Review of Psychology
2000, Vol. 7, No. 1-2, 15-18

UDC 159.9

Bisections on backgrounds with different luminances

MARCO TOMMASI

Psychophysical methods are valid if participants' judgments are unaffected by the context wherein stimuli are presented. In this paper, the validity of brightness judgments obtained by bisections is tested. Standards were squares of different brightnesses presented on a bipartite background. By matching the brightnesses of standards on one side of the background with those of the standards of the other side, participants produced two equal brightness intervals for the two backgrounds. If bisection is unaffected by background variations, then the luminance of the square obtained by matching its brightness with that of the square obtained by bisection on the other background would be equal to that of the square obtained by bisection on the same background. Results show that bisection is substantially unaffected by context, because the luminances of bisecting squares are substantially similar to those of matched squares.

Bisections on backgrounds with different luminances

The consistency of scales obtained by psychophysical methods is an important topic in psychophysics. This consistency depends on the validity of judgments of a perceptual attribute of stimuli (e.g., length of lines, brightness of surfaces). Judgments are valid if they are independent from the context wherein the stimulus is presented. In other words, judgments are valid descriptions of the variations in a particular stimulus attribute if they are not affected by variations in other attributes of the same stimulus or in the environment wherein the stimulus is presented. However, it is quite impossible to obtain judgments that are completely independent from the contextual effects, because perceptual systems detect relationships between attributes rather than the intensities of single attributes to reliably identify things in a world of continuously changing characteristics and circumstances (Lockhead, 1992). The impossibility to obtain psychophysical judgments that are independent from the context does not hinder psychologists to produce valid psychophysical scales, provided that they are able to develop psychological models of response functions wherein contextual effects are included. In this case, it is necessary a systematic study of the effects of context variations on the judgments obtained by using a particular psychophysical method (Birnbaum, 1974).

Marco Tommasi, Department of General Psychology, Via Venezia 8, 35131 Padova, Italy. E-mail: tommasi@snoopy.psy.unipd.it. (Correspondence concerning this article should be sent to this address).

At the present time, there is no clear evidence that context affects only the observed responses of participants or also the internal sensory magnitudes corresponding to intensities of stimulus attribute. This is an important question, because some psychophysical methods, as magnitude estimation, consist of assigning a number to stimulus intensities, while other methods, as bisection, consist of producing or adjusting stimulus intensities according to experimenter's instructions. If context affects psychological magnitudes, then all psychophysical methods will produce biased judgments. On the other hand, if context affects verbal responses, then only psychophysical methods based on adjustment of stimulus intensities will produce valid judgments. Experimental results show that contextual effects occur for some psychophysical methods wherein participants give verbal response, such as magnitude estimation (Garner, 1954a; Nowell and Woskow, 1966) and category ratings (Parducci, 1982; Parducci & Wedell, 1986), and also for some methods wherein participants adjust stimulus intensities (Fagot and Stewart, 1969).

For the bisection method, the effect of context on participants' judgments is yet an obscured matter. Stevens (1957) found that bisection judgments are affected by the order of presentation of stimuli and he called this *hysteresis* effect. On the other hand, Garner (1954b) found that judgments obtained by bisection were unaffected by variation in the number of stimuli presented. However, no systematic research was carried on to detect the existence of other possible contextual effects on bisection method.

In this paper, I test the validity of brightness judgments obtained by bisection of stimuli presented on backgrounds

with different luminances. The stimuli used in the experiment were squares with different luminances presented on a background vertically divided in two parts. These squares were the standards that delimited the brightness interval that participants had to bisect. Participants produced equal brightness intervals for the two parts of the background by matching the brightnesses of the standards on the right side of the background with those of the respective standards on the left side. Of course, equal brightness intervals does not mean that the luminance intervals are also equal. If brightness judgments obtained by the bisection method were affected by the different luminances of the background, then participants should had selected bisecting squares with different brightnesses on the two brightness intervals. This hypothesis was tested by asking participants to match the brightness of a square on one side of the background with that of the bisector of the other side. If the brightness of the matched square was different to that of the bisector obtained on the same background, then brightness judgments obtained by bisections could be considered invalid. Because participants respond by varying stimulus intensity, if bisection method results are affected by context, then the hypothesis that context acts on psychological magnitudes rather than on verbal responses is strengthened.

METHOD

Participants

Participants were 21 University of Padua students with normal or-corrected-to-normal vision.

Materials

Stimuli were presented on the screen of a Sony 200PS monitor of 32.6 × 23 cm controlled by a Power Macintosh G3. Viewing distance was 85 cm. The screen was vertically divided into two parts with different luminances to obtain a bipartite background. Figure 1 shows the pattern and the dimensions of the stimuli used in the experiment. Let X and Y be the left and right side of the background, respectively. Let A and C be the initial standard squares presented on X. D and F were the standards which brightnesses were matched to those of A and C, respectively. B and E were once the squares which brightnesses bisected the intervals delimited by A and C and by D and F, respectively, and once the squares which brightnesses matched those of the squares obtained by bisection on the other side of the background.

Procedure

The experiment was divided into two parts: Part 1 and Part 2.

Procedure for Part 1. The luminances of X and Y were 56.3 and 15.1 cd/m^2, respectively. There were three sessions. In Session 1, the luminances of A and C were 3.7 and 21.5 cd/m^2, while the luminances of D and F were equal to that of Y. A and C appeared in sequence. The order of this sequence was randomized for each participant. A was once darker and once brighter than C. For each luminance sequence of A and C, participants matched the brightnesses of D and F with those of A and C, by pressing alternatively two keys of a keyboard. By pressing one of these keys, participants made D or F brighter; by pressing the other key, they made D or F darker. Brightness variations were continuous. Each participant made one trial for each brightness matching.

In Session 2, participants first adjusted the brightness of B to bisect the brightness interval between A and C, and then they adjusted the brightness of E to bisect the brightness interval between D and F. The positions of the darker and brighter standard were inverted, and for each position the initial luminance of B or E was equal once to the luminance of the darker standard and once to the luminance of the brighter standard. Each participant performed four bisections on each side of the background.

In Session 3, B initially appeared with a luminance corresponding to the mean luminance obtained by bisections

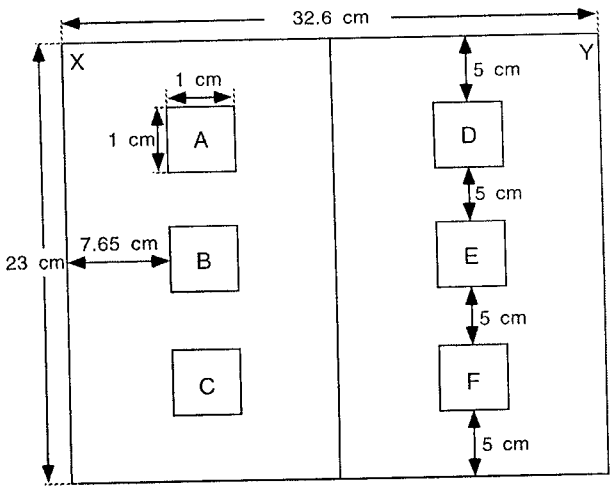

Figure 1. Pattern of stimuli used in the experiment, with the measurements of surface dimensions. X and Y are the two sides of the background with different luminances. A and C, and D and F are the standard squares for bisections on X and Y, respectively. B and E are the squares which brightnesses were obtained by bisections or by brightness matchings.

Table 1

Mean luminance values in cd/m^2 for squares obtained by bisection and brightness matching for each side of the background in Parts 1 and 2 of the experiment.

	Background surfaces	Background luminances	Variable squares	Square luminances (bisection)	Square luminances (brightness matching)
Part 1 of the experiment	X	56.3	B	11.1	14.1
	Y	15.1	E	6.1	6.1
Part 2 of the experiment	X	0.02	B	21.6	19.0
	Y	15.1	E	34.2	33.8

on *X*, while *E* had the same luminance of *Y*. Participants matched the brightness of *E* to that of *B*. Then the luminance of *B* was set equal to that of *X* and participants matched the brightness of *B* to that of *E* which was equal to the mean luminance obtained by bisections on *Y*.

Procedure for Part 2. The procedure was equal to that for Part 1, except that the luminances of *X* and *Y* were 0.02 and 15.1 cd/m^2, respectively, and the luminances of the standards *A* and *C* were 13.4 and 29.8 cd/m^2, respectively.

Ten participants performed first Part 1 and then Part 2; for the remaining 11 participants the order was reversed.

RESULTS AND DISCUSSION

The mean luminance values of the darker and brighter standard on *Y* selected by participants were 2.2 and 10.0 cd/m^2, for Part 1, and 26.2 and 46.2 cd/m^2, for Part 2.

Let L_B and L_E be the bisector luminance values of *B* and *E*, respectively, and λ_B and λ_E the luminance values of *B* and *E* obtained by matching their brightnesses with those of the bisectors of the other side of background. Because brightness is an exponential function of luminance (Marks, 1974, p. 151), it is possible to test the validity of brightness judgments obtained in bisection tasks by testing whether the differences $(L_B-\lambda_B)$ and $(L_E-\lambda_E)$ are significantly different from zero.

Table 1 shows the mean luminances for the squares obtained by bisection and matching method. A *t*-test shows that $(L_E-\lambda_E)$ is not significantly different from zero for Parts 1 and 2 of the experiment ($t(20) = -.06$ and $t(20) = -.44$, respectively) and that $(L_B-\lambda_B)$ is significantly different from zero for Parts 1 and 2 of the experiment ($t(20) = -3.18$, $p< 0.01$ and $t(20) = 3.67$, $p< 0.01$, respectively).

Experimental results show that brightness judgments obtained by bisection are substantially not affected by context, even if the statistical analysis shows a significant difference between the luminances of the bisector and the square obtained by brightness matching on white or black background. This significant difference is due to a systematic effect that can be ascribed to the different numbers of possible brightness variations involved by matching tasks on the two different backgrounds. Participants could perform a greater number of brightness variations for brightness matchings on the white or black background than they could for brightness matchings on the gray background. Table 1 shows that the luminances of the squares obtained by brightness matching on white or black background are higher or lower, respectively, than those obtained by bisection on the same background. This shows that participants preferred to stop their adjustments of brightness before finding the square whose brightness was perfectly similar than that of the reference square of the other background when they had to perform a greater number of brightness adjustments. In conclusion, the test of a psychophysical method by using another method based on adjustments of a perceptual attribute in different contexts could be biased by the different numbers of adjustments involved by this last method for each context.

REFERENCES

BIRNBAUM, M. H. (1974). Using contextual effects to derive psychophysical scales. *Perception & Psychophysics, 15*, 89-96.

FAGOT, R. F., & STEWART, M. R. (1969). Individual half-judgment brightness functions. *Perception & Psychophysics, 5*, 165-170.

GARNER, W. R. (1954a). Context effects and the validity of loudness scales. *Journal of Experimental Psychology, 48*, 218-224.

GARNER, W. R. (1954b). A technique and a scale for loudness measurement. *The Journal of the Acoustical Society of America, 26*, 73-88.

LOCKHEAD, G. R. (1992). Psychophysical scaling: Judgments of attributes or objects? *Behavioral and Brain Sciences, 15*, 543-601.

MARKS, L. E. (1974). *Sensory Processes.* New York and London: Academic Press.

NOWELL, J. F., & WOSKOW, M. J. (1966). Some effects of context on the slope in magnitude estimation. *Journal of Experimental Psychology, 71*, 177-180.

PARDUCCI, A. (1982). Category ratings: Still more contextual effects! In B. Wegener (Ed.), *Social attitudes and psychophysical measurement* (pp. 89-105). Hillsdale, NJ: Erlbaum.

PARDUCCI, A., & WEDELL, D. H. (1986). The category effect with rating scales: Number of categories, number of stimuli and method of presentation. *Journal of Experimental Psychology, 12*, 496-516.

STEVENS, S. S. (1957). On the psychophysical law. *Psychological Review, 64*, 153-181.

Received November 1999
Accepted July 2000