

## Stress responses in medical students in ambulatory and in-hospital patient consultations

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**CONTEXT** Little is known about health professionals' responses to acute stressors encountered in the clinical environment. The goal of this study was to measure the subjective and physiological stress responses of medical students to consultations in familiar (in-hospital) and unfamiliar (ambulatory) settings. We hypothesised that: (i) providing a consultation in an unfamiliar setting would result in increased stress responses in medical students, and (ii) some differences in stress responses according to gender might become apparent.

**METHODS** A quantitative cross-over study was conducted over a 6-month period. Participating students were invited to provide consultations to patients in an ambulatory setting. In order to provide a control condition, each student was required to conduct a similar consultation (without reporting back to the patient) with an in-hospital patient during his or her rotation in internal medicine. Pre- and post-consultation subjective and physiological responses were measured using a visual analogue scale (VAS),

the State-Trait Anxiety Inventory (STAI), a cognitive appraisal scale and salivary cortisol levels.

**RESULTS** All of the subjective and physiological stress responses were greater in the ambulatory setting than the in-hospital setting. There was an effect of gender on the responses. Women showed greater pre-consultation subjective stress levels in the ambulatory setting, whereas men exhibited greater physiological stress levels in the ambulatory setting. No correlations were observed between subjective and cortisol responses.

**CONCLUSIONS** Ambulatory consultations are more stressful for medical students than consultations carried out in the more familiar in-hospital setting. Further studies should be conducted to investigate the nature of the stressors in this particular environment, to explore the possible explanations for a gender effect, and to explore the effects of these stress responses on students' diagnostic skills.

*Medical Education* 2011; **45**: 678–687  
doi:10.1111/j.1365-2923.2011.03935.x

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 INTRODUCTION

Although there is a growing body of literature on the prevalence and nature of chronic anxiety in health students<sup>1–8</sup> and general practitioners,<sup>9</sup> and on the coping strategies used to address such anxiety, little is known about the nature and impact of acute stress responses experienced during real clinical situations.

In the laboratory setting, significant research has been conducted in order to understand the stress response itself, as well as its impact on performance. Although the term ‘stress’ is often used in lay settings to refer to the different kinds of pressures and demands encountered in a particular environment (the ‘stressors’), stress researchers define the term as the individual’s response to these pressures and demands. These individual responses appear to be modulated by a two-stage cognitive appraisal of a situation. Individuals first assess the demands placed on them by the situation and then assess the resources they are able to access to respond to these demands. If the demands are assessed as exceeding the perceived resources, the perceived threat is appraised.<sup>10,11</sup> This appraisal of threat, which is considered to represent the stress response, has been associated with specific subjective and physiological responses.<sup>12,13</sup> Subjectively, anxiety is one of the main emotional manifestations induced by stressful situations. Physiological responses to stress are caused by the stimulation of the hypothalamic–pituitary–adrenal axis, which results in the release of the hormone cortisol. Both the subjective and physiological stress responses have been associated with significant impairments in memory, attention, decision making and general performance.<sup>14</sup> However, although important patterns have emerged from the study of stress in laboratory or simulated settings, there has been very little research into the patterns of stress responses to actual stressors in the clinical setting. Furthermore, although there is some evidence for a theoretical link between cognitive appraisals, subjective stress and physiological stress responses, the data supporting this relationship are mixed.<sup>12,13</sup>

In addition, the role of gender in stress responses is not well understood. Some researchers have reported that men are more likely to exhibit higher cortisol responses than women in stressful situations,<sup>15</sup> especially those involving achievement tasks.<sup>16</sup> Furthermore, some research suggests that the cortisol response is modified by the use of oral contraceptives and menstrual phase in women.<sup>17</sup> However, some recent meta-analyses suggest that the relationship

between gender and the magnitude of stress responses is tenuous.<sup>18,19</sup>

The goal of this study was to measure subjective stress levels in male and female medical students during patient encounters in familiar and unfamiliar settings. In France, undergraduate medical students are currently neither exposed to ambulatory patients nor asked to perform ambulatory consultations during their training. Instead, they generally deal with in-patients who do not expect to be given any report or conclusions regarding their symptoms at the end of a student’s first visit. During an in-hospital consultation, which is not subject to any time constraint, an undergraduate student is expected to generate a hypothesis about the patient’s complaint; however, in actuality, many of them merely fill in the first part of the medical dossier according to a standardised guide used to document the medical history and physical signs.<sup>20</sup> Although students are allowed to propose a diagnosis and a management plan for the patient, they are not obliged to do so.

Hence stress responses that occur in students in their first professional immersion in the ambulatory setting may have at least two sources of origin: (i) the novelty of the situation (novelty has been shown to be a strong predictive factor for the stress response<sup>13</sup>), and (ii) the requirement to perform a high-stakes cognitive activity represented by the solving of a diagnostic problem in a time-limited consultation. With reference to the laboratory- and simulation-based research showing that stress responses may have important effects on the cognitive abilities required for the delivery of clinical care, this study represents a first step towards understanding where stress responses occur in the clinical environment and is intended to inform further research into the effects of these stress responses on the ability of medical trainees and health care professionals to care for patients. Within this context, the objectives of this study were: (i) to compare the subjective and physiological responses to acute stress in ambulatory versus in-hospital settings in medical students confronted with a real patient complaining of a medical problem, and (ii) to investigate the effect of gender on this stress response.

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 METHODS
**Design**

We obtained approval from the local hospital ethics committee to conduct a prospective cross-over study.

Participating students were required to conduct two consultations with actual patients, one in an ambulatory setting and one in an in-hospital setting. In each consultation, the student was required to obtain and document the patient's medical history and to conduct any necessary physical examination. In the ambulatory setting, the student was also required to report his or her diagnostic reasoning back to the patient.

### Participants

Year 6 medical students from one medical school were recruited during their month-long, full-time internal medicine rotation at a university-affiliated hospital. Of the 157 students enrolled in Year 6 in 2009, 96 completed their internal medicine rotations over the 6 months during which this study was conducted. These 96 students did not differ from the remainder of the class in either gender distribution or academic level. Students treated with oral corticosteroids and students who were repeating Year 6 were excluded. In France, Year 6 is the final year of medical school prior to residency training.

### Groups

After providing informed consent, participants were randomly allocated (by means of a software-generated random list of numbers), stratified by gender, to one of two groups in which they performed:

- 1 the ambulatory consultation first, followed by the in-hospital consultation, or
- 2 the in-hospital consultation first, followed by the ambulatory consultation.

### Trainee tasks

#### *In-hospital setting*

No modifications were made to the usual protocol for in-hospital consultations conducted by students. The study consultation represented the initial visit made to a patient on the first day of his or her admission to the internal medicine ward. The student was required to systematically collect and document the patient's medical history and physical signs and symptoms, according to a pre-existing guide. The student was allowed to provide a differential diagnosis, but was not obliged to do so, and was not expected to present a clinical interpretation to the patient. No time limit was imposed on the consultation.

#### *Ambulatory setting*

Ambulatory consultations were not systematically scheduled for medical students in our department prior to this study. Therefore, we implemented the following procedure:

- 1 ambulatory patients were asked to provide consent by telephone several days prior to an appointment and were then asked to attend their regularly scheduled appointments 30 minutes early in order to be assessed by one of the participating students;
- 2 the participating student was asked to perform, within 30 minutes (the standard time allotted to ambulatory consultations), an ambulatory consultation in the usual consultation area in the Department of Internal Medicine;
- 3 in order to reflect naturalistic conditions, the student was asked to communicate his or her working diagnosis to the patient during the last 5 minutes of the consultation, and
- 4 during the subsequent 30 minutes, the patient was examined by his or her own attending doctor; the student was able to attend this consultation if he or she wished to do so.

Students were not informed in advance of the patients' medical conditions. All in-hospital and ambulatory consultations were performed in the afternoon to control for circadian variations in cortisol levels. Students in whom cortisol levels were sampled in the morning were excluded from the study.

### Patients

Eligible patients were selected by the principal investigator from the list of patients for whom appointments were scheduled. Inclusion criteria required hospitalised and ambulatory patients to be presenting with new and acute medical symptoms and to be in need of a diagnosis. Ambulatory patients were required to be attending their first internal medicine consultation. In-patients were enrolled following the second week of the student rotation in order to reduce the effect of confounding imposed by factors related to working in an unknown department.

### Measures

Data generated by four measures of subjective stress responses and one measure of physiological stress responses were collected for the study.

Scores on a visual analogue scale (VAS) ranging from 0 (not stressed) to 100 (very stressed) were estimated by students before and after the patient encounter. Such scales have been used as a marker of anxiety in previous research.<sup>21</sup>

The French version of the State-Trait Anxiety Inventory (STAI), validated by Bruchon-Schweitzer and Paulhan,<sup>22</sup> was administered within 15 minutes before and after each visit. The STAI measures anxiety experienced at a given moment and includes 20 items scored on a Likert scale of 1–4 to obtain a total score of 20–80. The STAI has been shown to have high internal consistency ( $\alpha$ -coefficient: 0.92).<sup>23</sup>

A cognitive appraisal (threat/challenge) score, based on the framework described by Tomaka *et al.*,<sup>11</sup> was assessed before the consultations by calculating the ratio of primary appraisal (perceived demands) to secondary appraisal (perceived resources) for each student. Primary and secondary appraisal were, respectively, evaluated by the following questions (translated from French): ‘How demanding do you expect the upcoming task to be?’ and ‘How are you able to cope with this task?’ Responses were recorded using a 7-point Likert scale. Threat appraisal was defined by a ratio  $> 1$  and challenge appraisal by a ratio  $\leq 1$ . In laboratory studies, threat appraisals have been associated with greater subjective and physiological stress responses than challenge appraisals.<sup>12,13</sup>

The French version of Cohen’s Perceived Stress Scale (PSS),<sup>24</sup> which measures chronic job stress, was administered at the end of data collection. This questionnaire includes 14 items scored on a Likert scale of 1–5, for a total score of 14–70. This scale has adequate internal and test/re-test reliability and is correlated with life event impact score, health-related outcomes and depressive symptomatology.<sup>24</sup>

Cortisol salivary samples were collected within 15 minutes before and after each patient consultation. Salivary cortisol sampling is a non-invasive test (students chew on a swab for 1 minute, after which the swab is frozen until analysis). Cortisol levels have been shown to increase in stressful situations and to correlate with some personality traits.<sup>25</sup> Salivary cortisol levels were measured in duplicate by radioimmunoassay (ref. CA-1549E RIA; Diasorin, Inc., Stillwater, MN, USA) from frozen centrifuged salivary sampling. Saliva sampling was performed using Salivettes<sup>®</sup> (Sarstedt AG, Nümbrecht, Germany).

## Statistical analysis

Statistical analyses were performed using STATA Version 10.0 (StataCorp LP, College Station, TX, USA) and SPSS Version 17.0 (SPSS, Inc., Chicago, IL, USA) multivariate analysis software. Two-sample paired mean comparisons were performed using Student’s paired *t*-tests. Multivariate analyses of variance (ANOVA) were conducted on the levels of subjective and physiological stress, with ‘order’ and ‘gender’ as between-subject variables and ‘setting’ and ‘time’ as repeated-measure variables. Correlations between subjective and physiological stress levels were estimated using Pearson’s correlation coefficient. Based on data given in the literature, sample sizes calculated to obtain an alpha risk of 0.05 and power of 90% required that 14 men and 15 women be tested for salivary cortisol<sup>26</sup> and eight men and 20 women complete the STAI.<sup>27</sup> We decided to include 30 men and 30 women in order to ensure normal distributions of the samples. Means and standard deviations (SDs) are reported in the text and in Table 1.

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## RESULTS

### Participants

Of the 96 eligible students who completed their internal medicine rotations during the period from November 2009 to April 2010, 30 women and 29 men were included in the study (Fig. 1).

Seven students (two men, five women) declined to participate. Disinclination to experience the stress that might be induced by undertaking an additional and unusual consultation was the main reason given for refusal. Four students were excluded because they were on medication known to affect cortisol levels ( $n = 1$ ), the time at which salivary cortisol samples were obtained was inappropriate ( $n = 2$ ) or they did not complete an in-hospital consultation prior to completing the internal medicine rotation ( $n = 1$ ). Three of the exclusions occurred prior to the end of the data collection phase and therefore two additional students were recruited into the study.

### Characteristics of the consultations

The presenting complaints of patients in both the ambulatory and in-hospital consultations were representative of our general internal medicine department’s typical case load. The nature of the task (diagnostic versus therapeutic) and the typicality of the

Table 1 Effect of setting, sex and time on visual analogue scale and State-Trait Anxiety Inventory scores, cognitive appraisal and salivary cortisol levels

	Ambulatory consultations, mean ± SD		In-hospital consultations, mean ± SD		ANOVA	
	Before	After	Before	After	Univariate analysis	Multivariate <sup>†</sup> analysis
Visual analogue scale						
All (n = 59)	49.4 ± 20.9	28.2 ± 20.7	17.6 ± 11.9	14.2 ± 12.4	Setting: F = 155.2*	Setting–time: F = 23.5
Male (n = 29)	44.3 ± 18.8	30.9 ± 21.4	17.0 ± 10.1	14.6 ± 9.0	Time: F = 44.3*	Time–sex: F = 5.5
Female (n = 30)	54.4 ± 21.8	25.8 ± 19.9	18.2 ± 13.6	13.8 ± 15.2	Sex: F = 0.3	
State-Trait Anxiety Inventory						
All (n = 59)	42.2 ± 9.8	35.7 ± 8.5	31.6 ± 5.8	30.7 ± 5.8	Setting: F = 113.4*	Setting–time: F = 14.6
Male (n = 29)	39.0 ± 8.7	36.2 ± 9.7	31.3 ± 5.6	31.7 ± 6.1	Time: F = 25.8*	Setting–sex: F = 11.5
Female (n = 30)	45.3 ± 10.0	35.2 ± 7.3	32.0 ± 6.1	29.8 ± 5.4	Sex: F = 10.1*	Time–sex: F = 5.2
Cognitive appraisal						
All (n = 59)	1.7 ± 0.7		0.7 ± 0.5		Setting: F = 276.5*	
Male (n = 29)	1.5 ± 0.6		0.8 ± 0.5		Sex: F = 3.6	Setting–sex: F = 18.3
Female (n = 30)	1.9 ± 0.8		0.7 ± 0.4			
Salivary cortisol, ng mL <sup>-1</sup>						
All (n = 57)	5.1 ± 3.4	5.1 ± 3.0	3.3 ± 1.8	2.9 ± 2.0	Setting: F = 45.0*	
Male (n = 29)	6.3 ± 4.2	5.8 ± 3.1	3.5 ± 2.0	3.2 ± 1.7	Time: F = 0.4	Setting–sex: F = 4.7
Female (n = 30)	3.8 ± 1.7	4.3 ± 2.8	2.9 ± 1.5	2.6 ± 2.2	Sex: F = 3.5	

\* Significant interactions in univariate analysis (p < 0.05)  
<sup>†</sup> Significant interactions in multivariate analysis (p < 0.05)  
 SD = standard deviation

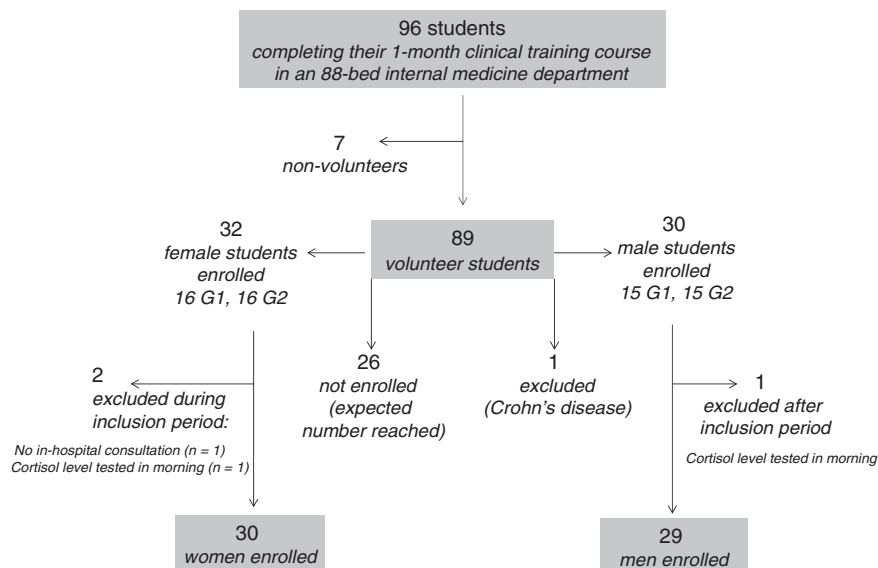


Figure 1 Participants. G1 = students undertaking the ambulatory consultation first and the in-hospital consultation second; G2 = students undertaking the in-hospital consultation first and the ambulatory consultation second

diseases (common versus rare diseases) did not differ significantly between the ambulatory and in-hospital consultations ( $p < 0.05$ , Fisher's exact test). The mean  $\pm$  SD length of the consultation did not differ between the two settings (ambulatory:  $29 \pm 6.4$  minutes; in-hospital:  $32 \pm 10.8$  minutes;  $p > 0.05$ ). Although the ambulatory consultations occurred, on average, earlier than the in-hospital consultations, they all occurred between mid-morning and early evening, when circadian levels of cortisol are most stable.

### Stress responses

Overall (without making any distinction for gender or time), students experienced greater subjective and physiological stress levels in the ambulatory setting than in the in-hospital setting ( $p < 0.01$ , Student's paired  $t$ -test). The students all appraised the ambulatory consultations as threats (demands greater than resources), reflected in overall higher VAS and STAI scores and higher salivary cortisol levels. As Table 1 shows, subjective stress responses were greater prior to the consultations than after them, indicating that the source of stress for the medical students lay in the anticipation of the consultation rather than the consultation itself. The order in which the consultations occurred had no effect on any of the stress measure ( $p$ -values 0.19–0.92).

There were important differences in patterns of responses according to gender. In the ambulatory

condition, women exhibited greater subjective stress levels, whereas men exhibited greater cortisol levels.

The overall mean  $\pm$  SD PSS score was  $33.7 \pm 8.1$  (population norm:  $23.2 \pm 7.3$ ). There was no difference in PSS score according to sex and order of tests ( $F = 2.47$ ,  $p > 0.05$ ).

### Correlations between psychological and physiological responses

In the ambulatory setting, there were significant positive correlations between scores on the VAS and the STAI and students' cognitive appraisals (Table 2). In the in-hospital setting, VAS scores were significantly correlated with both STAI scores and cognitive appraisal ratios, but STAI scores and cognitive appraisal ratios were not significantly correlated with one another.

Scores on the PSS, a measure of chronic work stress, were positively correlated with both VAS and STAI scores in both settings, suggesting that chronic stress can predict acute stress responses to clinical situations. However, the correlations between PSS scores and cognitive appraisals were not significant.

Students' cortisol levels were not correlated with any of the subjective measures of stress. Cortisol levels in the ambulatory and in-hospital settings were positively correlated.

Table 2 Correlations between psychological and physiological measures (Pearson's coefficient)

	VAS Pre-amb	VAS Pre-hosp	STAI Pre-amb	STAI Pre-hosp	CA Amb	CA Hosp	PSS	SC Pre-amb
STAI, pre-amb	0.54*							
STAI, pre-hosp		0.52*						
CA, pre-amb	0.28*		0.37*					
CA, pre-hosp		0.28*		0.16				
PSS	0.28*	0.30*	0.52*	0.49*	0.20	0.01		
Cortisol, pre-amb								
Male	-0.17	0.25	-0.13	0.25	-0.17	0.08	0.004	
Female	0.09	0.07	-0.01	-0.26	-0.26	-0.04	-0.05	
Cortisol, pre-hosp								
Male	0.04	0.20	0.05	0.08	-0.006	-0.19	0.27	0.46*
Female	-0.02	0.21	-0.12	0.07	0.27	0.08	0.19	0.49*

\*  $p < 0.05$

VAS = visual analogue scale; STAI = State-Trait Anxiety Inventory; CA = cognitive appraisal; PSS = Cohen's Perceived Stress Scale; SC = salivary cortisol; pre-amb = before ambulatory consultation; pre-hosp = before in-hospital consultation

## DISCUSSION

In recent years, evidence has accumulated to show that subjective anxiety and the elevation of cortisol levels in response to acute stressors are associated with impairments in cognitive ability and performance in laboratory<sup>28</sup> and clinical settings.<sup>29</sup> This body of research provides an important impetus for further investigation into the stress response and into when stress responses are most likely to occur in the clinical environment.

In this study, we demonstrated that ambulatory consultations in an internal medicine out-patient clinic represent an acutely stressful experience for medical students who have not previously been exposed to that context. The subjective stress responses observed in the ambulatory setting were similar to levels observed during examinations in emergency settings,<sup>30</sup> slightly higher than in simulated 'bad news delivery' scenarios,<sup>21</sup> and similar, for the women in our study, to those in simulated paramedic acute cardiac resuscitation conditions.<sup>31</sup> In chronically stressful conditions, salivary cortisol levels lie in the range of 1.8–3.0 ng mL<sup>-1</sup>.<sup>32,33</sup> In acutely stressful conditions, such as student written examinations, salivary cortisol levels lie in the range of 2.0–7.7 ng mL<sup>-1</sup>.<sup>34–36</sup> Thus, our mean values of salivary cortisol (6.3 ng mL<sup>-1</sup> in men and 3.8 ng mL<sup>-1</sup> in women) are comparable with those observed in situations commonly acknowledged as stressful. Furthermore, both the subjective and physiological stress differences observed in this study are similar to levels associated with impaired performance in simulated settings (Harvey *et al.*, unpublished data, 2010).<sup>30</sup>

Specific features of ambulatory versus in-hospital consultations may account for this finding, including the imposition of a time limit on ambulatory consultations, the requirement to generate 'on-the-spot' diagnostic hypotheses, environmental differences, and the novelty of the context.<sup>13</sup> The finding that ambulatory consultations were more stressful for students than in-hospital consultations has three practical implications. Firstly, the vast amount of laboratory-based research on stress<sup>14</sup> suggests that students' acute stress responses may potentially impact on their clinical performance. If this relationship is confirmed in natural settings, it would appear important to ensure that students are given early exposure to ambulatory consultations in French medical undergraduate curricula. Secondly, depending on the nature of the potential stressors in

ambulatory consultations, it may also be useful to introduce early training sessions in coping with stress in order to help undergraduate students manage their stress responses. Indeed, faculties that have implemented such interventions with medical students have achieved improvements in students' abilities to deal with complex clinical cases.<sup>37</sup> Finally, much of the research into stress interventions and related approaches has focused on either chronic stress and mental health<sup>38</sup> or on high-acuity events such as anaesthesia and emergency crises.<sup>39,40</sup> However, the results of this study indicate that even in non-emergency events, the stress levels of trainees can fall within the ranges of responses that have been previously associated with impairments in performance (Harvey *et al.*, unpublished data, 2010).<sup>30</sup>

The results of this study also reveal an important dissociation between subjective and physiological stress responses to acute events. This is consistent with previous research by Gaab *et al.*,<sup>34</sup> who looked at stress responses to written examinations in third-semester economics students. Similarly, Allen and Carifio<sup>41</sup> observed that the physiological components of emotions were weak contributors to both the intensity and quality of subjective emotions experienced by participants trying to solve mathematical problems. The lack of relationship between subjective and physiological responses poses a challenge to the concept of cognitive appraisal – the assessment of perceived demands and resources – as a determinant of stress responses. In the present study, cognitive appraisals predicted some, but not all, of the subjective stress levels. However, they were not predictive of cortisol levels. These findings are contradictory to those of previous research,<sup>12,13,42</sup> including those of a study conducted by members of this research team, showing a strong relationship between cognitive appraisals and stress responses. Taken together, these studies suggest that the relationship between cognitive appraisals and stress responses is not straightforward. Research investigating the sources of individual differences in stress responses has revealed that acute and chronic stress responses are mediated by social support, coping styles and locus of control. Further research is warranted to identify the factors that predict stress responses in acute situations, as well as to better understand the stress process itself and the relationship (or lack thereof) between its various subjective and physiological components.

Further research into the dissociation between subjective and physiological stress responses, in addition to elucidating our theoretical understanding of stress

responses, might also have important practical implications. Anxiety and cortisol responses have been associated with different performance profiles. Anxiety has been primarily associated with biases in attentional processes, but also with performance enhancements.<sup>30,43–45</sup> By contrast, elevations in cortisol levels have been consistently associated with impairments in performance on tasks of working memory and memory recall, but also with improvements in memory consolidation.<sup>14</sup> This suggests that, although elevations in cortisol may be detrimental to performance in acute events, they may facilitate learning from these same events. A better understanding of the various components of stress, as well as the factors that predict their occurrence, including gender, would help educators to better predict when performance might be impaired or facilitated during potentially stressful events. In addition, interventions aimed at supporting clinical performance or reducing stress responses could be targeted at those situations or individuals most in need of them.

Our findings suggest that these two distinct responses may be gender-dependent; female and male students presented different stress responses. Women were more likely to report higher subjective stress before consultations than men and demonstrated higher variations in subjective tests (i.e. the VAS, STAI and cognitive appraisal), and men exhibited a higher cortisol response than women in the ambulatory setting. These findings are similar to those of numerous studies in laboratory and naturalistic tasks.<sup>14</sup> As an example, the same order of variations in cortisol response between men and women was reported by Weekes *et al.*<sup>35</sup> in college students participating in behavioural sessions during two periods of low or high stress. However, there is also evidence to suggest that sex does not contribute to stress responses.<sup>18,19</sup>

Various hypotheses may explain discrepancies in stress response between male and female students and should be tested in subsequent studies. Stroud *et al.*<sup>16</sup> reported that men have higher salivary cortisol levels in achievement-oriented tasks, whereas women's cortisol response is higher in tasks involving risk for social rejection. In our study, the task consisted of solving a medical problem, which is an achievement-oriented rather than a socially oriented task. Secondly, menstrual cycle stage and use of oral contraceptives, two factors potentially affecting women's cortisol responses, were not controlled during the study. Indeed, Kirschbaum *et al.*<sup>17</sup> have shown that salivary cortisol response was two-fold

higher in women in the luteal phase compared with women using oral contraceptives. It is thus possible that sex differences in stress responses may be limited to particular types of task or to the point in the menstrual cycle at which the subject is investigated. Subsequent quantitative and qualitative studies should be conducted to confirm and explain the discrepancies between psychological and physiological responses according to gender in naturalistic conditions.

Finally, the relationship between chronic stress levels and acute stress responses to particular events should be considered in the interpretation of our results. Mean scores on Cohen's PSS indicated a moderate job stress level among our study participants, consistent with PSS values recently reported in medical students.<sup>46</sup> This chronic job stress was positively correlated with scores on acute psychological stress measures (i.e. VAS, STAI) observed prior to the consultations in both settings, but not with cortisol levels. This link between chronic and acute stress has not been clearly described in the past. Denson *et al.*<sup>13</sup> found an association between uncontrollable repetitive thoughts and chronic brooding and acute stress, but not between acute stress and worry or global mood state. This result may suggest that, if the link between stress and performance impairment is confirmed in the field of medical education, it may be useful to improve job well-being in order to improve task performance, as has been shown in other professional settings.<sup>47</sup>

An important limitation of this study is that, for ethical considerations, participation was voluntary. Volunteer participants may have differed from non-participating students, thereby reducing external validity. However, given that the main reason for refusal was anxiety provoked by the undertaking of an additional ambulatory consultation, this bias would be likely to minimise any difference in the magnitude of the stress response experienced by the student in the ambulatory setting.

In conclusion, the results of this study reveal that medical students exhibit significant stress responses to patient consultations in unfamiliar settings. Furthermore, we observed important dissociations between the subjective and physiological responses of medical students, as well as between female and male students. These findings raise new questions regarding stress responses in general and in medical students in particular. Findings of high levels of stress in medical students prior to consultations in an



ambulatory setting raise questions about the potential impact of such stress on clinical reasoning. We might also wonder whether an intervention in stress management, such as might be provided by early immersion in the ambulatory setting or by introducing stress management training into the curriculum, would reduce levels of stress and eventually improve medical students' clinical performance. These important questions should be addressed in subsequent studies.

*Contributors:* PP contributed to the conception and design of the study, the acquisition, analysis and interpretation of data, and the drafting and revision of the article. J-BH and VL contributed to the conception and design of the study, the analysis and interpretation of data, and the drafting and revision of the article. TD and A-GLL contributed to the acquisition of data, and the drafting and revision of the article. AB contributed to the conception and design of the study, the interpretation of data, and the drafting and revision of the article. BP contributed to the conception and design of the study, and the drafting and revision of the article. All authors approved the final manuscript for publication.

*Acknowledgements:* we would like to thank Jean-Michel Rogez, dean of the Nantes University Medical School, for his support of this study, and to acknowledge the following researchers in health professional education for their valuable editorial revisions: Arijia Birze, Laura Dempster, Dominique Piquette, Carilynne Yarascavitch, Sylvain Boet and Walter Tavares.

*Funding:* this study was funded by Nantes University Medical School, Nantes, France.

*Conflicts of interest:* none.

*Ethical approval:* this study was approved by the Ethics Committee of the University Hospital Centre Nantes (Centre Hospitalier Universitaire Nantes) (2009-00878-49).

## REFERENCES

- Morrison J, Moffat K. More on medical student stress. *Med Educ* 2001;**35**:617–8.
- Sarikaya O, Civaner M, Kalaca S. The anxieties of medical students related to clinical training. *Int J Clin Pract* 2006;**60**:1414–8.
- Dahlin M, Joneborg N, Runeson B. Stress and depression among medical students: a cross-sectional study. *Med Educ* 2005;**39**:594–604.
- Moffat KJ, McConnachie A, Ross S, Morrison JM. First year medical student stress and coping in a problem-based learning medical curriculum. *Med Educ* 2004;**38**:482–91.
- Schmitter M, Liedl M, Beck J, Rammelsberg P. Chronic stress in medical and dental education. *Med Teach* 2008;**30**:97–9.
- Polychronopoulou A, Divaris K. Perceived sources of stress among Greek dental students. *J Dent Educ* 2005;**69** (6):687–92.
- Pöhlmann K, Jonas I, Ruf S, Harzer W. Stress, burnout and health in the clinical period of dental education. *Eur J Dent Educ* 2005;**9**:78–84.
- Sheu S, Lin HS, Hwang SL. Perceived stress and physiopsychosocial status of nursing students during their initial period of clinical practice: the effect of coping behaviours. *Int J Nurs Stud* 2002;**39**:165–75.
- Chambers R, Wall D, Campbell I. Stresses, coping mechanisms and job satisfaction in general practitioner registrars. *Br J Gen Pract* 1996;**46**:343–8.
- Lazarus RS, Folkman S. *Stress Appraisal and Coping*, 1st edn. New York, NY: Springer 1984:1–445.
- Tomaka J, Blaskovich J, Kelsner RM, Leitten CL. Subjective, physiological and behavioural effects of threat and challenge appraisal. *J Pers Soc Psychol* 1993;**65** (2):248–260.
- Dickerson S, Kemeny ME. Acute stressors and cortisol responses: a theoretical integration and synthesis of laboratory research. *Psychol Bull* 2004;**130** (3):355–91.
- Denson TF, Spanovic M, Miller N. Cognitive appraisals and emotions predict cortisol and immune responses: a meta-analysis of acute laboratory social stressors and emotion inductions. *Psychol Bull* 2009;**135** (6):823–53.
- LeBlanc VR. The effects of acute stress on performance: implications for health professions education. *Acad Med* 2009;**84** (Suppl):25–33.
- Kajantie E, Phillips DIW. The effects of sex and hormonal status on the physiological response to acute psychosocial stress. *Psychoneuroendocrinology* 2006;**31**:151–78.
- Stroud LR, Salovey P, Epel ES. Sex differences in stress responses: social rejection versus achievement stress. *Biol Psychiatry* 2002;**52**:318–27.
- Kirschbaum C, Kudielka BM, Gaab J, Schommer NC, Hellhammer DH. Impact of gender, menstrual cycle phase, and oral contraceptives on the activity of the hypothalamic–pituitary–adrenal axis. *Psychosom Med* 1999;**61**:154–62.
- Kudielka BM, Kirschbaum C. Sex differences in HPA axis responses to stress: a review. *Biol Psychol* 1995;**69**:268–82.
- Michaud K, Matheson K, Kelley O, Anisman H. Impact of stressors in a natural context on release of cortisol in healthy adult humans: a meta-analysis. *Stress* 2008;**11**:177–97.
- Pottier P, Planchon B, Barrier JH, Fabre M. Place of problem-building in clinical reasoning. A qualitative study in medical students and in experts. Congress of the International Association for Medical Education (AMEE), Malaga, 29 August–02 September 2009.
- van Dulmen S, Tromp F, Grosfeld F, ten Cate O, Bensing J. The impact of assessing simulated bad news consultations on medical students' stress response and communication performance. *Psychoneuroendocrinology* 2007;**32** (8):943–50.

- 22 Bruchon-Schweitzer M, Paulhan I. Manuel Français de l'Échelle d'Anxiété-Trait et d'Anxiété-État de Spielberger. Paris: Editions Centre Psychologie Appliquée 1993.
- 23 Spielberger CD, Gorsuch RL, Lushene R, Vagg PR, Jacobs GA. *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press 1983.
- 24 Cohen S, Kamark T, Mermelstein R. A global measure of perceived scale. *J Health Soc Behav* 1983;**24** (4):385–96.
- 25 Pruessner JC, Gaab J, Hellhammer DH, Lintz D, Schommer N, Kirschbaum C. Increasing correlations between personality traits and cortisol stress responses obtained by data aggregation. *Psychoneuroendocrinology* 1997;**22** (8):615–25.
- 26 Paris JJ, Franco C, Sodano R, Freidenberg B, Gordis E, Anderson DA, Forsyth JP, Wulfert E, Frye CA. Sex differences in salivary cortisol in response to acute stressors among healthy participants, in recreational or pathological gamblers, and in those with post-traumatic stress disorder. *Horm Behav* 2010;**57** (1):35–45.
- 27 Lac G, Chamoux A. Biological and psychological responses to two rapid shiftwork schedules. *Ergonomics* 2004;**47** (12):1339–49.
- 28 Keinan G. Decision making under stress: scanning of alternatives under controllable and uncontrollable threats. *J Pers Soc Psychol* 1987;**52** (3):639–44.
- 29 Cumming SR, Harris LM. The impact of anxiety on the accuracy of diagnostic decision making. *Stress Health* 2001;**17**:281–6.
- 30 LeBlanc VR, Bandiera GW. The effects of examination stress on performance of emergency medicine residents. *Med Educ* 2007;**41**:556–64.
- 31 LeBlanc VR, McDonald RD, McArthur B, King K, Lepine T. Paramedic performance in calculating drug dosages following stressful scenarios in a human patient simulator. *Prehosp Emerg Care* 2005;**9**:439–44.
- 32 Laudenslager ML, Noonan C, Jacobsen C, Goldberg J, Buchwald D, Bremner JD, Vaccarino V, Manson SM. Salivary cortisol among American Indians with and without post-traumatic stress disorder (PTSD): gender and alcohol influences. *Brain Behav Immun* 2009;**23** (5):658–62.
- 33 Hong RH, Yun-Jung Y, Kim SY, Lee WY, Hong YP. Determination of appropriate sampling time for job assessment: the salivary chromogranin A and cortisol in adult females. *J Prev Med Public Health* 2009;**42** (4):231–6.
- 34 Gaab J, Sonderegger L, Scherrer S, Ehlert U. Psycho-neuroendocrine effects of cognitive-behavioural stress management in a naturalistic setting – a randomised controlled trial. *Psychoneuroendocrinology* 2005;**31**:428–38.
- 35 Weekes N, Lewis R, Patel F, Garrison-Jakel J, Berger DE, Lupien SJ. Examination stress as an ecological inducer of cortisol and psychological responses to stress in undergraduate students. *Stress* 2006;**9** (4):199–206.
- 36 Takatsuji K, Sugimoto Y, Ishizaki S, Yasuka O, Matsuyama E, Yama-Guchi Y. The effects of examination stress on salivary cortisol, immunoglobulin A and chromogranin A in nursing students. *Biomed Res* 2008;**28** (4):221–4.
- 37 Campo AE, Williams V, Williams RB, Segundo MA, Lydston D, Weiss SM. Effects of LifeSkills training on medical students' performance in dealing with complex clinical cases. *Acad Psychiatry* 2008;**32** (3):188–93.
- 38 Shapiro SL, Shapiro DE, Schwartz GER. Stress management in medical education: a review of the literature. *Acad Med* 2000;**75**:748–59.
- 39 Reznek M, Smith-Coggins R, Howard S, Kiran K, Harter P, Sowb Y, Gaba D, Krummel T. Emergency medicine crisis resource management (EMCRM): pilot study of a simulation-based crisis management course for emergency medicine. *Acad Emerg Med* 2003;**10**:386–9.
- 40 Blum RH, Raemer DB, Carroll JS, Sunder N, Felstein DM, Cooper JB. Crisis resource management training for an anaesthesia faculty: a new approach to continuing education. *Med Educ* 2004;**38**:45–55.
- 41 Allen BD, Carifio J. Mathematical discovery: a covariance analysis. *Acad Exchange Q* 2000;Summer 2004:115–9.
- 42 Harvey A, Nathens AB, Bandiera G, LeBlanc VR. Threat and challenge: cognitive appraisal and stress responses in simulated trauma resuscitations. *Med Educ* 2010;**44**:587–94.
- 43 Mathews A, Macintosh B. A cognitive model of selective processing in anxiety. *Cogn Ther Res* 1998;**22**: 539–60.
- 44 Mogg K, Bradley BP. A cognitive-motivational analysis of anxiety. *Behav Res Ther* 1998;**36** (9):809–48.
- 45 Allen BD, Carifio J. Mathematical sophistication and differentiated emotions during mathematical problem solving. *J Math Stat* 2007;**3**:163–7.
- 46 Shah M, Hasan S, Malik S, Sreeramareddy CT. Perceived scale, sources and severity of stress among medical undergraduates in a Pakistani medical school. *BMC Med Educ* 2010;**10**:2.
- 47 Judge TA, Thoresen CJ, Bono JE, Patton GK. The job satisfaction–job performance relationship: a qualitative and quantitative review. *Psychol Bull* 2001;**376** (3):376–407.

Received 9 September 2010; editorial comments to authors 25 November 2010; accepted for publication 7 January 2011