Depression and cognition: New insights from the Lorenz curve and the Gini index[1]

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ABSTRACT. This *ex post facto* prospective study reports the use of statistical techniques known as the Lorenz curve and Gini index to analyze the content of depressive cognitions as a function of attributional negative style (*i.e.*, internal, global and stable causal attributions for failure or negative events, as proposed by the learned helplessness model) and negative cognitive triad (*i.e.*, a negative view of oneself, ones future and ones world, according to Beck's cognitive model of depression). These statistical techniques revealed that attributional style was poorly related with depression level, whereas the negative cognitive triad showed a close relationship and provided a more accurate description of the depressive cognitive pattern. We also document how the Lorenz curve and Gini index can be used to assess the predictive capacity of different instruments or the strength of the relationship between different variables and psychological disorders, and to evaluate different models proposed to explain these disorders. This pioneering study reveals the potential usefulness in Psychology of these statistical techniques, mainly used in Economical sciences, for analyzing the validity of different factors and possible predictors of specific psychological disorders, or to enhance existing instruments, as our present study with depression shows.

KEYWORDS. Depression. Lorenz curve. Gini index. Attributional style. Negative cognitive triad. *Ex post facto* prospective study.

RESUMEN. La principal aportación del actual estudio prospectivo *ex post facto* es el uso de técnicas estadísticas conocidas como la Curva de Lorenz o el Índice de Gini, para analizar el contenido de las cogniciones depresivas, en función del estilo atribucional (*i.e.*, atribuciones internas, estables y globales para las causas del fracaso o de sucesos negativos, como propone el modelo de la indefensión aprendida) y la triada cognitiva negativa (*i.e.*, una visión negativa de sí mismo, del mundo y del futuro, acorde al modelo cognitivo de Beck de la depresión). Tanto las curvas de Lorenz, como los índices de Gini, revelaron que, mientras el estilo atribucional estaba poco relacionado con el nivel de depresión, la triada cognitiva negativa mostraba una alta relación, lo que sugiere que esta última constituye una mejor descripción del contenido cognitivo de los pensamientos depresivos. Al mismo tiempo, este estudio documenta como ambas técnicas, Índice de Gini y Curva de Lorenz, pueden usarse para evaluar tanto la capacidad predictiva de diferentes instrumentos o técnicas de medida psicológicas, como la validez de las variables propuestas por los modelos teóricos que pretenden explicar trastornos psicológicos concretos. Este estudio pionero revela por tanto, la utilidad potencial de estas técnicas estadísticas en Psicología tanto para analizar los factores o predictores de trastornos psicológicos específicos, como para potenciar los instrumentos de medida existentes, como se ha mostrado en este trabajo para la depresión.

PALABRAS CLAVE. Depresión. Curva de Lorenz. Índice de Gini. Estilo atribucional. Triada cognitiva negativa. Estudio prospectivo *ex post facto*.

RESUMO. O presente estudo prospectivo *ex post facto* relata o uso de técnicas estatísticas conhecidas como a Curva de Lorenz ou o Índice de Gini, para analisar o conteúdo das cognições depressivas, em função do estilo atribucional (*i.e.*, atribuições internas, estáveis e globais para as causas do fracasso ou de acontecimentos negativos, como propõe o modelo do desânimo aprendido) e a tríade cognitiva (*i.e.*, uma visão negativa de si mesmo, do mundo e do futuro, de acordo com o modelo cognitivo de Beck da depressão). Tanto as curvas de Lorenz, como os índices de Gini, revelaram que, apesar de o estilo atribucional estar pouco relacionado com o nível de depressão, a tríade cognitiva mostrava uma alta relação, o que sugere que esta última constitui uma melhor descrição do conteúdo cognitivo dos pensamentos depressivos. Ao mesmo tempo, este estudo documenta como ambas as técnicas, Índice de Gini e Curva de Lorenz, se podem usar para avaliar tanto a capacidade preditiva de diferentes instrumentos ou técnicas de medida psicológicas, como a validade das variáveis propostas pelos modelos teóricos que pretendem explicar perturbações psicológicas concretas. Este estudo pioneiro revela portanto, a utilidade potencial destas técnicas estatísticas em Psicologia tanto para analisar os factores ou preditores de perturbações psicológicas específicas, como para potenciar os instrumentos de medida existentes, como se mostrou neste trabalho para a depressão.

PALAVRAS CHAVE. Depressão. Curva de Lorenz. Índice de Gini. Estilo atribucional. Tríada cognitiva negativa. Estudo prospectivo *ex post facto*.

Introduction

Epidemiological studies have shown that approximately 16% of all persons in the general population have at least one episode of depression during their life in USA (Kessler *et al.*, 2003; Matud, Guerrero, and Matías, 2006)**.** Many authors have described

depression as a heterogeneous group of disorders ranging from transitory mood changes to chronic syndromes, with differences in the manifestation of symptoms. Variability is seen not only in the nature of the symptoms and duration of the manifestations, but also in the causes of the disorder. Although some studies have shown a significant association between negative events and depressive symptoms (*e.g.*, Billings and Moods, 1982), the fact is that most people who experience situations that could be considered extremely negative and stressful do not become depressed. The diversity of responses that people show to the same stressors has led researchers to look for the underlying causes of this variability, with the ultimate aim of predicting who can be expected to have a depressive reaction and under which circumstances. Among the factors that may be involved in the origin, and especially in the maintenance, of depressive behavior, certain cognitive features such as habitual thought patterns, the way in which persons cope with the world, or how they perceive the world, may be key determinants in this disorder. Some studies have found evidence of a role of negative cognitions during a depressive episode, *i.e.*, cognitions that distinguish depressed subjects from non-depressed persons (see reviews by Haaga, Dyck, and Ernst, 1991; Joiner and Wagner, 1995; Sweeney, Anderson, and Bailey, 1986).

From a cognitive perspective, two theoretical proposals that have attracted researchers' interest in recent decades are the models of depression based on learned helplessness (Abramson, Seligman, and Teasdale, 1978; Peterson and Seligman, 1984) and on Beck's cognitive theory (Beck, 1987). The learned helplessness model postulates that the explanations persons give for events that happen to them, particularly for negative events, affect the likelihood of suffering from a mental disorder as well as the severity and duration of the disorder. Specifically, the learned helplessness model proposes an attributional style that typifies depressed subjects and makes them more likely to make internal, stable and global attributions for their own failures or for the negative events that happen to them (for example, "It's my fault because I'm worthless"). These attributions, as the perceived causes of a given event, act as modulators in the formation of future negative expectations, thereby propitiating the onset and maintenance of the disorder. Therefore attributional style is defined as a cognitive risk factor (considered as a factor similar to a personality trait, see Peterson and Seligman, 1984) which predisposes the individual to depression, and which is manifested as the appearance of a depressed state.

Beck's theory of depression (Beck, 1987), developed within the conceptual framework of cognitive schemata, centers on the existence of self-schemata with negative content, which may act as causal factors of depression by inducing the subject to perceive and interpret environmental stimuli in a negative or pessimistic manner. These schemata are cognitive structures that filter incoming information, guide attention, and influence expectations, interpretations and memory functioning. In this model, dysfunctional schemata involving contents of loss or failure referred to oneself, the future and the world (Beck's cognitive triad) are considered risk factors for depression. The effect of these schemata on information processing leads to a distorted and skewed perception of reality. According to Beck and colleagues, persons develop these schemata in early stages of development. Although they can remain inactive for prolonged periods, these

schemata can be activated later in life by stressful or negative environmental events giving rise to depression (Beck, 1987; Beck, Rush, Shaw, and Emery, 1979).

Most of the research into the relationship between cognitions and depression, and into the influence of cognitions as a factor that increases vulnerability to depression, has consisted of correlational and longitudinal studies in which the relation between levels of depression and differences in cognitive style was investigated concurrently or during prolonged periods. In general, the results of these studies have been inconclusive and only a small amount of the variance was explained by these cognitions (see review by Haaga *et al.*, 1991). Apart for the lack of consensus regarding the potential usefulness of these approaches to explain the relationships between cognitions and depression, some authors have noted that there may in fact be some overlap between the learned helplessness (attributions) theory and Beck's (schemata) theory of depression (Abramson, Alloy, and Metalsky, 1988; Fiske and Linville, 1980; Reno and Halaris, 1989). The differences between these models lie in the paradigms and metaphors each one uses to characterize cognition (Fiske and Linville, 1980). The schemata-based approach centers on the organization of previous knowledge, and on how this organization determines the ways in which incoming information is processed; attributional analysis, on the other hand, examines how incoming information is explained by the subject, and how these explanations determine subsequent cognitions, affect and behavior. Empirical support to date for the two theories summarized above is confusing, and although there appears to exist a cognitions set of negative content that accompany depressive disorder, the exact nature of these cognitions is unclear.

The main contribution of this research however, is the application of "new" statistical techniques in Psychology -the Lorenz curve and Gini index- which have been previously used in other scientific disciplines (Lee, 1997). The Lorenz curve was developed in the field of economics (Dagum, 1981) and originally it was constructed from continuous variables comparing the cumulative proportion of population in x-axis, and cumulative proportion of incomes in y-axis. It has been later used in demographics and even in epidemiological studies to evaluate the risk of occurrence of diseases or death as a function of different risk factors (Lee, 1997; Llorca and Delgado-Rodriguez, 2002). In this case, the y-axis is constructed from a dichotomous variable (diseased/non-diseased, died/alive). In the present study we have used this last approach to analyze the relationships between depression and cognitive style from the distribution of persons with depression in the y-axis with the cumulative proportion of population with a depressive cognitive style (*i.e.*, persons with a depressive attributional style or a negative cognitive triad) in the x-axis.

In essence, the Lorenz curve in the epidemiological and clinical approach is just the plot of the cumulative percentage of cases along a given variable or disease against the cumulative percentage of population with a given level of another variable (for example: gender, exposure to stressors, cognitive style, etc). The data are plotted in a unit square field, and the resulting straight line and curve illustrate the concentration or dispersion of such cases in different population groups. When the percentage of the affected individuals in all population groups is the same, the Lorenz curve overlaps the diagonal line that crosses the unit field from the origin upward toward the right. Otherwise,

the degree of convexity of the curve represents the different concentration of cases in different groups. This abstract measure makes it possible to compare dispersions in different populations and to draw a qualitative analysis of the relationships between the plotted variables (Lee, 1977). To plot the Lorenz curve it is first necessary to define the levels of disease risk from the lowest, *i.e.*, the absence of disease, to the highest level of disease designated i (i = 1, 2..., k). The number of subjects in each level of this variable is designated n_1 to n_k from the total sample (N). The number of cases in each of the other dichotomous variables (for example, sex or the two different cognitive styles, in this study) is represented by d (d_1 to d_k, D being the total number of cases having this specific cognitive style; see Table 1 from the second to the last column). The curve is plotted with the help of the equations presented in the Appendix.

In the present study we used the Lorenz curve to illustrate the relationship between being depressed and having a specific cognitive style. If the risk of depression were exactly equal for the chosen level of the other variables (attributional style or negative cognitive triad), the Lorenz curve would overlap the diagonal line; this would indicate the absence of any relationship between the two variables. However, if all cases occurred at a given level of depression, the Lorenz curve would overlie the x-axis up to the point where the variable under study is related with the occurrence of the disease (either at a sub-clinical or clinical level) at which point the Lorenz curve would begin to bend upward (Lee, 1997). Therefore, the area between the Lorenz curve and the diagonal is a qualitative index of the association between the two plotted variables, in our case depression and cognitions. Accordingly, a smaller area or a flatter curve (see for example, Figure 1) means a more uniform distribution in the disease risk, in other words, the absence of relationship between depression and the factor plotted on the x-axis, whereas a larger area or a more strongly bowed curve shows that the risk of depression is indeed associated with the chosen level of the other variable (see for example, Figure 2). This qualitative analysis goes beyond any type or correlational or regression coefficient.

Among the analytical measures of this fit when distribution is not normal, the Gini index is the most widely used. The Gini index is a summary measure of the deviation in the Lorenz curve, and represents twice the area between the Lorenz curve and the diagonal line. It provides a numerical value between zero, meaning greater uniformity or a flatter curve and the absence of relationships between the two variables, and one, indicating greater variability or a more bowed curve and the existence of an association between the presence of disease and the other variable (Lee, 1997). The area under the Lorenz curve is calculated as (1 – Gini)/2 and the Gini index calculation can be seen in the Appendix. For a quantitative analysis, the Gini index allowed us to convert the curves into numerical values to facilitate comparisons with other measures, such as correlation. However, in order to derive any conclusion from this numerical measure, it is necessary to analyze the plot of the curves, as different curves can produce the same.

Our ultimate aim in this *ex post facto* prospective study (Montero and León, 2005; Ramos-Álvarez, Valdés-Conroy, and Catena, 2006) was to show how both the Lorenz curve and the Gini index can be used as tools to analyze the qualitative and quantitative

degree of the relationships between cognition and depression in a more accurate manner than is offered by correlation or regression analyses mainly used to date (Haaga *et al.*, 1991; Lee, 1997).

Method

Subjects

The participants were 178 first-year psychology students at the University of Granada (Spain), who volunteered to complete the questionnaires and provide the data requested for this study. Mean age was 20 years, and there were 143 women and 35 men.

Instruments

  – Beck Depression Inventory (BDI; Beck, Steer, and Garbin, 1988). This questionnaire consists of 21 items that evaluate the intensity of depression The BDI was used to distribute participants into different groups depending on the level of depression. This is the most widely used self-report instrument internationally for quantifying symptoms of depression in populations of healthy persons and persons with any clinical diagnosis, in professional practice and in research (Vredenburg, Flett, and Krames, 1993). The BDI scores correlate highly with the interview-based diagnosis (Taylor and Klein, 1989) and the reported Spanish reliability of the BDI is .83 (Sanz and Vázquez, 1998).
  – Cognitive Triad Inventory (CTI; Beckham, Leber, Watkins, Boyer, and Cook, 1986). This instrument was used as a measure of the cognitions an individual sustains about himself or herself, the world and the future. The inventory is presented as a list of different statements, 10 items are devoted to each of these three dimensions and participants indicate which of them they agree or disagree with. The responses are marked on a 7-point Likert scale (1 indicates total disagreement, 7 indicates total agreement, 4 indicates neutrality). The scores range from –30 to +30 for each dimension, and from –90 to +90 for the entire inventory. Reported reliability is .95, with an alpha for each dimension of .81 (self), .91 (world), and .93 (future).
  – Attributional Style Questionnaire (ASQ; Peterson *et al.*, 1982). This instrument was used to evaluate the cognitions proposed by learned helplessness theory. The 12 items describe six positive and six negative situations, and the subject is asked to imagine her or himself in each situation and then answer three questions, each of which corresponds to the dimensions proposed by Abramson *et al.* (1978): internality, stability, and globality. Each of the resulting 36 items is scored on a 7-point Likert scale, with 1 indicating attribution to external, unstable and specific causes, and 7 indicating attribution to internal, stable and global causes. Reported reliability of the ASQ for each dimension evaluated for the negative situations is .46 for internality, .59 for stability and .69 for globality (Golin, Seweeney, and Schaeffer, 1981; Peterson *et al.*, 1982; Sanjuán and Palomares, 1998).

Statistical procedure

The main requirement by the statistical technique used to plot the Lorenz curve is to know the normal population distribution on the factor under study, in our case depression. It is well established and accepted in the literature that the BDI allows the distinction between people with different levels of depression, and even this measure can be used to determine the therapeutical need of patients or their improvement during or after therapy (Alloy and Clements, 1998; Beck *et al*., 1979; Burns, 1980; Oliver and McGee, 1982). In defense of the notion of levels of depression, it is important to remember that depression is diagnosed by the number and severity of symptoms, and what actually appears to be a linear relationship between the two, seems to be compatible with a view of discontinuity. Moreover, moderate depression usually precedes severe depression, and subjects who have had moderate depression are often at greater risk of suffering severe depression (Vredenburg *et al*., 1993).

Accordingly, the participants were first divided into two groups on the basis of their BDI score: without depression (BDI < 10) and with depression (BDI ≥ 10). In other words, we determined how many individuals had depression according to the Beck Depression Inventory. The "with depression" group was divided into two subgroups: participants with mild mood disturbance (BDI 10-16) and those whose score indicated intermittent depression to severe depression requiring professional care (BDI > 16). All these cut-off has been widely used either in research (see Oliver and McGee, 1982) or in the therapeutical practice (Beck *et al*., 1979; Burns, 1980). The "without depression" group was also divided into two subgroups: those whose score (BDI 0-5) indicated absence of depression, and those with very mild depression of negligible clinical significance (BDI 6-9). The variable depression, as identified and quantified with the BDI, was thus stratified into four levels ranging from the absence of depression to the existence of a depressive state (Table 1). This distribution is the diagonal against which we will compare the distribution of the other variables derived from the questionnaires based upon the two cognitive models of depression.

Once the total sample was distributed according to their level of depression, first of all, we established different groups of participants who were identified as having a depressive attributional style, *i.e*., the tendency to make internal, stable and global attributions for failure (see Seligman, Abramson, Semmel, and von Baeyer, 1979) on the basis of their scores on the Attributional Style Questionnaire. As stated in the introduction we will plot in the y-axis the proportion of population having a "depressive attributional style", which means that we are using a dichotomous variable (Lee, 1997). To analyze the influence of each of the three dimensions of the ASQ, we used the midpoint of the scale (internal, stable and global > 4) as a cut-off to identify the population with an internal, stable, global attributional style for failure, as it has been made in previous research to select people with a depressive attributional style. To analyze the combined influence of all three dimensions we established firstly, the total cut-off score as >12. However, we note that a composite score > 12 does mean that the score on each of the three dimensions was always > 4 (*i.e*., indicative of internal, stable and global attributions for failure). We therefore reanalyzed the scores with a cut-off of 14 for the total composite score. This cut-off produced different results and it did

guarantee the existence of a depressive attributional style as the lowest score on any of the three dimensions separately was always > 4.17; however, it considerably reduced the population identified as having this style (see Table 1).

As a final preliminary step, we classified the participants on the basis of the Cognitive Triad Inventory, which measures the negative cognitive triad hypothesized by Beck's model to be a basic component in individuals with depression. To analyze each factor of the CTI separately, we used cut-off scores of < 0 for "self," < 5 for "world" and < 5 for "future." These choices were based on previous studies of persons with and without depression, which showed that the mean score for "self" among persons with depression was lower than 0, whereas for "world" and "future" the mean scores were consistently between 0 and 5 (Herrera and Maldonado, 2002). We then used a cut-off for the composite score for all three factors of < 10 to evaluate their joint influence. The results were very similar when a composite score of < 0 was used (Gini index = .69), although the sample size was reduced (D = 16) for participants with this more negative cognitive style (Table 1).

TABLE 1. Distribution of participants as a function of depression and cognition.

BDI	BDI	Int	Stab	Glo	NC>12	NC>14	Self	World	Fut	CTI<10
Level 1: 1-5	77	33	15	20	21	3	1	5	2	1
Level 2: 6-9	45	20	13	21	19	5	8	4	3	3
Level 3: 10-16	38	20	12	14	18	5	18	13	9	11
Level 4: > 16	18	12	8	14	11	8	14	13	7	11
Total	N=178	D=85	D=48	D=69	D=69	D=21	D=41	D=35	D=21	D=26
Gini Index		.071	.151	.172	.155	.428	.573	.483	.513	.619
Correlation	BDI	Int	Stab	Glo	ASQ-COMP		Self	World	Fut	CTI-COMP
BDI	-	.16*	.17**	.30**	.26**		-.70**	-.51**	-.57**	-.69**

Notes. Distribution of participants in each level or group according to their score on the BDI (Beck Depression Inventory) (first column) as a function of BDI score, each dimension of the ASQ (Attributional Style Questionnaire) separately (internal, stable and global > 4), ASQ negative composite score (NC > 12 and NC > 14), each dimension of the CTI (Cognitive Triad Inventory) separately (self < 0, world < 5, future < 5) and CTI total score (CTI < 10). N: total sample number; D: sample for each dimension or factor. The ASQ-COMP and CTI-COMP are the sum of all three dimensions. Significant correlations: *p < .05, **p < .01.

The Lorenz curves allowed us to plot the distributions, to show graphically their relationships and to make a qualitative study about which model best explains depression in the population we studied and the degree of the relationships between these cognitive variables and depression. The more evenly individuals with a particular depressive cognitive style (according to the CTI or the ASQ) were distributed between the different groups according to the BDI, which indicates the degree of depression, the less accurate that particular cognitive style could be related to depression. In this way, the curves provide information about qualitative variables, even although they are measure in a quantitative way, and they can allow to infer the degree of validity of each instrument and theoretical model.

Results

Table 1 lower panel shows the Pearson coefficient correlation between the BDI scores with CTI and ASQ scores. All measures showed a significant correlation with level of depression (BDI), with most correlations at $p < .01$. These results are similar to the findings usually reported when these instruments are used with university students. Moreover, all measures correlated significantly with each other with the exception of view of the world according to the CTI and internality dimension in the ASQ. These results, like those of other studies, make it difficult to draw definite conclusions from the correlations we obtained (Haaga *et al*., 1991). Further conventional analysis of such correlations would have been inconclusive beyond the more or lesser significant level and the amount of variance each measure is able to explain. However, a re-analysis with the Lorenz curve and the Gini index yielded intriguing new insights.

First of all, for a quantitative analysis, the Gini index provided a numerical abstract measure of the Lorenz Curve. Table 1 showed the index for each measure. It is important to acknowledge that the results are qualitatively similar to those provided by the correlation index (see Table 1), which suggest that this measure is accurate enough to describe the relationships between such cognitive patterns and depression. It is also important to note that according to this index, only the composite ASQ > 14 and any of the CTI scores were significant which suggest a more stringent criterion of statistical significance according to this index. However, this index, as well as any other numerical index derived from the distribution (for example, the Pietra index), need to be complemented by the qualitative analysis of the Lorenz curves, given that the same Gini index can be obtained from different curves and distributions. Consequently, the most important contribution came from the qualitative analysis of the data based upon the Lorenz curves. Table 1 shows how the participants were distributed on the basis of their level of depression. Again, the results are similar to those of epidemiological studies (Kessler *et al*., 2003): more than 10% of the participants could be considered depressed. This table also summarizes how participants were distributed according to the different factors we analyzed, *i.e*., as a function of attributional style or cognitive style.

The distributions of people having an internal or stable or global attributional style were closely similar to the distribution of depression among the total population. Figure 1 shows the Lorenz curve for the ASQ scores for each attributional dimension. Given that each curve almost overlaps the diagonal, any of the three dimensions separately was not a good predictor of depression. Even when the composite negative score for the ASQ was > 12, this result was not significantly associated with depression, as neither the distribution (Table 1) nor the curve (see Figure 2) differed from the total population distribution. However, it should be noted that when the composite score cut-off was increased (ASQ > 14), the distribution (Table 1) and the curve (Figure 2) changed and this composite score became a much better predictor of depression, although the risk that depression would not be accurately predicted (false positives) remained high (38%).

FIGURE 1. Lorenz curves for scores on each of the dimensions of the Attributional Style Questionnaire (ASQ): Internal, Stable and Global.
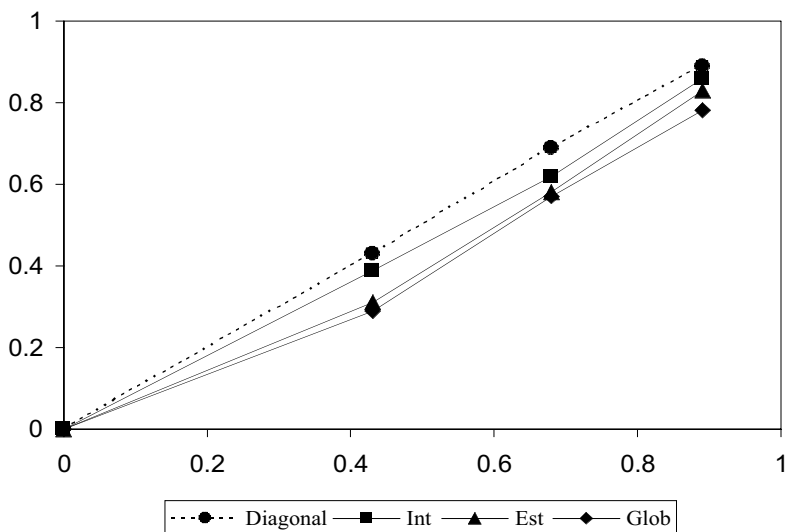
Note. The straight diagonal line illustrates a hypothetical absence of any relationship between the BDI score and other variable.

FIGURE 2. Comparison of the Lorenz curves for scores on the BDI plotted against the ASQ negative composite with cut-off scores of > 12 and > 14 and CTI composite score < 10.
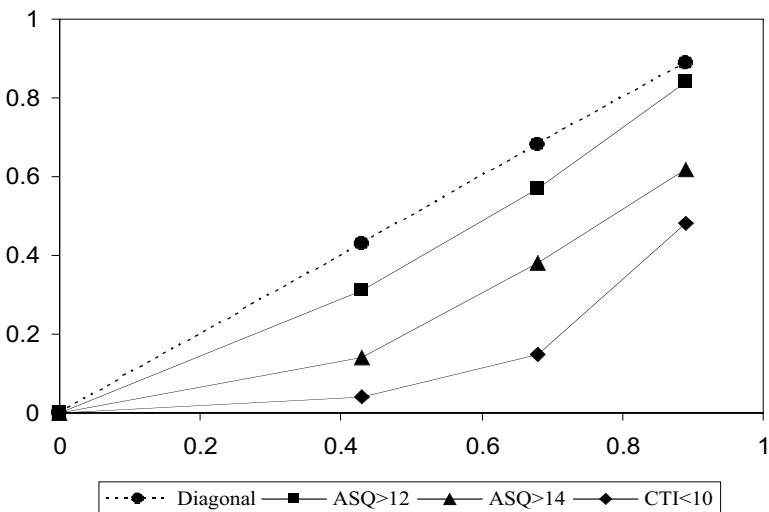
A very different picture appeared looking at the distribution of people with a negative cognitive triad, proposed by Beck (1987). The Lorenz curve showed a close relationship between CTI composite score and depression (Figure 2). The distribution of people having such cognitive pattern accumulated in the two depressive levels of the total population (Table 1) and the proportion of false positives were low (15%). In addition, each of the dimensions separately was also an excellent predictor of depression, especially view of self (see, Figure 3). Nonetheless, the best related was the composite score.

In summary, these last results contrasts with those obtained for the ASQ: neither the composite score nor any of the dimensions separately was especially good related to depression (see Figures 1 and 2), and the composite score was somewhat effective only at a very high cut-off value, which greatly reduced the number of individuals identified as being depressed. This lack of effectiveness of the ASQ was further underscored by the considerable number of false negatives (44%) and false positives (38%) (see Table 1). These findings confer a greater degree of plausibility to the negative cognitive triad theory of depression (Beck, 1987) than to the attributional theory based on the learned helplessness model (Abramson *et al.*, 1978).

FIGURE 3. Lorenz curve for scores on each of the dimensions of the Cognitive Triad Inventory (CTI): Self, World and Future.
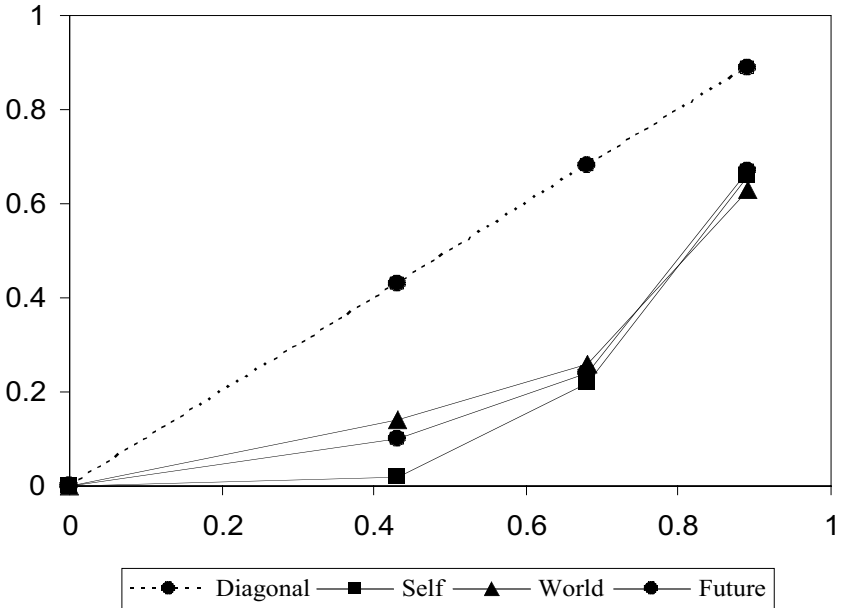
Discussion

The main contribution of this research lies in our demonstration of the usefulness of "new" techniques -the Lorenz curve and Gini index- for statistical analysis in Psychology. These techniques allowed to quantitative and especially qualitatively assess the risk of depression as a function of an individual's cognitive style. This approach also sheds light on the discriminant power of different instruments, factors and theories; in this case, the ASQ and CTI as instruments to measure the depressive attributional style proposed on the basis of the learned helplessness model, and the depressive negative cognitive triad based on Beck's model of schemata.

The Lorenz curve as an analytical tool

The results obtained with our application of the Lorenz curve and Gini index suggest different conclusions. Firstly, our analysis of the ASQ scores as a measure of attributional style showed that none of the three dimensions separately was related with the level of depression, despite the previous replication of significant correlation found between each dimension separately and depression in accordance with previous research. Moreover, the results of our analysis of the composite negative score raise serious questions regarding its value as a predictor of depression, as an internal, stable and global attributional style for failure frequently exists in normal individuals. This, however, does not mean that individuals with depression do not have this attributional style. Depression, in fact, appears to have some relationships with a negative attributional style at higher cut-off scores, *i.e.*, when a stringent criterion is used to identify a negative attributional style (ASQ > 14). Nonetheless, the risk of failed prediction (false positives) remains high even when using this high cut-off score.

Secondly, our analysis of the CTI as a measure of the negative cognitive triad showed that a negative view of oneself, the world and the future was highly related to depression. It should nonetheless be noted that this cognitive style does not differentiate between levels of depression, as it was uniformly distributed among patients with moderate degrees of emotional alteration (BDI 10-16) and those with more severe depression (BDI > 16). This distribution suggests that although such negative cognitions exist among depressed people, they are not able to further discriminate among levels and probably types of depression, although this issue remains open to future research. In any case, the findings will need to be validated for other types of samples. However, before the present findings are interpreted in detail, some clarification is in order regarding the usefulness of the type of sample used in the present study.

Sampling problems and the conceptualization of depression as a continuum

Most research into the relationship between cognition and depression has used samples composed of university students (Spangler, Simons, Moroe, and Thase, 1997). This has given rise to several criticisms with regard to the generalizability of the findings to the general population, owing to differences in factors such as age, education and socioeconomic status (Depue and Monroe, 1978). In particular, questions have been raised about the validity of using students with moderate degrees of depression, selected on the basis of scores on self-reporting questionnaires (mainly the BDI), as a

population analogous to patients with clinical depression, which is more severe and requires therapy and occasionally hospitalization. The use of this type of sample is based on the consideration of depression as a continuum; under this assumption, subjects selected from nonclinical populations are at the lowest end of the continuum, whereas individuals with clinically diagnosed depression are at the opposite end. In other words, the difference between the two populations is quantitative rather than qualitative (Peterson, Maier, and Seligman, 1993). In defense of the notion of levels of depression as a continuum, Peterson *et al.* (1993) (see also Vredenburg *et al.*, 1993) wrote that depression is diagnosed by the number and severity of symptoms, and what actually appears is a linear relationship between the two. Moreover, moderate depression usually precedes severe depression, and subjects who have had moderate depression are often at greater risk of suffering severe depression. This is not compatible with a view of discontinuity (Kessler *et al.*, 2003).

Some authors have suggested that this view does not reflect reality. Depue and Monroe (1978) have argued that clinical samples show patterns of symptoms that are much more somatic and behavioral that those observed in students, and Gotlib (1984) has noted that measures of depression in samples of college students correlate with a variety of other psychopathological constructs, including anxiety, hostility and maladaptive beliefs. As a result, depression in this type of sample can be considered as merely a general psychological disturbance. In addition, Coyne and Gotlib (1983) have reported that many of the high scores found in this type of sample are ephemeral and do not correspond to what is usually observed in the clinical population. However, recent research has shown that the risk factors are the same for both "degrees" of severity and the most important data, published in meta-analyses that included studies with students and those with clinical samples as subjects, suggest that the findings are similar when the two types of sample are considered separately (Joiner and Wagner, 1995; Sweeney *et al.*, 1986).

Although the results of the present study do not allow us to resolve this issue, the fact that negative cognitions occur equally frequently in persons with different degrees of depression suggests that depression exits, from a cognitive standpoint, as a continuum in which the degree of severity of depression does not depend on the negative cognitions -which are common to both moderate and severe depression- but rather on other factors that may be altered and that await characterization in future research. Because of the pioneering nature of this study, the findings will need to be validated for other types of samples that include individuals with clinically diagnosed depression and with different types of depression (whether treated or untreated), however, such a study exceeds the scope and aims of the present report.

Cognitive models of depression: attributions versus schemata

It is clear that there exists a relationship between depressive state and cognitive style, such that the more negative the content of the cognitions, the higher the risk of depression. This connection has been found in most pertinent studies, which have reported a relationship between the severity of symptoms and a negative cognitive style (*e.g.*, Golin *et al.*, 1981; Seligman *et al.*, 1979; Sweeney *et al.*, 1986). However, the

present analysis, which considers each of the dimensions separately, provides evidence that the relationship between negative cognitions and depression is clearer when depression is examined from the theoretical precepts of Beck's cognitive model. Any of the dimensions of the CTI is able to distinguish between the presence and the absence of depression, whereas this is not true for the individual dimensions of the ASQ. With regard to attributional style, only the composite score predicted depression to some degree, but only when a high cut-off score was used. Even under these conditions its discriminant power remained poor: the number of false positives, *i.e.*, individuals in the normal population identified erroneously as having a depressive cognitive style were high, hence the rate of failure of prediction (mainly false positives) was also high.

The problem with the learned helplessness model, which assumes a major role for attributional style, is that making internal, stable and global attributions for failure is not a unique characteristic of individuals with depression. This is not to say that persons with depression do not show this characteristic, or that it is not proportionally more frequent among persons with depression than among normal individuals. Rather, the learned helplessness model is not useful in predicting depression because it yields a large number of false positives (up to 40% even in the best analyses). In contrast, having a negative view of oneself, the world and the future does appear to be a feature specific to individuals with depression, and in this sense the discriminant capacity and predictive power of the CTI are greater. This confers a greater degree of plausibility to the negative cognitive triad theory of depression (Beck, 1987) than to the attributional theory based on the learned helplessness model (Abramson *et al.*, 1978).

The present analysis offers is a novel contribution to the study of how cognition and depression are related, and suggests that an individual's view of self, the world and the future is a more powerful discriminator and predictor of depression than is his or her attributional style. When the negative cognitive triad is tested, negative cognitions are found almost exclusively in persons with depression, whereas when a depressive attributional style is sought (with different dimensions of the ASQ), the relationship between attributions and depression appears to be more complex than the model has assumed to date. Several authors have noted this apparent complexity, which will be discussed in more detail below.

Different authors have pointed out the possibility of a certain degree of overlap between the concepts that underpin the two models of depression, in view of their similarities. Our results run against this position due to the differences found in the predictive value of each model. However, it is possible that both models are complementary, as suggested by recent research. For example, the approach of Abramson *et al.* (1988) is based on a hypothetical causal chain that culminates in the appearance of depressive symptoms. Within this chain, the authors distinguish between distal (attributional style) and proximal factors (negative expectations, traumatic events) depending on their temporal proximity to the symptoms. Distal factors act at the beginning of the chain, and hence have a lower predictive capacity as risk factors; in contrast, proximal factors (negative expectations, which form part of the negative cognitive triad) are closer in time to the appearance of symptoms, and are therefore better predictors. Abramson and colleagues thus suggest that the two models may converge on the same

subgroup of depression -that which is associated with these negative cognitions- as a factor that increases an individual's vulnerability to depression. These cognitions are thought to become activated in stressful situations and to act as triggering elements for this type of depression.

The findings of the present study are more compatible with this latter model of depression. A complementary relationship between attributional style and the negative cognitive triad is suggested by the fact that the joint use of both the CTI and the ASQ yielded the most accurate predictions, and thus had a better discriminant capacity than either of the instruments alone. (Only 2 participants were misidentified as false positives, although this number represented a 12% rate of failed predictions in the final sample). Moreover, the fact that not all individuals with the higher level of depression have the depressive cognitive style identified by both measures suggests that this cognitive style may select a particular subtype of depression, as pointed out above (Abramson *et al.*, 1988).

In any case it should be clarified that the greater part of the combined predictive value of the CTI and ASQ was mainly due to the influence of the CTI, *i.e.*, the negative content of cognitions identified by this instrument. This raises the possibility that the problem with the attributional theory is that it is silent about the specific contents of causal attributions. When an unpleasant event occurs (for example, a failed marriage) the individual can make different types of internal, global and stable attributions whose contents and effects can differ. The individual may think that he or she is a failure as a person (a negative internal, stable and global attribution), and become depressed as a result. However, the individual may also think that he or she is always too kind and understanding with others (another internal, stable and global attribution), and decide that he or she should no longer continue to be this way, especially with his or her partner. This would lead to just the opposite: a normal, non-depressed state as a consequence of the separation. Hence it is only when attributions have a strictly negative content, as occurs when the individual has a thinking style characterized by the negative cognitive triad that depression necessarily ensues.

Conclusion

This study does not explain to what extent cognitions cause depression or vice versa, an issue that deserves also further research. However, it does show that a negative cognitive style is a factor that is related to depression in individuals, and could be used to rule out depression in persons who do not have such negative cognitive style. The next steps should be to study whether this cognitive depressive style is specific for depression and whether it is related or not to other psychological disorders such as anxiety, which will increment its discriminative power. Moreover, this technique can also be used to analyze vulnerability to depression by the identification of predictors or causes of future depression.

In summary, the present analysis offers is a novel contribution to the study of how cognition and depression are related, and suggests that an individual's view of self, the world and the future is a more powerful discriminator of depression than is his or her

attributional style. This pioneering study reveals the potential usefulness in Psychology of "new" statistical methods, the Lorenz curve and the Gini index, for analyzing the validity of different factors and possible predictors of a specific psychological disorder, or to enhance existing instruments, as our present study with depression shows. As a consequence, these statistical tools can be used to assess the predictive capacity of different instruments or the strength of the relationship between different variables and psychological disorders, and to evaluate different models proposed to explain these disorders, such as the cognitive theories proposed to explain the depressive cognitive style and evaluated in this study.

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APPENDIX

The original and most extended use of the Lorenz curve represents cumulative proportion of population in x-axis, and cumulative proportion of incomes in y-axis constructed from a continuous variable. However, as we have also employed in this study, Lee (1977) and Llorca and Delgado-Rodriguez (2002) used cumulative proportion of population in x-axis, and cumulative proportion of disease in y-axis from a dichotomous or qualitative variable (diseased/non-diseased, died/alive, or levels of depression in this study). According to Lee (1977, p. 732), "the Lorenz curve is just the plot of the cumulative percentage of cases along a given disease against the cumulative percentage of population with a given level of the other variable" (*i.e.*, gender, exposure to stressors, or depressive cognitive style in our case). For example, Figures 1 and 3 show this plot from the lowest to the highest level of depression as a function of a given attributional style and the negative cognitive triad, respectively.

According to this second use, to plot the Lorenz curve it is first necessary to define the levels of disease risk in the studied population from the lowest, *i.e.*, the absence of disease to the highest levels of disease risk. This is designated i (i = 1, 2..., k, see Table 1, first column). In our study there were four levels, the first two indicated absence or normal depressive mood (in this case a score of 0-5 or 6-9 on the BDI), while the other two indicated subclinical or clinical level of depressive symptomatology (BDI scores 10-15 and > 16, see Table 1, first column). The number of subjects in each level of this variable is designated n (n_1 to n_k, N being the total number of subjects in the sample; see Table 1, second column). The number of cases of the other variables (different cognitive styles, in this case) is represented by d (d_1 to d_k, D being the total number of cases of the sample in each variable; see Table 1 from the third to the last column), because the sample in each variable is usually different (D) from the total one (N). Looking at the table, it is easy to find whether the distribution of the sample is similar when measuring depression and when measuring the other variables (see for example, the similar distribution on depression –BDI- and any of the ASQ dimensions –internal, stable, global- and the dissimilar distribution between depression and the CTI dimensions –world, future- in which the number of cases increase at the higher levels of depression).

The curve is plotted with the help of the following equations (see Lee, 1997):

$$x_i = \sum_{j<i} \frac{n_j}{N}$$

$$y_i = \sum_{j<i} \frac{d_j}{D}$$

The coordinates in the Lorenz curve are denoted by (x, y) i = 1, 2..., k.. x_0, y_0 = 0 and x_k, y_k = 1. The values of "x" are derived from the BDI column, whereas the values of "y" from the column of each variable represented in each curve (see Figures 1-3).

For example, Figures 1 and 3 show this plot from the lowest to the highest risk of depression as a function of a given attributional style and the negative cognitive

triad, respectively. If the risk of depression were exactly equal for the chosen level of the other variables (attributional style or negative cognitive triad), the Lorenz curve would overlap the diagonal line; this would indicate the absence of any relationship between the two because of the similar or equal distribution in both variables as it can be seen in Figure 1. However, if all cases occurred at a given level of depression, the Lorenz curve would overlie the x-axis up to the point where the variable under study is related with the occurrence of the disease, at which point the Lorenz curve would begin to bend upward, as it happens at the third level in Figure 3. Therefore, the area between the Lorenz curve and the diagonal is an index of the relationships between depression and cognitions. Accordingly, a smaller area or a flatter curve (see Figure 1) means a more uniform distribution in the disease risk, in other words, the absence of relationship between depression and the factor plotted on the x-axis, whereas a larger area or a more strongly bowed curve (see Figure 3) shows that the risk of depression is indeed associated with the chosen level of the other variable. In order to qualitatively make comparisons among different curves (factors under study), the larger the area of the Lorenz curve, the more the inequality between the distribution of this factor and the variable under study in the general population. In our case, the negative attributional style is more evenly distributed among the general sample; while the negative cognitive triad appear only at the highest depression levels (see also Figure 2).

The Gini index is one of the summary numerical measures of the deviation in the Lorenz curve, as the Pietra index among others. In our study it was calculated as Lee (1997):

$$\text{Gini index} = \sum_{i=1}^{k} \begin{vmatrix} x_{i-1} & y_{i-1} \\ x_i & y_i \end{vmatrix} = \sum_{i=1}^{k} \left(x_{i-1} y_i - x_i y_{i-1} \right)$$

It stands for a numerical measure of the area between the Lorenz curve and the diagonal line. It provides a numerical value between zero, meaning greater uniformity or a flatter curve and the absence of relationships between the two variables, and one, indicating greater variability or a more bowed curve and in our case, the existence of an association between the presence of disease and the other variable (Lee, 1997). Although *p* values depend on sample size and cannot be translated from a study to another, Monte Carlo simulations in Lee (1977) study showed that a Gini index greater than .207 indicated a lack of uniformity ($p < .01$) and it is widely accepted than a Gini index under .2 usually indicates uniformity. The last row of Table 1 lists the Gini indexes obtained in the present study showing a more intensive association between CTI than ASQ with depression. In summary, a Lorenz curve can be used to visualize and qualitatively analyze the inequalities or intensity of associations between variables, quantitatively described in aggregate by the Gini index.