High stress and Self-assessment: Assumption of Systematic Over-estimation

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Abstract

The use of questionnaires for self-assessment of stress is broadly applied within the scientific community, often complemented with physiological measurements. A few cases of over-estimation of perceived stress using such questionnaires with healthy adult subjects were reported; most of the time, this point is never questioned in the articles. It thus appeared interesting to undertake experiments in the aim of characterizing the possible deviation regarding self-assessment through questionnaires. Peritraumatic Distress Inventory (PDI) questionnaire was used for self-assessment of short term mental stress for two cohorts of subjects (*N*=19) (residents in anesthesiology working in hospital and charter engineers working on an industrial plant) having experienced stressful situations during which mean heart rate was measured. The PDI scores obtained were compared to expected values using the Fauquet-Alekhine et al.'s model for HR response under mental stress. The resulting significant deviation observed was confronted to four assumptions which led to conclude for an effective over-estimation due to the subjects' perception occurring for high level of stress.

1. Introduction

Assessment of stress is a key point in many research domains: for instance it is investigated in terms of factor of performance (Osler, 1954; Van Gemmert et al., 1997; Drach-Zahavy et al., 2002; Beilock et al., 2004, 2007; O'Connor et al., 2010; Jo et al.; 2013), of pathological factors (e.g. Hayes et al., 2009; Combs et al., 2015), studied when combined with tiredness (Harjumaa et al., 2015; Hodgson, 2016) or related to sleepiness (Woodward et al., 2009; Cho et al., 2013). Different kinds of stress were thus identified and therefore studied such as chronic stress (e.g. Maslova et al., 2002 ; Wolf et al., 2008 ; Schubert et al., 2009) or short term stress (e.g. Schubert et al., 2009 ; Fauquet-Alekhine et al., 2014), both including physical or mental dimensions.

Two ways are possible for stress assessment: subjective or objective; however, both are indirect ways of stress assessment. Subjective assessment relates to the use of questionnaires and provides an assessment of stress through its perception by the subjects. Objective assessment relates to the use of physiological measurements and provides an assessment of stress through the reaction of the subjects' metabolism. Therefore in both cases, only consequences of stress are accessed.

Whereas objective assessment may be considered as not being distorted by the subjects, reflecting the actual reaction of the subjects' metabolism to stressors, the distortion might be effective for subjective assessment due to the facts that questionnaires are not filled during the stressful episode but after and due to the subjective nature of perception. In this case we are considering scientifically validated questionnaires, not arbitrary scale of stress self-assessment based on one question which has not been subjected to a validation process (about this latter point, see the analysis of Fauquet-Alekhine & Rouillac, 2015).

This assumption of distortion regarding self assessment of stress was clearly observed in a previous work (Fauquet-Alekhine et al., 2014).

Data was collected regarding training of residents in anesthesiology. They tackled situations of medical training on full scale simulator. The situations lasted from 10 to 15 min. during which subjects had to deal with scenarii among which some of them required cardiac massage, thus involving physical effort. The subjects' heart rate increased due both to the mental stress and the physical effort provoked by the situation. Subjects were asked to assess their stress by means of Peritraumatic Distress Inventory questionnaire (Brunet et al., 2001) and the scores (Q_{mean}) were compared to the mean heart rate (HR_{mean}) measured during the situation. Data (plotted on Fig. 1) clearly showed a shift of some points towards higher values of Q_{mean}, suggesting an overestimation of self assessment of stress for the highest values.

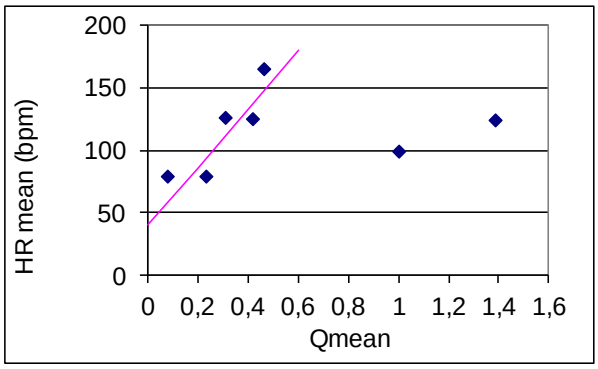

Fig. 1.Mean heart rate vs scores of PDI questionnaire for residents in anesthesiology experiencing a stressful situation during simulation training.

The present short paper aims at illustrating this possible over estimation of self assessment of mental stress through questionnaires after experiencing stressful conditions.

2. Material and methods

Experiments were carried out with French subjects. They had two different professional profiles and all tackled stressful situations; they are described §2.3. Stress state was self-assessed through validated questionnaires (§2.1) and through heart rate measurement as a physiological parameter (§2.2).

2.1 Stress self-assessment

Peritraumatic Distress Inventory questionnaire (PDI questionnaire) was chosen for self-assessment of stress because it includes items such as frustration or guilt in not doing more, shame, fear for one's safety or for that of others, which were important parameters regarding the stressful situations that were encountered by the subjects. It also includes the subject's feelings regarding physiological parameters (sweating, shaking, pounding heart). This questionnaire 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 (Brunet et al., 2001). It was validated in its French form (see Jehel et al., 2005, 2006).

In order to gauge possible bias due to the PDI questionnaire, a cohort of the subjects answered the ALES questionnaire and scores obtained with PDI and ALES were compared. ALES, Appraisal of Life Events Scale was elaborated by Ferguson et al. (1999), with 16 items with reference to the four primary evaluation forms described by Folkman and Lazarus (1985).

Questionnaires were fulfilled by the subjects just after tackling the stressful situation.

2.2 Physiological measurement for stress state assessment

Heart rate was measured by means of a Polar FS2c composed of two parts. The first one was a detector with two electrodes to be put on the breath, touching the skin, close to the heart. The second one was a monitor the size of a watch worn on the wrist. The technical specifications were:

- accuracy of time measurement: better than ± 2.0 s / 24 h
- accuracy of heart rate measurement: ± 1% or ± 1bpm, whichever larger
- measuring range : 15-240 bpm

Heart rate (HR) was measured for each subject whilst tackling the stressful situation and the average value HR_{mean} calculated all over this time was saved for further analysis.

2.3 Stress conditions and subjects

All subjects were healthy adult volunteers without any mental or physical disability.

2.3.1 Comparing PDI and ALES response

Volunteers subjects, *N*=44 (mean age: 27.5 yo., 68% male), were asked to fill ALES and PDI

questionnaire just after experiencing a stressful anesthesiology training session on a full scale simulator. Individual scores were calculated for inter-comparison.

2.3.2 Analyzing HR vs PDI score

Two cohorts of subjects (N_{total}=39) participated to the study.

The first cohort (21 participants) was residents in anesthesiology working in hospital with age ranging from 25 to 30 yo. They provided data among which some of them had to be rejected. The rejection criteria were: i) when subjects had involved themselves in physical efforts (e.g. cardiac massage) with thus a possible bias on HR measurement (this was observed during the simulated situation), ii) when subjects had coffee (or stimulating beverage), tobacco (or stimulating substances) or had experienced a stressful situation before coming to the experiment (this was investigated through a questionnaire). This cohort tackled situations of medical training on full scale simulator as described in Fauquet-Alekhine et al. (2014). The situations lasted from 10 to 15 min. during which subjects 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 arthoplasty 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.

The second cohort (18 participants) was chartered engineers working at an industrial plant with the same kind of academic background with ages ranging from 25 to 35 yo. It was verified that none of them had coffee (or stimulating beverage), tobacco (or stimulating substances) or having experienced a stressful situation before coming to the experiment. In their own office, subjects individually tackled a stress-test (an office task type not implying any physical effort) made up of 12 psychotechnical and cultural questions, lasting from 5 to 10 min., said stressful or not depending on contextual factors added for the test (see full details in Fauquet-Aleklhine et al., 2012).

2.4 Data analysis

As suggested by Berton et al. (2015), the data was treated by range: an average score $Q_{PDImeas}$ was calculated for intervals 0.2 width and the associated average *HR* was also calculated. Then, for each *HR* calculated, an expected score was calculated as follows.

Figure 1 illustrates a case of *HR* variation with Q_{mean}, the score per subject, when perceived stress is assessed through the PDI questionnaire. The graph shows a deviation of data for some of them towards the highest levels of stress. However the graph illustrated this deviation with reference to a linear line while heart rate does not evolve linearly with a stressor: Levy et al. (1998: 1237) pointed out this fact and this was highlighted again, mathematically modelized and tested by Fauquet-Alekhine et al. (2016) who showed that heart rate variation with an indicator of stress (such as a score of the PDI questionnaire) actually follows a power trendline which is generalized through a unique power coefficient *a*. The model takes the form:

$$HR = kS^a + c \qquad (1)$$

where :

- *S* is a stress indicator (as the score of the PDI questionnaire),
- *c* is the y-intercept of the curve,

with:

$$k = {}^{\alpha}/_{a\ S_1^{(a-1)}} \qquad (2)$$

where:

- α is the slope of the linear function linking HR_1 and S in the neighborhood of 0,
- $a = .2$
- S_1 is adjusted to 15% of the range of experimental data covered by the linear function (HR and S in the neighborhood of 0).

The model correlated with 8 different studies providing 24 points gathering altogether 295 healthy adult subjects and involving 6 different stress indicators was r=.95 (p<.0001).

In the present study, Fauquet-Alekhine et al.'s model for HR response under mental stress (eq. 1) was applied to the collected data in order to calculate the expected scores $Q_{PDIcalc}$ of the PDI questionnaire and compare them with the values $Q_{PDImeas}$ obtained.

2.5 Ethics

Deontology was presented during each introduction of training sessions or experiments to the subjects. All subjects were volunteers. It was clearly explained that all data would be used for research, anonymously, and that no access to personal data or to the links between data and identity would be given to anyone. An informed consent was filled up and co-signed by each subject and the researcher each time.

3. Results

3.1 Comparing PDI and ALES response

The ALES questionnaire offers the possibility to differentiate stress factors referring to excitement from those referring to constrain. As the PDI questionnaire items only refer to constrain, the ALES score was calculated only taking into account the items of constrain. The correlation coefficient with the PDI questionnaire for N=44 subjects was significant: $r(N=44)=.70$, p<.001. When gathering data per intervals according to the PDI values ([0;1];]1;3];]3;5];]5;7];]7;10]) the correlation coefficient was higher: $r(N=6)=.89$, $p<.008$.

This permitted to reject the hypothesis that a questionnaire bias could explain a possible over (or under) estimation of stress.

3.2 Analyzing HR vs PDI score

For the first cohort (residents), after applying the selection criteria for the 21 participants summoned, the remaining selected subjects were N=11 (50 % male, mean age: 28 yo.). The Cronbach coefficient calculated for this remaining sample regarding answers provided for the PDI questionnaire was α=.63.

For the second cohort (chartered engineers), after applying the selection criteria for the 18 participants summoned and taking into account that some subjects perceived a level of stress too low differentiated by the PDI questionnaire (thus yielding a bias due to statistical weight), the remaining selected subjects were N=8 (38% male, mean age: 31.5 yo.). The Cronbach coefficient calculated for the remaining sample regarding answers provided for the PDI questionnaire was α=.66.

For both cohorts, data was treated by range: an average score $Q_{PDImeas}$ was calculated for intervals of 0.2 in width and the associated average HR was also calculated. The expected score $Q_{PDIcalc}$ was calculated for each HR using Fauquet-Alekhine et al.'s model for HR response under mental stress (eq. 1).

Figure 2 draws the score $Q_{PDImeas}$ vs $Q_{PDIcalc}$ for each cohort on the same graph. If the PDI scores would be as expected, all points would be aligned over the linear line $y=x$ intercepting 0. This is the case for the low values of scores but very soon the points deviate from this line which clearly shows a higher score than expected.

4. Discussion

The deviation appearing on Fig. 2 accounts for an obvious trend towards higher values than expected when subjects scored high levels of stress. It is remarkable that the trend is similar for both cohorts despite different occupational profiles as well as different stress contexts.

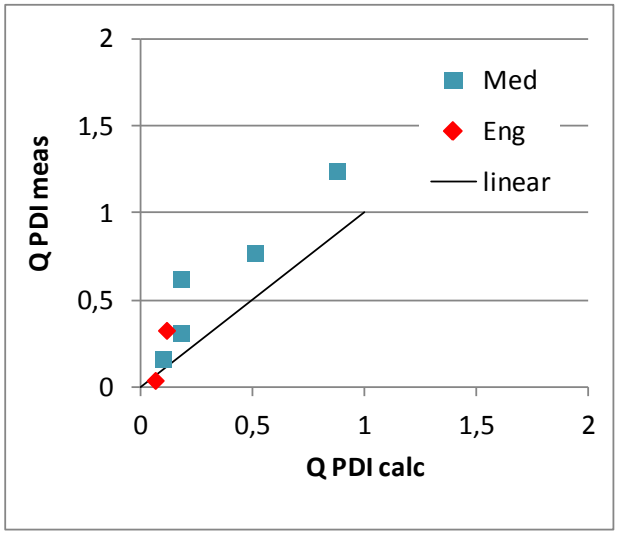

Fig. 2. Measured PDI scores $Q_{PDImeas}$ vs expected PDI scores $Q_{PDIcalc}$ for subjects (Med=residents; Eng=charter engineers) experiencing a stressful situation lasting from 5 to 15 minutes.

Several assumptions may be suggested to explain this deviation. This may be due to:

- the physiological parameter chosen to characterize stress: HR could underestimate the level of stress and therefore lead to lower expected values of PDI scores. However, on one hand a previous work (Fauquet-Alekhine et al., 2016) showed that this parameter was relevant and reliable and on the other hand the low values of stress give points aligned on the linear line.
- the inappropriateness of the model used to calculate expected PDI scores. However the aforementioned previous work showed the reliability of the model.
- a distortion intrinsic to the PDI questionnaire. However self-assessments through PDI were compared with these obtained through ALES and gave good correlation coefficients.
- the subjects' perception of stress engaging them to over-estimate the stress when the level of stress increased over a given threshold. In other words, when stress became high, subjects could have a tendency to perceive it higher than it was and then over-scored it on the scale of the questionnaire.

Among these assumptions, only the last one may be retained. In addition, this assumption is reinforced by findings obtained elsewhere: cases of overestimation of stress through recalls of stressful events were already noticed by Gittins et al. (2015) regarding individuals who experienced a traumatic event in forensic settings and by Archer et al. (2005) in the frame of assessment of pediatricians in training who rated twice higher their inability to deal with stress when compared with observers' evaluation.

Therefore the finding is that there is effectively an over-estimation of stress for high levels when self-assessed through a questionnaire by subjects who just experienced a stressful situation.

Further analysis is needed now to investigate the factors that contribute to this over-estimation.

5. Conclusion

The experiments undertaken with healthy adult subjects showed an effective over-estimation of self-assessment of short term mental stress whilst using the Peritraumatic Distress Inventory (PDI) questionnaire. Analysis showed that using the Appraisal of Life Events Scale (ALES) would have led to the same conclusions. Analysis showed that this over estimation was due to the subjects' perception occurring for high level of stress. Yet the limits of the present study lie on the reduced scope of questionnaires used: a systematic investigation of the available questionnaires would be welcome.

However the main conclusion of this study is that researchers must take into account such a possible over-estimation through questionnaires and the possible bias induced subsequently on their data, even if the deviation was observed here only for high levels of stress.

The questionnaires used in the present study being made of items which may be categorized, this may permit to characterize the overestimation through categories of the questionnaire items. Therefore, as a research perspective, a refined analysis of questionnaire scores may be carried out in order to better understand what make subjects overestimating the stress. As two different professional populations were involved in this study, this may provide lights regarding the nature

of the overestimation when, for example, confronted to occupational personality traits.

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