

“Borg scales” – why so good?

Basic principles and some applications

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Measurement

- Psychophysical scaling
- Category scales
- Borg-scales
- Applications



Psychophysical scaling

Psychophysics

The field within psychology studying how sensations and perceptions relate to the physical world and how sensations relate to each other

Psychophysics

Detection – is something there?

Do I perceive any specific feeling when I'm standing here, talking to you?

Discrimination – is there a difference?

Is this feeling different from what I felt yesterday, when I sat in the audience?

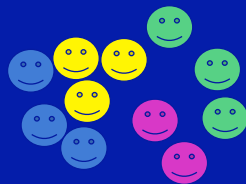
Identification – what is it?

What exactly is the feeling? Tension? Nervousness? Nausea?

Scaling – how much/strong is it?

Well... – how do I measure that? "Weak"; "Moderate"; "Strong"? "Ten times as nervous..."?

Level of measurement



Nominal scale



Ordinal scale



Interval scale



Ratio scale

Psychophysical scaling

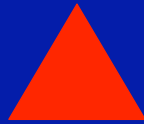
A challenge to obtain ratio data for subjective variables!



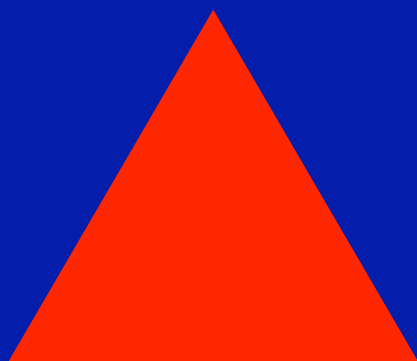
Scaling according to Stevens with magnitude estimation (ME):

Instructions: You will soon see a series of red triangles. Your task is to assign a number to every triangle in such a way that your impression of how large the number is matches your impression of how large the triangle is. Assign a number for the first triangle, you may choose any positive number that you find appropriate. If the next triangle is larger, e.g., twice as big, you choose a number that is two times your first number, if it is smaller, e.g. half as big, your chosen number should be half of the first number....

Magnitude estimation



Magnitude estimation



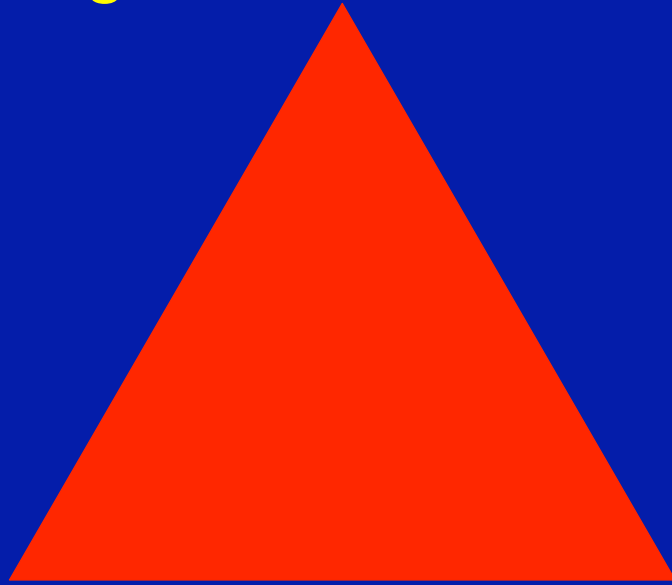
Magnitude estimation



Magnitude estimation



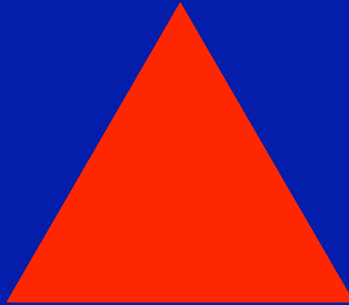
Magnitude estimation



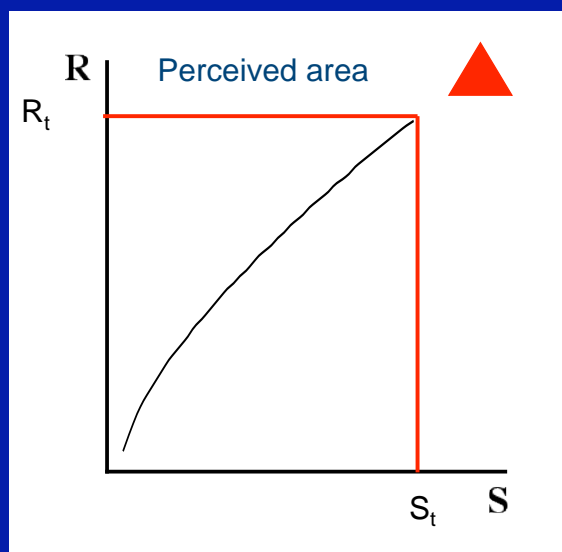
Magnitude estimation



Magnitude estimation



Often not a linear relation!



Often not a linear relation

Picture driving a car at 100 km/h and slowing down to half that speed, 50 km/h.



Often not a linear relation

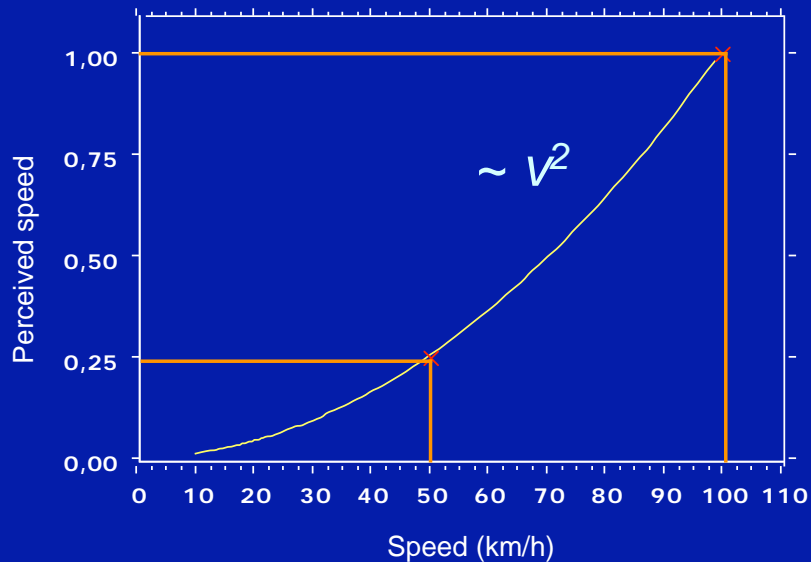
Picture driving a car at 100 km/h and slowing down to half that speed, 50 km/h.



Do you *perceive* the speed to be half?

Or do you perceive it to be more than or less than half?

Perceived speed when driving



Power functions

Stevens: $R = c \times S^n$

G. Borg: $R = a + c (S - b)^n$

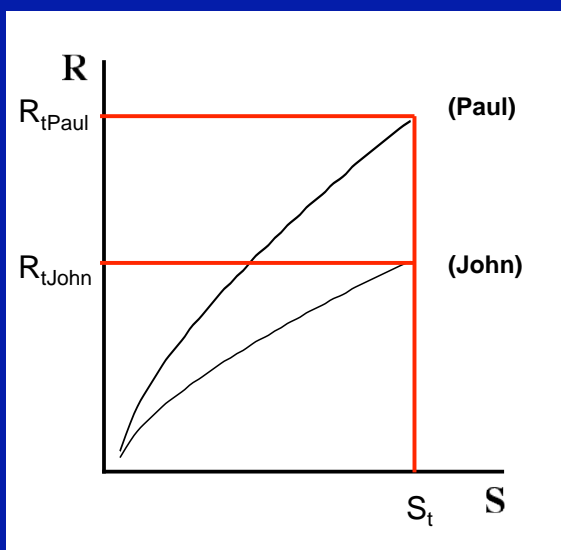
Where a and b describe the starting point of the growth function, e.g. the absolute threshold, and n is the exponent.

Exponents

System	Exponent	Stimulus
Brightness	0.5	Point source
Smell	0.6	Heptane
Loudness	0.6	3000-Hz tone
Taste	0.7	Citric acid
Visual length	1.0	Projected line
Taste	1.3	Succrose
Heaviness	1.4	Lifted weights
Perceived exertion	1.6	Bicycle ergometer
Warmth	1.6	Metal contact on arm
Force of handgrip	1.7-1.8	Hand dynamometer
Electric shock	3.5	Current through fingers

(based on Coren, Ward and Enns, 1994; S. S. Stevens, 1975; G. Borg, 1962; G. Borg, Diamant, Ström, and Zotterman, 1967)

Perceived area



Problem: does this mean that Paul perceives the largest triangle as almost twice as large as John does?

Solution: we ask them "How large was the largest triangle?" Both say "Very large"...

Category scales

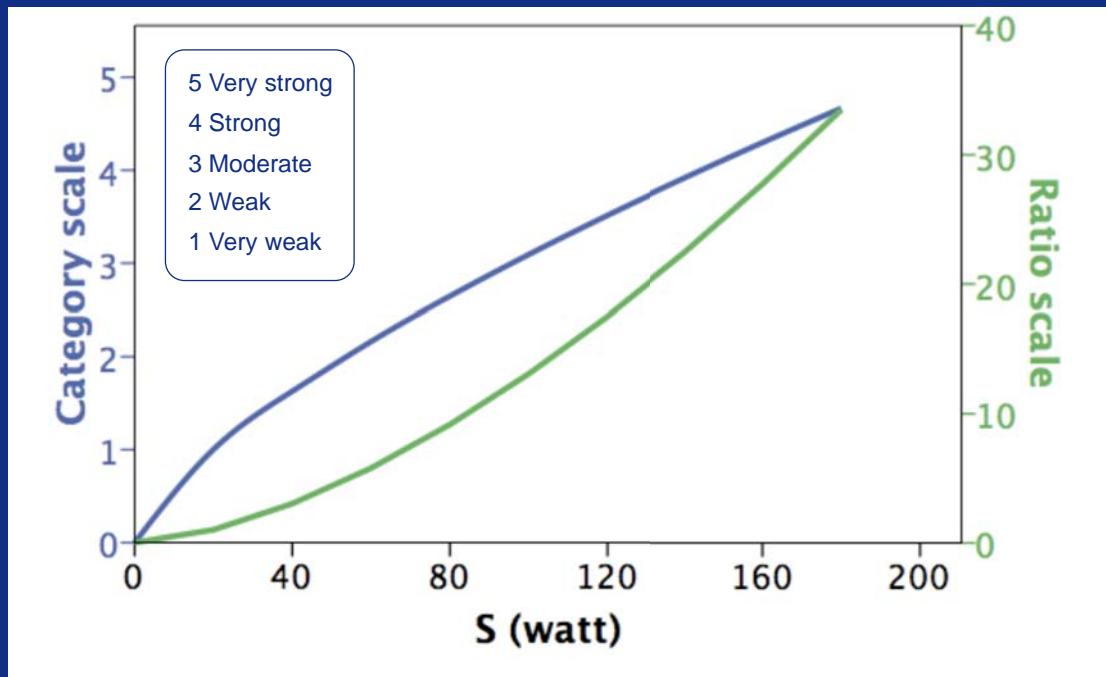
Simple Category scale

Pros?

- | | |
|---|----------------|
| 1 | Nothing at all |
| 2 | Very weak |
| 3 | Weak |
| 4 | Moderate |
| 5 | Strong |
| 6 | Very strong |
| 7 | Maximal |

Cons?

Growth function depends on data level



Angina Scale

- 0 No angina
 - 1 Light, barely noticeable
 - 2 Moderate, bothersome
 - 3 Severe, very uncomfortable
 - 4 Most severe pain ever experienced
-

Dyspnea Scale

- 0 No dyspnea
 - 1 Mild, noticeable
 - 2 Mild, some difficulty
 - 3 Moderate difficulty, but can continue
 - 4 Severe difficulty, cannot continue
-

PVD Scale

- 0 No claudicatio pain
- 1 Initial, minimal pain
- 2 Moderate pain
- 3 Intense pain
- 4 Maximal pain, cannot continue

How to
interpret a
mean of
2.5?

Visual Analogue Scale (VAS)

No pain

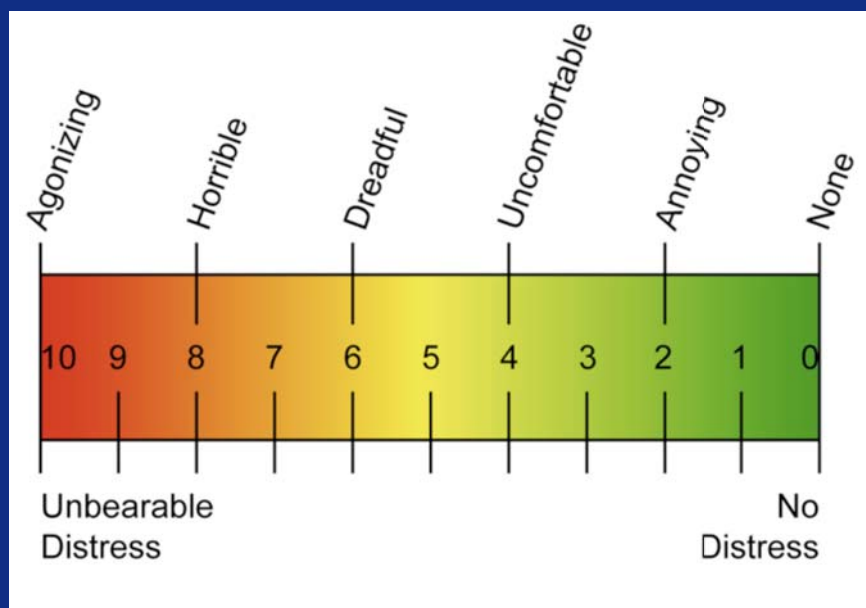
Severe pain



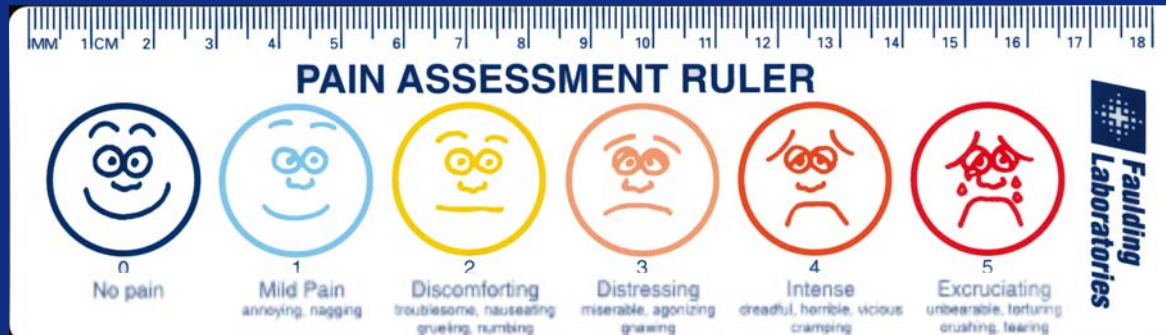
Pros?

Cons?

Any better...???



A paining scale...



Borg RPE Scale®

- 6 No exertion at all
- 7 Extremely light
- 8
- 9 Very light
- 10
- 11 Light
- 12
- 13 Somewhat hard
- 14
- 15 Hard (heavy)
- 16
- 17 Very hard
- 18
- 19 Extremely hard
- 20 Maximal exertion

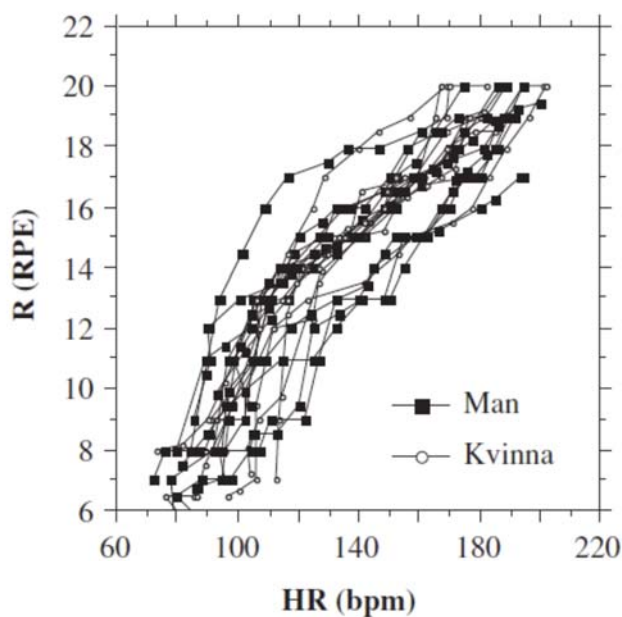
"by plotting the... [used category] scale to workload and HR and then replacing ... some expressions to correspond to a linear growth function"

Borg RPE Scale®

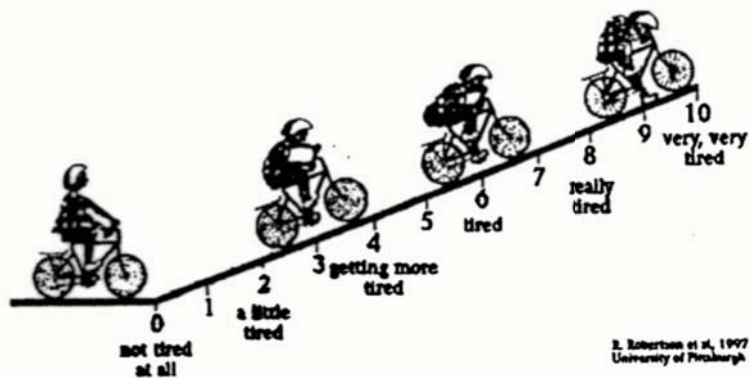
Pros?

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- 16
- 17 Very hard
- 18
- 19 Extremely hard
- 20 Maximal exertion

Cons?



OMNI Perceived Exertion Scale for Children

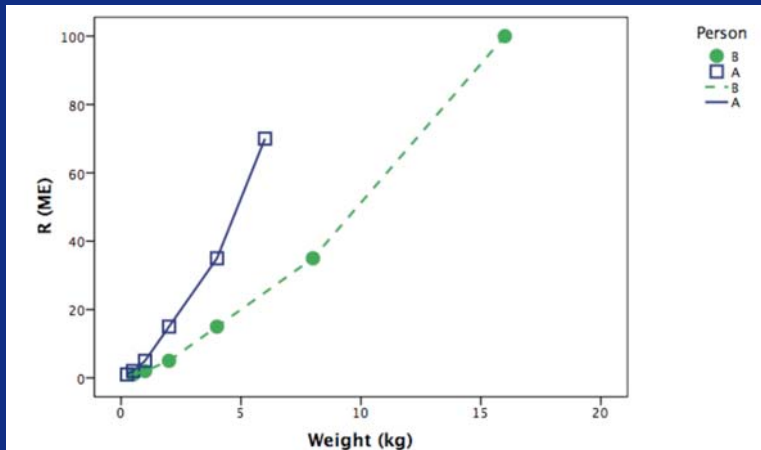


Robertsson et al., 1997

Some foundations for
Borg-scales,
"Level-anchored ratio
scaling"

Some foundations for "Level-anchored ratio scaling"

- Stevens "ratio scaling" and S-R-functions



$$R = c \times S(\text{kg})^{1.4}$$

But how can
we solve the
problem of
interindividual
comparison?

G. Borg & E. Borg, 2001

Some foundations for "Level-anchored ratio scaling"

- Stevens "ratio scaling" and S-R-functions
- The natural size of the subjective dynamic range
- The Range Model
- One specific anchor, a "fixed star"

G. Borg & E. Borg, 2001

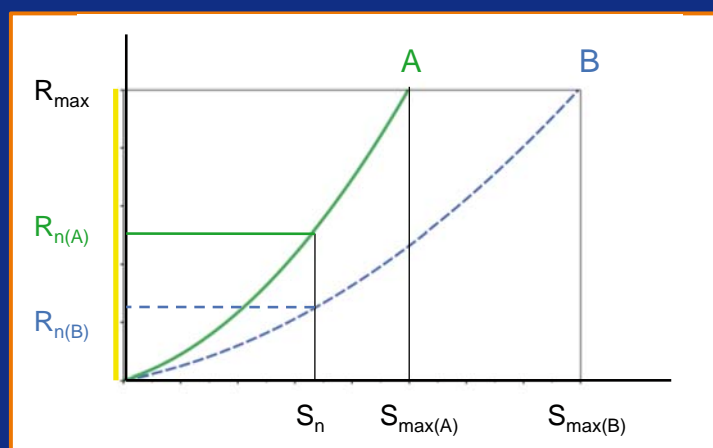
The subjective dynamic range

All biological systems have their natural boundaries from a minimum to a maximum

Our perceptions are adapted to this

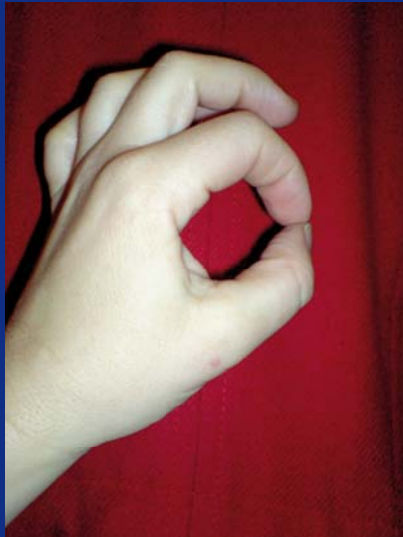
The total subjective range will be perceptually approximately equal across individuals

Borgs' Range Model



*According to the range model, the sensation or experience depends upon its position in the natural, **subjective dynamic range** that, together with a certain peak experience, can be set as interpersonally equal.*

The size of the subjective dynamic range



The number range on the scale needs to be large enough to cover the size of the perceptual range from a minimal to a maximal level

G. Borg & E. Borg, 2001

Perceived exertion as a main anchor - a "Fixed star"



Most people have exercised so hard or so long that they cannot go on any more. Or they may have lifted a burden so heavy they could hardly manage.

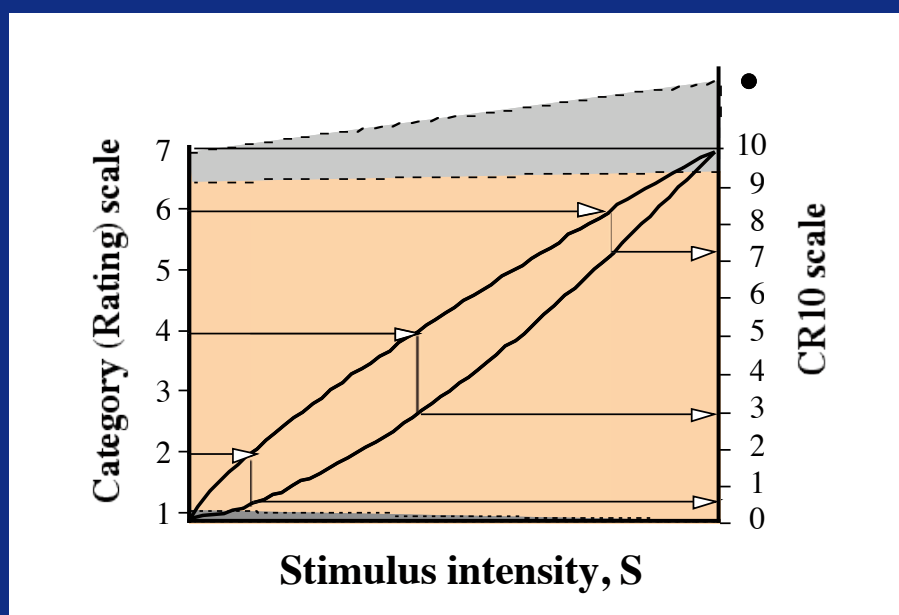
G. Borg, 1992

Some foundations for "Level-anchored ratio scaling"

- Stevens "ratio scaling" and S-R-functions
- The natural size of the subjective dynamic range
- The Range Model
- One specific anchor, a "fixed star"
- Quantitative semantics for other anchors
- Congruence between numbers and anchors

G. Borg & E. Borg, 2001

Constructing a CR scale



G. Borg, 1998

Some foundations for "Level-anchored ratio scaling"

- Stevens "ratio scaling" and S-R-functions
- The natural size of the subjective dynamic range
- The Range Model
- One specific anchor, a "fixed star"
- Quantitative semantics for other anchors
- Congruence between numbers and anchors
- Subjects for scale construction
- Iterative trials (empirically based)
- Avoiding end effects and truncation
- The visual design

G. Borg & E. Borg, 2001

Scale evolution

1973

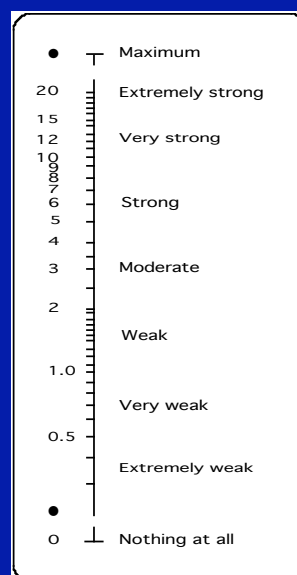
Absolutely no feeling
0 at all of exertion
1
2 Very light
3
4
5
6 Somewhat hard
7
8
9
10 Hard
11
12
13
14 Very hard
15
16
17
18 Very, very hard
19
20 Maximal exertion

1980

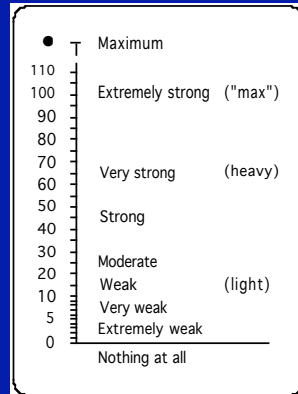
0	Nothing at all	
0.5	Extremely weak	(just noticeable)
1	Very weak	
2	Weak	(light)
3	Moderate	
4		
5	Strong	(heavy)
6		
7	Very	
8		
9		
10	Extremely	(almost max)
	• Maximal	

© Gunnar Borg, 1981, 1982

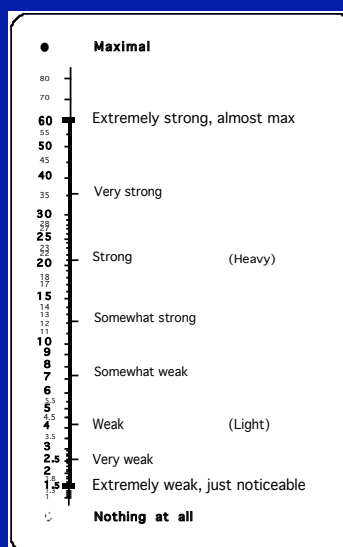
1987



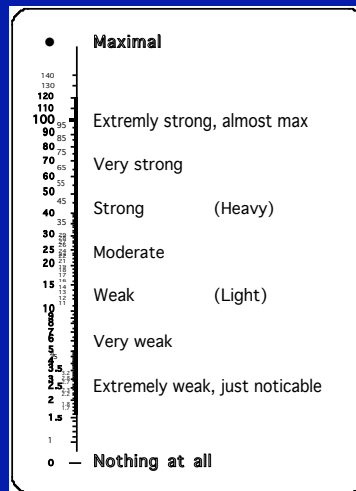
≈1990



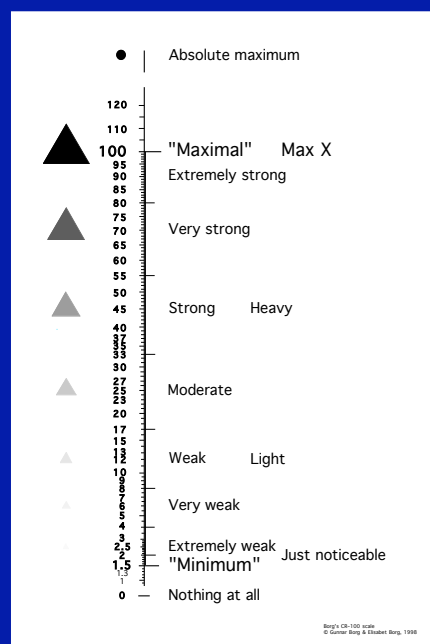
1994



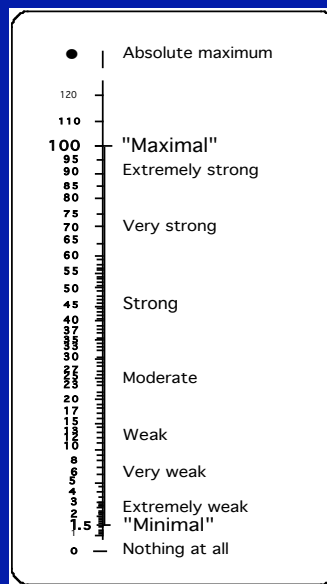
1994



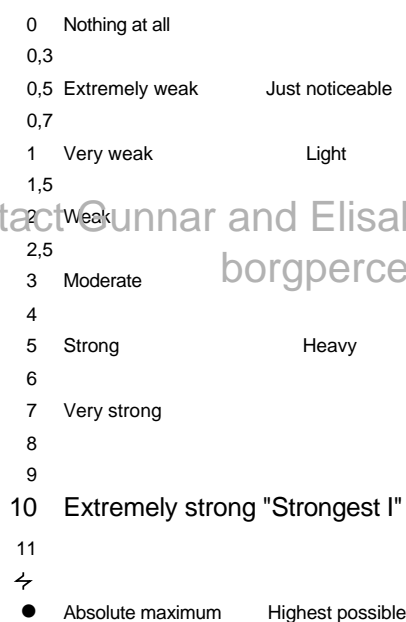
1998



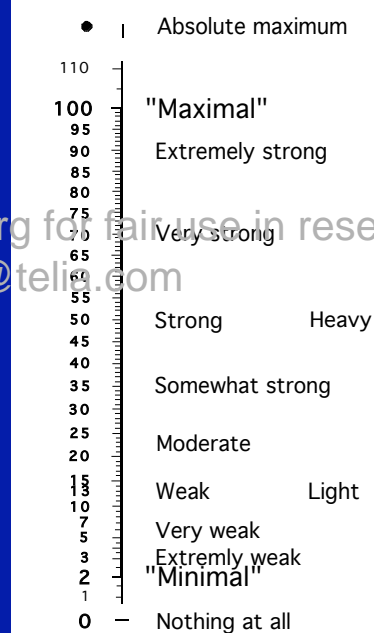
2001



Borg CR10 Scale®



Borg CR100 (centiMax) Scale®



Contact Gunnar and Elisabet Borg for fair use in research:
borgperception@telia.com

Shortness of Breath Modified Borg Dyspnea Scale	
0	Nothing at all
0.5	Very, very slight (just noticeable)
1	Very slight
2	Slight
3	Moderate
4	Somewhat Severe
5	Severe
6	
7	Very Severe
8	
9	Very, very severe (almost maximal)
10	Maximal




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 www.scottcare.com



www.scottcare.com

Échelle de Borg		Borg's Scale	
très très facile	6		very, very light
	7		
très facile	8		very light
	9		
assez facile	10		fairly light
	11		
un peu difficile	12		somewhat hard
	13		
difficile	14		hard
	15		
	16		very hard
très difficile	17		
	18		
	19		
très très difficile	20		very, very hard

Trojan & Finch, 1997

Does it work?

Squeeze "strong":



Transformation

Table 1. Approximate transformation table for ratings according to the Borg RPE Scale®, the Borg CR10 Scale® and the Borg CR100 (centiMax) Scale®.

RPE	CR10	CR100	RPE	CR10	CR100
6	0	0	14.5	5	50
7	0.3	2	15	5.5	55
8	0.5	3	15.5	6	60
8.5	0.7	4.5	16	6.5	65
9	1.0	6	16.5	7	70
10	1.5	9	17	7.5	75
11	2	12	17.5	8	80
11.5	2.5	17	18	9	90
12	3	23	19	10	100
13	3.5	30	19.5	11	110
13.5	4	35	20	12	120
14	4.5	42			

The Borg CR Scales® folder

Some applications

Some applications

Clinical diagnostics

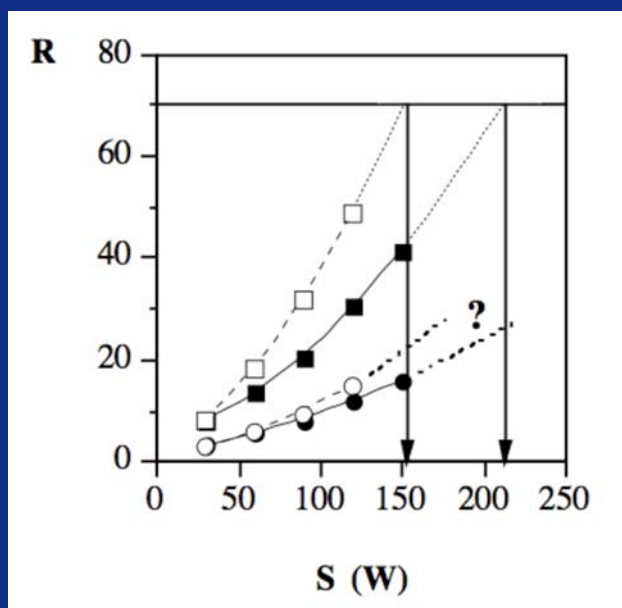


Perceived exertion
Breathlessness
Breathing difficulties (Dyspnea)
Aches and Pain
Feeling sick
Eating disturbances (Anorexia)
Emotions and moods

Rehabilitation

Cardiac
Musculoskeletal

Predict working capacity



Prediction based on HR:

W_{150} Men 176 W

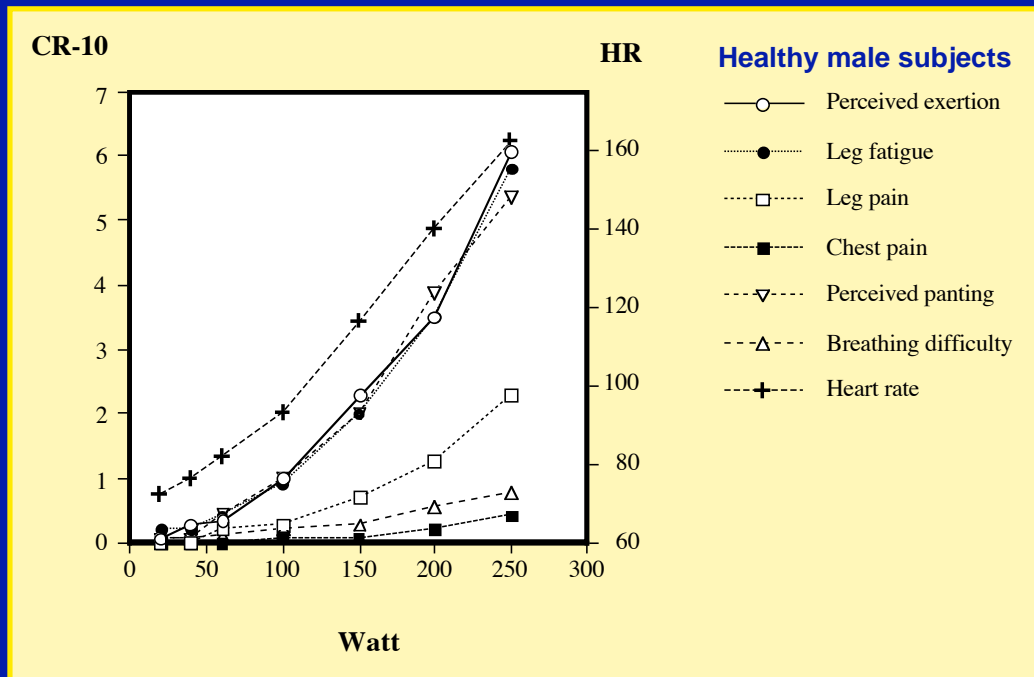
W_{150} Women 133 W

Prediction based on CR100:

W_{R50} Men 168 W

W_{R50} Women 136 W

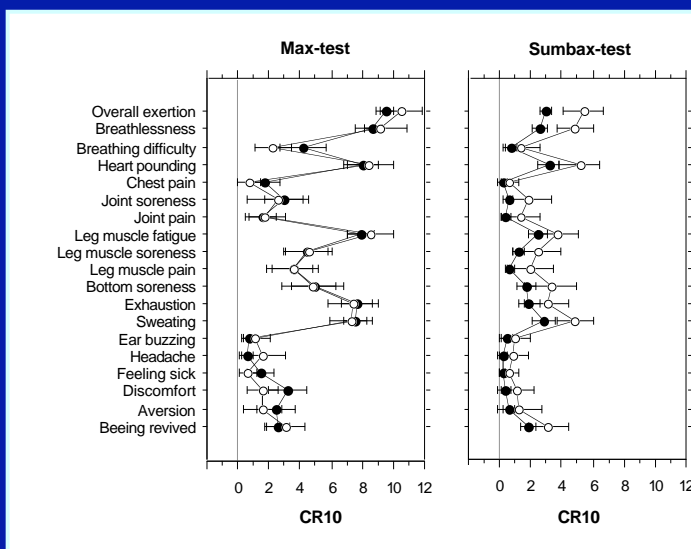
Symptoms



Borg, Karlsson & Lidbland, 1976

Symptoms profiles

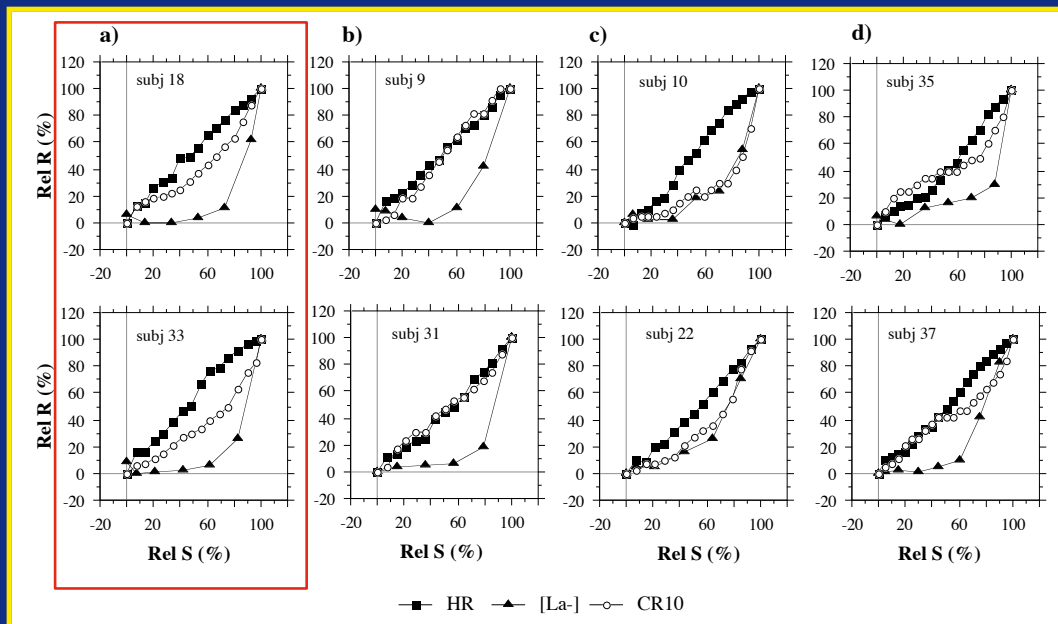
Symptoms (95% CI)



Significant differences between men and women at submax for
Oe; B, Hp; Js; Lmf;
Lmp; Bs; S; Br

E. Borg (2007)

Perceived exertion



E. Borg (2007)

Symptom indices

Group	$ERI_{b/l} \text{ CR10}$	$ERI_{b/l} \text{ CR100}$
Weak Males	0.71 (0.27)	0.70 (0.32)
Strong Males	0.82 (0.24)	0.80 (0.23)
Weak Women	0.74 (0.33)	0.69 (0.36)
Strong Women	0.80 (0.31)	0.82 (0.33)
All	0.77 (0.28)	0.75 (0.30)

E. Borg et al (2009)

Some applications

Ergonomics and Human Factors

Physical strain
Mental load
User interface
Risk assessments

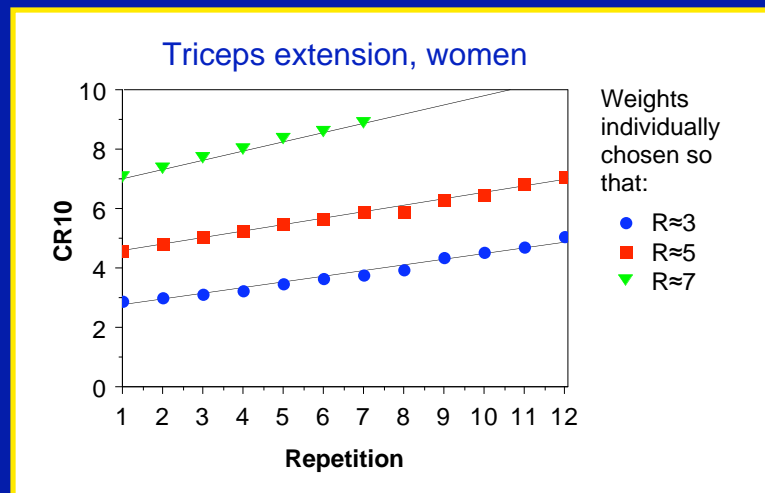
Epidemiology

Sports

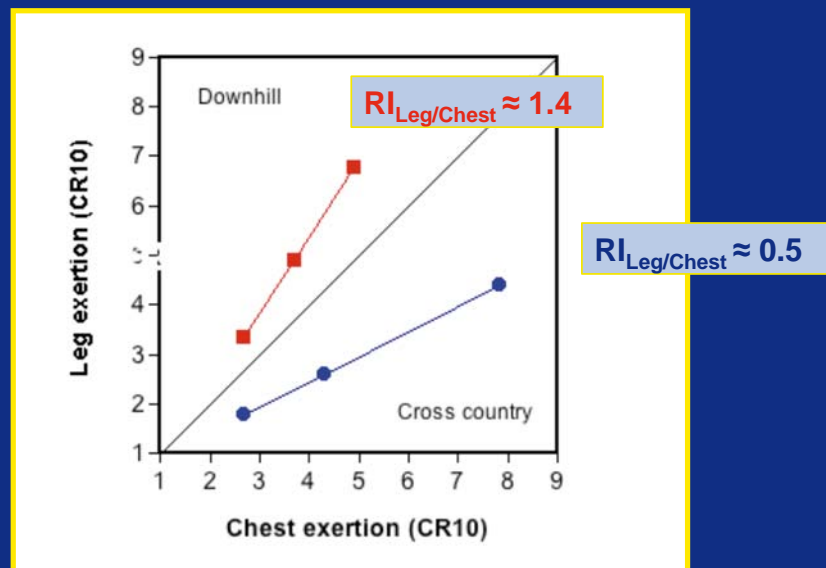
Training athletes
"Sports for all"

Resistance training

0	Nothing at all	
0,3		
0,5	Extremely weak	Just noticeable
0,7		
1	Very weak	Light
1,5		
2	Weak	
2,5		
3	Moderate	
4		
5	Strong	Heavy
6		
7	Very strong	
8		
9		
10	Extremely strong "Strongest I"	
11		
↔		
●	Absolute maximum	Highest possible

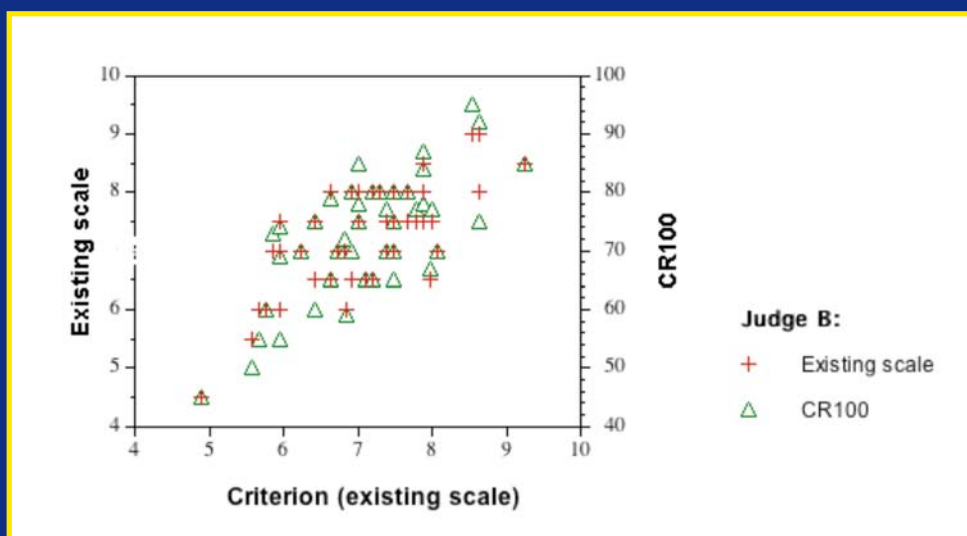


Skiing



Ceci, et al. (1986), E. Borg et al. (2009)

Diving



G. Borg, et al (unpublished data)

Some applications

Activities of daily life

Food quality

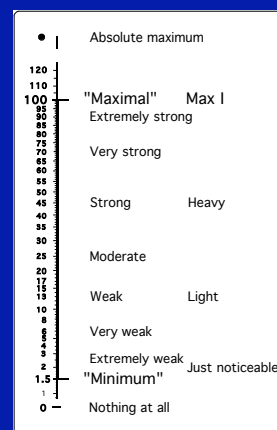
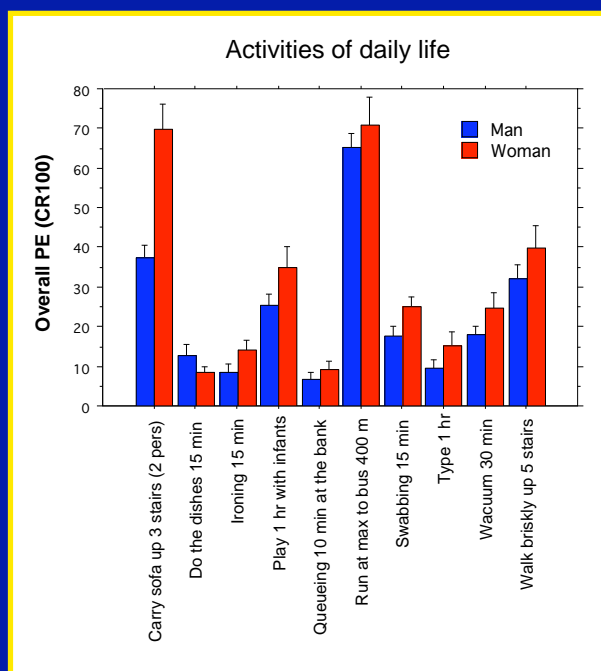
Age differences in taste

Wine tasting

Sleepiness

Emotions

Activities of daily life



Conclusion

"Borg-scales" – *Why are they so good?*

Ratio data – to study relations

Level estimations – to study "meaning"

Interindividual comparisons

Interprocess comparisons

Thank you!

And special thanks to
Gunnar Borg,
Colleagues and students
at the SU, and KI

And many thanks to
CeBiSM for inviting me!

