

## A STUDY OF RANGE EFFECTS FOR THE BORG CR100 (CENTIMAX) SCALE® AND MAGNITUDE ESTIMATION IN LOUDNESS

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### Abstract

*To compare range effects in loudness scaled with magnitude estimation (ME) and the Borg CR100 (centiMax) Scale®, a classroom experiment with a total of 53 subjects (27+26) was conducted. Two conditions with a wide and a narrow stimulus range were used (Group A: ME-narrow; ME-wide; CR-wide; CR-narrow; and Group B: ME-wide; ME-narrow; CR-narrow; CR-wide). Average exponents obtained were:  $n_{ME-narrow} = 0.69$ ;  $n_{ME-wide} = 0.47$ ;  $n_{CR-narrow} = 0.48$ ;  $n_{CR-wide} = 0.43$  for group A; and:  $n_{ME-narrow} = 0.70$ ;  $n_{ME-wide} = 0.49$ ;  $n_{CR-narrow} = 0.66$ ;  $n_{CR-wide} = 0.46$ , for group B. For ME, the range effect was significant for both groups, but for CR100 a significant range effect was only obtained for group B. These results suggest that the CR100 is less sensitive than ME to context effects related to stimulus range.*

When scaling intensities of different modalities, range effects are typically observed as a steepening of the psychophysical function for narrow stimulus ranges. This is found for ratio scales like magnitude estimation, as well as for category scales, and has mainly been attributed to judgment bias, but also to perception (e.g., R. Teghtsoonian, 1971, 1973; R. Teghtsoonian, & M. Teghtsoonian, 1978; Poulton, 1989; Schneider & Parker, 1990; Algom & Marks, 1990; Marks, 1993).

Category-Ratio scaling, and especially the Borg CR10 scale®, was introduced by Gunnar Borg in the 1970's and 80's (G. Borg, 1982; 1998). On this scale with a numerical range from 0 to 10 (with a possibility to also use numbers beyond 10 in extreme situations), verbal anchors, "categories", are placed in congruence with numbers in order to keep the ratio relations among responses to stimuli that are obtained with magnitude estimation. Several principles behind Category-Ratio scaling are identified and discussed by G. Borg and E. Borg (2001), as well as reasons for using the newer and more fine-graded Borg CR100 (centiMax) scale® from 0 to 100 (see also E. Borg and G. Borg, 2002; E. Borg, 2007).

One very important principle, is G. Borg's "range-model" (G. Borg, 1962; Sagal and Borg, 1993). According to this principle, the total natural subjective dynamic range from zero (or a minimal intensity) to maximum (or a near maximal intensity) is perceptually approximately the same for most individuals. A previously experienced maximal intensity, of for example perceived exertion, may then serve as a main point of reference, or "fixed star" (G. Borg, 1992; G. Borg and E. Borg, 2001). Any perceived level of intensity will then be evaluated in relation to its position in the range. As we grow up, adjectives and adverbs are given meaning by personal experience and communication, and are gradually schematized at natural positions in the subjective dynamic range. If this inner frame of reference and the connections between the verbal anchors and perceptions are rather stable, range effects such as mentioned in the first paragraph, may be less prominent when a CR scale is used.

Lawless, Horne and Spiers (2000) found, however, that the so called Labelled Magnitude Scale (a scale constructed by Green, Shaffer and Gilmore, 1993, that builds on a modification of the Borg CR10 scale<sup>®</sup>), showed the common range effect of a steeper slope when subjects were presented a more narrow stimulus range.

The purpose of this study was to compare range effects obtained when scaling loudness with magnitude estimation and the Borg CR100 (centiMax) Scale<sup>®</sup>. Due to the construction of the Borg scale it is hypothesized that exponents obtained for a narrow and a wide stimulus range will be more similar when scaling is done with the Borg scale compared to magnitude estimation.

## Method

The experiment was carried out during a lecture on magnitude estimation and Category-Ratio scaling. A total of 57 students, divided into a morning (A) and an afternoon (B) group, took part in a classroom experiment. Four students from Group B did not want their data to be included in a reported study. Of the remaining 53 participants (27 in group A and 26 in group B), 46 were women (mean age 26, sd = 5.2 yrs) and 7 were men (mean age 27, sd = 4.6 yrs). One woman did not report her age. Five subjects had partial drop outs on in total 11 ratings (equally spread). These were replaced with mean values. Four subjects gave zero ratings with ME. These were replaced with 0.01.

Two series of white noise were used in a classroom setting, a narrow range with  $S = \{54; 57; 60; 63; 66; 69; 72\}$  dB and a wide range with  $S = \{36; 45; 54; 63; 72; 81; 90\}$  dB. The background noise was 32 dB. Each stimulus was presented four times in the same randomized order for all participants. Both groups started with classical free magnitude estimation (ME) and were asked to try to use the same scale throughout the whole experiment. Following ME there was an approx. 20 minutes instruction with presentation of the Borg CR100 (centiMax) Scale<sup>®</sup> (G. Borg, 1998; G. Borg and E. Borg, 1994, 2001; E. Borg, 2007). Both groups started with ME since it has previously been found that CR100 may affect ME but not the other way round (E. Borg and G. Borg, 200). Group A started with the narrow range scaled with ME, followed by a 10 min pause and then the wide range scaled with ME, had the 20 min information on the Borg CR100 scale<sup>®</sup> and then scaled the wide range followed by a 10 minutes pause and then the narrow range with this scale. Group B did the same thing but started with the wide range with ME and the narrow range with the CR100. For stimulus presentation a MacBook computer with separate loudspeakers was used.

## Results

The results for the different conditions are presented in Figure 1. Psychophysical powerfunctions without extra constants were computed for group data (geometric means) as well as for individual data. For Group A the average exponents obtained were:  $n_{ME-narrow} = 0.69$ ;  $n_{ME-wide} = 0.47$ ;  $n_{CR-narrow} = 0.48$ ; and  $n_{CR-wide} = 0.43$ ; and for Group B the average exponents were:  $n_{ME-narrow} = 0.70$ ;  $n_{ME-wide} = 0.49$ ;  $n_{CR-narrow} = 0.66$ ; and  $n_{CR-wide} = 0.46$ .

Paired t-tests of individual exponents showed that the differences between the wide and narrow ranges were significant for both groups when ME was used,  $t_{26} = 6.72$  ( $p < 0.001$ ) for Group A and  $t_{25} = 5.62$  ( $p < 0.001$ ) for Group B. When the Borg CR100 (centiMax) Scale<sup>®</sup> was

used the difference was not significant for Group A,  $t_{26} = 1.97$  ( $p=0.102$ ), but it was significant for Group B,  $t_{25} = 7.34$  ( $p<0.001$ ).

### Discussion

The purpose of this study was to compare the Borg CR100 Scale<sup>®</sup> to magnitude estimation (ME) on a narrow and a wide stimulus range using loudness stimuli. For ME, steeper psychophysical functions were obtained with the narrow range, regardless of whether the narrow or the wide range was presented first. For the Borg CR100 Scale<sup>®</sup> this range effect was only observed when the participants started with the narrow range (Figure 1). From the figure it looks, however, as if it is especially the two or three lowest stimulus values in the narrow range (around “Weak” (13) on the CR100) that contributes to this range effect (Group B). Thus, the Borg CR100 Scale seem to be somewhat less sensitive to the effect of stimulus range, than is ME, at least under some circumstances.

According to the principles for scale construction behind the Borg CR Scales (see, e.g., G. Borg and E. Borg, 2001), it was hypothesized that the range effect would be less pronounced with the Borg CR100 Scale<sup>®</sup> than with ME. Why this was only observed when the wide range was presented first, is not answered by this study.

If the instruction for the CR100 together with the verbal anchors on the scale was enough to override the range effect, the result ought to have been the same for both groups (A and B). If it was enough to have heard the large stimulus range prior to the narrow range, the result ought to have been the same for this presentation order with ME. This was not the case. It can also be ruled out that it was enough to have heard the large stimulus range once, since both groups had done so with ME.

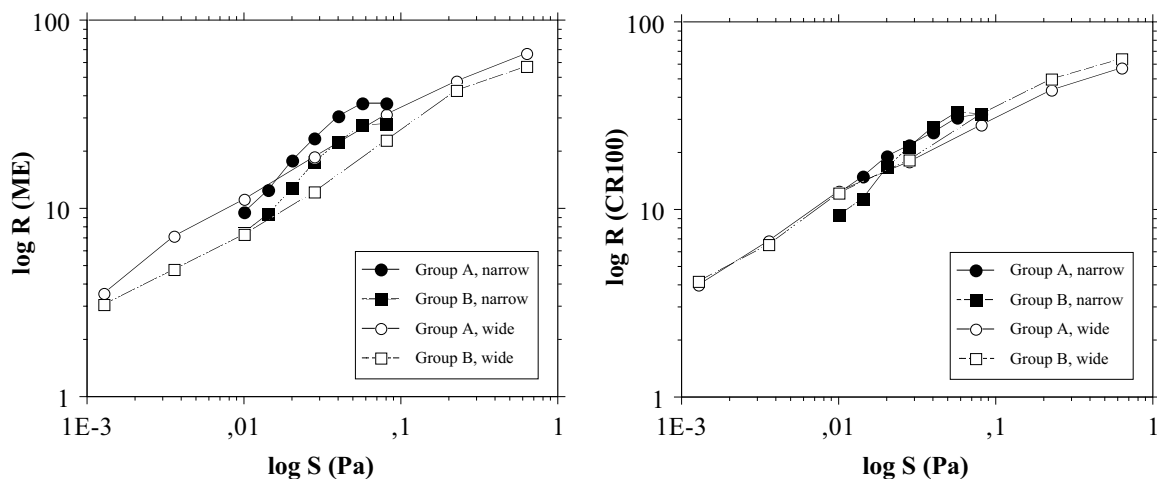


Figure 1. Average data for the two groups (A, N=27 and B, N=26) and the two different ranges with ME to the left and Borg CR100 to the left.

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