Perception & Psychophysics
1989, 45 (3), 273-274

Notes and Comment

The distinction among dependence, specificity, and contingency in the orientation and length domains

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It has long been recognized that a number of psychophysical phenomena are domain-specific, where the term "domain" refers to a particular parameter of a stimulus, such as orientation, spatial frequency, or length. For example, the contrast threshold elevation of a sine wave grating is greatest when the adapting grating has the same orientation and the same frequency as the test grating, so this threshold elevation is both orientation- and spatial frequency-specific (see Frisby, 1979).

A clear distinction can be drawn between *domain specificity* and *domain dependency*. For example, the tilt illusion and aftereffect are orientation-dependent in that the effects vary in a systematic way with the relative test and inducing orientations. However, they are not orientation-specific, because local maxima occur at more than one inducing orientation, with the largest positive (or direct) effect occurring when the test-inducing angle is about 15° and the largest negative (or indirect) effect when the angle is about 75° (see Wenderoth & Johnstone, 1987).

In brief, a domain-specific effect is one in which the effect is greatest only at one value of the inducing stimulus (which often has, but need not necessarily have, the same value as the test stimulus); whereas domain dependency implies merely that the magnitude of the effect is modulated by variation in the value of the inducing stimulus. Thus, domain dependency includes domain specificity as a particular case in which the effect being measured not only varies with the value of the inducing stimulus (dependency) but is maximum at only one particular value (specificity).

In light of these distinctions, Jordan and Haleblian (1988) have incorrectly referred to my own data as evidence for both the presence of length-specific orientation contrast (Wenderoth, O'Connor, & Johnson, 1986) and the absence of it (Wenderoth & Johnson, 1984). In the contexts of predictions derived from lateral inhibition theory (Carpenter & Blakemore, 1973) and data on the line-length tuning of single cells, Wenderoth et al. (1986) predicted and found that larger tilt illusions occurred when inducing lines were longer than test lines, with smaller effects when inducing lines were shorter than test lines. However, with test length fixed at 2°, although illusions increased as the inducing length increased from 0.5°, illusion magnitude saturated *but remained large* with inducing lengths of 2.5° and 3.5°. Had the illusion been length-specific, it would have been largest at one particular inducing length—probably 2°, when the test and inducing lengths were equal—falling off in magnitude both for shorter and longer inducing lengths. In a much earlier paper (Wenderoth, O'Toole, & Curthoys, 1975), this failure to find a reduction with longer inducing lengths led to the conclusion (pp. 6-7) that "the AE [aftereffect] and illusion are not length specific ... in that an IF [inducing figure] longer than the TF [test figure] does not induce consistently or significantly smaller effects than an IF equal to the TF." Additionally, Tyler and Nakayama (1984), to whom Jordan and Haleblian also make reference, showed only that the Zöllner illusion increased monotonically with segment length, with no inflexion in the data. It is misleading, therefore, for Jordan and Haleblian (p. 453) to claim that their data

> are complementary to the work of Wenderoth and his colleagues, who have reported that under some conditions, orientation contrast is not specific to length (Wenderoth & Johnson, 1984, Experiment 3) and under other conditions, orientation contrast is length specific (Wenderoth et al., 1986; see also Tyler & Nakayama, 1984).

The preceding reference to the Wenderoth and Johnson (1984) experiment is misleading for a separate but related reason as well. Returning again to the example of contrast threshold elevation, that effect is orientation-specific in that maximum effect occurs when both the test and inducing stimuli have orientation θ, but the absolute value of θ can be anything (i.e. a 45° grating maximally elevates the threshold of a 45° grating; a 30° grating that of a 30° grating; etc.). The *relative* test and inducing orientations indicate specificity, not their absolute values. Yet Wenderoth and Johnson (1984, Experiment 3) showed only that equal magnitude illusions occurred when *both* inducing and test lines were 1°, 2°, or 3° long. This finding bears upon length specificity not at all, because specificity refers to the effects of altering the *relative* values of the test and inducing stimuli. When both have the same value, effects should be maximal, regardless of the absolute values of each (i.e., length, orientation, spatial frequency, etc.).

Elsewhere in the Jordan and Haleblian (1988) paper, the authors use the word "contingent" presumably as a synonym for "specific." Thus, they refer (p. 454) to evidence for "a length-contingent orientation distortion (Tyler & Nakayama, 1984; Wenderoth et al., 1986)," and

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"a non-length-contingent orientation distortion (Wenderoth & Johnson, 1984)," where the word contingent can only mean "dependent." Usually, the term contingent is reserved for effects such as the McCollough effect, in which the color reported is contingent upon the orientation presented in the test. On this usage, a length-contingent orientation distortion would imply that changing *test length* causes a change in the *judged test orientation*. Not only have these authors misinterpreted some data, but their use of specialized terms in an interchangeable manner is in itself not conducive to clear communication.

Finally, the distinctions made here have not been stressed merely to carp about minor matters. A major conclusion of the Jordan and Haleblian paper is as follows (p. 455): "The results of the present experiments, combined with those of Tyler and Nakayama (1984), Wenderoth and Johnson (1984), and Wenderoth et al., (1986), indicate that there is partial overlap of length and orientation coding in the visual system." While it has previously been argued by many others that contingent or domain-specific effects indicate partial overlap of neural coding mechanisms, the argument is much less compelling in the case of a mere dependency (i.e., a correlation between independent and dependent variables). A *dependence* of line-length judgement on inducing orientation may indicate simply that a process causing length misjudgment (e.g., lateral inhibition) is tuned for orientation. This does not necessarily imply anything about partial overlap between channels that code orientation and length, just as the dependence on pendulum speed of amount of depth seen in the Pulfrich effect implies nothing about partial overlap between channels that code velocity and depth. Rather, pendulum speed affects temporal disparity, which causes the depth effect when it is coded erroneously as a spatial disparity.

Given the very weak evidence for orientation specificity of length illusions in their own data, and the misuse of others' data to bolster their claim for it, one must consider the conclusions of Jordan and Haleblian with caution.

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(Manuscript accepted September 23, 1988.)