Sleeplessness, Stress, Cognitive Disruption and Academic Performance Following the September 4, 2010, Christchurch Earthquake

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Abstract

Two studies investigated psychological effects of the September 4, 2010 Christchurch earthquake. Study 1 found self-reported sleeplessness, cognitive dysfunction, and heightened stress, depression and anxiety in members of the general public who had experienced the earthquake and aftershocks, but many also reported positive experiences. The self-reported effects were much stronger for women than men. Those scoring higher on neuroticism were worse affected, but otherwise effects varied little with personality. Study 2 examined academic performance by over 9000 University of Canterbury undergraduate students in the second semester (July-October) of 2010 and found no performance decrement for either men or women.

Keywords: disaster, earthquake, mental health, cognitive disruption, academic performance

Introduction

The city of Christchurch, New Zealand and the adjacent Canterbury region has a population of about 500,000. At 4.35 a.m. on September 4, 2010, the city and region were struck by a 7.1 magnitude earthquake. Remarkably, no one was killed and only a handful of people injured, but there was major property and infrastructure damage. In the following weeks and months, there were numerous aftershocks with over 100 quakes of at least magnitude 2.0 on September 4 alone. By September 30, over 1800 had been recorded, and by October 31 over 2400. Depending on strength, depth, and position, some of these were widely felt and caused further damage (Quigley, Villamor, Furlong, Bevan, Van Dissen, Litchfield, Stahl., Duffy, Bilderback, Noble, Barrell, Jongens, & Cox, 2010). In this paper we examine some psychological effects on people who experienced the earthquake and its aftermath. The first instrument we used was a questionnaire survey, and the vast majority of responses to it were collected in the week 23 to 30 September.

That natural disasters in general, and earthquakes in particular, have detrimental effects on psychological functioning is well-known (Bergiannaki, Psarros, Varsou, Paparrigopoulos, & Soldatos, 2003; Cardena & Spiegel, 1993; Neria, Nandi, & Galea, 2008; Sahin, Batigün, & Yilmaz, 2007). Most studied has probably been the incidence and severity of post-traumatic stress disorder (Neria et al., 2008), but there have also been studies of more immediate or short-term effects. For example, Bergiannaki et al. (2003) examined acute and post-acute stress from 48 hours after an earthquake in the Greek town of Egion.

The present study had a different focus to most previous research. We concentrated on a range of less serious and more short-term complaints than post-traumatic stress disorder. Thus, we investigated not only depression, anxiety and stress effects but also reports of cognitive impairment and sleeplessness. Indeed, our second study focussed on cognitive effects, specifically in academic performance. One reason for looking at the effects on cognition and sleep is that these may have consequences for such activities as driving performance (Su, Tran, Wirtz, Langteau, & Rothman, 2009).

When a natural disaster such as an earthquake strikes, not all members of the community are equally affected, either physically or psychologically. Do people of

particular personality types or people whose homes were more damaged suffer more (e.g. Kendler, Kuhn, & Prescott, 2004)? Is there a difference between the reactions of men and women (as reported by Potangaroa, 2006; Potangaroa, Wang, and Chan, 2010)?

The Depression Anxiety Stress Scales (DASS) provide useful brief measures of depression, anxiety, and stress (e.g. Potangaroa et al., 2010). The three scales are separate but correlated, with intercorrelations ranging from .54 to .65, and have good psychometric properties (Lovibond & Lovibond, 1995a, b). A 21-item version of the scales (7 items per scale), the DASS21, produces comparable results to the longer (42 item) version (Henry & Crawford, 2005; Lovibond & Lovibond, 1995a, b; Ng, Trauer, Dodd, Callaly, Campbell, & Berk, 2007).

Immediately following the Christchurch earthquake people often reported not thinking clearly. We included a simple five-item self-report measure of cognitive disruption. Validation for this ad hoc measure comes from another post-earthquake study by Helton, Head and Kemp (2011), which found that variability on two Sustained Attention to Response Tasks (e.g. Chan, 2001) was well predicted ($\beta = .78$) by performance on this cognitive disruption measure.

Many people reported losing sleep for weeks after the major event. The most obvious cause was the frequent aftershocks, although psychological disturbance might also play a role. We introduced two measures. One directly asked people how many hours of sleep they had per night. The other was a three-item scale of sleep disturbance.

Finally, many people received help from others, friends and family phoned or emailed to express sympathy and concern, and communities in New Zealand and overseas sent sympathetic messages and material aid. We attempted to measure whether people also had positive experiences of the earthquake

Study 1

Method

Questionnaire. The questionnaire asked about people's experiences following the September 4 Christchurch earthquake. Further information about uses of the data and organisations to contact for help were given on the introductory page and in a separate information sheet.

At the beginning of p. 2, respondents were asked to read and indicate how much each of a series of 33 statements "applied to you over the whole period since September 4". These statements consisted of the 21 statements included in the DASS-21 scale, with 7 each from scales measuring depression (e.g. "I couldn't seem to experience any positive feelings at all"), anxiety (e.g. "I was aware of dryness of my mouth"), and stress (e.g. "I tended to overreact to situations"). Statements from the DASS were haphazardly ordered, and interspersed with 12 other statements measuring sleep disruption, cognitive disruption, and mostly positive statements about reactions to the earthquake.

The three sleep disruption questions were: "I was often woken up from sleep"; "I found it difficult to sleep through the night"; and "I was tired during the day". Five statements related to respondents' perceptions of their own cognitive disruption: "I found it difficult to remember things"; "I felt it was very difficult to make decisions"; "I felt my brain was working more slowly than usual"; "I thought about the earthquake a lot"; and "I was frustrated by not being able to think clearly". The four positive statements were included partly to lighten the tone of the questionnaire for the respondents, and partly to see if there were positive aspects to the experience. They were: "I found my local community and neighbours helpful"; "I was cheered up by sympathy from people outside the city"; "I felt official New Zealand helped ordinary people"; and "I talked to other people about my experiences". (Note that the latter is not necessarily a positive experience, although we expected most people to find it helpful.)

All these statements were responded to on the four-point scale normally used with the DASS-21. This scale is: (0) Did not apply to me at all; (1) Applied to me to some degree, or some of the time; (2) Applied to me to a considerable degree, or a good part of the time; (3) Applied to me very much, or most of the time.

The following page presented brief measures of the Big Five personality traits. There were two word or phrase pairs for extraversion (extraverted, enthusiastic and reserved, quiet); agreeableness (sympathetic, warm and critical, quarrelsome); conscientiousness (dependable, self-disciplined and disorganised, careless); neuroticism (anxious, easily upset and calm, emotionally stable); and openness (open to new experiences, complex and conventional, uncreative). For all these traits, the second pair was reverse-scored. Each pair was followed by a seven-point scale from 1

(disagree strongly that these words or phrases apply to you) to 7 (agree strongly that these words or phrases apply to you). Respondents were asked to consider each pair as "a description of what you are **normally** like", and to "rate the extent to which each pair of words applies to you, even if one word or phrase applies more strongly than the other".

The personality measures were followed by requests for mostly factual information, namely whether the respondent was in Christchurch or the greater area on September 4, whether they owned a house or flat and what condition their accommodation was now in (uninhabitable; it's badly damaged but I can live in it; some but no really major damage; no apparent damage of any kind). They were asked to estimate how many hours sleep they had had on average since the earthquake, and whether they had contacted a welfare centre/emergency services/or official agency for help; helped someone else; seen a doctor or counsellor about your response to the earthquake; taken sleeping pills; considered moving to another city or country; considered moving to another part of town; and stocked up with a lot of groceries. The questionnaire concluded with gender and age group questions, detail about where they were at the time of the earthquake and the date of questionnaire completion. A slightly shortened version of the questionnaire that omitted some requests for factual information was used for most of the non-Christchurch respondents.

Respondents and procedure. A total of 299 people completed questionnaires. Two hundred and two of them were recruited by paid psychology graduates at the University of Canterbury, all of whom were asked to recruit non-student members of their acquaintance. Thirty-two respondents were themselves psychology students. Recruitment of these 234 respondents focussed on respondents who had experienced the earthquake and aftershocks although a few other respondents were obtained. A further 34 respondents were then recruited by again asking paid graduates to find respondents who had not experienced the earthquake or aftershocks. The final 31 respondents were obtained from an online version of the questionnaire which was made available both locally and outside of Christchurch.

The total sample contained 240 people who were in Christchurch on September 4 and for most of the following periods. Of this sample, 219 completed their questionnaires in the period 23-30 September, 17 between 1 and 6 October, and the remaining 4 later in October, the latest on 27 October. Thus, most of the earthquake sample responded between 19 and 26 days after the main earthquake. The 59 respondents who did not experience the earthquake were mostly recruited in October, the latest on 17 October.

Overall, the sample contained 143 males and 153 females (no information for 3 respondents). Thirty-four percent were between the ages of 15 and 24; 28% between 25 and 24; 11% between 35 and 44; 13% between 45 and 54; 9 % between 55 and 64; and 4% were 65 or over. One hundred and thirty-eight owned a house or a flat in Christchurch. No respondent reported that their house in Christchurch was uninhabitable following the earthquake; 7 that their house was badly damaged but liveable; 97 reported some damage; and 132 no apparent damage.

Results

The DASS-21 scales all proved to have good internal consistency reliability (Depression, Cronbach α = .80; Anxiety, α = .85; Stress, α = .89). The three sleep disruption items (α = .89) and the five cognitive dysfunction items (α = .84) also had high internal consistency. The four positive experience items had lower although still respectable reliability (α = .72). Inspection of the item-total correlations indicated that this reliability would not be improved by omitting any of the four items so they were all retained. The measures of sleep disruption, cognitive disruption and positive experience were composed by averaging the relevant items (producing possible scores between 0 and 3). DASS scale measures were composed by adding the relevant seven items and then multiplying by two. This is a standard procedure as it enables comparison with both previous DASS results and the full 42-item DASS scale (e.g. Henry & Crawford, 2005).

The three DASS scales, the sleep disturbance measure and the cognitive disruption scale correlated quite highly with one another, with Pearson correlations ranging from .61 (sleep disturbance and anxiety) to .83 (anxiety and cognitive disruption).

Table 1 shows comparisons on each of the scales between the earthquake and the non-Christchurch samples. Also shown are the average number of hours sleep per night reported by the samples, a measure which correlated moderately well with rated sleep disruption (r = .48, p < .05). In order to enable some comparison between the different measures employed,

and especially to investigate which of the measures were most affected by the earthquake, we also include a standardised measure (*d*) of the difference between the samples.

Table 1. Rated sleeplessness, cognitive dysfunction, positive experiences, reported average hours of sleep, and DASS depression, anxiety, and stress scores for those who did (n = 240) and did not (n = 59) experience the earthquake and aftermath.

Measure	Earthquake sample	non-Christchurch	*d*
Sleep disruption	1.57 (0.97)	0.47 (0.77)***	1.06
Positive experiences	1.44 (0.69)	0.64 (0.62)***	1.18
Average Stress	11.7 (9.6)	5.0 (8.0)***	.73
Cognitive disruption	0.84 (0.68)	0.39 (0.52)***	.69
Average Depression	5.8 (6.3)	2.4 (4.6)***	.57
Average Anxiety	6.4 (8.1)	2.9 (5.3)**	.46
Average hours sleep	6.7 (1.5)	7.1 (1.0)*	.30

Results of two-tailed t-test shown:
* $p < .05$; ** $p < .01$; ***$p < .001$.

d is a standardized measure of difference between the samples (equal to the difference inv sample means divided by the overall sample deviation)

The results are straightforward to interpret. Those who experienced the earthquake and its aftershocks reported a substantial increase in sleep disruption and related problems. They also reported positive experiences (although note that the control, non-earthquake sample had little opportunity to have these particular experiences). There were also significant effects of the earthquake on stress, depression, anxiety, and cognitive disruption. However, the average member of the eartthquake sample recorded levels of depression, stress, and anxiety that remained (just) within the DASS normal range (Lovibond & Lovibond, 1995a). A number of analyses focussed only on respondents who were in Christchurch for the earthquake and its aftermath. Measures of the five personality traits were constructed and correlations between them and the seven earthquake effects measures calculated. Neither openness nor extraversion correlated with any of the measures. More agreeable people reported slightly more sleep disruption ($r = .16$, $p < .05$) but also more positive experiences (r = .21, $p < .05$). More conscientious people also reported more positive experiences ($r = .16$, $p < .05$). Those scoring higher on neuroticism had more sleep disruption ($r = .28$, $p < .05$), more cognitive disruption ($r = .35$, $p < .05$), and more depression ($r = .36$, $p < .05$), anxiety ($r = .35$, $p < .05$) and stress ($r = .36$, $p < .05$). Older people reported sleeping fewer hours ($r = -.26$, $p < .05$).

Women reported substantially more serious effects than men. Table 2 shows comparisons for the seven measures for just those who had been in Christchurch for the earthquake. The differences seem earthquake related: The non-Christchurch group showed no significant gender differences on any measure, and when two-way analyses of variance were conducted using gender and being present for the earthquake or not as factors, all measures except for positive experiences showed significant ($p < .05$) interactive effects. Compared to DASS norms (Lovibond & Lovibond, 1995a), the average male scores were all well within the normal range; the average woman produced normal depression scores but moderate anxiety and mild stress.

Table 2. Rated sleeplessness, cognitive dysfunction, positive experiences, reported average hours of sleep, and DASS depression, anxiety, and stress scores for men (n = 118) and women (n = 119) who experienced the earthquake and aftermath.

Measure	Men	Women	d
Average Stress	6.9 (7.0)	16.6 (9.3)***	1.17
Cognitive disruption	0.51 (0.48)	1.16 (0.69)***	1.10
Sleep disruption	1.12 (.89)	2.01 (0.82)***	1.03
Average Anxiety	3.0 (5.0)	10.0 (9.1)***	.95
Average Depression	3.2 (4.8)	8.4 (6.5)***	.91
Average hours sleep	7.2 (1.3)	6.3 (1.5)***	60
Positive experiences	1.28 (0.70)	1.60 (0.64)***	48

Results of two-tailed t-test shown:
* p < .05; ** p < .01; ***p < .001.

d is a standardized measure of difference between the samples (equal to the difference in sample means divided by the overall sample deviation)

Table 3 shows differences in the six measures between those whose homes received either serious or some damage (pooled because only 7 respondents lived in homes with serious damage) and those whose homes had received no damage. In general, those with some damage were worse affected. With the Table 2 results in mind, we also investigated interactive effects of gender and damage on each of the seven measures. Significant interactive effects were found for cognitive disruption, depression and stress. Men's scores showed little effect of damage to the home on these three measures, whereas women's scores were increased. However, women's scores were higher than men's even for those in undamaged homes.

Table 3. Rated sleeplessness, cognitive dysfunction, positive experiences, reported average hours of sleep, and DASS depression, anxiety, and stress scores for those who reported some or severe damage (n = 104) or no damage (n = 132) to their homes from the earthquake or aftershocks.

Measure	Damage	No damage	*d*
Cognitive disruption	0.99 (0.74)	0.72 (0.60)**	.40
Positive experiences	1.55 (0.69)	1.34 (0.68)*	.30
Average Stress	13.3 (10.2)	10.6 (9.0)*	.28
Average Depression	6.6 (6.9)	5.2 (5.7)	.22
Average Anxiety	7.4 (8.5)	5.7 (7.7)	.21
Average hours sleep	6.8 (1.4)	6.6 (1.5)	.13
Sleep disruption	1.62 (0.96)	1.53 (0.97)	.09

Results of two-tailed t-test shown:
* $p < .05$; ** $p < .01$; ***$p < .001$.

d is a standardized measure of difference between the samples (equal to the difference in sample means divided by the overall sample deviation)

The relationships shown in Tables 1, 2 and 3 were also investigated in a series of analyses of covariance using the five personality measures as covariates. When this was done, the difference in positive experiences between men and women (see Table 2) achieved significance at only the $p < .01$ (instead of .001) level of significance. The difference in positive experiences and the difference in stress between those who had or had not suffered damage now failed to achieve significance (instead of the .05 level of significance). For all eighteen other differences examined the level of statistical significance (or not) was unchanged under analysis of covariance. In no case, including those where the level of significance was changed did inspection of the corrected means suggest major changes from those obtained with the simple *t*-test analyses. Thus, effects of experiencing the earthquake, gender or damage sustained to one's home could mostly not be subsumed under personality differences.

The most frequently reported reaction to the earthquake and its aftermath was helping others (62 % of the earthquake sample). Next most frequent was stocking up on groceries (33%), followed by taking sleeping pills (18 %), contacting a welfare centre, emergency services or official agency for help (12 %), considering moving to another city or country (12 %), considering moving to another part of Christchurch (9 %), and seeing a doctor or counsellor (5 %). Taking any of the steps (including helping others) were associated with higher levels of sleep and cognitive disruption, lower average numbers of hours slept, higher scores on all three DASS scales, but also a higher incidence of positive experiences.

Study 2

Study 1 indicated that the earthquake had produced substantial cognitive disruption, especially in women. An obvious issue arises as to whether the gender effect reflects differences in readiness to self-report or differences in actual cognitive disruption. Linked to this is the issue of whether reported cognitive disruption relates to actual cognitive performance, and, if so, which aspects of cognitive performance. As remarked earlier, Helton et al. (2011) found a strong relationship between performance on the cognitive disruption scale and performance on a vigilance task, but it is not clear that real-world thinking or performance would necessarily be affected. Previous research has often found that sleep deprivation has a substantial effect on vigilance but not on other cognitive performance (Altena, van der Werf, Strijers, & van Someren, 2008).

In Study 2 we looked at the academic performance of undergraduates enrolled in the University of Canterbury.

Method

Ethical and administrative consent was obtained to access edited academic performance information from the University of Canterbury student records. We were permitted to access the grade point averages of all undergraduate students enrolled in 2010 and 2009. We also obtained information about individual students' gender, faculty of enrolment, and level (first, second, third, or, for four-year undergraduate degrees, fourth year of study).

In 2010, the University of Canterbury's first teaching semester extended from 22 February to 4 June, with all examinations ending by 26 June. The second teaching semester extended from 12 July to 22 October, with all assessment completed by 11 November. We averaged grade points only over courses taught wholly in either the first or second semester. Almost all undergraduate courses had a proportion (and frequently *all*) of their assessment due before teaching ended (i.e., 22 October), although in the second semester of 2010 many extensions were allowed.

Grade points for all courses ranged from 9 (A+) through to 0 (D) and -1 (E). Both D and E are fail grades. Grade point averages for each student in each semester

were obtained by averaging these numbers taking into account the course weighting. (Some courses carry greater course weights.)

A total of 9313 students (4435 female and 4878 male) completed at least one undergraduate course in each semester of 2010. Of these, 3577 completed their most advanced paper at first, 2768 at second, 2591 at third, and 377 at fourth-year level. In 2009, 9107 students (4343 female and 4764 male) completed at least one undergraduate course in each semester.

Results and Discussion

The key result, comparing first and second semester grades for male and female students in 2010, is shown in Figure 1. Analysis of variance showed a statistically significant effect of gender ($F(1, 9311) = 124.9$, $p < .001$), but not of semester ($F < 1$), or the interaction ($F(1, 9311) = 3.06$, $p = .08$).

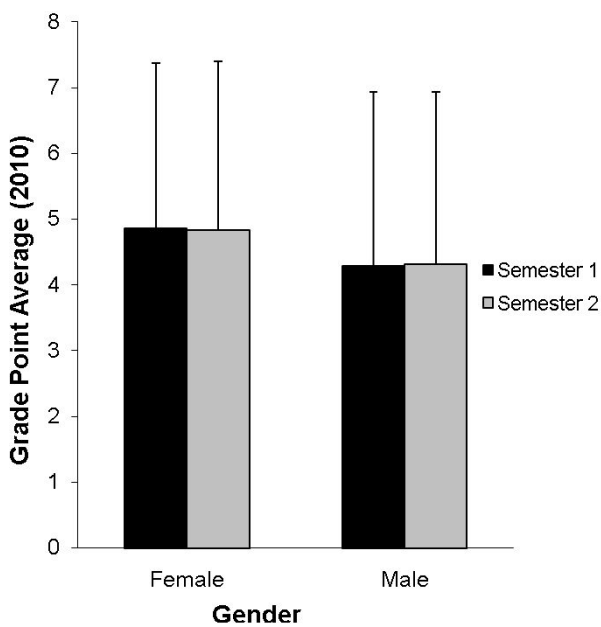

Figure 1. Grade Point Average of Semester 1 and Semester 2 courses for all undergraduate students at the University of Canterbury in 2010. Bars above the boxes indicate standard deviations.

Figure 2 shows comparable results from 2009, a year unmarked by any major natural disaster in Canterbury. Analysis of variance showed statistically significant effects of gender ($F(1, 9105) = 112.5$, $p < .001$), semester ($F(1, 9105) = 9.25$, $p = .002$), but not of the interaction ($F(1, 9105) = 1.28$, $p = .26$).

Taken together, these results indicate that the earthquake had no negative effect on the grade obtained in the second semester of 2010. Indeed, a slight but significant deterioration of average grades between Semester 1 and Semester 2 in 2009 (also found in 2008 and 2007) did not occur in 2010, raising the possibility that the earthquake might even have produced slightly better performance. On the other hand, assessment may have been more generous than normal in 2010 as markers consciously or unconsciously allowed for potential earthquake effects.

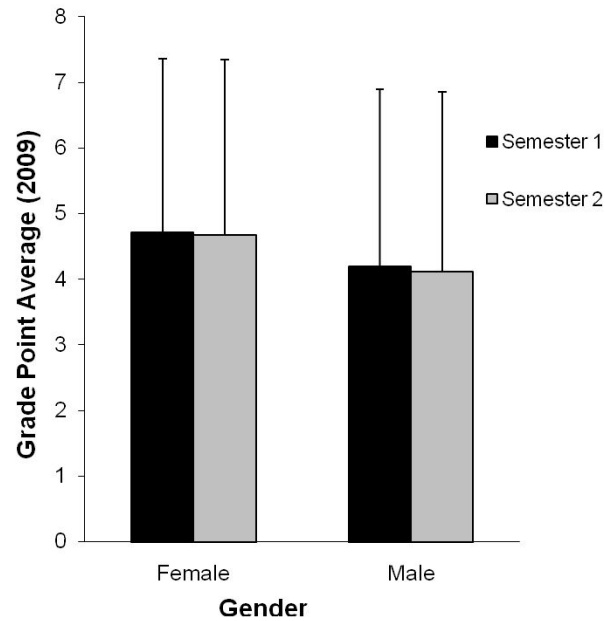

Figure 2. Grade Point Average of Semester 1 and Semester 2 courses for all undergraduate students at the University of Canterbury in 2009. Bars above the boxes indicate standard deviations.

Nor do the data support the hypothesis that the grades of female students were particularly badly affected by the earthquake. Thus, the gender differences in self-reported cognitive disruption found in Study 1 were not mirrored in university performance.

Overall withdrawal rates in 2010 were 2.6 % in Semester 1 and 2.0 % in Semester 2; corresponding figures for 2009 were 2.6 % and 1.8 %. Thus, the earthquake did not produce a much greater withdrawal rate than normal, although it is likely that some individuals did withdraw for that reason. We conducted other analyses comparing across different faculties and years of study, but these shed no light on any earthquake effects, so we do not report them.

Discussion

Although most previous research on psychological effects of natural disasters has focussed on negative emotional effects, especially post-traumatic stress, the

present research also indicated marked effects on sleep and thinking. Indeed, our strength of effects measure indicated greater effects on sleep disruption than on any other measure, and the reported effects indicated cognitive disruption was more widespread than depression or anxiety. These results do not necessarily mean that, say, having disrupted sleep was worse than having more stress, and they certainly should not be taken to imply that the problems of the many people reporting disrupted sleep are of more consequence than the problems of the relatively few who may develop a post-traumatic stress disorder. Moreover, although sleep was disrupted following the earthquake, it is not clear whether the effect arose from being awakened by aftershocks or as a result of heightened stress (cf. Bernert, Merrill, Braithwaite, Van Orden, & Joiner, 2007).

Interestingly, those who had experienced the earthquake often reported positive as well as negative experiences. This tendency correlated positively with reporting negative experiences, possibly because those who were worse affected also received more sympathy and help from others, and possibly because those who report negative experiences are more likely to report experiences of any kind.

Four of the five personality variables proved poor predictors of who was most affected by the earthquake. However, those who scored high on neuroticism were worse affected on a variety of measures. This result replicates earlier findings that neurotic people generally appear to suffer, or are at least more willing to report, more adverse effects of stressful events than other people (Feldman, Cohen, Doyle, Skoner, & Gwaltney, 1999; Kendler et al., 2004). Older people reported sleeping fewer hours, but the elderly often report poorer sleep (Floyd, Medler, Ager, & Janisse, 2000; Vitiello, 2009) so this may not be earthquake-specific. Those now living in damaged homes were more likely to have negative experiences than those living in undamaged homes.

The most noticeable predictor variable in Study 1, however, was gender. Females overall reported stronger effects than males. There are a number of different possible explanations. One is simply that women are generally (for example) more stressed or slept fewer hours, but this explanation is unlikely in view of finding no gender differences in the non-earthquake sample and interactions of gender with whether or not the respondents were present for the earthquake and aftermath.

Study 2 investigated whether the gender differences in self-reported cognitive disruption were reflected in a more behavioural measure. They were not. Indeed, there was no evidence that this earthquake had any effect on academic performance at all. Three possible reasons for the apparent discrepancies between Studies 1 and 2, by no means mutually exclusive, occur to us.

Firstly, it is possible that the University of Canterbury students showed resilience and recovered quickly, and because half the scheduled classes had already taken place before the earthquake and much post-earthquake assessment was not completed until October, they may have been able to escape the effects of the disruption.

Secondly, suppose that the reported cognitive disruption was closely linked to sleep deprivation. Sleep deprivation is unpleasant, and produces poorer performance on vigilance tasks, such as the Sustained Attention to Response Tasks. However, people who have endured even prolonged sleeplessness usually show little impairment of most cognitive abilities (Fulda & Schultz, 2001). Perhaps real cognitive disruption was produced by the mechanism of sleep deprivation, and these effects persisted and were worse in women, but the disruption simply did not affect academic assessment.

Thirdly, the gender differences of Study 1 may reflect only gender differences in self report. New Zealand women may be more likely to self report cognitive disruption, sleeplessness, depression, anxiety, or stress. Overall, some but not all previous studies have found gender effects (Chou, Huang, Lee, Tsai, Tsay, Chen and Chou, 2003; Potangaroa et al., 2010; Sahin et al., 2001).

The present studies have obvious limitations. Study 1 was a cross-sectional study that looked at the effects only over a limited time-span. However, the unpredictability of earthquakes makes it impractical to take pre-earthquake measures. It is quite possible that Study 2 was influenced by academic grading changes following the earthquake (although it is unlikely that these changes would have masked a real gender effect in response to the earthquake). We should perhaps also admit the possibility of cognitive disruption to our own research capabilities.

Further studies underway, following the earthquake on February 22, 2011, may help resolve these issues. Regardless of their outcome, however, the possibility of cognitive disruption following a disaster is worth taking

seriously. The situation is one in which people are forced to think and make important decisions, as well as to perform everyday tasks, such as driving, which impose a cognitive load.

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