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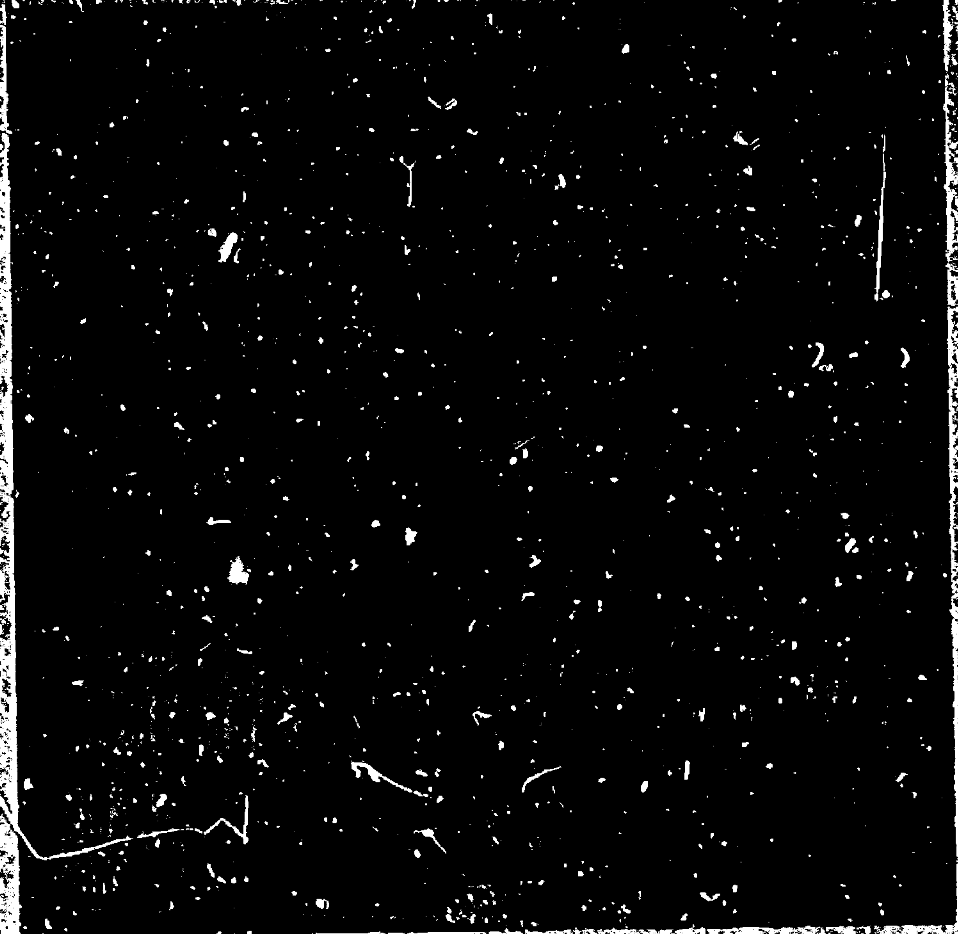
ABSTRACT

The suppressor variable, a variable wholly uncorrelated with a criterion, but which nevertheless improves prediction because of its relationship with a predictor, is critically examined. For a suppressor so defined, formal identities are shown with part, partial, and multiple correlational procedures. It is demonstrated that if maximum prediction is the primary goal, the use of the suppressor approach is appropriate if, and only if, the suppressor-criterion correlation is zero. Otherwise multiple correlation will always yield a higher validity. Mathematical constraints are shown to be operating on suppressors with a resultant effect of producing minimal incremental validity for suppressors within the range of typical validity coefficients. It is also demonstrated that additional predictors will yield a greater increment in prediction in comparison with suppressors. On the other hand, because of its conceptual advantages, the formally equivalent part correlation is recommended over the multiple correlation approach for suppressor variables which enter into theoretical relationships and for the measurement of latent constructs. (Author/DG)



SUPPRESSOR VARIABLES, PREDICTION, AND THE INTERPRETATION OF PSYCHOLOGICAL RELATIONSHIPS

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Abstract

The suppressor variable--a variable wholly uncorrelated with a criterion, but which nevertheless improves prediction because of its relationship with a predictor--is critically examined. For a suppressor so defined, formal identities are shown with part, partial and multiple correlational procedures. Mathematical constraints are shown to be operating on suppressors with a resultant effect of producing minimal incremental validity for suppressors within the range of typical validity coefficients. It is also demonstrated that additional predictors will yield a greater increment in prediction in comparison with suppressors. Because of its conceptual advantages, the formally equivalent part correlation is recommended over the multiple correlation for suppressor variables which enter into theoretical relationships and for the measurement of latent constructs.

Suppressor Variables, Prediction, and the Interpretation of Psychological Relationships

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One of the traditional problems confronting the applied measurement specialist in psychology is the large-scale prediction of particular criteria. Because it is often difficult to find more than a small number of predictors contributing to incremental validity, the idea of a suppressor variable (Horst, 1941)--one contributing to incremental validity while itself uncorrelated with the criterion--has continued to capture periodically the imagination of those confronted with prediction problems. The fact that bona fide suppressors have only rarely been reported (Lord & Novick, 1968) has not diminished the search. In a similar manner, ever since the technique of partial correlation was developed, research workers have sought to interpret psychological relationships more accurately and more meaningfully, by seeking to eliminate statistically the effects of unwanted variance in evaluating the correlation between two psychological variables.

The present paper seeks to cast additional light on these two distinguishable but related approaches. In particular, three major aims are proposed: (a) to explicate, definitionally and mathematically, the nature of the suppressor variable, and to show the conditions under which there are formal identities between results based upon analyses using a suppressor variable, and those based upon approaches involving multiple, and part and partial correlational procedures; (b) to demonstrate certain mathematical constraints upon the degree of gain in predictability of a criterion by the addition of a suppressor, and to compare this potential gain with that attainable by seeking new predictors; and (c) to distinguish the distinct aims of prediction and of construct measurement as they each are relevant to the statistical control of unwanted variance, and to make appropriate recommendations.

The Definition of a Suppressor Variable

While a number of authors (Horst, 1941; Meehl, 1945; McNemar, 1945; Rozeboom, 1966; Lord & Novick, 1968) have defined the mode of operation, as well as the mathematical basis, for the suppressor variable, there continues to remain a certain degree of disagreement in the literature about such variables. Disagreement exists mainly as to what constitutes a suppressor variable, its relation to other well-known approaches, like part and partial correlation, and the situations in which it is, and is not, appropriate. Some of this confusion is based upon an unwarranted loosening and re-interpretation of the original definition, but the major difficulty is due, in our opinion, to the failure to distinguish between the use of suppressor variables in three different contexts: (a) in the prediction of a particular criterion; (b) for the measurement of a latent trait or construct; and (c) in the delineation of relationships between constructs. For these distinct uses, different logical and psychological foundations are required.

Before taking up these issues in detail, it would be appropriate to review the classical definition of a suppressor variable, and to review more recent discussions of this formulation. While portions of this introductory section, particularly the illustrative material, may appear elementary to some readers, it is considered worthwhile to eliminate simple definitional ambiguity prior to proceeding with the main arguments of this paper.

A suppressor variable is here defined, in a manner consistent with the classical definition, as one wholly uncorrelated with a criterion, but which, by virtue of a correlation with a predictor, improves the prediction of the criterion.

There is a paradoxical quality (McNemar, 1945) associated with a suppressor, in that it is possible to increase prediction by utilizing a variable which shows a negligible correlation with the criterion, provided it correlates well with a variable which does correlate with the criterion. This apparently paradoxical quality becomes intelligible when one considers an illustrative example, one provided by Horst (1966, p. 355) growing out of his experience in the prediction of success in pilot training in World War II. Included in a prediction battery were tests of mechanical ability, numerical ability, spatial ability, and verbal ability. Each of the first three had substantial positive correlations with the criterion of success. Verbal ability, however, had a near-zero correlation with the criterion but fairly high correlations with the scores for the other three tests. The multiple correlation with the criterion proved to be higher when verbal ability was included, than when it was not included in the predictor battery, in spite of its negligible zero-order correlation. Horst interpreted this finding psychologically by pointing out that high verbal aptitude was not important in the kind of flight training conducted in World War II. However, verbal ability was to some degree important in obtaining relatively higher scores on mechanical, numerical, and spatial aptitude tests; for example, reading comprehension facilitated understanding of test instructions, leading in turn to a higher score. When variance associated with criterion-irrelevant verbal aptitude was subtracted from the weighted score based on the other three predictors, their efficiency as predictors improved. Persons who obtained a particular weighted composite score on these tests primarily because of high verbal aptitude would thus not tend to be selected over those who obtained a similar score based primarily on the abilities required to learn to fly an aircraft. Thus, prediction was improved because variance associated with verbal ability was suppressed.

The operation of a suppressor variable may be illustrated further by considering a Venn diagram (Figure 1) and by utilizing the common elements formulation of correlation (cf. McNemar, 1945, 1962). The criterion (c) is comprised of 16 elements, of which seven are in common (depicted by c-p) with the predictor (p). The predictor also is comprised of 16 elements, with nine irrelevant to the criterion. For this relationship the common element correlation yields $r_{cp} = .44$. If eight of the nine irrelevant elements are accounted for (depicted by p-s) by the suppressor (s) , which shares no elements with the criterion, the zero-order correlations r_{ps} and r_{cs} are .75 and .00 respectively. Inspection of Figure 1 shows that although the suppressor is wholly unrelated to the criterion, it is useful in identifying those elements in the predictor common to the criterion. This influence is apparent in the multiple regression equation based on the zero-order correlations: $Z_c = .661\ Z_p - .496\ Z_c$. The regression weights indicate that the weighted suppressor variable should be subtracted from the predictor in order to remove the criterion irrelevant variance.

Insert Figure 1 about here

Ordinarily, the regression weight of a suppressor variable in a multiple regression equation will be negative in sign, but a potential source of confusion arises when all negatively-weighted variables are considered as suppressors. For example, Lubin (1957) and Darlington (1968) loosen the traditional definition to include such "negative suppressors," *viz.*, a variable with a positive relation to a criterion, but a negative one with some other predictor. Darlington defines a suppressor as a variable which, when included with a positive predictor, receives a negative weight when a regression weight is derived on the "population." Darlington's definition thus includes Lubin's negative suppressor as well as Horst's traditional suppressor. It is possible that the practice of referring to all variables with negative regression weights as suppressor variables derives from experience in predicting performance criteria from aptitude and achievement test batteries. Aptitude tests showing a significant but negative correlation with a performance criterion--indicating that persons with *lower* aptitude scores are showing superior criterion performance--are perhaps just as paradoxical as traditional suppressor variables. But paradoxical or not, this situation is logically distinct from the suppressor variable as here defined. This apparent paradox is eliminated if one considers predictors to be like bipolar attitudinal or personality scales or cognitive style variables, whose direction of keying and direction of positive evaluation may be arbitrary. What is a predictor (e.g., flexibility) for one

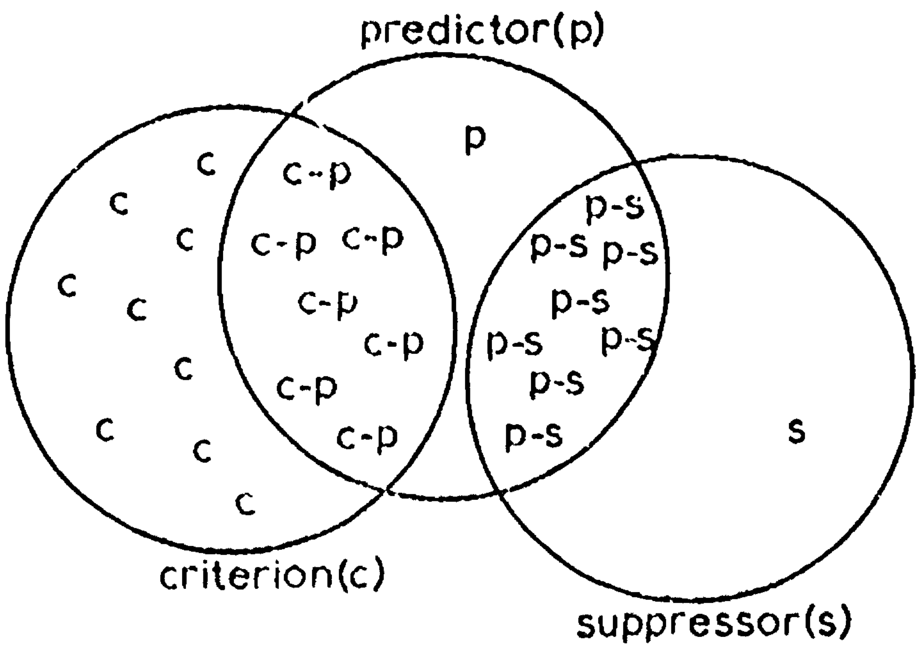

Figure 1

Venn Diagram Explanation of Suppressor Variables investigator, might become a suppressor (e.g., rigidity) for a second investigator. Obviously there are problems with these more general "suppressors" in that excluding some variables and including others could change a predictor to a suppressor and vice versa, or as Lord and Novick (1968) point out, simple reflection of the variables converts the predictor to a suppressor and the suppressor to a predictor. Obviously, the more general definitions of suppressor variables need closer scrutiny. In order to avoid terminological and conceptual confusion, we recommend that the term, suppressor, be limited in the psychological literature to the classical definition, and that it be expunged from other contexts. Following this recommendation, this paper is limited to a discussion of the traditional suppressor as originally defined by Horst (1941).

The Relation of the Suppressor to Part and Partial Correlation

Gardner Murphy (1932) once stated that the partial correlation, together with the discovery of the conditioned response, ranked as one of the two most important discoveries of twentieth century psychology. As early as four decades ago Murphy had insight into the tremendous power inherent in the possibility of holding one variable constant statistically while observing the effects of additional variables, a power that has more recently become manifest with developments in factor analysis. While some might dispute Murphy's assertion about their importance, the part and partial correlation have enjoyed a place in the psychological statistics texts of the present century. But in spite of their appearing together in measurement texts, the suppressor variable has not been sufficiently related to partial (and part) correlation. Perhaps this is because they stem from different traditions--the suppressor from large scale prediction of criterion performances, and the part and partial correlation from attempts to interpret the psychological bases for relationships by the statistical control of theoretically distinct variance. While there have been isolated hints of a relation between these two formulations (Jackson & Pacine, 1961; McNemar, 1962, p. 406, Problem 10.27; Rozeboom, 1966), a review of the literature has revealed to us no explicit mathematical treatment of their relationship.

According to McNemar (1962), if the influence of one variable is removed from another and correlated with a third variable, a situation exists in which the part correlation should be used; however, this is precisely the justification for suppressor relationships. The part correlation, $r_{c(p.s)}$, is given by

$$r_{c(p.s)} = \frac{r_{cp} - r_{cs} r_{ps}}{\sqrt{1 - r_{ps}^2}} .$$

In particular, if r_{cs} is equal to zero, an ideal suppressor situation, then the part correlation formula yields

$$r_{c(p.s)} = \frac{r_{cp}}{\sqrt{1 - r_{ps}^2}} .$$

This correlation is clearly higher than r_{cp} in all circumstances where $r_{ps} \neq 0$. This formula is identical to that derived by Meehl (1945) for a suppressor variable with $r_{cs} = 0$. <u>Thus, the part correlation and the suppressor variable are mathematically identical.</u>

Removing the influence of a third variable from two others (the influence of a suppressor from both the predictor and criterion) is a situation in which a partial correlation should be used, i.e.,

$$r_{cp.s} = \frac{r_{cp} - r_{cs}\, r_{ps}}{\sqrt{1 - r_{ps}^2}\,\sqrt{1 - r_{cs}^2}} .$$

This correlation would be even greater than the part correlation. Under classical suppressor conditions with $r_{cs} = 0$ this yields

$$r_{cp.s} = \frac{r_{cp}}{\sqrt{1 - r_{ps}^2}} .$$

This is the same as the part correlation and, again, is a result identical to Meehl's formula for the suppressor. This should not be surprising because the suppressor does not really influence the criterion, only the predictor; there is thus no influence to remove from the criterion. The part correlation theoretically explains the suppressor relationship and offers no paradox. It also yields the same degree of relationship (under "ideal" conditions) as multiple regression.

The equation for a two variate multiple correlation is

$$r_{c.ps} = \frac{\sqrt{r_{cp}^2 + r_{cs}^2 - 2r_{cp}\, r_{cs}\, r_{ps}}}{\sqrt{1 - r_{ps}^2}} .$$

Under ideal suppressor conditions $(r_{cs} = 0)$ this reduces to,

$$r_{c.ps} = \frac{r_{cp}}{\sqrt{1 - r_{ps}^2}} .$$

This is a formulation we have already seen in the part and partial correlation situation, and in the suppressor. That is, there is no difference either in meaning or in formula between any of these formulations under ideal suppressor conditions. The similarity between the part and partial correlation is a result of the "suppressor" having no influence on the criterion and might be considered to border on the trivial in comparison with the other identities. The equality of the suppressor and multiple regression formulations is well known and needs little elaboration. The most striking result is the equivalence of the part correlation and the multiple correlation. This equivalence provides a mathematical basis for considering a part correlation approach to suppressor variables as an alternative to the multiple regression approach. Conceptually, the part correlation approach seems more appropriate and less paradoxical.

Which Should be Used, the Part, Partial, or Multiple Correlation?

The Classical prediction Problem

Suppose ideal suppressor conditions do not exist, should the part, partial or multiple correlations be used? The answer depends upon one's purpose. Consider the case where maximum validity is sought. Consideration of the squared part correlation versus the squared multiple correlation yields a definite relationship between the two. The squared part correlation is found from

$$r^2_{c(p.s)} = \frac{r^2_{cp} - 2r_{cp}\, r_{cs}\, r_{ps} + r^2_{ps}\, r^2_{cs}}{1 - r^2_{ps}} \quad ;$$

and, the squared multiple correlation is given by

$$r^2_{c.ps} = \frac{r^2_{cp} - 2r_{cp}\, r_{cs}\, r_{ps} + r^2_{cs}}{1 - r^2_{ps}} \quad .$$

The difference between them is

$$r^2_{c.ps} - r^2_{c(p.s)} = \frac{r^2_{cs} - r^2_{cs}\, r^2_{ps}}{1 - r^2_{ps}}$$

and this further simplifies to r^2_{cs}. That is, $r^2_{c.ps} - r^2_{c(p.s)}$ is equal to r^2_{cs}. As expected, the squared multiple correlation yields the maximum value and this value is simply a function of the degree to which ideal conditions are not met, that is, the degree to which r^2_{cs} is not equal to zero. This suggests that even if part correlation is the best theoretical formulation of suppression, it unfortunately will not invariably yield the maximum relationship; when ideal suppressor conditions do not exist, regular multiple regression will be better. If the goal is strictly empirical prediction, with the emphasis upon maximum validity, there is no advantage in using part or partial correlation rather than the standard multiple regression formula. If suppression effects are present, they will be revealed as a result of this analysis. But it is important to be clear as to one's intent. Empirical prediction implies that one seeks repeatedly to use a battery of tests on samples of subjects to make decisions to optimize the utility of certain outcomes. In empirical prediction the primary goal is not the understanding of relationships but it is a strictly utilitarian one. Although this is the context in which a great deal of test theory is promulgated, it is important to recognize that some authors (Loevinger, 1957) have argued that the assumptions underlying this model (e.g., an invariant criterion) are rarely precisely met. In any case, it is important to differentiate the goals implicit in empirical prediction from those of understanding the nature of psychological processes. If theoretical interpretation of psychological relationships is the primary goal, a different rationale is appropriate, one embodying that underlying the part correlation rather than the suppressor.

Partial Regression and the Nature of Psychological Relationships

The term, suppressor variable, has probably been associated with the development of the *K* scale of the MMPI (Meehl & Hathaway, 1946) more frequently than with any other single scale. The rationale for the development of the *K* scale was essentially based upon the empirical prediction model. The goal was to identify within a deviant psychiatric population a set of items differentiating those individuals with (presumably valid) elevated clinical scale scores from those with apparently normal (presumably invalid) scale scores. Subsequently, this set of items was to be used to suppress the reliable but apparently invalid variance in the clinical scale scores with the expectancy of more valid assessment. The rationale of the *K* scale has an appeal when considered in the context of large sample prediction of a particular stable criterion. Unfortunately, it is inappropriate when applied to the vast majority of uses to which the MMPI is put. The resulting use of the *K* scale as a "correction," while possibly defensible on other grounds, is an irrelevant application of the suppressor rationale, yielding at times some rather illogical results. For example, pathological behavior can be ascribed to a respondent because, and only because, he has received an elevated K-scale score.

There is, furthermore, the problem of the instability of regression weights derived from a particular sample. The criterion of the concurrent assignment of psychiatric diagnoses at the University of Minnesota Hospitals was susceptible to a number of local conditions affecting validity, such as the type of population attracted, local administrative procedures and biases affecting antecedent probability and base rates (Meehl & Rosen, 1955). In spite of the widespread use of the MMPI, its application in large sample prediction of this type has been rare, and we are aware of no study seeking to cross-validate the use of the $\underline{K}$ scale as a suppressor in the classical sense. But the suppressor rationale is based on the prediction of a particular criterion; its generality is an empirical matter and cannot be assumed. Nevertheless, the MMPI typically has been used as a means by which characteristics or latent attributes are assigned to individuals on the basis of their test scores (Jackson & Messick, 1958, 1962). Under these circumstances, what is important is a reliable, unbiased estimate of a respondent's location on the latent dimension, based on measures which are free, insofar as possible, from sources of substantive and methodological irrelevance. Therefore, it would be justifiable to remove an unwanted source of variance even if this resulted in a decreased validity with a particular empirical criterion.

The important consideration here is that the test score should reflect a particular dimension possessing construct validity rather than merely empirical validity. On these grounds, the part correlation rationale seems preferable to the multiple regression rationale. The focus would thus shift from maximizing validity to minimizing sources of bias. There can be no objection to the part correlation approach on the grounds that regression weights cannot be obtained, since the partialling procedure would be done in such a way as to remove maximally the unwanted variance. This could be done by the equation originally suggested by Horst (1941) and by Lubin (1957) or Meehl (1945) with reference to suppressor variables, namely to form a new variable by removing the unwanted variances of the suppressor:

$Z'_p = Z_p - r_{ps} Z_s$. In a second step one could correlate the variable p' with a second variable with the intent of understanding the nature and magnitude of the relationship between two variables, one with a correction for irrelevance. Alternatively, one might wish simply to interpret the corrected score as reflecting a certain degree of an attribute, which forms the basis for some further analytical treatment or assessment decision. The part correlation thus provides a basis similar to multiple regression for the suppression of irrelevance even if the increment in validity is not great. For example, if presenting a good impression of oneself is irrelevant or logically distinct from a certain personality trait, then this influence should be removed from any measure of the trait, so that people who manage impressions do not receive biased scores.

Perhaps because of the association of the suppressor with the K scale of the MMPI, or perhaps for other theoretical reasons, a number of attempts have been made (Fricke, 1956; Fulkerson, 1958) to remove the influence of acquiescence by the use of the suppressor variable format. These early attempts failed to find a large improvement in prediction. Dicken (1963) undertook an investigation in which he expected good impression, social desirability and acquiescence to act as suppressors for the California Personality Inventory. Dicken summarized his results as follows:

> Suppression of desirability resulted in significant predictive gain in only 4 of 24 comparisons in the high school data. In the non-high school data, only 2 of 36 comparisons show a significant suppression effect, a result attributable to chance. There is no instance in the grand total of 50 comparisons of

> a large gain in validity by suppressing desirability...
> The expectation that correcting personality scores for individual differences in desirability responding will increase validity is not fulfilled. There were no instances of significant gain in validity by suppression of acquiescence variance. (p. 712).

Dicken's results thus indicate that these stylistic scales do not raise the empirical validity of the standard CPI scales; however, it should be pointed out that Dicken was dealing with low validities, i.e., validities of the order of .30, which, as will be shown, markedly constrains the possibility of suppressor effects. More recently, Goldberg, Rorer, and Greene (1969; Greene, 1967) investigated the usefulness of stylistic scales as potential suppressors or moderator variables in predictions from the CPI. Their stylistic scales for the most part satisfied suppressant criteria; they were highly correlated with CPI scales and virtually uncorrelated with their various criteria. They used 13 potential suppressors and moderators for 13 criteria-predictor pairs. In 30 of the 169 combinations there was a reasonable expectation of suppression. Under cross-validation half of them yielded a lower value than the zero-order validity, something not entirely unexpected in view of Lubin's (1957) analysis of the suppressor situation. Of all of their relations, only one showed any substantial incremental validity over the predictor alone.

It would be instructive to examine what reasonably might have been expected, given the magnitude of predictor-criterion correlations, as they typically occur, e.g., in the Goldberg, Rorer, and Greene study. This study is selected merely as illustrative. Others might have served equally well. Table 1 presents a set of validity coefficients selected from the single CPI scale with the highest validity for predicting each of 13 criteria. If the suppressors correlated zero with

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Insert Table 1 about here

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their criterion measures and possessed an r_{sp} of .50 , the maximum theoretical value is given in the second row of Table 1. (In practice, the suppressor-criterion correlation will not usually be precisely zero, nor, given the short stylistic scales used by these authors, will the reliability always be high enough to warrant the assumption of an $r_{sp} = .50$; these departures from our assumptions would tend to lower the maximum theoretical suppressor effect.) In reviewing Table 1, note that the theoretical increments in validity through the use of a suppressor of the order of .02 through .08 are not very large; however, they are the best that can be expected under the stated conditions. The best suppressor effects obtained in this study selected from a much larger number are given in the third row of Table 1. Note that the only substantial gain was for the CPA scale, a gain of .11, and that the departures from the theoretical maximum values ranged from .02 to .06. While substantial suppressor effects did not appear empirically, there were scant mathematical grounds for expecting any. The level of the reported validities did not permit such effects.

The conclusion of Goldberg, et al. was substantive however:

Table 1

Analyses of Stylistic Scales as Suppressor Variables:

The Cross-Validities of a Predictor plus a

Style Scale vs. the Validity of

Predictor Alone

Predictor Characteristic	Criterion												
	SOC	DOM	RES	HWK	DAT	SOR	FEM	GPA	PSY	YLD	MAJ	ACH	CDO
Predictor alone	51	44	41	41	40	39	36	33	29	28	25	19	13
Theoretical upper bound, assuming $r_{cs} = 0$, $r_{sp} = 50$	59	51	47	47	46	44	42	38	33	32	28	22	15
Maximum observed value of predictor + style scale for 13 style scales--average cross validity	53	46	42	39	42	39	39	44	--*	--*	24	--*	13
Difference between maximum observed value and theoretical upper bound	06	05	05	08	04	05	03	06	--	--	04	--	02

Note: Decimals omitted. An asterisk indicates that no suppressor effect was observed. Data from Goldberg, Rorer, and Greene (1969).

"Consequently, it now seems safe to conclude that stylistic variables, per se, do not function as general suppressor variables." These authors concluded the same about moderator variables, something that might be expected, given the intimate relationship that does exist between a suppressor variable and a moderator variable (Conger, 1969). But had these authors used the part or partial correlational rationale, they might equally well have concluded that under the conditions of their study, validities showed no substantial <u>decrease</u> when unwanted stylistic variance and response biases were eliminated from their predictors.

Limitations in Incremental Validity

Through the Use of Suppressors

It would seem that some systematic knowledge of the mathematical limitations imposed upon incremental validity in the use of suppressor variables is called for, given the disappointing empirical results. Consider the ideal classical suppression situation. Using either the formula for part or for multiple correlation will yield the suppressor equation

$$r_{c.sp} = \frac{r_{cp}}{\sqrt{1 - r_{sp}^2}} .$$

From this it is easy to see that the increment in prediction δ is, as derived by Lubin (1957),

$$\delta = r_{c.sp} - r_{cp} = r_{cp} \left[(1 - r_{sp}^2)^{-\frac{1}{2}} - 1 \right] ;$$

a difference which is not independent of the zero order validity. Lubin pointed out, for example, that to increase the validity by ten percent,

r_{ps} greater than .40 is required. Thus, if the original validity were .20, the increased validity would be only .22. Rather high values of r_{ps} must be obtained if any validity increase of practical importance is to take place. Of course, there are limits on r_{cp} and r_{ps} . Nevertheless, considering that $r_{cs} = 0$ the relation between r_{cp} and r_{ps} is $r_{cp}^2 + r_{sp}^2 = 1$. This is easily shown by using the partial correlation formula, i.e., r_{sp} is in the interval

$$r_{cs}\, r_{cp} \pm \sqrt{1 - r_{cp}^2 - r_{cs}^2 \pm r_{cp}^2\, r_{cs}^2}$$

Under the condition that $r_{cs} = 0$, the interval in which r_{sp} is found is $\pm \sqrt{1 - r_{cs}^2}$. If $r_{cp}^2 + r_{sp}^2$ is equal to 1, prediction would be perfect, as all variance is accounted for. Realistically, one should not expect to find the suppressor-predictor correlation to be much larger than the criterion-predictor correlation; probably, r_{cp} and r_{sp} will each be nearer .40 than .75, but all possibilities should be evaluated. Table 2 shows what can be expected in the way of incremental validity for pairs of validity and suppressor relations. For example, if a validity of .40 is obtained, a suppressor relation of .60 is needed to

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Insert Table 2 about here

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increase this by .10. Or taking Goldberg, Rorer and Greene's (1969) maximum validity of .51, a suppressor-predictor correlation of .50 is required to increase the overall relationship to around .59. The lowest validity reported by Goldberg, et al. was .13; in order to increase this by .07 one needs a suppressor-criterion

Table 2

Increment in Validity, δ , Due to Traditional Suppression

Suppressor-Predictor Correlation r_{sp}	Predictor-Criterion Correlation r_{cp}												
	.10	.20	.30	.40	.50	.60	.71	.80	.87	.92	.95	.98	.995
.10	000	001	002	002	003	003	004	004	004	005	005	005	005
.20	002	004	006	008	010	012	014	016	017	018	019	020	
.30	005	010	015	021	026	031	037	042	045	048	050		
.40	009	017	026	035	044	052	062	070	076	080			
.50	015	030	045	060	075	090	107	120	130				
.60	025	050	075	100	125	150	175	200					
.71	041	082	122	163	204	245	290						
.80	067	133	200	267	333	400							
.87	100	200	300	400	500								
.92	150	300	450	600									
.95	233	467	700										
.98	400	800											
.995	900												

Note: Decimal points are omitted from the increments which are expressed in thousandths correlation of over .80, a value which might well exceed the reliability of the predictor. Removing the suppressant would be equivalent to removing all of the valid variation. If one considers .40 as a validity typical of many psychological tests, the largest increase that could be expected would be .267. This would increase the original validity to .667, which would be very impressive; however, the suppressor-criterion correlation would have to be .80 for this to be achieved. To make things worse, improvement is not linearly related to the suppressor-predictor correlation. The relationship is such that the increment in improvement is less for lower correlations than for larger ones.

Insert Figures 2 and 3 about here

In Figure 2 curves are shown in which δ , the increment in prediction, is expressed as a function of the suppressor-predictor correlation for a fixed criterion-predictor correlation. These show that maximal increases can be expected for large validities and the expected gain becomes near zero for small validities, unless the suppressant effect is very large. The total picture is given in Figure 3. It clearly shows that a linear relationship obtains between the change in prediction for a fixed suppressor-predictor correlation (r_{sp}), whereas there is a curvilinear relationship when the criterion-predictor correlation (r_{cp}) is fixed and the remaining two components are free to vary. Thus, there is likely to be a discrepancy between subjective expectations and findings. An investigator who expects a linear improvement for suppressor effects is likely to be disappointed because these effects are curvilinear; they are smallest for lower and more frequently-encountered values

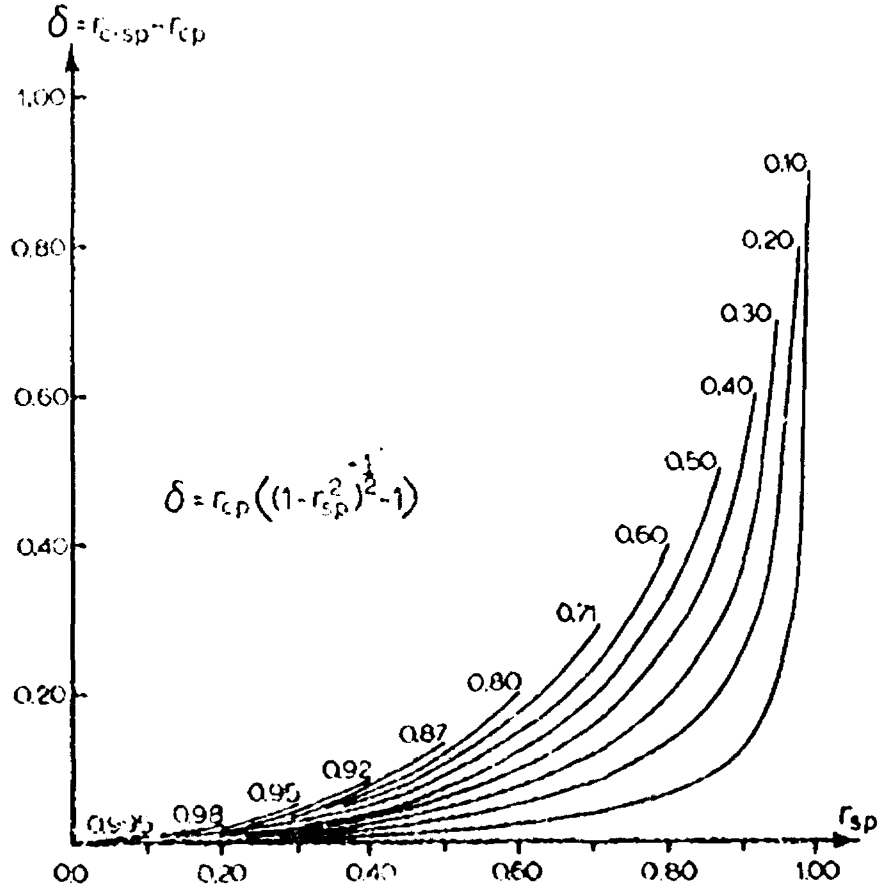

Figure 2

The Increment in Prediction, δ , Due to the Addition

of a Suppressor Variable shown as a Function

of r_{ps} for Different Values of r_{cp} .

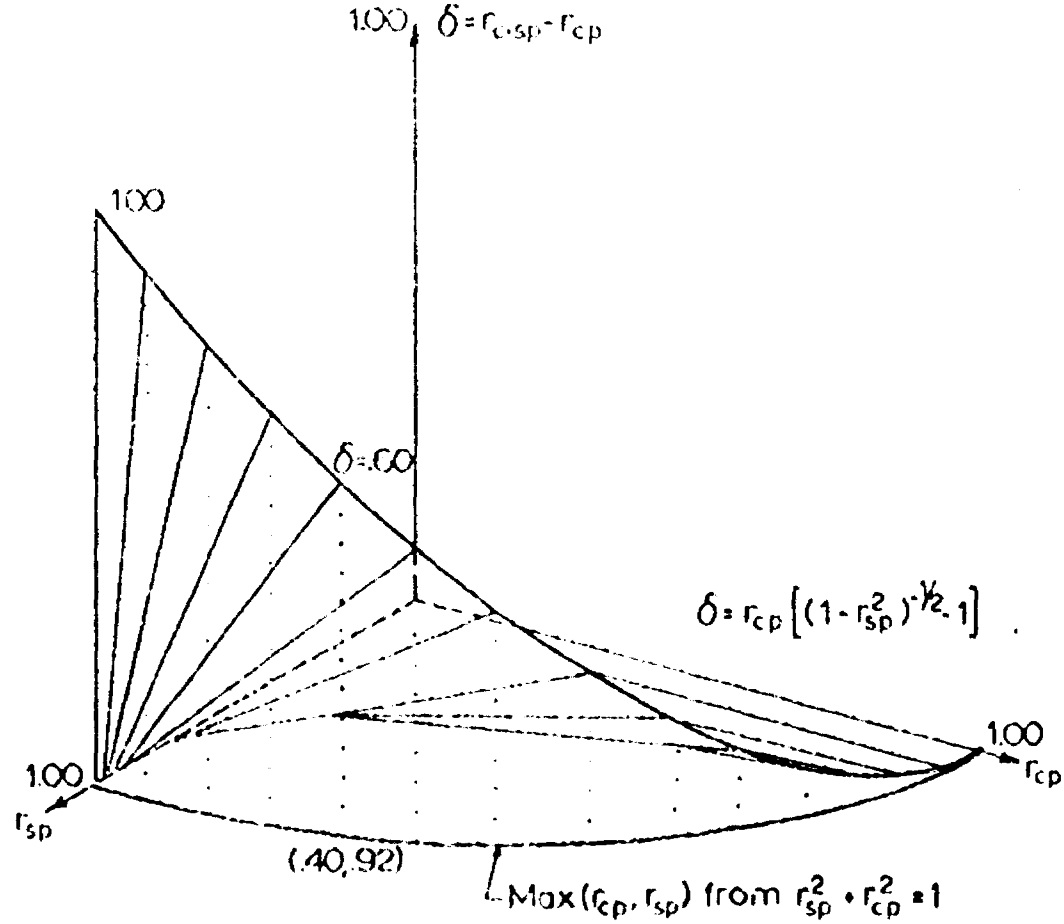

Figure 3

Three Dimensional Representation of the Increment in Prediction, δ, Due to the Addition of a Suppressor Variable shown as a Function of r_{cp} and r_{cs}

of r_{cp} , while showing an accelerating increment only for higher and more rarely-encountered zero-order validities.

Is It more Useful to Seek Suppressors or to Seek New Predictors?

Which strategy will generally yield the best payoff in terms of incremental validity, adding a second predictor or adding a suppressor? Will a predictor with a given level of validity add more than a suppressor with the same level of correlation with the first predictor?

Denoting the second predictor by q and letting r_{qc} be greater than zero we have a maximum <u>independent</u> contribution from q when $r_{pq} = 0$. Of course, if negative suppressors are allowed, q could contribute more if r_{pq} were less than zero; however, the present concern is with a simple predictor rather than the more complex (and less likely) negative suppressor. The increment in validity due to the additional predictor is $r_{c.pq} - r_{cp}$ where $r_{c.pq}$ is the multiple correlation for predicting c from both p and q , and it is given by the equation

$$r_{c.pq} = \frac{\sqrt{r_{cp}^2 + r_{cq}^2 - 2r_{cp}\, r_{cq}\, r_{pq}}}{\sqrt{1 - r_{pq}^2}} .$$

Under the stated conditions that r_{pq} is zero, this reduces to

$$r_{c.pq} = \sqrt{r_{cp}^2 + r_{cq}^2} .$$

The increment δp , which represents the improvement in prediction of multiple correlation over zero order correlation, is therefore

$$\delta_p = r_{c.pq} - r_{cp} = \sqrt{r_{cp}^2 + r_{cq}^2} - r_{cp} .$$

The increment for the suppressor given above is

$$\delta_s = r_{cp} \left[(1 - r_{sp}^2)^{-\frac{1}{2}} - 1 \right] .$$

If the increments are to be equal, then $\delta_p = \delta_s$ and

$$r_{cp} (1 - r_{sp}^2)^{-\frac{1}{2}} = \sqrt{r_{cp}^2 + r_{cq}^2} .$$

Simple algebra reduces this to $\delta_s = \delta_p$ if and only if

$$\frac{r_{cq}^2}{r_{cp}^2 + r_{cq}^2} = r_{sp}^2$$

This shows that r_{sp} must be greater than r_{cp} in order to obtain the same increase in validity. For example, let $r_{cp} = .40$, then

$$\delta_s = .40 \left[1 - r_{sp}^2)^{-\frac{1}{2}} - 1 \right]$$

and

$$\delta_p = \sqrt{.16 + r_{cq}^2} - .40 .$$

If a second predictor is found such that $r_{pq} = 0$ and $r_{cq} = .30$, then δ_p will be equal to .10, that is, there will be an increase in validity of .10. In order to get an increment of .10 with a suppressor, we solve the δ_s equation for r_{sp}^2 and find that r_{sp} must be equal to .60. In this case, the suppressor-predictor correlation must be twice as large as the second predictor-criterion correlation. In terms of variance accounted for, the suppressor must account for four times as much variance in the predictor as the second predictor must account for in the criterion. Obviously, efforts would be better spent looking for correlations of the same size with the criterion rather than with the predictor. A suppressor for any given degree of correlation does not yield as much incremental validity as an additional predictor. Therefore, more can be gained by finding that part of the criterion not being predicted rather than that part of the predictor not being used.

In the light of all of these considerations, should the uncritical search for the suppressor variable be suppressed?

Conclusions

1. The use of a suppressor rationale in prediction may be justified under certain conditions where it can be demonstrated that it is possible to account for a reliable proportion of the predictor variance after cross-validation in terms of a variable not associated with the criterion. This situation is rarely encountered in practice.
2. Under ideal conditions for the operation of suppressor effects, i.e., where the suppressor-criterion correlation is zero, it is shown that the suppressor approach will yield results mathematically identical with those obtained from the part and partial correlation.
3. If maximum prediction is the primary goal, the use of the suppressor approach is appropriate if, and only if, the suppressor-criterion correlation is zero. Where the value of the suppressor-predictor correlation departs from zero, it is shown that the use of the

multiple correlation will always yield a higher validity than will the use of the pure suppressor approach. It should be recognized, however, that estimates of the contribution of a predictor to a multiple correlation will be unstable where both the magnitude of the relationship and the sample size are modest.

4. A theoretical limit on the suppressor is operative such that the upper bound of incremental validity over the predictor alone is curvilinearly related to the magnitude of the predictor-criterion validity, with the increment smaller for lower initial validities than higher ones. The curvilinearity may be important in that the researcher's subjective expected improvement is likely to be linear; however, the objective improvement is not.

5. It is shown that attempting to isolate the part of the predictor not relevant to the criterion is ordinarily less efficient than predicting that part of the criterion not being predicted. New predictors will be easier to find than will effective suppressors.

6. A valid distinction may be drawn between the use of the suppressor approach in the context of prediction and in the context of the construct interpretation of psychological measures and relationships. Whereas the suppressor can be justified in prediction only if it substantially improves prediction, the use of the part or partial correlation is justified even if the resulting validity remains unchanged or is reduced, provided its application removes a conceptually irrelevant portion of the variance. This latter approach is preferable in studies focusing upon the interpretation of psychological relationships.

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