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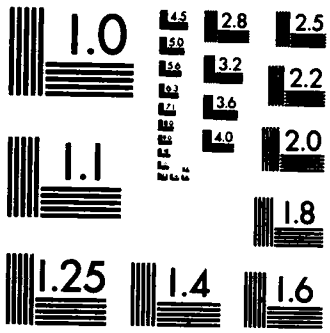

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A Cross-Study Analysis of Covariation Judgments

Marlys Gascho Lipe
University of Chicago
Graduate School of Business
Center for Decision Research

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Literature on covariation judgments has suggested that such judgments are effected by task, data, and subject characteristics. However, as a general rule, research studies have been confined to only one or two situations or sets of traits. In this paper data from several studies are pooled

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20. in order to mitigate the effects of specific characteristics, and a lens model analysis is done.

It is found that subject achievement is high in the covariation task as opposed to tasks used in other lens model studies. However, subjects did not use all of the available information to the extent specified in the statistical covariation model. The normativeness of this model is questioned.

A Cross-Study Analysis of Covariation Judgments

Marlys Gascho Lipe

Crocker (1981a) summarized a recent review of covariation judgments by stating "Evidence has accumulated indicating that intuitive covariation judgments are subject to several sources of bias. In all likelihood, our conceptions of our social world which are based on these judgments are simply incorrect much of the time." (p. 288)

Crocker's paper is an illuminating review of the individual studies that have been conducted regarding covariation judgments. However, her analysis could be profitably supplemented with research on what these individual studies reveal when taken as a whole. The purpose of this note is to present such an overview by providing a cross-study analysis of covariation judgments.

Crocker notes several conditions that can affect the accuracy of covariation judgments. These include characteristics of the task, characteristics of the data, and characteristics of the perceiver. Any of these aspects, it is argued, could cause subjects to systematically over- or under-estimate the correlation relative to that actually present in a given task. Therefore, any single study will contain such confounding factors thereby limiting the generalizability of its conclusions. The present project uses data from 5 different studies in order to draw conclusions that can be generalized more readily to a range of situations.

The usual covariation study presents subjects with data from the four cells of a 2X2 table (for an example, see Fig. 1) either instance-by-instance or in summary form. A common finding is that, relative to the normative statistical model of correlation, cell A receives too much weight in subjects' judgments (Smedslund, 1963; Jenkins & Ward, 1965; Alloy & Abramson, 1979). Also, disconfirming evidence, cells B and C, receive too little weight, and cell D is virtually ignored. Crocker (1981b) found similar results when she tried an unusual task format, having subjects request the cell data necessary to make judgments of covariation.

The proposition that subjects do not use disconfirming evidence has been the subject of much study. However, the results of this research have been quite inconsistent and, contrary to the studies cited above, several authors have concluded that subjects do not use decision rules based exclusively on cell A (Ward & Jenkins, 1965; Shaklee & Mims, 1981; Seggie & Endersby, 1972). Ward and Jenkins (1965) and Shaklee and Mims (1981), for example, analyzed each subject's judgments individually and concluded that subjects used sophisticated rules for judging covariation. Furthermore, Seggie and Endersby (1972) have raised the issue that covariation judgments may not be very informative in themselves. Hence, they asked their subjects to make decisions based on the cell data, rather than asking for judgments of correlation. Results showed that Seggie and Endersby's subjects made decisions that were consistent with the normative model of correlation. However, we cannot know what judgmental rule these subjects were actually using. They may, in fact, have used a much simpler model, such as conditional probabilities or some linear combination of the cell data.

The conclusions of these latter studies contrast sharply with the frequently cited assertion that "normal adults with no training in statistics do not have a cognitive structure isomorphic with the concept of correlation." (Smedslund, 1963, p. 172.) However, such contradictory findings should come as no surprise given Crocker's statements about the importance of task characteristics and their effects on experimental results. It is possible that any result could be obtained given the appropriate combination of task characteristics, data characteristics, and perceiver traits. Of course we are more interested in conclusions that can be widely generalized. Thus, it would be informative to see how heavily each kind of cell information is weighted over a range of situations, when task characteristics are varied.

Method

As previously stated, this research used data from 5 studies. Other studies simply did not provide the necessary information for inclusion in this project. The studies used and the number of data points taken from each are listed in Table 1, along with the context that was used in each task. Each "data point" consists of cell frequencies and the average judged covariation based on those cells. For example, one data point was:

Cell A	B	C	D	Judgment
23	2	7	18	.79

(Complete data sets may be obtained from the author.) Because the studies used different judgment scales, these were standardized to a percentage basis (e.g. 3.7 on a 5-point scale was converted to 3.7/5, or 74%).

The formula for correlation based on a 2X2 joint frequency table is a complex nonlinear function of the four cell entries, namely:

corr = (AD-BC)/square root[(A+B)(C+D)(A+C)(B+D)].

Although this equation is known to the experimenter in any given study, it is not clear whether it would be known to the subjects nor whether the subjects could use such a formula without computational aids. Thus, using such a model as a benchmark may be an unfair or inappropriate method of assessing subjects' abilities at covariation tasks. For this reason the "lens model" framework (Hursch, Hammond, & Hursch, 1964) is a useful methodology for this project. In essence, the lens model assumes that the actual correlational model is unknown or unavailable. However, the experimenter is able to build a linear model of correlation using the cell frequencies as variables in the model. By also building a linear model of the subjects' judgments, the experimenter can make an assessment of the subjects' abilities at the task, while using a simple linear benchmark.

Thus, the three important components of the lens model are the cell data (A, B, C, D), the actual correlation as computed using the cell data (Ye), and the correlation as estimated by the subjects (Ys). These are used in two multiple regression equations, one of which models the environment while the other models the judgments of the subjects. Therefore, the following regressions were run using data from the five studies listed in Table 1:

$$Y^*e = K + \alpha_1 A + \alpha_2 B + \alpha_3 C + \alpha_4 D \qquad (1)$$

$$Y^*s = K' + \alpha_1' A + \alpha_2' B + \alpha_3' C + \alpha_4' D \qquad (2)$$

The correlation matrix was also calculated in order to obtain the following measures;

Re = the correlation between Ye and Y*e. This is a measure of the linear predictability of the criterion Ye.

Rs = the correlation between Ys and Y*s. This is analogous to Re above and measures the linear predictability of the judge or subjects.

G = the correlation between Y*e and Y*s. This is a measure of the degree to which the regression equations of the subjects and the environment match.

C = the correlation between the residuals of the two regression models. This is a measure of the degree of match of the nonlinear portion of the subjects' judgments and the nonlinearity in the environment.

ra = the correlation between Ye and Ys. This denotes the subjects' achievement.

Rn = the correlation between Y*e and Ys. This is a measure of the subjects' achievement assuming the linear model of the environment is used as a normative model.

These measures also allow comparisons of subjects' achievement in this task with subjects' achievement in other situations (see Camerer, 1981).

Results

Regression results are given in Table 2. First, it should be noted that subjects are using the cell data in the normative direction. In other words, subjects give positive weight to the A and D cell data and negative weight to B and C cell data. However, it is also obvious that subjects do not attend to cells C and D as strongly as the model suggests. Although all coefficients in equation 1 are significant at the 1% level (one-tailed t test), only cells A and B reach this level of significance in the subjects' judgments (equation 2). (Cell C is marginally significant at the 5% level.)

In a recent paper, Schustack and Sternberg (1981) also used regression equations to test the weight given to each cell's data in a causal reasoning task. They used five different scenarios, estimating regression equations for each scenario. In general, they found all cells to be significant and that cell A was the most important in subjects' judgments. It is interesting that our results do not coincide with theirs, in that the Schustack and Sternberg results show that all the cells, as well as an additional variable proxying for the impact of alternative causes, do figure significantly in subjects' causal judgments. However, this difference in results may be due to the difference between the task characteristics of their study and the task characteristics of the studies used in this project. One important difference is that Schustack and Sternberg were specifically asking for causal judgments while the 5 studies used as data for this project called for judgments of contingency, causality, or control.

Einhorn and Hogarth (1981), in fact, have hypothesized that questions of causality will focus subjects' attention on cells B and C to a greater extent than will questions regarding contingency. A comparison of Schustack and Sternberg's findings and the results of this study tends to support that claim.

The Lens Model statistics are given in Table 3. Before turning to them, however, we should note that the adjusted R-squared for equation 1, given in Table 2, is .72. This means that 72% of the variance in Ye is accounted for in the regression equation. It is interesting that such a complex nonlinear function can be so well approximated with a linear model and this suggests that using this linear function as a normative model may not be very costly in terms of statistical accuracy. As can be seen in Table 3, subjects' judgments can be fitted fairly well with a linear model; Rs = corr[YsY*s] = .67. In addition, the linear models of the subjects and the "environment" match quite well; G = corr[Y*eY*s] = .96. It is instructive to compare these values with the average values of such statistics in other lens model studies. Camerer (1981), for instance, did a cross-study analysis of such projects and the average values of the relevant statistics are also listed in Table 3. In general it can be noted that the Re in this study is higher than average (.87>.64) while Rs is lower than average (.67<.74). However, caution must be exercised in drawing inferences from these comparisons, since most lens model studies ask subjects to predict some noisy criterion, while in these studies subjects were predicting the predictability of the criterion. Perhaps predicting a criterion is a more difficult task in that the criterion is observed in a probabilistic, or "noisy," environment. Despite this caution, however, it is interesting that the match of the two linear models, equations 1 and 2, is very high: .96 as opposed to an average of .56. Also, the subject achievement measure, ra, for this task is considerably higher than the average in other tasks (.63>.33). Also, Rn for this project is .65 which means that subjects' judgments of correlation are highly related (correlation of .65) to actual correlation, if we use equation 1 in Table 1, as our model of actual correlation. Another comparison of interest is that Rn and ra are very close (.65 and .63). This means that subject achievement is practically the same whether we use the complex Pearson's phi equation or a much simpler linear function as our benchmark for subjects' judgments of correlation.

A final result of interest is the significance of the constant term in equation 2 (see Table 2). Although the constant in the Y*e equation is not significantly different from zero, the constant term in the subject equation is highly significant (t statistic of 4.73) and is close to .5. This suggests that subjects are either using a different judgment scale than they are instructed to use or that they have a priori expectations of a significant degree of covariation. Indeed, Peterson (1980) hypothesized that subjects expect experimental tasks to be 'meaningful' and therefore do not consider the possibility of noncontingency. He suggested that making such a possibility available to subjects would help them recognize noncontingency. Moreover, Peterson was able to empirically demonstrate the accuracy of his hypothesis. In only one of the 5 studies included in this analysis were subjects made aware of the possibility of noncontingency through explicit instructions (Jenkins & Ward). Thus, a priori expectations of contingency may be the reason for a nonzero constant term in the subjects' regression equation. It is also possible, however, that subjects assume that the middle of the judgment scale is the "average" judgment and, thus, use this as a starting point for their judgments. This would suggest the possibility that subjects' judgments may not be sufficiently adjusted away from this .5 starting point. In fact, the variance, or dispersion, of the actual correlations (Ye) in the data used here is significantly greater than the variance of the subjects' judgments (Ys). (F statistic of 3.65 with 30 and 30 degrees of freedom is significant at the 5% level.) Thus, either an anchoring and adjustment heuristic or a priori expectations may account for the constant term in equation 2.

Implications

This study raises several issues. First, it was noted that although cell A is not the only data receiving subjects' attention, it does receive the greatest weight in judgments of covariation. However, this could be due to the form of the covariation question presented to subjects. Crocker (1981b) demonstrated that subjects tend to focus their attention on the cells which are explicitly mentioned in the covariation question. In the studies used as data for this research, the questions focused attention on various cells. The particular cells stressed in each study are listed in Table 1. Note, in particular, that cell A is stressed in each of these studies, and, thus, the importance of cell A in the regression may be due to the question format. However, the apparent importance of cell A could also be due to variation in subjects' decision rules. Ward and Jenkins (1965), for example, did individual analyses of their subjects and found that commonly used decision rules included the following: (A/A+B)-(C/C+D), A+D, and A/A+B. Obviously, all of these rules rely heavily on the A cell data and this could drive our results regarding the importance of cell A.

Further research needs to be done to investigate the factors which cause different cells to receive subjects' attention. Many studies, particularly the early ones, assumed that cell A is likely to receive the greatest amount of attention. It would be interesting, however, to delineate the conditions under which this is true. Although there have been contradictory conclusions in the literature regarding subjects' abilities at covariation tasks, only Ward and Jenkins (1965) and Crocker (1981b) have made systematic studies to investigate the reasons for these contradictions.

A second issue raised by this study is whether the statistical model of correlation is an appropriate benchmark to impose on subjects' judgments. The results of Seggie and Endersby's (1972) study, for example, suggest that subjects cope well with decision tasks that require covariation assessments when the task does not call for covariation judgments per se. Furthermore, in a classic paper, Taylor and Russell (1939) showed that simply knowing the direction of a relationship can have important effects on decision performance. For example, if college grades and achievement in graduate school are uncorrelated and the base rate of graduate students that are satisfactory is 50%, then even if admissions officers admit only the

10% of their applicants who have the best college records, only 50% of their students will be satisfactory. However, as Taylor and Russell showed, if college grades and graduate performance are correlated only .2, the percentage of satisfactory graduate students rises to .64. With a correlation of .45 this rises to 81%! That is, simply knowing that there is a positive relationship improves the decisions made. It was found, both in this study and in that of Schustack and Sternberg (1981), that subjects do properly sign the cell data. Thus, the direction of the relationship (i.e. positive or negative) was generally correctly inferred. Perhaps this is 'good enough' in the real world where decisions are actually made, and, therefore, use of a model as complex as Pearson's phi is not necessary.

A further example of this point comes from a replication of Seggie and Endersby's study where subjects were provided with information such as that shown in figure 1. The subjects were asked to decide whether or not to hospitalize a new patient based on the information given about past patients. When the actual correlation of hospitalization and recovery was zero, only 5 or 6 of the 20 subjects chose to hospitalize the patient. With a negative correlation of .4, no subject chose to hospitalize the patient and the number of subjects choosing hospitalization when the correlation was set at .08 and .19, was 13 and 17, respectively. Thus, it appears that subjects are able to utilize the direction of relationships even when the correlations are rather small in absolute terms.

In summary, this study has provided an overview of human abilities at covariation judgment tasks. Contrary to opinions expressed in the literature, the conclusion is quite positive; subjects appear to do quite well at ascertaining the direction of a relationship, and to use information in the normatively correct direction. Furthermore, this would often seem to be "good enough" in practical circumstances, thus raising questions regarding the normative status of the correlational model as the benchmark for human judgment.

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Example of 2X2 Contingency Table

	Recovered	Did not Recover
Hospitalized patient	A	B
Did not hospitalize patient	C	D

Figure 1

Papers Containing Data Used in this Study

	Number of Data Points	Task Context	Cell(s) stressed
Alloy and Abramson (1979)	11	Button Press and Light Onset	A, C
Cordray and Shaw (1978)	4	Test Taking Effort and Performance	A
Jenkins and Ward (1965)	5	Button Press and Light Onset	A, B, C, D
Smedslund (1963)	1	Symptom and Disease	A
Ward and Jenkins (1965)	10	Cloud Seeding and Rainfall	A, D
	31		

Table 1

Coefficients and (t-statistics) for Regression Models of

Judged and Actual Correlation

	Constant	Cell A	Cell B	Cell C	Cell D	Adj. R-squared
Y*e	.162	.0164	-.0225	-.0260	.0182	.72
	(1.24)	(4.76)	(4.22)	(3.92)	(3.61)	
Y*s	.487	.0072	-.0110	-.0088	.0042	.37
	(4.73)	(2.65)	(2.63)	(1.69)	(1.06)	

Table 2

Lens Model Statistics

	This Study	Average (Camerer, 1981)
Re	.87	.64
Rs	.67	.74
G	.96	.56
C	.17	NA
ra	.63	.33
Rn	.65	NA

Table 3

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ONR Detachment
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AFHRL/CCN
Brooks Air Force Base, TX 78235

Foreign Addressees

Dr. Daniel Kahneman
University of British Columbia
Department of Psychology
Vancouver, BC V6T 1W5
Canada

Foreign Addressees

Dr. Kenneth Gardner
Applied Psychology Unit
Admiralty Marine Technology
Establishment
Teddington, Middlesex TW11 OLN
England

Director, Human Factors Wing
Defence & Civil Institute of
Environmental Medicine
Post Office Box 2000
Downsview, Ontario M3M 3B9
Canada

Dr. A. D. Baddeley
Director, Applied Psychology Unit
Medical Research Council
15 Chaucer Road
Cambridge, CB2 2EF England

Other Government Agencies

Defense Technical Information Center
Cameron Station, Bldg. 5
Alexandria, VA 22314 (12 copies)

Dr. Craig Fields
Director, System Sciences Office
Defense Advanced Research Projects
Agency
1400 Wilson Blvd.
Arlington, VA 22209

Dr. M. Montemerlo
Human Factors & Simulation
Technology, RTE-6
NASA HQS
Washington, D. C. 20546

Dr. J. Miller
Florida Institute of Oceanography
University of South Florida
St. Petersburg, FL 33701

Other Organizations

Dr. Robert R. Mackie
Human Factors Research Division
Canyon Research Group
5775 Dawson Avenue
Goleta, CA 93017

Dr. Amos Tversky
Department of Psychology
Stanford University
Stanford, CA 94305

Dr. H. McI. Parsons
Human Resources Research Office
300 N. Washington Street
Alexandria, VA 22314

Dr. Jesse Orlansky
Institute for Defense Analyses
1801 N. Beauregard Street
Alexandria, VA 22311

Professor Howard Raiffa
Graduate School of Business Administration
Harvard University
Boston, MA 02163

Dr. T. B. Sheridan
Department of Mechanical Engineering
Massachusetts Institute of Technology
Cambridge, MA 02139

Dr. Arthur I. Siegel
Applied Psychological Services, Inc.
404 East Lancaster Street
Wayne, PA 19087

Dr. Paul Slovic
Decision Research
1201 Oak Street
Eugene, OR 97401

Dr. Harry Snyder
Department of Industrial Engineering
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061

Other Organizations

Dr. Ralph Dusek
Administrative Officer
Scientific Affairs Office
American Psychological Association
1200 17th Street, N. W.
Washington, D. C. 20036

Dr. Robert T. Hennessy
NAS - National Research Council (COHF)
2101 Constitution Avenue, N. W.
Washington, D. C. 20418

Dr. Amos Freedy
Perceptronics, Inc.
6271 Variel Avenue
Woodland Hills, CA 91364

Dr. Robert C. Williges
Department of Industrial Engineering and OR
Virginia Polytechnic Institute and State University
130 Whittemore Hall
Blacksburg, VA 24061

Dr. Meredith P. Crawford
American Psychological Association
Office of Educational Affairs
1200 17th Street, N. W.
Washington, D. C. 20036

Dr. Deborah Boehm-Davis
General Electric Company
Information Systems Programs
1755 Jefferson Davis Highway
Arlington, VA 22202

Dr. Ward Edwards
Director, Social Science Research Institute
University of Southern California
Los Angeles, CA 90007

Dr. Robert Fox
Department of Psychology
Vanderbilt University
Nashville, TN 37240

Other Organizations

Dr. Charles Gettys
Department of Psychology
University of Oklahoma
455 West Lindsey
Norman, OK 73069

Dr. Kenneth Hammond
Institute of Behavioral Science
University of Colorado
Boulder, CO 80309

Dr. James H. Howard, Jr.
Department of Psychology
Catholic University
Washington, D. C. 20064

Dr. William Howell
Department of Psychology
Rice University
Houston, TX 77001

Dr. Christopher Wickens
Department of Psychology
University of Illinois
Urbana, IL 61801

Mr. Edward M. Connelly
Performance Measurement
Associates, Inc.
410 Pine Street, S. E.
Suite 300
Vienna, VA 22180

Professor Michael Athans
Room 35-406
Massachusetts Institute of
Technology
Cambridge, MA 02139

Dr. Edward R. Jones
Chief, Human Factors Engineering
McDonnell-Douglas Astronautics Co.
St. Louis Division
Box 516
St. Louis, MO 63166

Other Organizations

Dr. Babur M. Pulat
Department of Industrial Engineering
North Carolina A&T State University
Greensboro, NC 27411

Dr. Lola Lopes
Information Sciences Division
Department of Psychology
University of Wisconsin
Madison, WI 53706

Dr. A. K. Bejczy
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91125

Dr. Stanley N. Roscoe
New Mexico State University
Box 5095
Las Cruces, NM 88003

Mr. Joseph G. Wohl
Alphatech, Inc.
3 New England Executive Park
Burlington, MA 01803

Dr. Marvin Cohen
Decision Science Consortium
Suite 721
7700 Leesburg Pike
Falls Church, VA 22043

Dr. Wayne Zachary
Analytics, Inc.
2500 Maryland Road
Willow Grove, PA 19090

Dr. William R. Uttal
Institute for Social Research
University of Michigan
Ann Arbor, MI 48109

Dr. William B. Rouse
School of Industrial and Systems
Engineering
Georgia Institute of Technology
Atlanta, GA 30332

Other Organizations

Dr. Richard Pew
Bolt Beranek & Newman, Inc.
50 Moulton Street
Cambridge, MA 02238

Dr. Hillel Einhorn
Graduate School of Business
University of Chicago
1101 E. 58th Street
Chicago, IL 60637

Dr. Douglas Towne
University of Southern California
Behavioral Technology Laboratory
3716 S. Hope Street
Los Angeles, CA 90007

Dr. David J. Getty
Bolt Beranek & Newman, Inc.
50 Moulton street
Cambridge, MA 02238

Dr. John Payne
Graduate School of Business
Administration
Duke University
Durham, NC 27706

Dr. Baruch Fischhoff
Decision Research
1201 Oak Street
Eugene, OR 97401

Dr. Andrew P. Sage
School of Engineering and
Applied Science
University of Virginia
Charlottesville, VA 22901

Denise Benel
Essex Corporation
333 N. Fairfax Street
Alexandria, VA 22314

END

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