Notes and Comment

Discrimination measures in an ROC analysis of pain reactions

PAULA GOOLKASIAN

University of North Carolina, Charlotte, North Carolina

and

DONALD DORFMAN

University of Iowa, Iowa City, Iowa

In two recent pain studies (Goolkasian, 1980, 1983), a receiver operating characteristic (ROC) analysis was conducted on rating scale responses to radiant heat stimuli, and in both of these studies the discrimination measure was erroneously reported to be a d'_c score. Instead, a different measure was used; this will henceforth be denoted by the symbol d'_g .

The formula for d'_c is

$$d'_c = 2 \Delta m [b/(1+b)],$$

where b is the slope of the linearized ROC curve. Also, note that $\Delta m = a/b$, where a is the y intercept and b is the slope of the linearized ROC curve.

The discrimination measure used in the Goolkasian studies, d'_g , is defined as

$$d'_g = 2 \Delta m [b^{-1}/(1+b^{-1})].$$

Clearly,

$$d'_c = d'_g$$

only when $b = 1$. There is a simple relation between the two measures. Specifically,

$$d'_c = b d'_g,$$

where b ($b = \sigma n / \sigma s$) is the slope of the linearized ROC curve.

The measure d'_g was used rather than d'_c because it produced the most orderly results. This can be seen by considering the Δm and b values obtained in the Goolkasian (1980) study. Parameters were estimated by the method of maximum likelihood using RSCORE, a modified version of the program noted in Dorfman and Alf (1969).

For Δm fixed, d'_c is an increasing function of b . Specifically, for a fixed Δm ,

$$\frac{\partial d'_c}{\partial b} = 2 \Delta m \frac{[(1+b)-b]}{(1+b)^2} = \frac{2 \Delta m}{(1+b)^2} > 0,$$

where the left-hand side of the equation denotes the first partial derivative of d'_c with respect to b . On the other hand,

$$\frac{\partial d'_g}{\partial b} = -\frac{2 \Delta m}{(b+1)^2} < 0.$$

Thus, for fixed Δm , d'_c increases as b increases, whereas d'_g decreases as b increases. Equivalently, d'_c decreases as b decreases, where d'_g increases as b decreases. The data in Table 1 on page 292 show that the values of b decline in association with increases in stimulus intensity. For these data, then, d'_g was a better measure of pain discrimination than d'_c because it produced the most orderly data. The measure d'_g increases nicely as a function of increases in stimulus intensity (see Goolkasian, 1980). When d'_c was used, the decreases in b offset the increases in Δm that occurred with increases in stimulus intensity, and the data were disorderly.

For these data, then, d'_g was a better measure of pain discrimination than d'_c . Since all measures of pain discrimination are definitions, the measure that gives orderly results is in a scientific sense the best measure of pain discrimination. Hence, on the basis of the criterion of orderly results,

$$d'_g = 1/b d'_c$$

was the best measure of pain discrimination, at least for the data reported in these two studies. Perhaps d'_g will prove to be the best measure of pain discrimination for other data as well.

REFERENCES

- DORFMAN, D., & ALF, E. (1969). Maximum-likelihood estimation of parameters of signal detection theory and determination of confidence intervals: Rating-method data. *Journal of Mathematical Psychology*, 6, 487-496.
- GOOLKASIAN, P. (1980). Cyclic changes in pain perception: An ROC analysis. *Perception & Psychophysics*, 27, 499-504.
- GOOLKASIAN, P. (1983). An ROC analysis of pain reactions in dysmenorrheic and nondysmenorrheic women. *Perception & Psychophysics*, 34, 381-386.

P. Goolkasian's mailing address is: Department of Psychology, University of North Carolina, UNCC Station, Charlotte, NC 28223.

(Manuscript received December 14, 1983;
accepted for publication January 12, 1984.)

Table 1
Average Δm and b Values Obtained in Each of the Experimental Conditions (Goolkasian, 1980)

Group	Menstrual Phase							
	Menstrual		Postmenstrual		Ovulatory		Premenstrual	
	Δm	b	Δm	b	Δm	b	Δm	b
Intensity = 1								
Women	1.07	1.25	1.33	1.30	1.07	1.25	1.00	1.20
Men	.90	1.40	.90	1.26	1.01	1.33	1.03	1.37
Birth Control	.95	1.43	1.00	1.23	1.09	1.42	1.13	1.43
Intensity = 2								
Women	1.60	1.24	1.89	1.23	1.64	1.18	1.68	1.06
Men	1.27	1.24	1.43	1.06	1.37	1.05	1.43	1.23
Birth Control	1.45	1.33	1.49	1.13	1.52	1.26	1.69	1.29
Intensity = 3								
Women	2.21	1.12	2.48	1.07	2.33	1.03	2.49	.94
Men	1.78	1.15	2.07	.98	1.83	1.14	1.99	1.01
Birth Control	1.91	1.17	2.11	.90	2.08	1.32	2.52	1.04
Intensity = 4								
Women	3.18	1.00	3.10	1.23	4.35	.64	3.12	1.04
Men	2.87	1.02	3.14	.86	3.12	.78	2.99	1.02
Birth Control	2.96	.91	3.51	.82	3.18	.84	3.58	.89
Intensity = 5								
Women	4.74	.97	4.75	.90	6.13	.76	4.56	.99
Men	4.55	.88	5.40	.68	5.03	.94	5.49	.76
Birth Control	4.33	1.01	4.38	.86	4.72	.96	5.11	.88