



Subjective versus Objective Assessment of Short Term Occupational Stress: Bias and Analysis of Self-Assessment of High Stress Levels

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAMMR/2020/v32i1030519

Editor(s):

(1) Chan-Min Liu, Jiangsu Normal University, China.

Reviewers:

(1) Zahra Poursafar, Islamic Azad University, Iran.

(2) N. Veena, Christ Academy Institute for Advanced Studies, Bangalore University, India.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/58251>

Original Research Article

Received 21 April 2020

Accepted 27 June 2020

Published 10 July 2020

ABSTRACT

Aims: Experiments undertaken with two professions (engineers and anesthesiologists) have shown the possible overestimation of perceived stress by subjects when self-assessing stress through questionnaires for high levels of acute stress. Previous analyses having demonstrated that the overestimation was effective, the present study aimed at analyzing a possible effect due to professional traits.

Study Design: Data were compared with models of professional personality: Myers-Briggs Type Indicator approach, Holland's theory of careers and vocational choice and the Five-Factor model of personality.

Place and Duration of Study: Data from previous studies were used: A sample of engineers working at the nuclear power plant of Chinon in France (published in 2014) and a sample of anesthesiologists working at the University Hospital of Angers, France (published in 2015).

Methodology: Anesthesiologists (N=11, 50% male, 25 to 35 years old) experienced a stress episode in an operating theater simulator. Engineers (N=8, 38% male, 25 to 35 years old) underwent a stress-test in their office. Heart rate was measured for each subject. Comparison was examined between the stress perceived by the subjects through the Post-traumatic Disorder Inventory and the expected levels of stress estimated using the heart rate data. Characterization of the difference was undertaken using models of professional personality.

Results: While a Myers-Briggs Type Indicator approach did not provide any relevant information, an approach based on Holland's theory of careers and vocational choice and on the Five-Factor model of personality showed that overestimation of stress was linked with occupational preoccupations specific to the professions. Limitations, perspectives and scientific implications are discussed.

Conclusion: As a major recommendation for researchers, during experiments inducing high levels of acute stress, it is worth to consider the possibility to compare self-assessment of stress with physiological measurements in order to detect a possible overestimation of perceived stress.

Keywords: Subjective stress; acute stress; overestimation; professional personality; behavioral psychology.

1. INTRODUCTION

A previous study aiming at characterizing performance of French anesthesiologists during stressful occupational situation [1] led to the suspicion that self-assessment of stress through questionnaires might lead to overestimating high levels of short term mental stress: a few subjects presented scores for self-assessment significantly higher than the others. In this study [1], it was neither quantified nor characterized. Similarly, this particularity has also been mentioned in other contexts of acute stress self-assessment [2,3] but no investigation has been found addressing this issue in the literature. The aim of the present study was to examine the effectiveness of such particularity.

As this assumption was formed when plotting heart rates (HR) of anesthesiologists measured during the stress episode versus their score when answering a self-assessment of perceived stress questionnaire, the first hypothesis H1 was:

H1: there is a bias due to the questionnaire.

This came as a first hypothesis because the self-assessment was subjective (perceived stress by the subjects) thus less accurate than HR which was objective in that it was a physiological measure.

The questionnaire chosen to be filled in by the subjects just after experiencing the stressful situation was the Posttraumatic Distress Inventory questionnaire (PDI questionnaire, see appendix 1). It was selected because it includes

issues such as frustration or guilt in not doing more, shame, fear for one's safety or for that of others. It also includes the subject's feelings regarding physiological parameters (sweating, shaking, perceived accelerated heart rate). This sort of items are important when experiencing an acute stress situation and are well taken into account in the PDI questionnaire conversely to others. However, it was elaborated by Prof. Brunet's team in order to obtain a quantitative measure of the level of distress experienced during and immediately after a traumatic event [4] (validated in its French form by [5,6] and might thus induce a bias when applied to non-traumatic situations.

A second hypothesis H2 addressed the profession:

H2: the overestimation, if real, is linked to professional concerns.

In other words, analyzing acute stress for a profession other than that of anesthesiologist could yield different findings.

H1 and H2 have been explored in previous studies as exposed hereinafter.

To investigate H1 [7], a cohort of residents in anesthesiology (N=44, 68% male, age ranging from 25 to 35 years old) underwent a stressful situation on full scale simulator lasting from 10 to 15 min. during which participants had to deal with one of the following scenarii: i) a compressive cervical hematoma in a 43 yo. patient after thyroidectomy in the recovery room, quickly leading to asphyxia, ii) local anesthetic toxicity

after regional anesthesia in a 64 yo. patient undergoing total shoulder arthroplasty with frequent PVCs (premature ventricular contractions) followed by asystole, iii) the occurrence of profound hypotension after induction in a 70 yo. patient treated by an angiotensin converting enzyme inhibitor, complicated by a third degree atrioventricular block due to myocardial ischemia, iv) an error in drug administration (muscle relaxant instead of midazolam) before a regional block performed in a 27.0 yo. patient resulting in a respiratory arrest, v) Anaphylactic cardiac arrest after succinylcholine administration for rapid-sequence induction with a patient being a young man with emergency surgery treatment for leg injury, vi) Hemodynamic deterioration after increase of pneumothorax (failure of central venous access) which needs for emergency exsufflation for a 30 yo. man sedated for postoperative hypothermia in after a right nephrectomy.

Just after the stress episode, they filled in the PDI questionnaire and the Appraisal of Life Events Scale (ALES questionnaire; [8]). The latter was chosen because it proposes some items comparable with the PDI: As the PDI questionnaire items only refer to constraint, only the items of constraint were taken into account when calculating the ALES score. Five of the participants were equipped with a Polar FS2c (electrodes on the chest, heart rate measurement accuracy: ± 1 bpm) in order to physiologically characterize stress using HR measurement.

The correlation coefficient between scores obtained in the PDI questionnaire Q_{PDI} and scores obtained in the ALES scale Q_{ALES} was significant: $r(N=44)=0.70$, $p<.001$; when gathering data per interval of 2 points on the PDI scale (as suggested by [9] according to the PDI values ([0;1]; [1;3]; ...) the correlation coefficient was higher: $r(N=6)=0.94$, $p<.007$ (Fig. 1).

These results led us to reject H1.

To investigate H2 [7], two cohorts were used, each related to a different profession, self-assessing stress through the PDI questionnaire and undergoing HR measurement as when investigating H1.

The first cohort (N=11, 50% male, age ranging from 25 to 35 years old) was made up of part of the original study group that gave rise to a suspicion of overestimation of stress self-assessment [1]. It included 15 residents in anesthesiology from the University of Paris (France) among which 7 were rejected because their task required physical effort that could influence HR values and were thus not comparable with other cases. The other part of the first cohort was 5 residents from the cohort presented in the previous paragraph (University of Angers, France) equipped with Polar FS2c among which 2 were rejected because they performed the task requiring physical effort or had drunk coffee or tea or had smoked a cigarette or had been subjected to stress less than one hour before the experiment.

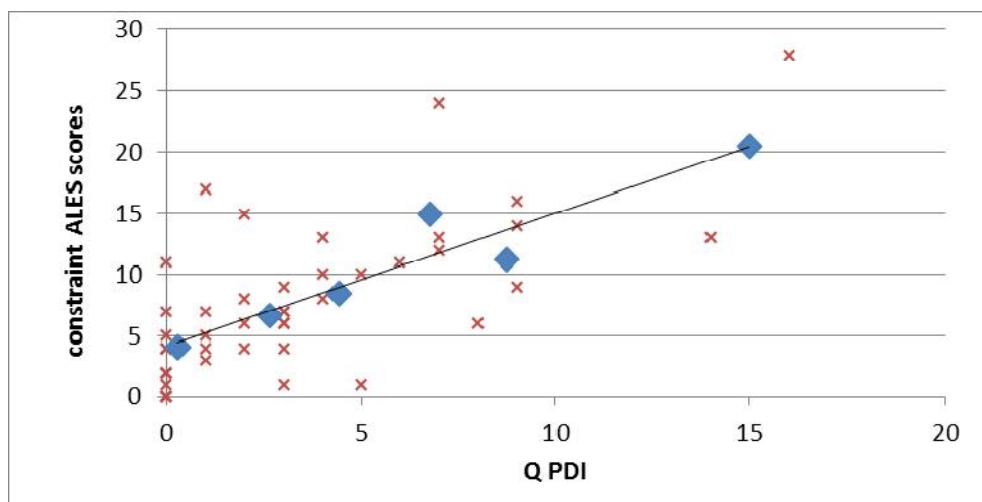


Fig. 1. Scores obtained in the PDI questionnaire Q_{PDI} vs scores obtained in the constraint ALES scale (Red cross: Raw data; Blue square: Mean data per interval)

The second cohort made up of French nuclear and mechanical engineers working in the nuclear industry (N=8, 38% male, age ranging from 25 to 35 years old) underwent a stress-test [7,10], i.e. an office task made up of 12 psycho-technical and cultural questions, lasting from 5 to 10 min. Participants were randomly assigned to a stressful (resp. stressless) context, having to perform the task individually within time limit (resp. no time limit), with no social support (resp. with social support), whilst enduring distracting noises (resp. without noise).

Data was analyzed by range as suggested by Berton et al. [9]: for each cohort, an averaged normalized score $Q_{PDI_{meas}}$ ("normalized" is the score divided by the number of PDI questions) was calculated with intervals of 0.1 and the associated averaged HR_{meas} was calculated from the data measured. However, in order to have at least two values per interval, some of them had to be grouped together. After that, applying the mathematical model for HR variation under acute stress [11], we calculated the expected value $Q_{PDI_{calc}}$ per interval for each cohort. This model was presented in [11] with a reliability $r=0.95$ ($p<0.0001$). When plotting the measured values versus the expected values for Q_{PDI} (Fig. 2), a

deviation from the diagonal $x=y$ clearly appeared for each cohort ($\chi^2=2$, $p>0.4$), that of the engineers deviating from the diagonal at a lower threshold than that of the physicians, leading H_2 not being rejected.

It was thus decided to undertake further analysis to characterize the apparent overestimation of high level acute stress self-assessment, firstly because this had never been done (probably due to the fact that very few studies addressing acute mental stress explore conditions with high level of stress) and secondly because the practical implications might be of importance when using self-assessment questionnaires in research. Indeed, while the literature is profuse in studies about the accuracy of self-assessment when addressing performance (see for example for the most recent: [12-16], it is void of studies analyzing to which extent and by which factors the accuracy of self-assessment of stress may be impacted.

We thus examined whether specific factors of stress were contributing towards a deviation between self-assessment and physiological characterization of acute mental stress state.

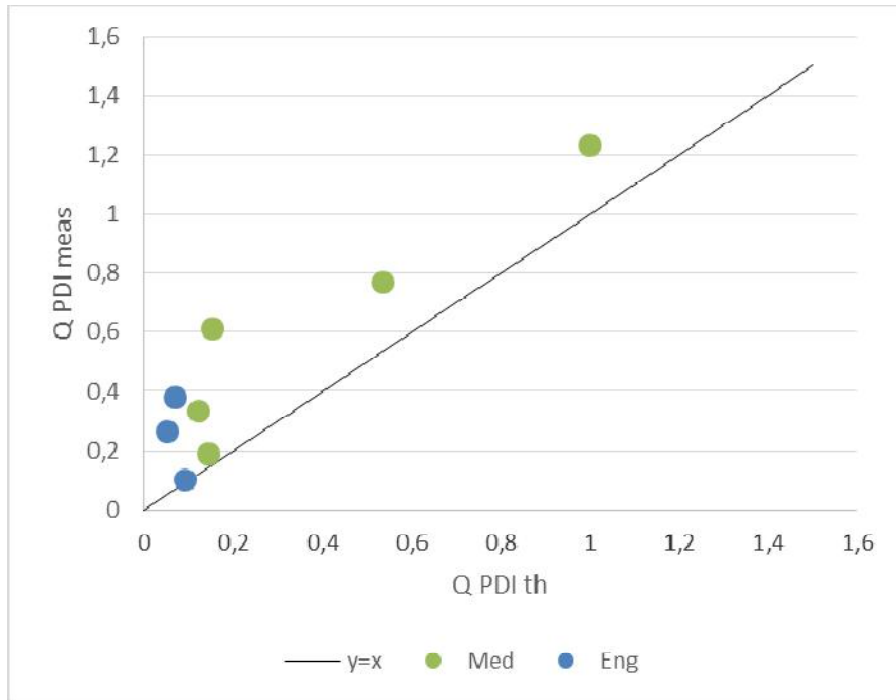


Fig. 2. Measured PDI normalized scores $Q_{PDI_{meas}}$ vs expected PDI normalized scores $Q_{PDI_{calc}}$ for subjects (Med=residents in anesthesiology; Eng= engineers) experiencing a stressful situation lasting from 5 to 15 minutes

2. MATERIALS AND METHODS

2.1 Stressors Contributing to a Deviation of Self-assessment of Stress: Data Collection

In order to understand how a deviation might occur during the self-assessment of acute mental stress, a refined analysis of the answers provided by subjects at the PDI questionnaire was undertaken. The analysis was carried out for each profession. Data was thus that of previous studies as briefly described in the next two paragraphs.

The first cohort (N=18, 50% male, age ranging from 25 to 35 years old) was that of the original study that gave rise to a suspicion of overestimation of stress self-assessment [1]: 15 residents in anesthesiology from the University of Paris (France) and 3 from the University of Angers (France). The second cohort was made up of French nuclear and mechanical engineers (N=8, 38% male, age ranging from 25 to 35 years old) experiencing a stress-test [7,10].

Each cohort was divided into two groups corresponding to, on one hand, subjects with scores Q_{PDI} close to the theoretical value (group #1) and, on the other hand, those concerned by overestimation (group #2). For each profession, in each group, an average score was calculated per PDI question. The difference $\Delta Q_{PDI\ meas\ i}$ in

scores per question #i between groups per profession was then calculated and expressed in terms of a percentage of the Likert scale (0-4) used for the PDI:

if $Q_{PDI\ meas\ 1i}$ (resp. $Q_{PDI\ meas\ 2i}$) is the mean score for question #i in the group #1 (resp. group #2) for a given profession, the percentage was calculated using:

$$\Delta Q_{PDI\ meas\ i} / 4$$

Where

$$\Delta Q_{PDI\ meas\ i} = Q_{PDI\ meas\ 2i} - Q_{PDI\ meas\ 1i}$$

The PDI questions that displayed a difference were ranked per profession and compared between professions when greater than 10%.

3. RESULTS

Figs. 3 and 4 show the percentage of overestimation (scoring scale ranging from 0 to 4) per PDI question for each profession.

It should be noted that none of the questions gave rise to an underestimation (all values are positive) for both professions.

The percentages over 10% are compared between professions in Table 1. This comparison gives indication regarding stressors contributing to a deviation of self-assessment of stress.

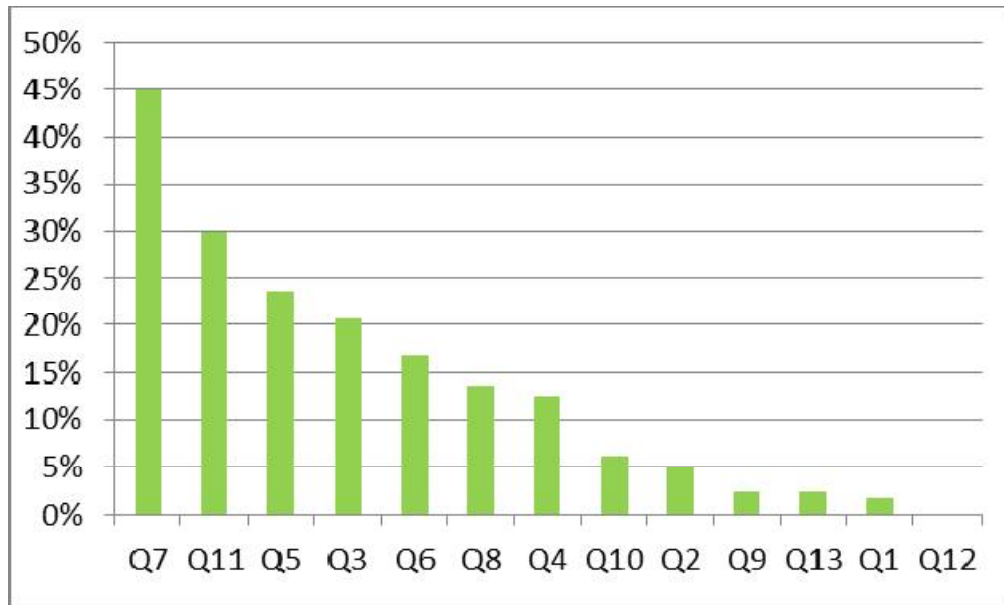


Fig. 3. Percentage of overestimation per PDI question Q_i for the residents in anesthesiology

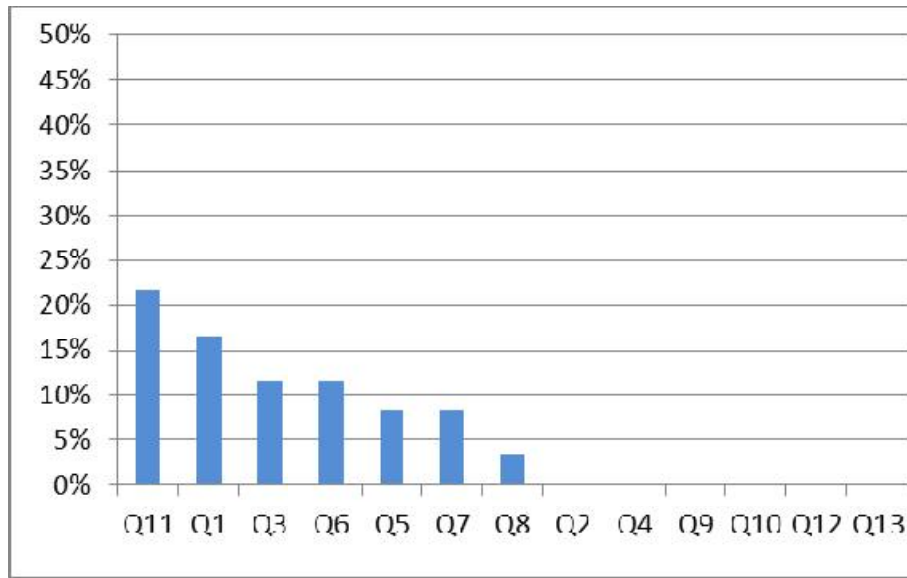


Fig. 4. Percentage of overestimation per PDI question Q_i for the engineers

Table 1. Percentage of overestimation per PDI question Q_i over 10%; characteristics of the questions; proportion (between brackets) of group #2 members scoring more than 0 on Q_i

Q _i	Question	Characteristics of the question	Overestimation of Residents in anesthesiology	Overestimation of Engineers
Q7	I felt worried about the safety of others	Oriented towards the Other	45% (100%)	* (33%)
Q11	I had physical reactions like sweating, shaking, and pounding heart	Perception of physiological manifestations	30% (90%)	22% (100%)
Q5	I felt guilt that more was not done	Powerlessness (guilt)	24% (70%)	* (33%)
Q3	I felt frustrated or angry I could not do more	Powerlessness (frustration and anger)	21% (70%)	12% (67%)
Q6	I felt ashamed of my emotional reactions	Perception of emotional state	17% (60%)	12% (67%)
Q8	I had the feeling I was about to lose control of my emotions	Perception of emotional state	14% (60%)	* (33%)
Q4	I felt afraid for my safety	Oriented towards the Self	13% (30%)	* (0%)

* percentage under 10%

The ranking of questions based on overestimation percentages shows that overestimation of perceived stress for residents in anesthesiology is mainly induced by factors of stress related to concerns oriented towards preservation of the Other (Q7; 100% of group #2 is concerned). This is not the case for engineers for whom the main factors are linked to the perception of physiological manifestations (Q11;

100% of group #2 is concerned), and thus oriented towards the preservation of the Self. However, this aspect is also important for residents in anesthesiology as it ranks second with 90% of group #2 concerned.

Indeed, overestimation of perceived stress associated with an increased perception of physiological (Q11) and emotional (Q6) states

appears in both professions. This relates to concerns oriented towards the preservation of the Self. This orientation is confirmed for residents in anesthesiology by Q4 but not for engineers, however, the contribution of Q4 is about 3.5 times less than that of Q11 for residents in anesthesiology.

Overestimation of perceived stress is associated with powerlessness and feelings of frustration and anger (Q3) in both professions, with the additional "guilt" factor for residents in anesthesiology (Q5).

To summarize the findings:

- Overestimation is mainly explained by concerns oriented towards preservation of the Other for residents in anesthesiology while it is mainly explained by concerns oriented towards preservation of the Self for engineers,
- Overestimation is explained by an increased perception of physiological and emotional states in both professions,
- Overestimation is explained by powerlessness and feelings of frustration and anger in both professions, with the additional "guilt" factor for residents in anesthesiology.

4. DISCUSSION

4.1 Unnoticed Overestimation

The overestimation of self-assessment of acute mental stress for high levels of stress was confirmed. It means that the more constraining the stress, the more subjects may over-estimate the perception of its intensity. The question is now: why did this phenomenon go unnoticed? Several factors may explain that:

- In the studies available in the literature, the use of questionnaires was not systematically compared to physiological characterization of the state of stress. Furthermore, as most of the questionnaires were scientifically validated, they were considered as reliable by researchers even though the validation process did not include a comparison with physiological characterization of the state of stress. In addition, the comparison of results using different self-assessment questionnaires for the same stress condition could not

pinpoint this bias as the process of overestimation is likely to be similar for all questionnaires as demonstrated in the present study for PDI and ALES questionnaires.

- Studies usually compared stress between only two conditions which prevented researchers from highlighting any deviation from an expected trend.
- Studies exploring acute mental stress often examined subjects tackling a mental task (e.g. arithmetic task) or a social interactive task (e.g. public speaking) which provided an effective stress condition but has a low probability to induce a stress of high intensity. For example, when reading the article presenting the mathematical model for HR variation under acute stress [11], among the eight studies gathered to validate the model, only two of them investigated acute mental stress generating HR values greater than 85 bpm.
- Raw data is spread over a large range of values which makes it difficult for researchers to identify any trends; conversely, as observed by Berton et al. [9], a trend may appear when considering the data per small cluster, i.e. averaging individual data per interval, thus helping to reduce the effects of subject's particularities by a statistical compensatory effect of discrepancies.

4.2 Specific and Common Factors of Overestimation

The fact that the main source of overestimation is different from one profession to another (materialized by different questions contributing to the overestimation for each profession) is noteworthy and encourages an in-depth discussion of H2 (the overestimation, if real, is linked to professional concerns). This may help to understand the process of overestimation of self-assessment of acute mental stress.

From the outset, the findings suggest a possible influence of professional traits as residents in anesthesiology are concerned by the preservation of the Other (a priori the patient) while the engineers are not affected by this sort of concern as indicated by the percentage in Table 1. Moreover, when considering individual data for each profession in group #2, residents in

anesthesiology scored 1 to 4 at Q7 while all engineers scored 0.

Regarding the engineers, it might be countered that nothing during the stress-test they took could lead them to feel such concern, but 1 out of 8 scored 1 on Q7 in group #1, the others scoring 0. This singularity shows that the stress-test for engineers made it possible for them to feel concern towards the preservation of the other.

A bibliographic review seeking recent articles (after 2005) characterizing occupational personality traits for anesthesiologists on one hand and for engineers on the other led to few studies using the Myers-Briggs Type Indicator (MBTI; [17]). In the field of medicine, Katz et al. [18] undertook a long-term survey in order to compare the MBTI type preferences of medical students who took MBTI assessment during orientation of the medical school year. They found out that future anesthesiologists were mainly ISTJ type. Briefly, the ISTJ personality type characterizes individuals who drain energy from collectives and like working on their own (Introvert), rely on facts from the reality (Sensing), make decision using rules and analyses (Thinking) and are results-oriented with quick decisions (Judging). In the field of engineering, Montequin et al. [19], comparing several engineering specialties, found that engineers “share a common pattern as regards majority profiles [...] there are a significant number of ISTJ profiles.” This confirmed the previous work of O’Brien et al. [20] as well as Rosati [21] who found ISTJ as the prominent profile for engineers. It is clear that these studies do not help to explain the findings of the present study as they characterized both engineers and anesthesiologists in a similar way.

Other studies used Holland’s theory of careers and vocational choice, based on personality types (developed by J.L. Holland; see for example [22] but did not give any meaningful

outcomes regarding the professions analyzed in the present study. However, Nauta [22] mentioned a study undertaken by the US Department of Labor using an updated and expanded version of Holland’s theory associated model in the online database O*NET (<https://www.onetonline.org/>) that provides updated characteristics of vocational choices. The database provides data for a wide range of professions including Anesthesiologists, Nuclear Engineers and Mechanical Engineers. The professions are characterized by 13 fields which two relate to personality: “interests” and “work values”. Interestingly, characteristics that came up when comparing anesthesiologists and engineers shed light on several findings in the present study.

The definition of each characteristic mentioned in Table 2 is given in appendix 2.

Regarding “interests”, the characteristics confirm or explain the findings:

- “investigative” and “realistic” are common to all professions and may explain the common perception of powerlessness;
- “conventional” is common to engineers and may explain the absence of “guilt” (conversely to residents in anesthesiology) linked with powerlessness in that “conventional” characterizes professionals involved in following procedures: provided that the procedure is followed (which was the case during the stress-test for engineers), guilt is less likely to be manifested;
- “social”, which is only related to anesthesiologists, defined as often involving helping or providing service to others, explains the orientation towards the preservation of the Other for residents in anesthesiology.

When looking at details that contradict the findings, none were found in “interests”.

Table 2. O*NET characterization of occupational choices (<https://www.onetonline.org/>)

	Anesthesiologists	Nuclear Engineers	Mechanical Engineers
Interests	Investigative Realistic Social	Investigative Realistic Conventional	Investigative Realistic Conventional
Work values	Achievement Relationships Independence	Achievement Recognition Support	Achievement Recognition Independence

Regarding “work values”:

- “achievement” is common to all professions and may explain the common perception of powerlessness in that it characterizes professionals who are “results oriented”;
- “relationships”, which only applies to residents in anesthesiology, is defined as “to provide service to others” and explains their orientation towards the preservation of the Other;
- “recognition”, which only applies to engineers, is defined as a characteristic of jobs that “offer advancement, potential for leadership” and is linked to the promotion of the Self; it may explain the orientation towards the preservation of the Self.

When looking at details that contradict the findings, none were found in “work values”.

In addition, the fact that powerlessness is linked to frustration and anger in both professions and to guilt uniquely in residents in anesthesiology can also be observed when considering the definitions of guilt, frustration and anger. The online American Psychological Association dictionary (<https://dictionary.apa.org>) quoted in appendix 3, associates these emotions with occupational traits.

Guilt, which is defined as an emotion characterized by a painful appraisal of having done something wrong and by a readiness to take action to mitigate this wrong, is therefore an altruistic emotion in that it castigates the Self rather than the Other. This confirms the orientation towards the preservation of the Other for physicians. Frustration shows a sensitivity to compliance with rules or requirements, which confirms what was deduced from the O*NET database regarding the characteristic “conventional” in engineers. Anger does not provide any additional information other than that of frustration, first because anger is included in the same question as frustration in the PDI questionnaire (Q3), and second because, in the cases studied, anger is subsequent to frustration rather than injury or injustice, thus systematically linked to frustration.

To summarize, the analysis of the definitions of guilt, frustration and anger confirm the previous findings.

Another approach to explain occupational traits is that related to the Five-Factor model of personality (e.g. [23-25]) which consists in checking to what extent a personality is concerned by the five dimensions: Openness to experience, Conscientiousness, Extraversion, Agreeableness and Neuroticism (OCEAN; see description of the five factors in appendix 4).

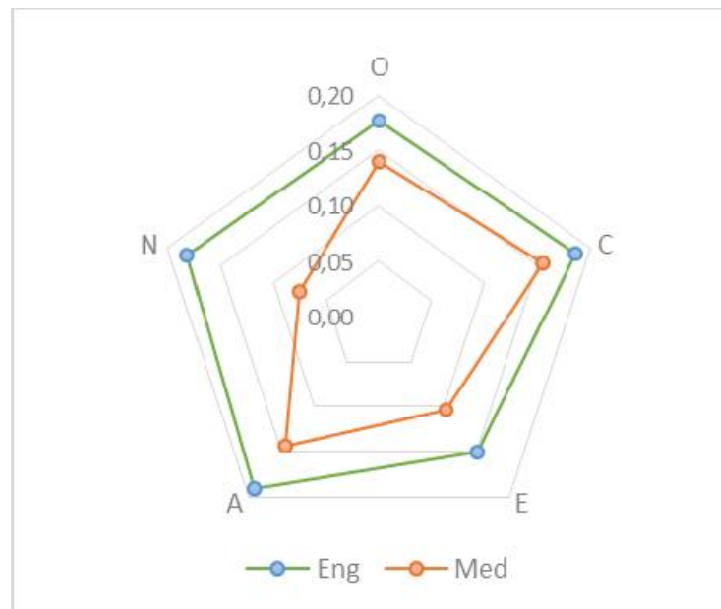


Fig. 5. Normalized scoring for the OCEAN dimensions of the five-factor model in Mechanical Engineering students (Eng) and anesthetists (Med)

Again, very few studies address the professions targeted by the present study and only two presented recent quantified data. Stidham et al. [26] studied traits of Mechanical Engineering students using the 44-item Big Five Inventory and Kisten & Kluyts [27] studied traits in anesthetists using the 50-item International Personality Item Pool. Both questionnaires were scored on a 5-point Likert scale. In order to compare data between professions, normalized scores were here obtained per dimension and per study by dividing the scores by the maximum possible score: Fig. 5 clearly illustrates a difference on the Neuroticism axis.

Although a high score for Neuroticism indicates “the general tendency to experience negative affects such as fear, sadness, embarrassment, anger, guilt and disgust” [24: 69], this does not help to explain the discrepancies between professions regarding stress factors contributing to overestimation as both professions in the present study are concerned by anger and/or guilt. However, the authors indicated that a low Neuroticism score is “indicative of emotional stability” characterizing people as “usually calm, even-tempered, relaxed and able to face stressful situations without becoming upset”. As physicians score less than engineers on the Neuroticism axis (thus physicians are supposed to cope better with stressful situations), this dimension may explain why physicians are sensitive to the overestimation bias for self-assessment of stress at a higher stress threshold than engineers (Fig. 2).

5. LIMITATIONS

The fact that the tests were not the same for the two professions might be a limitation because it may be assumed that a test context favored some given stressful dimensions that the other one does not. However it may be a nonsense to apply the test designed for one profession to the other (engineers will not do anything in a medical theater and anesthesiologists are more often in the operating theater than in the office).

A limitation is inherent to the partial character of a psychometric tool: During the design and the validation process of the self-assessment questionnaires, the selection of relevant and statistically validated characteristics inevitably led to a restricted portrait of the perceived stress which is different from one questionnaire to the other. This was mentioned in the “Introduction”

section when specifying that PDI focused only on constraining factors of stress while the ALES questionnaire also integrated the influence of excitement on stress. Subsequently, the results of the present study are limited by the content of the questionnaire and are not exhaustive; in other words, there may be other professional traits that explain the overestimation specific to a profession but that could not be detected with the questionnaires used.

A limitation might be due to the sample size. Although the deviation of stress assessment was found significant between measured and theoretical values (Fig. 2), we found equality for answers in questions Q6 and Q8 for engineers (Table 1) for example. Perhaps a higher number of subjects might have led to a discrepancy.

The questionnaires are retrospective: They do not question the stress at the time of the stressful episode but just after. In that, the results they provide may suffer from recall bias: “the memory of a past situation is arguably contaminated by its outcome and subsequent events” [28]. However, it is the only way to access subjective stress without disturbing the stress episode.

Subjects had all the same academic and professional profile per sample (i.e. same kind of studies, same kind of job in the same professional environment). However, no personality test was taken by the subjects: the present study cannot analyze its influence on the results.

6. CONCLUSION

Overestimation of perceived stress by subjects through self-assessment questionnaires for high levels of acute stress is effective. This was objectified when comparing the scores of subjective assessment of stress through questionnaires with physiological (thus objective) measures of the subjects’ heart rate when experiencing an acute stress episode. The present analysis shows that the bias of overestimation is characterized by the job’s preoccupations. As a research perspective, it might be interesting to undertake additional experiments using more than two questionnaires in order to cover a wider spectrum of the possible job’s preoccupations biasing stress assessment.

However, the present article was written after having noticed that an overestimation of self-

assessment of acute mental stress appeared for physicians at high level of stress, data which were then compared with those of engineers because our team had undertaken stress experiments with this profession too; after that, and only after that, models of professional traits were sought and analyzed to try to explain the findings. As a research perspective, it might be interesting to first identify which professions are well characterized by such models and then, on the basis of the availability and the relevancy of the information found, choose the professions to be analyzed under acute mental stress. Such an approach might also help to address a question that remains to be analyzed beforehand as pointed out in the section "Limitations": when comparing two professions experiencing a stress episode, must the research plan provide the same episode (the same stress-test) for both professions in order to reinforce the comparability of the two professions, or must it provide two different stress-tests, each being designed according to the specificity of the professions?

Finally, as a major recommendation for researchers, during experiments inducing high levels of acute stress, it is worth to consider the possibility to compare self-assessment of stress with physiological measurements in order to detect a possible overestimation of perceived stress.

CONSENT

It is not applicable.

ETHICAL APPROVAL

The study received ethical approval (Code of Approval: LRN-DHS/11/01) of the Ethics Committee of the Dept. of Human Science (Laboratory for Research in Sciences of Energy, Montagret, France) and has therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

ACKNOWLEDGEMENTS

The authors thank all the participants to the studies at the nuclear power plant of Chinon as well as at the University Hospital of Bicêtre (Paris, France) and Angers (France). The research was financially supported by Electricité de France.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX 1

The Peritraumatic Distress Inventory questionnaire (PDI questionnaire) for self-assessment of stress (Brunet et al. 2001):

- Q1-I felt helpless to do more
- Q2-I felt sadness and grief
- Q3-I felt frustrated or angry I could not do more
- Q4-I felt afraid for my safety
- Q5-I felt guilt that more was not done
- Q6-I felt ashamed of my emotional reactions
- Q7-I felt worried about the safety of others
- Q8-I had the feeling I was about to lose control of my emotions
- Q9-I had difficulty controlling my bowel and bladder
- Q10-I was horrified by what happened
- Q11-I had physical reactions like sweating, shaking, and pounding heart
- Q12-I felt I might pass out
- Q13-I thought I might die

The questionnaire was used in French version (Jehel et al. 2005, 2006).
Subjects were asked to answer each question according to a 5 levels Likert type scale.

APPENDIX 2

Excerpts from the database O*NET accessed in December 2019 (<https://www.onetonline.org/>)

Interests

- Investigative — Investigative occupations frequently involve working with ideas, and require an extensive amount of thinking. These occupations can involve searching for facts and figuring out problems mentally.
- Realistic — Realistic occupations frequently involve work activities that include practical, hands-on problems and solutions. They often deal with plants, animals, and real-world materials like wood, tools, and machinery. Many of the occupations require working outside, and do not involve a lot of paperwork or working closely with others.
- Social — Social occupations frequently involve working with, communicating with, and teaching people. These occupations often involve helping or providing service to others.
- Conventional — Conventional occupations frequently involve following set procedures and routines. These occupations can include working with data and details more than with ideas. Usually there is a clear line of authority to follow.

Work values

- Achievement — Occupations that satisfy this work value are results oriented and allow employees to use their strongest abilities, giving them a feeling of accomplishment. Corresponding needs are Ability Utilization and Achievement.
- Relationships — Occupations that satisfy this work value allow employees to provide service to others and work with co-workers in a friendly non-competitive environment. Corresponding needs are Co-workers, Moral Values and Social Service.
- Independence — Occupations that satisfy this work value allow employees to work on their own and make decisions. Corresponding needs are Creativity, Responsibility and Autonomy.
- Recognition — Occupations that satisfy this work value offer advancement, potential for leadership, and are often considered prestigious. Corresponding needs are Advancement, Authority, Recognition and Social Status.

- Support — Occupations that satisfy this work value offer supportive management that stands behind employees. Corresponding needs are Company Policies, Supervision: Human Relations and Supervision: Technical.

APPENDIX 3

Online American Psychological Association dictionary – definitions

Guilt: a self-conscious emotion characterized by a painful appraisal of having done (or thought) something that is wrong and often by a readiness to take action designed to undo or mitigate this wrong. It is distinct from shame, in which there is the additional strong fear of one's deeds being publicly exposed to judgment or ridicule.

Frustration: the emotional state for individuals experiencing the thwarting of impulses or actions that prevents them from obtaining something they have been led to expect based on past experience, as when a child is prevented from playing with a visible toy. Internal forces can include motivational conflicts and inhibitions; external forces can include the actions of other individuals, admonitions of parents or others, and the rules of society.

Anger: an emotion characterized by tension and hostility arising from frustration, real or imagined injury by another, or perceived injustice. It can manifest itself in behaviors designed to remove the object of the anger (e.g., determined action) or behaviors designed merely to express the emotion (e.g., swearing).

APPENDIX 4

Description of the factors of the Five-Factor model (excerpt from [24: 69]).

Openness to experience:

Openness to experience includes active imagination, aesthetic sensitivity, attentiveness to inner feelings, a preference for variety, intellectual curiosity and independence of judgement.

People scoring low on Openness tend to be conventional in behaviour and conservative in outlook. They prefer the familiar to the novel, and their emotional responses are somewhat muted. People scoring high on Openness tend to be unconventional, willing to question authority and prepared to entertain new ethical, social and political ideas.

Conscientiousness:

Conscientiousness refers to self-control and the active process of planning. The conscientious person is purposeful, strong-willed and determined. High Conscientiousness may lead to annoying fastidiousness, compulsive neatness or workaholic behavior. Low scorers may not necessarily lack moral principles, but they are less exacting in applying them.

Extraversion:

Extraversion includes traits such as sociability, assertiveness, activity and talkativeness. Extraverts are energetic and optimistic. Introverts are reserved rather than unfriendly, independent rather than followers, even-paced rather than sluggish.

Agreeableness:

An agreeable person is fundamentally altruistic, sympathetic to others and eager to help them, and in return believes that others will be equally helpful. The disagreeable/antagonistic person is egocentric, skeptical of others' intentions, and competitive rather than co-operative.

Neuroticism:

Neuroticism is a dimension of normal personality indicating the general tendency to experience negative affects such as fear, sadness, embarrassment, anger, guilt and disgust. High scorers may be at risk of some kinds of psychiatric problems. A high Neuroticism score indicates that a person is prone to having irrational ideas, being less able to control impulses, and coping poorly with stress. A low Neuroticism score is indicative of emotional stability. These people are usually calm, even-tempered, relaxed and able to face stressful situations without becoming upset.

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Peer-review history:
The peer review history for this paper can be accessed here:
<http://www.sdiarticle4.com/review-history/58251>