Highlight a word or sentence.
- Click on the Replace (Ins) icon in the Annotations section.
- Type the replacement text into the blue box that appears.

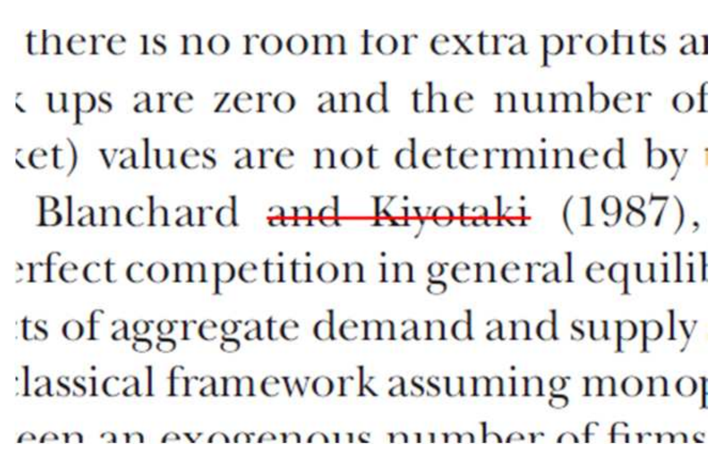


2. Strikethrough (Del) Tool – for deleting text.

Strikes a red line through text that is to be deleted.

How to use it

- Highlight a word or sentence.
- Click on the Strikethrough (Del) icon in the Annotations section.

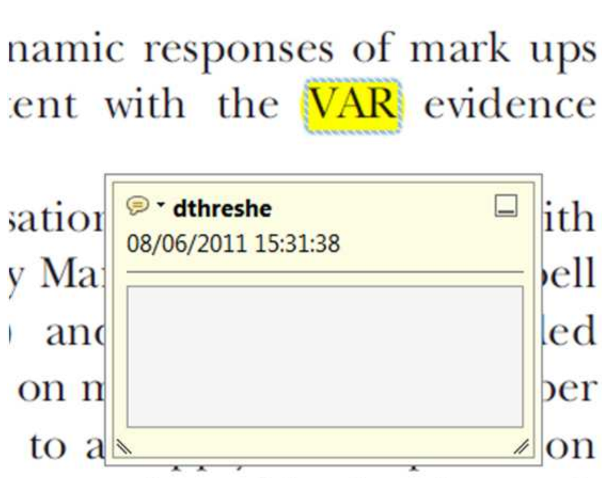


3. Add note to text Tool – for highlighting a section to be changed to bold or italic.

Highlights text in yellow and opens up a text box where comments can be entered.

How to use it

- Highlight the relevant section of text.
- Click on the Add note to text icon in the Annotations section.
- Type instruction on what should be changed regarding the text into the yellow box that appears.

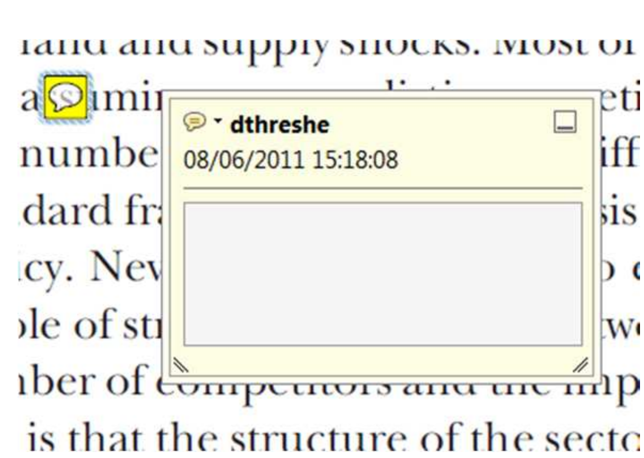


4. Add sticky note Tool – for making notes at specific points in the text.

Marks a point in the proof where a comment needs to be highlighted.

How to use it

- Click on the Add sticky note icon in the Annotations section.
- Click at the point in the proof where the comment should be inserted.
- Type the comment into the yellow box that appears.



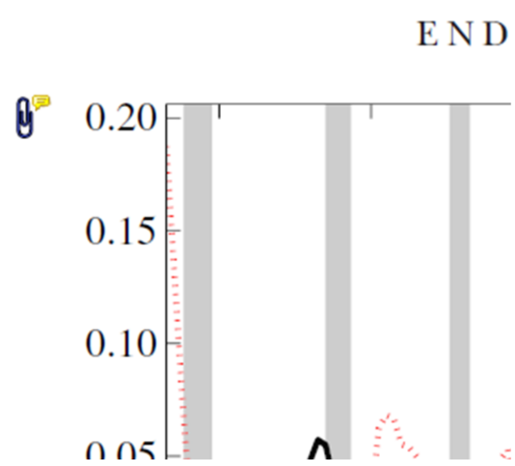
USING e-ANNOTATION TOOLS FOR ELECTRONIC PROOF CORRECTION

5. Attach File Tool – for inserting large amounts of text or replacement figures.

Inserts an icon linking to the attached file in the appropriate pace in the text.

How to use it

- Click on the Attach File icon in the Annotations section.
- Click on the proof to where you'd like the attached file to be linked.
- Select the file to be attached from your computer or network.
- Select the colour and type of icon that will appear in the proof. Click OK.

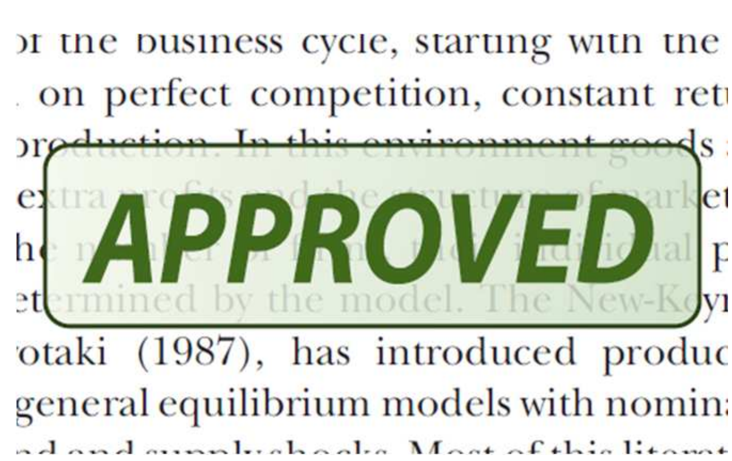


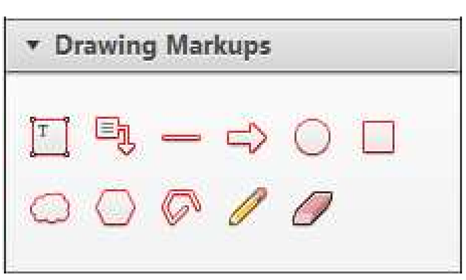
6. Add stamp Tool – for approving a proof if no corrections are required.

Inserts a selected stamp onto an appropriate place in the proof.

How to use it

- Click on the Add stamp icon in the Annotations section.
- Select the stamp you want to use. (The Approved stamp is usually available directly in the menu that appears).
- Click on the proof where you'd like the stamp to appear. (Where a proof is to be approved as it is, this would normally be on the first page).



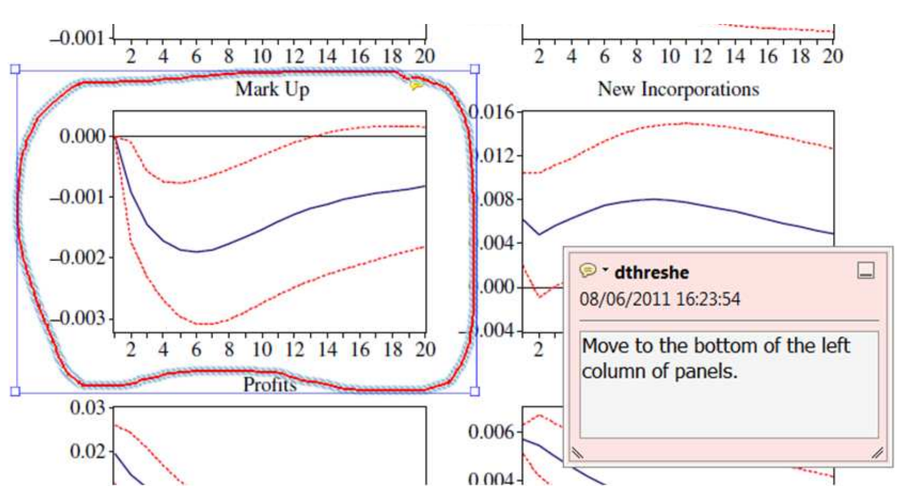


7. Drawing Markups Tools – for drawing shapes, lines and freeform annotations on proofs and commenting on these marks.

Allows shapes, lines and freeform annotations to be drawn on proofs and for comment to be made on these marks..

How to use it

- Click on one of the shapes in the Drawing Markups section.
- Click on the proof at the relevant point and draw the selected shape with the cursor.
- To add a comment to the drawn shape, move the cursor over the shape until an arrowhead appears.
- Double click on the shape and type any text in the red box that appears.



For further information on how to annotate proofs, click on the Help menu to reveal a list of further options: