## Psychophysical Scaling

#### Fechner's Law (Fechner, 1860)

R = unit of stimulus measurement (Reiz)

S = unit of subjective measurement

K, k, C and c are constants

(1) 
$$\frac{\partial R}{R} = K$$
 (for and at the JND)

E. H. Weber's Law

(2) 
$$\partial S = c \cdot \frac{\partial R}{R}$$

**Fundamental formel** 

Integrate to get the magnitude of S (sensation)

$$(3) S = c \cdot \ln R + C$$

At threshold, S = 0, R = r, therefore:  $0 = c \cdot \ln r + C$  or  $C = -c \cdot \ln r$ Substituting this relationship into (3):

$$S = c \cdot \ln R - c \cdot \ln r$$
 or  $S = c \cdot (\ln R - \ln r)$  or

$$(4) S = c \cdot \ln \left( \frac{R}{r} \right)$$

Converting Equation 4 from natural logarithms to base 10 logarithms

$$(5) S = k \cdot \log \left(\frac{R}{r}\right)$$

**Massformel** 

Making r (the threshold stimulus value) the unit of R, we have:

$$(6) S = k \cdot \log R$$

Fechner's Law

Conditions for the validity of Fechner's Law:

- 1. Unit of R is r (threshold value)
- 2. Integration of Equation 2 is valid
- 3. Valid to assume that S = 0 at R = r
- 4. That Weber's Law is valid

### Major Criticisms

- 1. All JNDs do not give rise to equal sensation magnitudes
- 2. Sensations don't only have magnitude, but also quality (e.g., color, pitch)

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### Stevens' Law (Stevens, 1936)

20 JND's above auditory threshold do not sound twice as loud as 10 JND's above threshold.

Prothetic Continua

$$S = k \cdot R^{n}$$
$$S = k \cdot (R - r)^{n}$$

$$\log S = \log k + n \cdot \log R$$

Stevens' Law

Metathetic Continua

$$S = k \cdot \log R$$

Fechner's Law

# General Psychophysical Law (Norwich & Wong, 1997)

Both Fechner's Law and Stevens' Law can be viewed as special cases of a more general law based on information processing principles.

$$S = \frac{1}{2} \cdot k \cdot \ln(1 + \gamma \cdot R^n)$$

Complete Form

Note that when  $\gamma \cdot R^n >> 1$  the complete form becomes

$$S = \frac{1}{2} \cdot k \cdot n \cdot \ln R + \frac{1}{2} \cdot k \cdot \ln \gamma$$

Equivalent to Fechner's Law

which is really Fechner's Law since  $\frac{1}{2}kn$  and  $\frac{1}{2}k\ln\gamma$  are constants. The Taylor series expansion of the complete form has a first-order term of

$$S = \frac{1}{2} \cdot k \cdot \gamma \cdot R^n$$

Equivalent to Stevens' Law

#### References

Fechner, G. T. (1860). Elemente der Psychophysik. Leipzig, Germany: Breitkopf and Härtel.

Norwich, K. H., & Wong, W. (1997). Unification of psychophysical phenomena: The complete form of Fechner's law. *Perception & Psychophysics*, *59*(6), 929–940.

Stevens, S. S. (1936). A scale for the measurement of a psychological magnitude: loudness. *Psychological Review*, *43*, 405–416.