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Functional measurement in physics

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Polemically, Iverson and Luce (1998) have said:

> Anderson…has provided detailed and comprehensive summaries, along with numerous applications to a wide range of psychological phenomena – including psychophysical, personality, and utility judgments – of a method that he and others using the same approach call *functional measurement*, presumably with the ambiguity intentional (p. 49).

The supposed ambiguity alludes that functional measurement is inadequate. However, functional measurement can yield measurement scales equivalent to those of physics (Anderson, 1981, pp. 361-362). The following evidence illustrates and confirms this statement.

Consider the minimum force necessary to slide a parallelepiped placed on a horizontal surface. This force is

$$F = C \cdot W \qquad (1)$$

with C the friction coefficient and W the parallelepiped weight. Equation 1 implies that the curves relating F to W for each C constitute a fan of straight lines. Customarily, this implication is tested by plotting the physical measure of F against that of W for each C.

Corneli and Vicovaro (2007) measured F with a dynamometer, and W with a balance, for a rough and a smooth horizontal surface. Figure 1 shows the curves relating the physical measure of F to that of W for each surface. The curves form a fan of straight lines. Hence, Equation 1 is confirmed.

However, one of the physical measures of F or W was redundant since each provided information already provided by the other. Measuring only F would have been sufficient for the test.

If one measures F with a dynamometer without measuring W, Equation 1 can be tested when the following premises are met:

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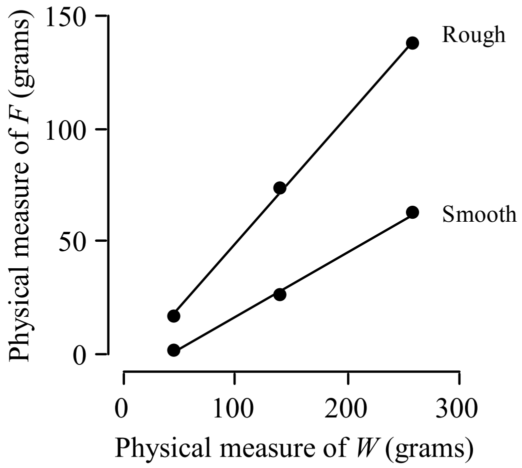

Figure 1. Physical measure of static frictional force, *F*, plotted against the physical measure of the weight, *W*, of a parallelepiped placed on a rough or a smooth horizontal surface. (After Corneli & Vicovaro, 2007)

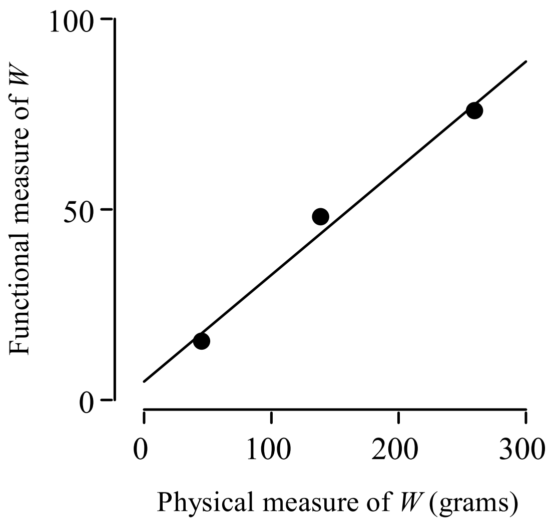

Figure 2. Functional measure of *W* (derived from the physical measures of *F* reported in Figure 1) plotted against the physical measure of *W*.

1) the dynamometer measures *F*,
2) a factorial experimental design is used.

If Equation 1 holds, these premises imply that the curves relating *F* to *W* for each *C* constitute a fan of straight lines.

For multiplicative physical laws, when there is no systematic error and no random error of measurements of *F*, row means are functional measures of *C* and column means are functional measures of *W*, both on a ratio scale. Neither *C* or *W* need be measured beforehand.

The difference between the physical measures of *F* in a column also is a functional measure of *W* (Anderson, 1982, pp. 82-83; Masin, 2004). Figure 2 shows these functional measures of *W* plotted against the corresponding physical measure of *W* [1]. The relation between these measures is linear, which implies that functional measurement and physical measurement yield equivalent scales of *W*.

In physics many laws are multiplicative. One advantage of functional measurement over physical measurement is that the independent variables of multiplicative laws may be measured indirectly when they could be hard to measure directly by customary physical methods.

Contrary to often repeated criticisms of functional measurement, as in the cited quote from Iverson and Luce (1998), functional measurement can yield ratio scales just as in physics.

References

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[1] In Figure 2, due to the difference operation, the functional measures of *W* have random error but no systematic error.

Abstract

It is shown empirically that functional measurement can yield scales equivalent to the scales of physics. One advantage of functional measurement is its possibility to provide indirect measures of the independent variables when these variables could be hard to measure by customary physical methods.

Riassunto

Viene mostrato empiricamente che la misurazione funzionale può produrre scale di misura equivalenti a quelle fisiche. Un vantaggio della misurazione funzionale è la sua possibilità di fornire misure indirette delle variabili indipendenti quando queste variabili dovessero essere difficili da misurare con i metodi ordinari della fisica.

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