

# A PILOT STUDY TO VALIDATE THE BORG CR100 (CENTIMAX) SCALE<sup>®</sup>, ON MENTALLY STRESSFUL STIMULI.

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## Abstract

*The aim was to validate the Borg CR100 (centiMax) Scale<sup>®</sup> for mental stress against heart rate and blood pressure as well as the Stress-Energy Questionnaire (Kjellberg and Wadman, 2002). Subtraction with 7 and 13 respectively was used as stressors, for 11 men and 11 women. Significant differences were obtained between the stressful and rest situations for perceived stress (cMax CR100), heart rate, systolic and diastolic blood pressure ( $p < 0.05$ ). A high and significant correlation was obtained between peak perceived stress (CR100) and the stress dimension of the Stress-Energy Questionnaire ( $r = 0.81$ ,  $p < 0.001$ ). A moderate, but non-significant correlation was obtained with heart rate ( $r = 0.41$ ,  $p = 0.056$ ) and a rather strong and significant correlation was obtained with diastolic blood pressure ( $r=0.48$ ,  $p=0.025$ ). The results show that the CR100 Scale functions well to measure mental stress.*

Research has shown that both long-term stress of an average intensity and acute stress load may cause health problems such as depression, burn-out, type 2 diabetes, cardiovascular disease, stomach problems, aches and pain in the neck and shoulders, sleeping problems, etc. (see e.g., Bültmann, Kant. Van den Brandt, and Kasl, 2002; Lundberg, 2005; Selye, 1976; Stansfeld et al., 1998; Währborg, 2002. Several theories on how stress is related to the work situation have been developed. Karasek (1979) suggested a two-factor model with the implication that it is especially a combination of heavy job demands and low individual control at the work place that is associated with high mental strain. The biopsychosocial model by Frankenhaeuser (1989) focuses on the person-environment interaction balancing environmental demands with individual resources. The Stress-Energy-model by Kjellberg and Wadman (2002) emphasizes the subjective and emotional aspects of stress and is linked to Karaseks (1979) model.

A large portion of the stress research focuses on relationships with physiological and biological reactions. One common stressor used in such studies is mental arithmetic. This has been found to give elevated blood pressure and heart rate responses as well as significantly higher perceived stress as compared to a base-line (measured on category scales and in one occasion the VAS). (See e.g., Blascovich et al., 1992; Carter, Kupiers, and Ray, 2005; Delahanty et al., 1996; Fechir et al., 2008; Keltikangas-Järvinen and Heponiemi, 2004; Lundberg et al., 1994).

The scales used to measure perceived stress have primarily been constructed according to the psychometrical tradition. The scales are commonly composed as questionnaires with a number of items to which individual answers are recorded on ordinary rating scales (with e.g., 5 to 11 categories). As an example, the Stress-Energy Questionnaire (Kjellberg and Wadman, 2002), consists of 6 adjectives for the stress dimension, and 6 for the energy dimension (half of each being positive, the other half negative), to be rated on a scale from 0 (not at all) to 5 (very, very). Such scales have, however, been criticized with regard to obtained data level (see, e. g., Svensson, 1998, 2000).

Scales that have the combined advantages of level-anchored category scales and psychophysical ratio scales, are the so called Category-Ratio (CR) Scales, developed by G.

Borg and colleagues. The most recent of these scales is the Borg CR100 (centiMax) scale<sup>®</sup>. The scales unique properties have been validated against magnitude estimation within several modalities, and against physiological and performance criteria within the area of perceived exertion (G. Borg, 1962, 1982, 1998; G. Borg and E. Borg, 1994, 2001, E. Borg, 2007).

The aim of this study was to validate the Borg CR100 (centiMax) scale<sup>®</sup> to measure mentally stressful stimuli, such as mental arithmetic, against some physiological variables (heart rate and blood pressure) and against the psychometric Stress-Energy Questionnaire by Kjellberg and Wadman (2002).

## Method

### *Participants*

Twenty-two healthy individuals (11 men and 11 women) volunteered as participants (Table 1). All subjects were non-smokers and had abstained from moist snuff, coffee/tea or Coca Cola, during the day for the experiment, and had not had anything to eat or drink during the last hour before. Neither had they participated in any heavy physical work 24 hours before the experiment. All subjects gave a written consent to participate.

### *Stimulus, apparatus and procedure*

Two types of mental arithmetic were used as stressors: subtraction from a 4-digit number with 7 and 13 respectively. The participants were asked to make as many subtractions as they possibly could during two subsequent 5 min sessions, starting with 7 directly followed by 13. An error was indicated by a beeping noise and the subject was instructed to continue from the number before the error.

Before the experiment started and then at 2.5 min intervals, the performance was noted, and perceived stress was measured with the Borg CR100 (centiMax) Scale<sup>®</sup> (G. Borg and E. Borg, 2001, E. Borg, 2007). Heart rate (HR) and blood pressure (SBP and DBP) were also measured, with a UA-751 automatic blood pressure monitor (A&D). After the mental tasks were completed (10 min), subjects were asked to use the Borg CR100 Scale<sup>®</sup> to appraise how difficult they had perceived the task to be. They also filled in the Stress-Energy Questionnaire (SEQ) (Kjellberg and Wadman, 2002). Subjects then lay down to rest for 15 minutes after which the last set of measurements were taken.

## Results

Age, Height, Weight and Body Mass Index (BMI) for the subjects are presented in Table 1, and may be considered to be representative for a Swedish population of the same age (SCB, 2009). Descriptive results for the measured variables are shown in Table 2, and for men and women separately in Figure 1. As can be seen from Table 2, performance was a little less in Task 2 as compared to Task 1,  $t(21) = 6.8$  ( $p < 0,001$ ).

A series of 2 x 4 mixed ANOVA's with Sex (Man, Woman) as between-subjects factor and Occasion (Before, Task 1, Task 2, Rest) as within-subjects factor were computed. When the assumption of sphericity was violated MANOVA results are reported. For Stress measured with the Borg CR100 Scale<sup>®</sup> a significant main effect for Occasion was obtained, Wilks' Lambda=0.234,  $F(3,18)=19.6$  ( $p < 0.001$ ), but the main effect for Sex as well as the interaction effect was non-significant ( $p > 0.05$ ). Sidak Post-Hoc test showed significant differences for all four occasions ( $p \leq 0.01$ ). See Figure 1.

Table 1. Mean and (standard deviations) for Age, Height, Weight, and BMI (N=22).

Sex	N	Age (yrs)	Height (cm)	Weight (kg)	BMI
Women	11	27.7 (7.5)	168.6 (3.5)	60.8 (7.0)	21.4 (2.4)
Men	11	30.2 (7.2)	179.5 (7.3)	74.3 (11.1)	23.0 (2.4)
All	22	28.9 (7.3)	174.1 (7.9)	67.5 (11.4)	22.2 (2.5)

Table 2. Mean values and (standard deviations) for the total group (N = 22).

Measure	Before	Task 1 <sup>1</sup>	Task 2 <sup>2</sup>	Rest
Performance		28.8 (15.8)	17.5 (9.0)	
Stress (cMax CR100)	14.5 (9.1)	27.3 (13.3)	32.8 (18.3)	7.6 (6.7)
HR (bpm)	69.6 (13.0)	80.9 (19.4)	78.7 (14.4)	61.4 (11.1)
DBP (mmHg)	74.5 (7.8)	80.7 (10.4)	82.2 (7.6)	66.6 (7.8)
SBP (mmHg)	116.8 (13.4)	130.7 (13.2)	126.8 (10.9)	114.4 (13.4)
Difficulty			35.7 (15.3)	
Stress (SEQ)			2.9 (0.9)	
Energy (SEQ)			3.2 (0.7)	

1) Average of the 2.5 and 5 min measurement

2) Average of the 7.5 and 10 min measurement

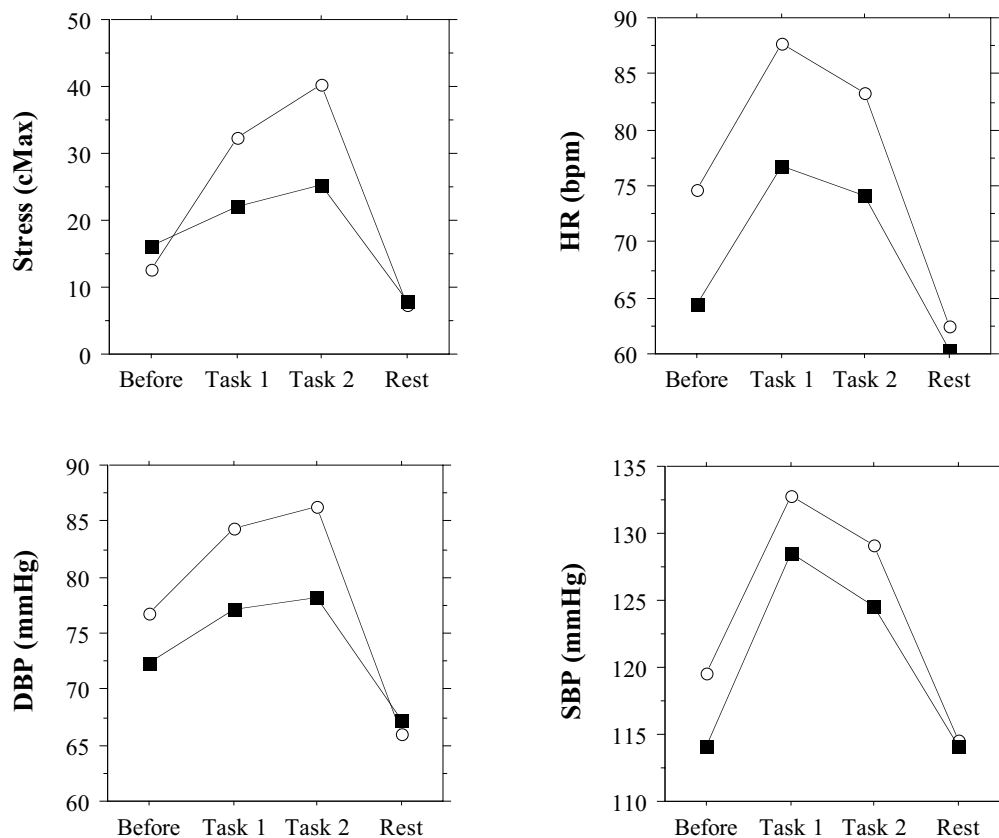


Figure 1. Mean values of, top left: perceived stress (cMax CR100); top right: heart rate (bpm); bottom left: systolic blood pressure (mmHg); and bottom right: diastolic blood pressure (mmHg), before and after each arithmetic task as well as after 15 min of rest (open circles = women, closed squares = men) (N=22).

Table 3. Correlations between perceived stress (Borg CR100), heart rate (HR), and blood pressure (DBT and SBT) (N=22).

	Stress (cMax CR100)	Stress SEQ	Energy SEQ	HR (bpm)	DBT (mmHg)
HR (bpm)	0.41	0.47*	0.23		
DBT (mmHg)	0.48*	0.56*	0.36	0.48*	
SBT (mmHg)	-0.06	0.07	0.15	0.26	0.34

\*)  $p < 0.05$     \*\*)  $p < 0.01$     \*\*\*)  $p < =.001$

For the physiological measurements only significant main effects for Occasion were obtained, but not for Sex, nor for the interaction effects. For HR ( $F(3,60)=26.7$ ,  $p<0.001$ ) Sidaks Post-Hoc test showed significant differences between all occasions except between Task 1 and Task 2 ( $p<0.05$ ). For DBP ( $F(3,60)=28.9$ ,  $p<0.001$ ) and Sidaks Post-Hoc test also showed significant differences between all occasions except between Task 1 and Task 2 ( $p<0.01$ ). For SBP, Wilks' Lambda=0.294,  $F(3,18)=14.4$ ,  $p<0.001$ ) Sidaks Post-Hoc test showed significant differences between all occasions except between Before and Rest and between Task 1 and Task 2 ( $p\leq 0.01$ ).

Correlations were calculated using the peak stress-value (CR100) and range-values for the physiological variables (the highest value obtained for each individual during the test subtracted with the lowest value). A rather strong and significant correlation,  $r=0.48$  ( $p=0.025$ ) was obtained between Stress (CR100) and DBT and a moderate but non-significant correlation of  $r=0.41$  ( $p=0.056$ ) was obtained between Stress (CR100) and HR. For the Stress-part of Stress-Energy Questionnaire rather strong correlations of  $r=0.47$  ( $p=0.027$ ) and  $r=0.56$  ( $p=0.007$ ) with HR and DBT respectively, were obtained. (see Table 3). The differences between these correlations for HR and DBT, with Stress measured with CR100 or with the Stress-part of Stress-Energy Questionnaire, were non-significant. A power analysis conducted for the correlation between Stress (CR100) and HR showed that for  $\alpha=0,05$ , obtained power was  $(1-\beta)=0.49$ . To obtain a power of 0.80, 44 subjects would have been needed.

A comparison was also made between: perceived stress measured with the Borg CR100 (centiMax) Scale<sup>®</sup> (peak value); the perceived difficulty of the full task, also measured with the CR100; the Stress and the Energy dimensions of the SEQ; and average performance (mean performance of Task1 and Task 2). High and significant correlations of about 0.8 were obtained between Stress and Difficulty (measured with CR100) as well as between these two measures and the Stress dimension of the SEQ, whereas correlations close to zero were obtained with the Energy dimension. A significant correlation of  $r=-0.49$  was also obtained between perceived difficulty (cMax, CR100) and average performance.

Table 4. Correlations between perceived stress (Borg CR100), perceived difficulty (Borg CR100), the Stress and the Energy dimensions of the Stress-Energy Questionnaire, and Average performance (N=22).

	Stress (cMax CR100)	Difficulty (cMax CR100)	Stress (S/E-quest)	Energy (S/E-quest)
Difficulty (cMax)	0.79***			
Stress (SEQ)	0.81***	0.77***		
Energy (SEQ)	0.13	-0.03	0.16	
Av. performance	-0.37	-0.49*	-0.36	0.23

\*)  $p < 0.05$     \*\*)  $p < 0.01$     \*\*\*)  $p < =.001$

## Discussion

Because of its construction as general intensity scale, it may be hypothesized that the Borg CR100 (centiMax) Scale<sup>®</sup> should work well for direct measurements of most kinds of perceived intensities, of symptoms or emotions. The aim of this study was therefore to validate the Borg CR100 (centiMax) Scale<sup>®</sup> for mentally stressful stimuli.

In this study, mental arithmetic (counting backwards with 7 and 13) was used as stressor. Significant differences were found between stressful and non-stressful situations for perceived stress measured with the Borg CR100 Scale<sup>®</sup> (Table 2 and Figure 1). In agreement with previous research effects were also found for heart rate and blood pressure (e.g., Blascovich et al., 1992; Carter, Kupiers, and Ray, 2005; Delahanty et al., 1996; Fechir et al., 2008; Keltikangas-Järvinen and Heponiemi, 2004; Lundberg et al., 1994). However, only for perceived stress was the difference between the two arithmetic tasks significant.

Moderate to strong correlations of approx. 0.4 – 0.5 were obtained between perceived stress (cMax CR100), heart rate (bpm) and diastolic blood pressure (mmHg). This was in the same order of magnitude as the correlations obtained for the Stress-part of the SEQ (Kjellberg and Wadman, 2002), and between heart rate and diastolic blood pressure. Low and non-significant correlations were, on the other hand, obtained between the physiological measurements and the Energy-part of the SEQ. It can thus be concluded that the Borg CR100 Scale<sup>®</sup> is valid in measuring perceived stress.

The Stress-Energy Questionnaire was used for parallel-test validity. A very strong, and significant, correlation of about 0.8 was obtained between the two different Stress-scales, but not between the Borg-scale and the Energy-part of the SEQ. This further supports that the Borg CR100 Scale<sup>®</sup> is valid as a stress-scale.

A rather strong and significant negative correlation, of approx. -0.5, was obtained between perceived difficulty of the total task (also measured with the Borg CR100 Scale<sup>®</sup>) and average performance. For perceived stress and energy measurements with the SEQ correlations with average performance were less than  $\pm 0.4$  and non-significant. This shows that the Borg CR100 Scale<sup>®</sup> is valid also to measure perceived task difficulty (in agreement with what was obtained for magnitude estimation, Borg, G., Bratfish, and Dornic, 1971).

The Borg CR scales<sup>®</sup> are well known as scales for “ratings of perceived exertion”, “pain-scales” and “dyspnea-scales”. The results of this study has shown that the Borg CR100 Scale<sup>®</sup> may also be called a “stress-scale”, and a scale for “perceived difficulty”, and it is the hope of the authors that it will be used as such.

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