**THE (WEBER'S) LAW THAT NEVER WAS**

Sergio Cesare Masin
*University of Padua, Italy*
*scm@unipd.it*

**Abstract**

*In the literature, attempts have been made to defend Weber's law against the empirical evidence that contradicts it. This paper briefly reviews these defenses and this evidence.*

The present study offers a framework for the history of Weber's law and scientific thinking. Since Fechner's time, a large body of evidence has accumulated which indicates that Weber's law is not truly a law. This notwithstanding, many still consider Weber's law a true law.

Weber's law is defined as follows. Given a perceived magnitude $\psi$ occasioned by a stimulus magnitude $\phi$, let $\Delta\psi$ be the smallest noticeable increment of $\psi$ and let $\Delta\phi$ be the corresponding increment of $\phi$. The supposed empirical finding made by Weber (1834) that $\Delta\psi$ remains constant when the relative stimulus increment $\Delta\phi/\phi$ remains constant was called *Weber's law* by Fechner (1860, v. 1, p. 65). The subsequent literature expressed this law as

$$\frac{\Delta\phi}{\phi} = c \tag{1}$$

with $c$ a constant (Gescheider, 1997, p. 3). The ratio $\Delta\phi/\phi$ is called *Weber's ratio* (or *fraction*) and the curve relating this ratio to $\phi$ is called the *Weber function* (Boring, 1942).

Should Weber's law hold, in a Cartesian diagram the Weber function would be a flat line parallel to the horizontal axis. Holway and Pratt (1936) reviewed Weber functions obtained since the 1860s. All reviewed functions were hyperbolic- or U-like in shape. Figures 1 and 2 represent a bestiary of empirical Weber functions similar to that of Holway and Pratt.

Figure 1: (a) visual length (Kiesow, 1926); (b) tactual length (filled circles: Danesino, 1932) or extent between two points on forearm (open circles: Ricci, 1937); (c) size between thumb and forefinger (Gaydos, 1958); (d) duration (Treisman, 1963); (e) pressure on the wrist caused by a hair stimulating a single Meissner's corpuscle (open circles: Gatti, 1923; filled circles: Gatti and Dodge, 1929); (f) pressure on one finger caused by a load with width of contact area of 4 (open circles: Stratton, 1896) or 6 mm (filled circles: Kobylecki, 1906); (g) heaviness (Oberlin, 1936); (h) pain produced by thermal radiation of forehead (Hardy, Wolff, & Goodell, 1947); (i) warmth felt in fingers immersed in water (Abbott, 1914).

Figure 2: (a) flavor of salt (Holway & Hurvich, 1937); (b) smell of India rubber (Zigler & Holway, 1935); (c) loudness at 4 kHz (Riez, 1928); (d) loudness at 800 Hz (Upton, 1936); (e) pitch at 5 (open circles) or 40 dB (filled circles) (Shower & Biddulph, 1931); (f) pitch (Vance, 1914); (g) saturation of red (Panek & Stevens, 1966); (h) brightness—data by Aubert, Blanchard, and König and Brodhun graphed by Hecht (1924); (i) brightness of continuous (open circles) or pulsed flashes (filled circles) (Leshowitz, Taub, & Raab, 1968).

Despite this evidence, Berelson and Steiner (1967, p. 146) said that "Weber's law holds for all the senses, and for almost all intensities," Link (1992, p. 193) said that "Weber's law is easily confirmed by experimental techniques applied to all sense modalities," and Drösler (1995) said that "Weber's ratio is the earliest psychophysical invariant in history."

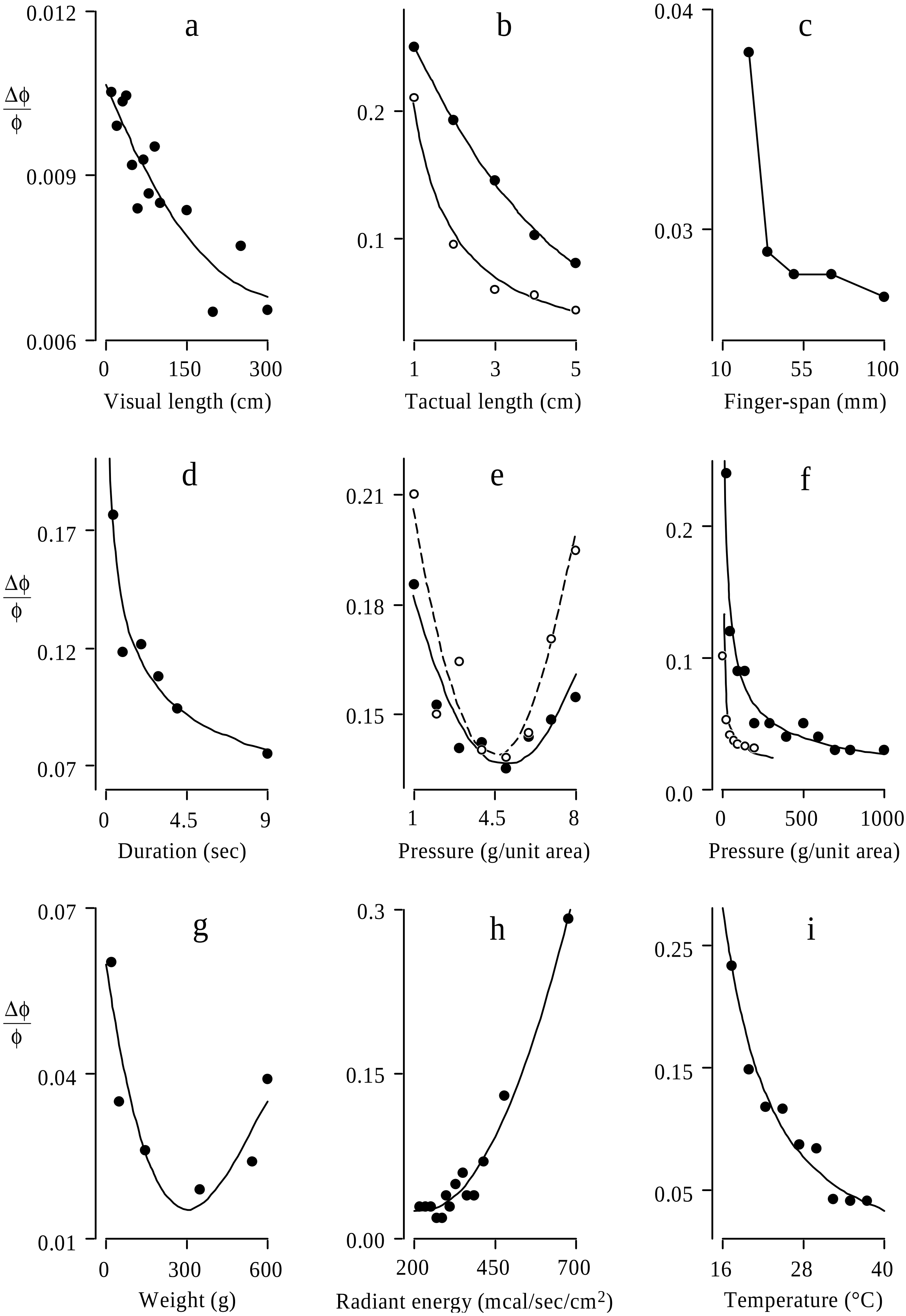


Fig. 1. Weber ratio, $\Delta\phi/\phi$, plotted against the stimulus value, $\phi$, for various continua (see text).

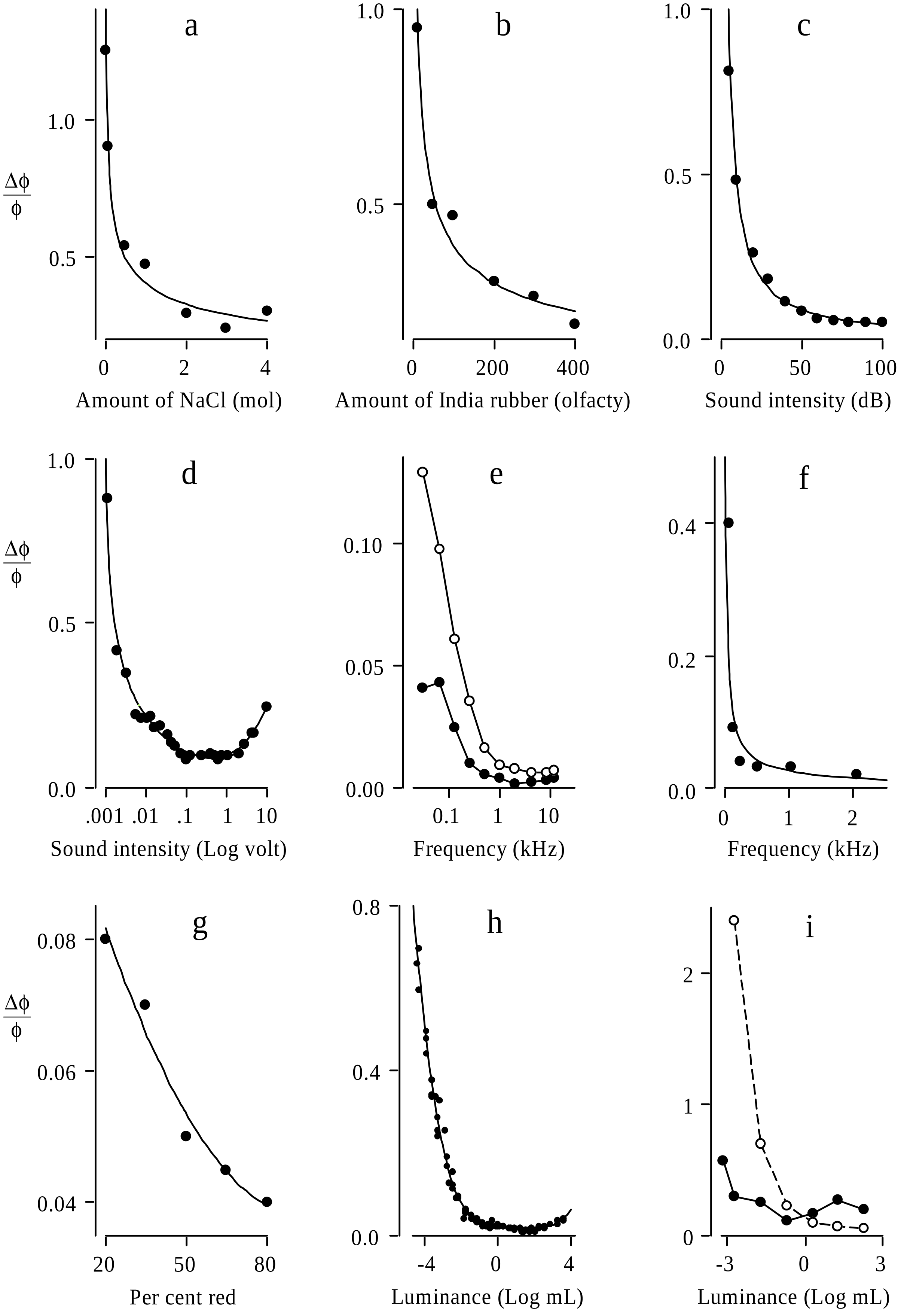


Fig. 2. Weber ratio, Δϕ/ϕ, plotted against the stimulus value, ϕ, for various continua (see text).

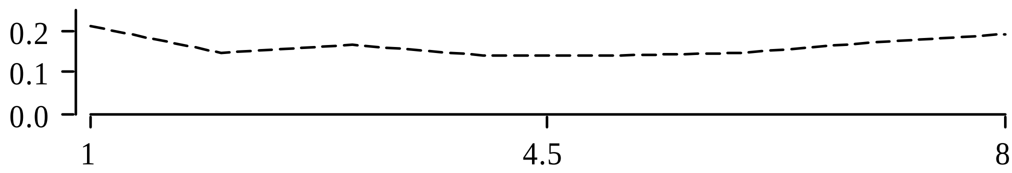


Fig. 3. The results shown by open circles in Figure 1e when represented as in Gatti (1923).

If the methods for determining $\Delta\psi$ work correctly, each Weber function in Figures 1 and 2 shows that Weber's law is not a true law. Among those that appear to think that these methods correctly determine $\Delta\psi$, some defend Weber's law against the data in Figures 1 and 2. The following are examples of defenses.

(A) Verbal fallacy. Stratton (1896) said that he verified Weber's law since the Weber ratios he obtained were approximately invariant between 75 and 200 g (open circles in Figure 1f). Kiesow (1923) noted that "approximate" refers to values clustering near a constant value while Stratton's data show instead a constant declining trend. Stratton's verbal fallacy is often repeated today for loudness (Figures 2d), pitch (Figure 2e), and brightness (Figure 2h).

(B) Visual disguise. Gatti (1923) represented the results shown by open circles in Figure 1e using a diagram stretched horizontally as in Figure 3. Visually, this stretched diagram suggests a constant Weber ratio. Gatti (1923) concluded that "Weber's law is verified in a very precise manner." He was mistaken. He reported mean individual Weber ratios for four blocks of trials for each stimulus value with no statistical test. A one-way analysis of variance on these ratios shows that the effect of stimulus value and the quadratic trend were significant [$F(7,21) = 24.7$, $p < .0005$, and $F(1,3) = 132.1$, $p < .005$, respectively].

(C) Mathematical disguise. Guilford (1932) proposed the law

$$\Delta\phi = k \cdot \phi^n \qquad (2)$$

with $k$ and $n$ constants. Weber's law holds if $n = 1$. McGill & Goldberg (1968) noted that $n$ is 0.9 when one uses Equation 2 to represent data as those in Figures 2c and 2d, calling this the near-miss to Weber's law. Focusing on $n$ surreptitiously suggests that, although "Weber's law does not hold in a strict sense," it holds almost perfectly. Thus, Augustine and Roscher (2008) said that "the term 'near-miss to Weber's law' refers to *small* but systematic deviations from Weber's classical law" (emphasis added). In Figures 2c and 2d these "deviations" look *large*.

(D) Inversion of evidence. Krueger (1989) stated that "The Weber [ratio] typically decreases as [$\phi$] increases." Laming (1989) said that Krueger was wrong since "Weber's law has been shown to describe discriminative sensitivity…by…Gatti & Dodge (1929), Gaydos (1958)…Oberlin (1936), Panek & Stevens (1966), Treisman (1963)…" The data obtained by these mentioned authors are reported in Figures 1e, 1c, 1g, 2g, and 1d, respectively.

(E) Conclusion from a special case. In Figure 2i the results shown by open circles replicate those in Figure 2h, and those shown by filled circles were obtained using pulsed flashes. According to Laming (1997, p. 33) these filled circles "cluster with acceptable accuracy around [a horizontal] straight line [that] represents Weber's law." Letting aside "acceptable accuracy," one positive case against many negative cases cannot validate any law.

(F) Collateral damage. Krueger (1989) proposed abandoning Weber's law. For Teghsoonian and Teghsoonian (1989) this is a mistake. Noting that the Weber ratio could be an index of discriminability characterizing perceptual continua, they warned investigators to be aware that rejecting Weber's law involves the rejection of the collateral plausible principle that there is a correlation between exponents of perceptual continua and Weber ratios.

(G) Psychophysical speculation. Ekman (1959) proposed the law

$$\frac{\Delta\psi}{\psi} = k \qquad (3)$$

with *k* a constant. He said that this equation "means that Weber's law is valid in the *subjective* continuum." However, one can test Ekman's law if one knows the psychophysical function, which nobody knows for sure yet. Gescheider (1997, p. 353) stated that "Stevens' power law implies that both Ekman's law and Weber's law are valid."

Surprisingly enough, all the above defenses and statements in favor of Weber's law have ignored that the form of the Weber function varies with the definition of the scale of $\phi$ and that this difficulty is particularly more severe when the Weber function also varies with the individual subjects (Householder & Young, 1940).

The above brief and incomplete review of defenses of Weber's law shows that the factors that have and still are making scientists defend Weber's law are multiple and interrelated. Probably the most important factor was suggested by Cobb (1932): "Doubtless it is rank heresy to raise the question whether the publication of Fechner's *Elemente der Psychophysik*…has been a net gain or a net loss to the cause of science. Possibly without it…Weber's law would have remained unknown to the present day."

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