# Part 2: Psychophysics

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# Outline of part 2

- **Introduction: what is psychophysics**
- **Laws of psychophysics**
- **Logarithms and other functions – quantitative relations between stimulus and response**
- **Weber - Fechner logarithmic law**
- **Stevens's law enables comparison between modalities**

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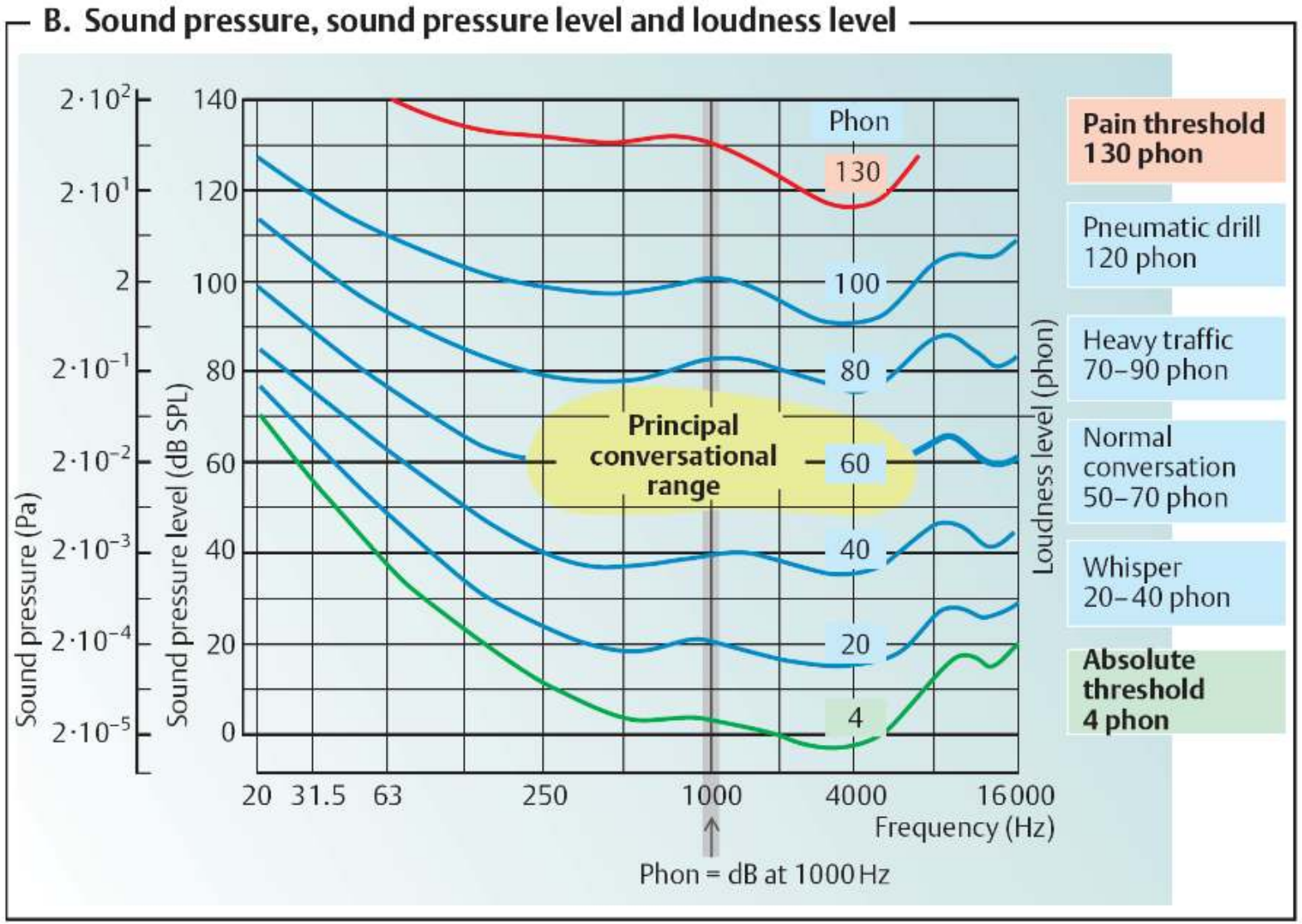



Despopoulos, Color Atlas of Physiology © 2003 Thieme

**Let us remind the hearing range again**

**Logarithms.** There are two kinds of logarithms: common and natural. Logarithmic calculations are performed using exponents alone. The **common** (**decimal**) **logarithm** (log or lg) is the power or exponent to which 10 must be raised to equal the number in question. The common logarithm of 100 (log 100) is 2, for example, because $10^2 = 100$. Decimal logarithms are commonly used in physiology, e.g., to define pH values (see above) and to plot the pressure of sound on a decibel scale (→ p. 363).

**Natural logarithms** (ln) have a natural base of 2.71828..., also called *base e*. The common logarithm (log x) equals the natural logarithm of x (ln x) divided by the natural logarithm of 10 (ln 10), where ln 10 = 2.302585. The following rules apply when converting between natural and common logarithms:

$\log x = (\ln x)/2.3$

$\ln x = 2.3 \cdot \log x.$

When performing mathematical operations with logarithms, the type of operation is reduced by one rank—multiplication becomes addition, potentiation becomes multiplication, and so on.

*Examples:*

$\log (a \cdot b) = \log a + \log b$

$\log (a/b) = \log a - \log b$

$\log a^n = n \cdot \log a$

$\log \sqrt[n]{a} = (\log a)/n$

*Special cases:*

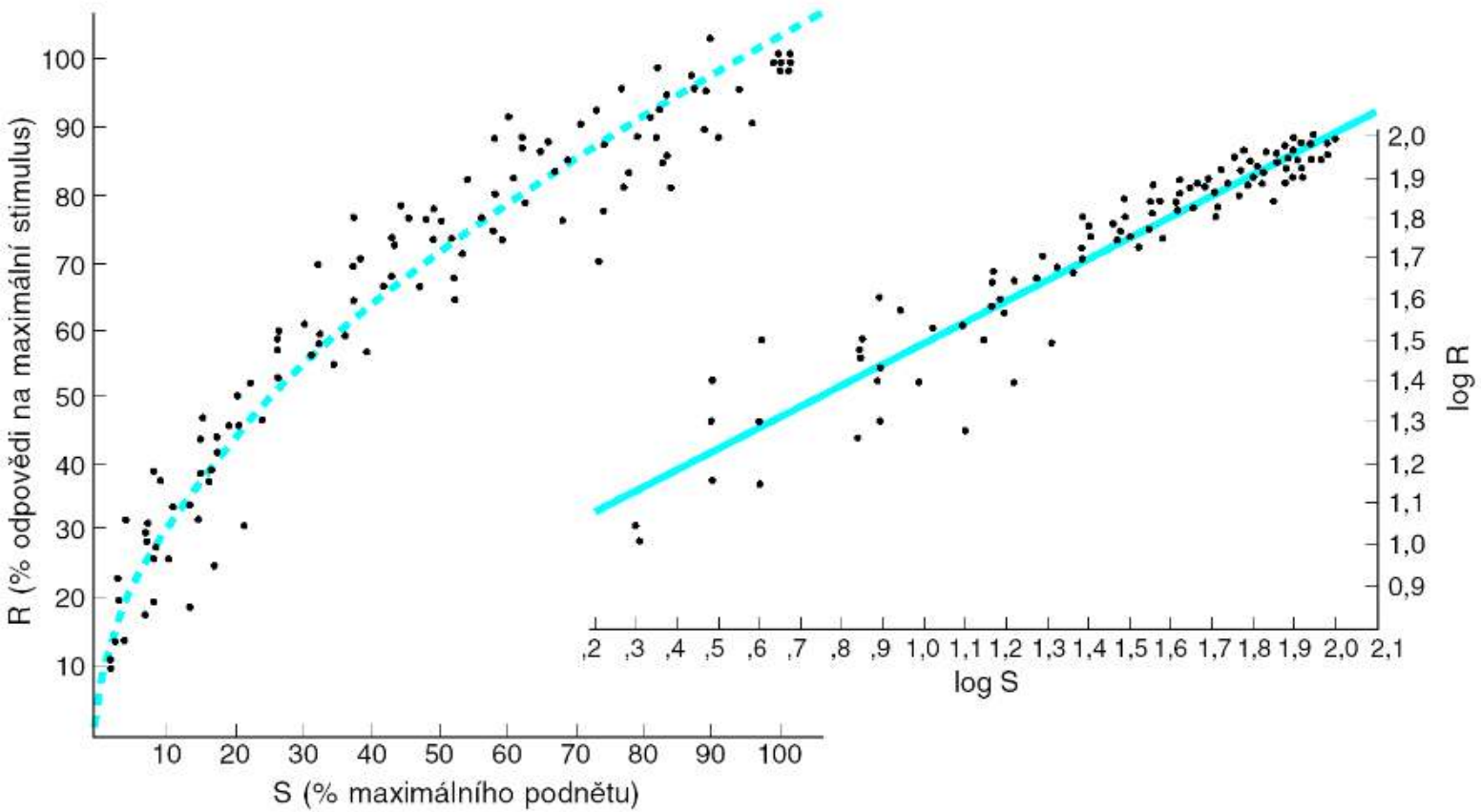
$\log 10 = \ln e = 1$

$\log 1 = \ln 1 = 0$

$\log 0 = \ln 0 = \pm \infty$

Decibel is defined as ten times decimal logarithm of the ration of intensities.

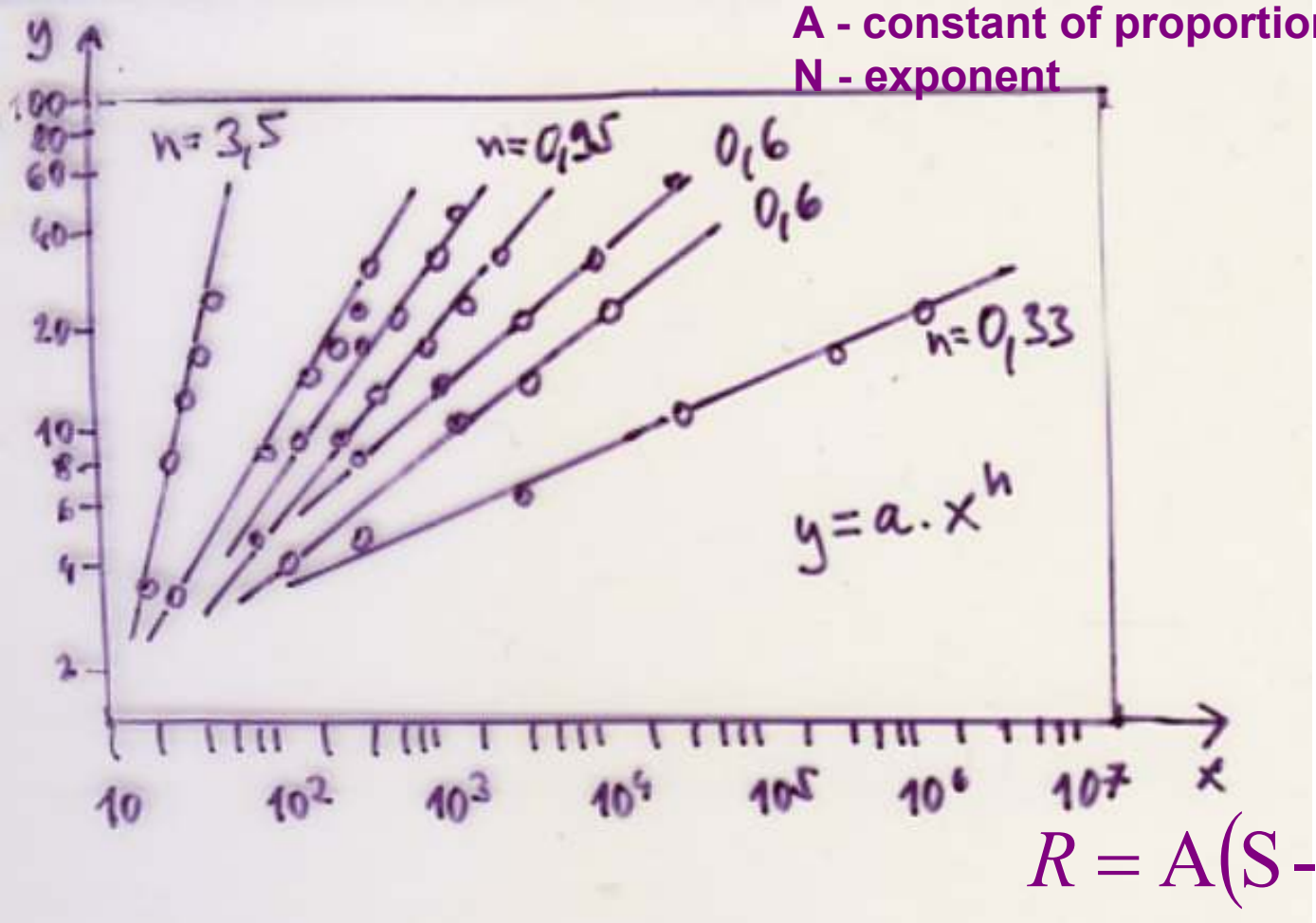
$$R = 10 \log\left(S / S_0\right)$$




**Obr. 5-5.** Vztah mezi intenzitou dotykového podnětu (S) a frekvencí akčních potenciálů v senzorických nervových vláknech (R). Tečky znázorňují jednotlivé hodnoty u koček; jsou vyneseny do souřadnic lineárních **(vlevo)** a logaritmických **(vpravo)**. Rovnice vyjadřuje vypočítaný exponenciální vztah mezi R a S. (Reprodukováno se souhlasem z WERNER, G., MOUNTCASTLE, VB. *Neural activity in mechanoreceptive cutaneous afferents. Stimulus-response relations, Weber functions, and information transmission*. J Neurophysiol, 1965, 28, 359.)

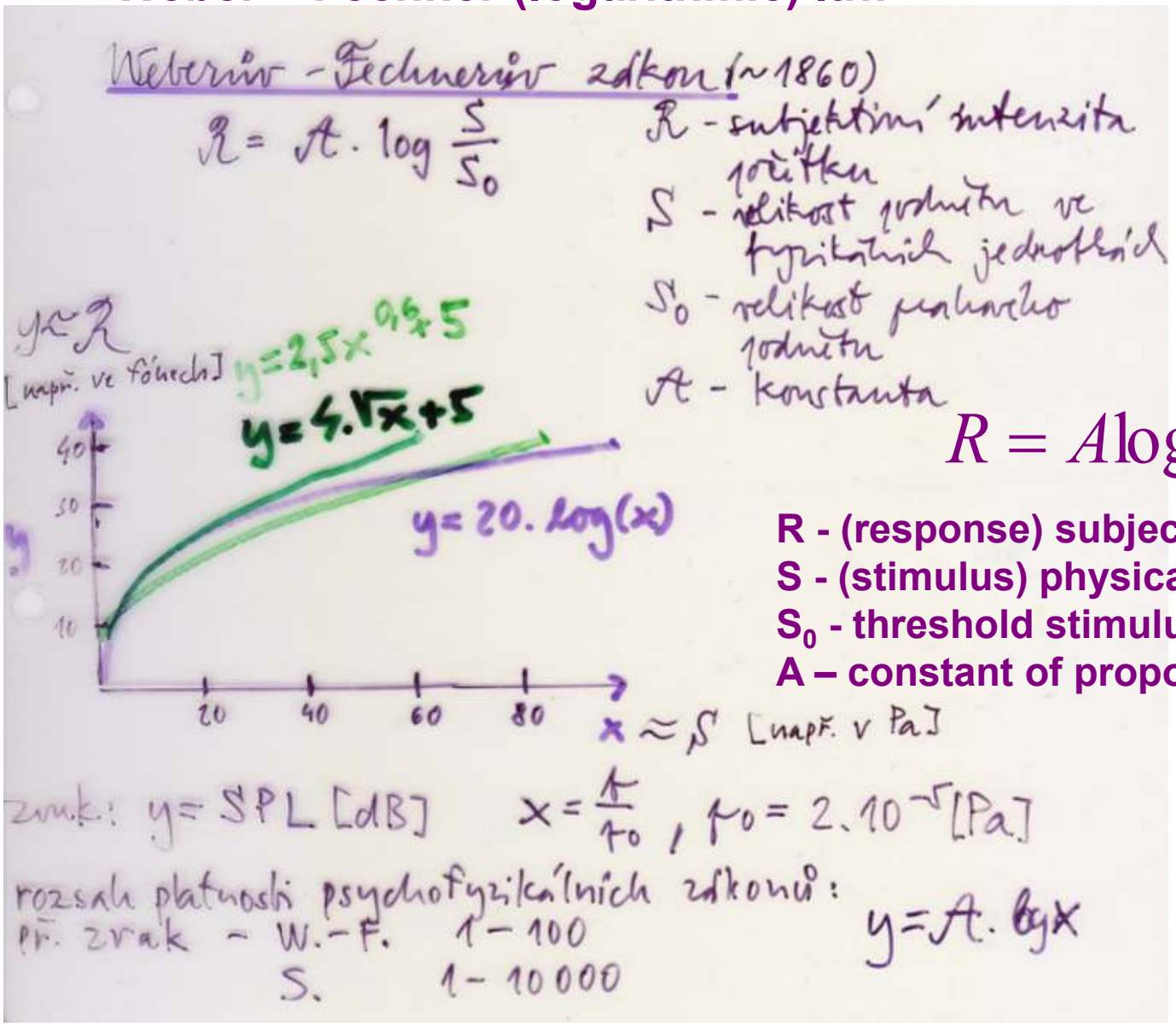
## Stevens (power) law

R - (response) subjective intensity
S - (stimulus) physical intensity
$S_0$ - threshold stimulus intensity
A - constant of proportion
N - exponent




$$R = \mathrm{A}\left(\mathrm{S} - \mathrm{S}_0\right)^N$$

# Weber – Fechner (logarithmic) law




$$R = A\log\left(S / S_0\right)$$

**R - (response) subjective intensity**
**S - (stimulus) physical intensity**
**$S_0$ - threshold stimulus intensity**
**A – constant of proportion**

## Exponents in the Stevens (power) law

$$R = A(S - S_0)^N$$

**Table 18-1.** Representative exponents of power functions relating psychophysical magnitude to stimulus magnitude on prothetic continua*

| Continuum | Exponent | Stimulus conditions |
|---|---|---|
| Loudness | 0.60 | Binaural |
| Loudness | 0.54 | Monaural |
| Brightness | 0.33 | 5° target—dark-adapted eye |
| Brightness | 0.50 | Point source—dark-adapted eye |
| Lightness | 1.20 | Reflectance of gray papers |
| Smell | 0.55 | Coffee odor |
| Smell | 0.60 | Heptane |
| Taste | 0.80 | Saccharine |
| Taste | 1.30 | Sucrose |
| Taste | 1.30 | Salt |
| Temperature | 1.00 | Cold—on arm |
| Temperature | 1.60 | Warmth—on arm |
| Vibration | 0.95 | 60 Hz—on finger |
| Vibration | 0.60 | 250 Hz—on finger |
| Duration | 1.10 | White-noise stimulus |
| Repetition rate | 1.00 | Light, sound, touch, and shocks |
| Finger span | 1.30 | Thickness of wood blocks |
| Pressure on palm | 1.10 | Static force on skin |
| Heaviness | 1.45 | Lifted weights |
| Force of hand-grip | 1.70 | Precision hand dynamometer |
| Autophonic level | 1.10 | Sound pressure of vocalization |
| Electric shock | 3.50 | 60 Hz, through fingers |

*From Stevens.[37a]