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Can the Holmes-Rahe Social Readjustment Rating Scale (SRRS) Be Used as a Suicide Risk Scale? An Exploratory Study

Hilario Blasco-Fontecilla
Autonoma University, Spain

David Delgado-Gomez
Carlos III University, Spain

Teresa Legido-Gil
Autonoma University, Spain

Jose de Leon
University of Kentucky, jdeleon@uky.edu

M. Mercedes Perez-Rodriguez
Mount Sinai School of Medicine

See next page for additional authors

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Hilario Blasco-Fontecilla,[1] M.D., David Delgado-Gomez,[2] M.D., Teresa Legido-Gil,[1] BsC, Jose de Leon,[3] M.D., M. Mercedes Perez-Rodriguez,[4] M.D., Enrique Baca-Garcia,[1,5] M.D.

[1]Department of Psychiatry, Jimenez Diaz Foundation, Autonoma University, IIS, CIBERSAM, Madrid, Spain
[2]Department of Statistics, Carlos III University, Madrid, Spain
[3]Mental Health Research Center at Eastern State Hospital, Lexington, Kentucky, USA
[4]Department of Psychiatry, Mount Sinai School of Medicine, New York, NY, USA
[5]Department of Psychiatry, New York State Psychiatric Institute, New York, NY, USA
Running title: life events and suicide risk
Corresponding author to whom reprint requests should be sent:
Hilario Blasco-Fontecilla M.D.
Research Fellow/Consultant Psychiatrist
Department of Psychiatry, Jimenez Diaz Foundation
Avenida Reyes Catolicos 2
28040, Madrid, Spain
Tel +34915504800
Fax + 34915504987
email: hmblasco@yahoo.es

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ABSTRACT

Objectives

To examine whether the Holmes-Rahe Social Readjustment Rating Scale, a life event scale, can be used to identify suicide attempters.

Methods

The Holmes-Rahe Social Readjustment Rating Scale's ability to identify suicide attempters was tested in 1183 subjects (478 suicide attempters, 197 psychiatric inpatients, and 508 healthy controls) using the Fisher Linear Discriminant Analysis and traditional psychometric methods.

Results

The Fisher Linear Discriminant Analysis outperformed traditional psychometric approaches (area under the curve: 0.85 vs. 0.78; $p<0.05$) and indicated that this scale may be used to identify suicide attempters. The life events that better characterized suicide attempters were change in frequency of arguments, marital separation, and personal injury.

Conclusion

The Holmes-Rahe Social Readjustment Rating Scale may help identify suicide attempters.

Declaration of interest

None

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Text

INTRODUCTION

Suicide is a leading cause of worldwide death, particularly among people aged 15-44 years (Manoranjitham, Rajkumar, Thangadurai, et al., 2010; Rutz, 2001; Vijayakumar, Nagaraj, Pirkis, et al., 2005). Annual costs of suicidal behavior are estimated to be $33 billion in the United States (Coreil, 2001), but the real economic costs may be far greater (Corso, Mercy, Simon, et al., 2007). In spite of this alarming data, it is encouraging to know that suicide is preventable (Jamison, 2000). A reasonable first step for suicide prevention is the detection of individuals at risk by using an adequate characterization of their profile. Early detection of patients at risk may reduce the risk of suicidal behavior (Melle, 2006). Moreover, adequate treatment of subjects at risk can reduce the rate of suicide up to 25% (Brown & Beck, 2005; Isaacson, 2000). Unfortunately, the characterization of subjects at risk is not an easy task (Davis & Schrueder, 1990) and the attempts to predict suicide have been disappointing since the classic study by Pokorny (1983). A recent study using the Affective States Questionnaire, a better-designed instrument than the predictive variables used by Pokorny, reported a sensitivity of 60% and specificity of 74% for predicting short-term suicidal behavior (Hendin, Al Jurdi, Houck, et al., 2010).

In order to improve the prediction of suicide, the selection of adequate variables seems fundamental (Hendin, Al Jurdi, Houck, et al., 2010). Different variables have been used as predictors of suicide to date, but none of them is capable of accurately predicting whether or not a particular subject will commit suicide. For instance, sociodemographic predictors of suicide lack specificity (Davis & Schrueder, 1990). Moreover, psychiatric disorders are closely associated with suicide, but most individuals suffering from them do not attempt suicide (Davis & Schrueder, 1990). In addition, a prior suicide attempt is the best predictor of a completed suicide (Coryell & Schlesser, 2001), but only roughly 50% of

suicide completers present with a history of suicide attempts (Isometsa & Lonnqvist, 1998; Obafunwa & Busuttil, 1994). Finally, biological tests such as the dexamethasone suppression test have yielded mediocre results (Coryell & Schlesser, 2001; Jokinen, Nordstrom & Nordstrom, 2008). On the other hand, most suicide attempts and completed suicides are preceded by life events (Blaauw, Arensman, Kraaij, et al., 2002; Cavanagh, Owens & Johnstone, 1999; De Vanna, Paterniti, Milievich, et al., 1990) such as interpersonal conflicts, physical illness, and financial problems (Kolves, Varnik, Schneider, et al., 2006). Surprisingly, whether or not life events are predictive of suicidal behavior still remains a controversial issue (Yen, Pagano, Shea, et al., 2005).

In view of the aforementioned difficulties in the detection of suicide attempters, the present study explores: (i) whether or not the Holmes-Rahe Social Readjustment Rating Scale (SRRS) (Holmes & Rahe, 1967) can be used as an instrument capable of accurately identifying suicide attempters when compared with healthy controls and psychiatric patients; and (ii) whether some life events have better discriminative abilities than others. In order to reach our aims, we applied the Fisher Linear Discriminant Analysis (FLDA), a statistical method for pattern classification (Delgado-Gomez, 2009) and the more traditional psychometric approach.

METHOD

Samples

Participants were 1183 individuals aged 18 years or older who provided written informed consent before participating in the study. The study was performed in accordance with the Declaration of Helsinki and approved by the appropriate ethics committee. Cases included 478 first-time suicide attempters (303 females and 175 males) admitted to two university hospitals in Madrid, Spain, between 1999 and 2003, after a suicide attempt. Suicide attempts were defined as "a self-destructive behavior with intent to end one's life independent of resulting damage" (O'Carroll, Berman, Maris, et al., 1996; Silverman,

Berman, Sanddal, et al., 2007). Approximately 84% of approached suicide attempters consented to take part in our study. As our group has reported previously, suicide attempters who rejected study participation did not significantly differ in demographics from attempter participants (Diaz, Baca-Garcia, Diaz-Sastre, et al., 2003).

The 705 non-suicide attempters included 197 psychiatric inpatients (112 females and 85 males) hospitalized for a reason other than suicidal behavior and without a history of suicidal behavior, and 508 healthy controls (blood donors) (201 females and 307 males) from the same hospitals.

Mean age (± standard deviations, SD) of suicide attempters and non-suicide attempters was 37.7 (± 14.6) and 37.6 (± 12.5), respectively (differences statistically non-significant). Table 1 and 2 display information with regard to socio-demographic and clinical variables of the samples.

--please insert **Table 1 and Table 2** about here-

Scales

Life events in the two years preceding suicide attempts were ascertained using the contextual method of Brown and Harris (Brown & Harris, 1978; Coyne, Thompson & Pepper, 2004). Information ascertained for each participant covered both the life event and the context and circumstances surrounding it. The contextual type of assessment is different from the checklist approach, because the information collected goes beyond just simply asking subjects which of the life events on a particular checklist they have experienced (Kessler, 1997). Contextual assessment involves deliberately ignoring a respondent's personal beliefs (Coyne *et al.*, 2004). The ratings of contextual threat are based on how an "average" individual with analogous life history and living in similar circumstances would be expected to feel. Life events were coded according to the standardized and adapted Spanish SRRS version (Gonzalez de Rivera, 1983). The SRRS

is a scale originally developed to investigate the relationship between life events, stress and susceptibility to illness. The SRRS includes 43 life events, each scored from 0 to 100 units of life change (ULC) (Holmes & Rahe, 1967). The SRRS provides two global scores: the Life Events Index, which is the total number of life events for each patient, and the Social Readjustment Index (SRI), which is obtained by adding the scores of all ULC (Blasco-Fontecilla et al., 2010). For instance, if a subject has been exposed to the death of a spouse, which is the most severe life event and has the highest score (ULC=100), and minor law violations, which has the lowest score (ULC=11), he/she will obtain a global score (SRI) of 111 ULC. A score ranging between 0 and 149 ULC is supposed to be associated with no significant stress problem; a subject scoring 300 ULC or higher is considered to be under major stress and to have an 80% of chance of illness or health change (Holmes & Rahe, 1967).

Statistical Analyses

Techniques

We compared two techniques in their capability to discriminate between suicide attempters and non-suicide attempters using life events: the traditional psychometric approach and the Fisher Linear Discriminant Analysis (FLDA). The traditional psychometric approach is how tests are usually considered, and is based on the sum of all item scores (global score) of a given questionnaire (SRI in the present study). If the total score surpasses a predetermined cut-off point, the subject is diagnosed with the associated disorder or dimension. For instance, a score ≥75 on the Barratt Impulsivity Scale (BIS-11) is indicative of highly impulsive behavior (Zouk, Tousignant, Seguin, et al., 2006). In the SRRS, a score ≥300 ULC is supposed to be associated with great stress (see comments above).

The FLDA is a multivariate technique widely used for dimension reduction (Delgado-Gomez, 2009). Basically, the FLDA transforms the data so that we can better

differentiate between different groups (e.g., suicide attempter vs. non-suicide attempter in our study). Unlike LDA, which requires that the data of each group (cases and controls) follow Gaussian distribution, FLDA does not make any assumption. FLDA is simply a sensible rule to classify observations. The FLDA allows finding the best projection of the data through maximizing the separation of the means of the projected data while minimizing the variances of both groups. For instance, in a two-dimensional problem (suicide attempters vs. non-suicide attempters), the FLDA chooses the line or threshold that best differentiate the two groups. The FLDA algorithm has previously been used to predict different biological events (i.e., the sexual orientation of subjects, perceptual performance) with high accuracy, sensitivity, and specificity (Das, Giesbrecht & Eckstein, 2010; Ponseti, Granert, Jansen, et al., 2009).

The concept of FLDA is graphically represented in Figure 1.

--please insert **Figure 1** about here-

Before applying the FLDA algorithm, a principal component analysis keeping 95% of the variance was applied to remove noise (Belhumeur, 1996).

Probabilistic measures

In clinical practice it is basic to know how good a particular test is at predicting the risk of abnormality (suicide attempts, in the present study) (Deeks & Altman, 2004). In order to compare the diagnostic ability of the FLDA and the traditional psychometric approach to classify suicide attemtpers and non-suicide attempterts, we used the following probabilistic measures: sensitivity, specificity, predictive values, likelihood ratios, accuracy, and ROC curves.

Sensitivity and specificity by themselves cannot assess the performance or diagnostic accuracy (the probability that the test will give us the correct diagnosis) of a test. Predictive values give us this information (Altman & Bland, 1994a; Altman & Bland, 1994c), but predictive values depend on the prevalence of abnormal results in a particular

sample and therefore cannot usually be generalized beyond a particular study. Likelihood ratios (sensitivity/1-specificity) are a solution for the prevalence problem (Deeks & Altman, 2004). Likelihood ratio indicates the certainty of the test about a positive diagnosis; in other words, whether or not the test is useful for measuring the disease, but not necessarily that a positive result indicates the presence of disease (Altman & Bland, 1994a). A likelihood ratio > 1 suggests that the test result is related to the presence of the disease. Likelihood ratios greater than 10 or less than 0.1 are considered to give strong evidence regarding the presence or absence of the disease, respectively (Deeks & Altman, 2004). ROC curves also give a global assessment of the performance of a test or diagnostic accuracy, and are particularly interesting when comparing two tests. A given test with an ROC that lies wholly above the ROC of another is in general better (Altman & Bland, 1994b). The area under the ROC curve (AUC) or c statistic is the standard metric for evaluating performance of predictive or classification models for binary outcomes. The AUC is equivalent to the likelihood that given two subjects, one with and the other without a particular event (e.g., a life event such as Marital separation), the subject positive for the event will have a higher probability of another event (e.g., suicide attempt). The relationship between the plot of the ROC curve and the AUC is basic for risk classification. Any study aimed at proposing a novel classification or risk prediction model should report the AUC (Deeks & Altman, 2004). Thus, we expect to find the AUC of the FLDA to be considerably better than the AUC of the traditional psychometric approach, thus supporting a novel rank for the different life events of the SRRS.

Set up (training, validation and test sets)

In order to discriminate suicide attempters from the controls, we randomly divided our sample into three representative sets of data: training set, validation set, and test set. This approach is frequently used in the pattern recognition community, and avoids some inconveniences of using a unique set of data. For instance, whenever a unique data set is

used, it can happen that the data are overfitted. This means that, an extremely high accuracy is achieved, but when the built classifier is used in another data set, the accuracy decreases dramatically. By using the three set approach, we simulate more real conditions.

The *training set* was used to build the model. Thus, during the training phase, the learning algorithm (FLDA) finds the most discriminating life events, in other words, the set of life events that better differentiate between suicide attempters and controls. The *validation set* was used to tune the parameters of the model. All parameters were set to the values that maximize the accuracy in the validation set. The threshold is not fixed in the training set to reduce overfitting. Finally, once the parameters were tuned, the *test set* was used to assess and compare the performance of the traditional psychometric approach and the FLDA. Thus, during the test phase, each life event from a new subject of the test data set is projected and provides an input to the system. Finally, the FLDA classifier "predicts" –the test set "simulate" a real, different set of patients- which life events are more closely linked to suicide attempters.

For each analysis, 100 repetitions of the set-up were conducted in order to obtain statistically more meaningful results. A paired t-test was used to test whether or not there was a significant mean difference between the two sets of paired data (FLDA vs. traditional psychometric approach) in all probabilistic measures (specificity, sensitivity, positive predictive value, likelihood ratio, accuracy, and receiver operating characteristic (ROC) curves with area under the curve (AUC)) (Deeks, 2001).

RESULTS

In the two years preceding a suicide attempt, suicide attempters had 2.96 (± 1.71) life events (female suicide attempters: 3.00 ± 1.75 vs. male suicide attempters: 2.90 ± 1.64; statistically non-significant), whereas non-suicide attempters showed 1.50 (± 1.47) life events (females: 1.58 ± 1.53 vs. males: 1.44 ± 1.41; statistically non-significant). Table

3 shows that FLDA performed significantly better ($p<0.05$) than the traditional psychometric approach in all probabilistic measures. In other words, the FLDA outperformed the traditional psychometric approach, offering better classification accuracy results. The FLDA offered a specificity of 82%, a sensitivity of 73%, a predictive value of 73%, a likelihood ratio of 4, and the accuracy rate was 78% (see Table 3). The ROC AUC using the FLDA also outperformed the traditional psychometric approach in classifying suicide attempters (0.85 versus 0.78) (see Figure 2).

--Please insert **Table 3 and Figure 2** about here-

Based on the absolute value of the weights of the optimal projection line provided by the FLDA, the ranking of importance of the various life events is shown in Table 4.

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From a clinical standpoint, change in frequency of arguments, personal injury or illness, and marital separation were the most influential life events in accurately discriminating between suicide attempters and non-suicide attempters.

Because gender is a particularly relevant factor in suicidal behavior, we repeated all analyses after gender stratification. Using the FLDA, women were particularly well classified as suicide attempters by the following life events in decreasing order of importance: change in frequency of arguments, marital separation, and revision of personal habits (e.g. quitting smoking, dress changes, etc.). Among men, the life events that better characterized suicide attempters were personal injury or illness, change in frequency of arguments, and marital separation. Death of wife ranked fourth using FLDA. This finding is particularly interesting because death of husband ranked 34th in females, thus suggesting a differential impact across gender.

DISCUSSION

The SRRS, a scale that was not designed to predict suicide but the impact of stress on health, may help measuring suicide risk, according to our study, which needs

replication. Compared with the traditional ranking of life events of the SRRS, the FLDA yielded a different ranking of importance of the various life events and demonstrated that there are certain life events that can better differentiate between suicide attempters and non-suicide attempters. In addition, the ranking of importance varies with regard to gender.

The most interesting finding of our study is that the SRRS traditional scoring may not be helpful in examining the importance of the various life events on suicidal behavior. For instance, death of spouse, which is the most highly scored life event (100 ULC) with the traditional use of the SRRS was worse for differentiating between suicide attempters and non-suicide attempters than the change in frequency of arguments, according to the FLDA. Thus, change in frequency of arguments ranked 1st using the FLDA, but it just scored 35 ULC in the SRRS as originally rated by the authors of the scale (Holmes & Rahe, 1967). Provided that our exploratory results are confirmed in longitudinal studies, clinicians might easily improve the accuracy of their assessments of suicide risk by considering the FLDA item ranking instead of the traditional ranking of the SRRS.

Another interesting finding is that, consistent with Paykel´s benchmark study, suicide attempters had more stressful life events than non-suicide attempters (Paykel, Prusoff & Myers, 1975). Thus, our results give further support to the “general quantitative” hypothesis of suicide attempts. This hypothesis suggests that a change from any state, more than value judgement of social desirability, is what determines perceived stress and eventually precipitates suicide attempts (Holmes and Rahe, 1967). In other words, the relevant issue is not if life events are positive, negative or neutral, but rather, the number of life events that individuals experience. Several studies have persuasively demonstrated that people attempting or even committing suicide show an increased number of life events (Adams, Overholser & Spirito, 1994; Cavanagh, Owens & Johnstone, 1999; Conner, Conwell & Duberstein, 2001; Kelly, Soloff, Lynch et al., 2000).

The “generalized qualitative” hypothesis was also supported by our study. The qualitative hypothesis posits that not change “per se”, but the event’s threatening quality or undesirability causes stress (Horesh, Sever & Apter, 2003). According to this hypothesis, undesirable life events should be associated with suicide attempts (Paykel, Prusoff & Myers, 1975; Yen, Pagano, Shea, et al., 2005), which was exactly what we found. Undesirable life events such as change in frequency of arguments, personal injury or illness, and marital separation characterized suicide attempters better than non-suicide attempters. Kolves and co-workers have reported that somatic illness and marital separation were more frequent in suicide completers than in controls (Kolves, Varnik, Schneider, et al., 2006). Separated people are at increased risk of suicidal behavior (Duberstein, Conwell, Conner, et al., 2004; Kolves, Ide & De Leo, 2010). Furthermore, both psychological autopsy studies and case-control studies have identified somatic illness as an important risk factor for completed suicide and suicide attempts, particularly in the elderly (Bergman Levy, Barak, Sigler, et al., 2010; Harwood, Hawton, Hope, et al., 2006; Heikkinen, Isometsa, Aro, et al., 1995; Paykel, Prusoff & Myers, 1975; Voaklander, Rowe, Dryden, et al., 2008; Waern, Rubenowitz, Runeson, et al., 2002). Moreover, neutral or positive life events such as outstanding personal achievements, holidays, vacation, pregnancy, and marital or relationship reconciliation did not differentiate between attempters and non-suicide attempters, giving further support to the “general qualitative” hypothesis. To date, little research has been carried out about the impact of neutral or positive life events on suicidal behavior, and conclusions cannot be drawn (Yen, Pagano, Shea, et al., 2005).

Analyses by gender also offered interesting insights into the relationship between life events and suicidal behavior. In both genders, marital discord was closely associated with suicide attempter status. Relationship loss and conflicts were the most frequent negative life events precipitating suicidal behaviours in a sample of 70 adult patients

attending acute community services, irrespective of gender (Cupina, 2009). Marital separation may increase the risk of psychological distress (Maughan & Taylor, 2001) and suicidal behavior (Wyder, Ward & De Leo, 2009). Recent research supports the concept that the pernicious effect of marital problems may be even more important in males than females (Kolves, Ide & De Leo, 2010; Kolves, Varnik, Schneider, et al., 2006). Consistent with some authors (Waern, Rubenowitz, Runeson, et al., 2002), we also found that somatic illness might be a more relevant factor among male than female attempters. Interestingly, death of a spouse can also differentially impact males and females. Death of a partner ranks as the most stressful life event in the traditional psychometric approach of the SRRS (Holmes & Rahe, 1967). The FLDA ranking, however, suggested that death of a spouse is more closely associated with suicidal behavior in males than in females. Although controversial, there is some evidence suggesting this may be true. The majority of studies indicate that, not only men are more negatively impacted by bereavement than women, but even that widowhood might be protective for women (see Taga, Friedman, & Martin, 2009 for a review). Bereaved elderly men had more than three times risk of suicide compared with their married counterparts, whereas bereavement for the elderly women was not related to an excess risk in a cohort of 3486 white widowed and 6266 white married persons aged 60 years or older (Li, 1995). Different studies have also reported that bereaved men, but not bereaved women, decline in cognitive performance, compared to non-bereaved individuals (Aartsen, van Tilburgh, Smits, et al., 2005; Grimby and Berg, 1995; Rosnick, Small, & Burton, 2011). This cognitive decline seem to be mediated by the presence of depression, anxiety, and stress (Ward, Mathias, & Hitchings, 2007).

Our findings might have important preventive implications. Most suicidal subjects contact a physician or emergency department within a year of their act (Da Cruz, Pearson, Saini, et al., 2011; Davis & Schrueder, 1990). However, clinicians lack instruments with adequate predictive properties. A system capable of preventing suicidal behavior should

be able to answer two apparently simple questions: who (subjects at risk; diathesis) will show suicidal behavior, and when (life events; stress). In the context of the stress-diathesis model of suicide (Mann, Waternaux, Haas, et al., 1999), research on predictive factors of suicide has mainly focused on diathesis (Coryell & Schlesser, 2001; Jokinen, Nordstrom & Nordstrom, 2008) rather than on life events. However, most suicide attempts and completed suicides are preceded by life events (Blaauw, Arensman, Kraaij, et al., 2002; Cavanagh, Owens & Johnstone, 1999; De Vanna, Paterniti, Milievich, et al., 1990). The inability to cope with these life events may contribute to suicidal behavior (Blasco-Fontecilla, Baca-Garcia, Duberstein, et al., 2010; Cavanagh, Owens & Johnstone, 1999; Kolves, Varnik, Schneider, et al., 2006). Our results confirm the relevance of certain life events among suicide attempters and suggest that clinicians should pay very close attention to patients at risk of suicide who are faced with particularly worrisome life events such as personal injury or illness or marital discord.

Strengths and limitations

This study presents some advantages over previous studies aimed at developing useful tools to classify and predict suicidal behavior. The major strength of this study is its novel methodology. To our knowledge, this is the first effort in applying pattern classifiers such as the FLDA to classify subjects showing suicidal behaviors. The FLDA performed better than the traditional psychometric approach. Our results offer acceptable sensitivity, specificity, positive predictive value, likelihood ratio, and accuracy, particularly when compared with previous efforts (Hendin, Al Jurdi, Houck, et al., 2010; Pokorny, 1983).

The main limitations of the present study are: i) its case-control design versus a longitudinal approach; ii) the use of the contextual method to assess life events versus the “relational-cognitive-orientation approach”, which emphasizes the subjective impact and

the meaning attributed to the event by the subject (Lazarus, DeLongis, Folkman, et al., 1985; Yen, Pagano, Shea, et al., 2005); iii) the lack of control for the effect of Axis I psychiatric disorders; and iv) the possibility of recall bias of life events. Another limitation is the lack of information about lethality of the suicide attempts.

Ideally, one would like to use a longitudinal approach instead of a case-control design. However, it would not be an easy task using a longitudinal approach to determine which individuals in the general population exposed to life events will become suicide attempters or completers. This type of general population design would require huge samples and be very time-consuming. If the longitudinal studies focus on psychiatric patients to verify exposure to life events, it would also require very large samples and a way of dealing with the complex issue of prior suicide attempts. In summary, with all its limitations, the case-control approach used in this study appears a reasonable approach for this type of preliminary study, which can be used for planning longitudinal studies.

In addition, we did not control for the mediating role of Axis I psychiatric conditions. A much larger sample would have been required for appropriately controlling for that confounder. However, negative life events can precipitate suicidal behaviors in vulnerable individuals independent of their latent psychopathology (Horesh, Sever & Apter, 2003).

Conclusions

If other studies replicate our findings this would indicate that after modifying the ranking of some items, the SRRS may be used as a scale measuring suicide risk and easily adopted by clinicians. Our results also suggest that both the “general quantitative” and the “general qualitative” hypotheses of the effects of life events on suicide attempts are complementary rather than opposing hypotheses. Change in frequency of arguments, marital separation, and personal injury or illness seem to be the life events that may better characterize suicide attempters. Clinicians should pay special attention whenever a

subject at risk for suicide (e.g. individuals with major depression or borderline personality disorders) is exposed to these most relevant life events.

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Table 1. Socio-demographic characteristics of suicide attempters and controls stratified by sex.

Table 2. Axis I mental disorders in suicide attempters and psychiatric inpatients stratified by sex.

Table 3. Classification accuracy using Fisher Linear Discriminant Analysis (FLDA) and the traditional psychometric approach that uses sum of weight items. The sample was randomly divided into three representative sets of data: the training set, the validation set, and the test set. The training set (not described) was used for learning. The validation set was used to tune the model. The test set was used to assess and compare the performance of the traditional psychometric approach and the FLDA and is described in this table.

Table 4. Classification of life events (SRRS): traditional ranking vs. ranking using the Fisher Linear Discriminant Analysis (FLDA).

* Life events are ranked according to the ULC described by the scale’s authors.

Table 1.

	Women			Men		
	Suicide attempters (N=303)	**Controls (N=313)**	**P value**	**Suicide attempters (N=175)**	**Controls (N=392)**	**P value**
Marital Status	%	%	**.006**	%	%	**<.001**
Single	50.2	46.5		41.7	50.1	
Married/cohabiting	31.0	42.9		32.0	44.8	
Separated/Divorced	15.5	8.0		23.4	4.6	
Widowed	3.3	2.6		2.9	0.5	
Years of Education			ns			**.001**
≤ 8	32.8	31.7		40.8	24.4	
9 to 12	44.2	37.3		37.3	38.6	
>12	23.0	32.0		21.9	37.0	
Socioeconomic status			**<.001**			**<.001**
Low-Middle (1&2)	37.5	22.7		43.5	20.3	
Middle (3)	51.5	65.3		44.1	65.5	
Middle- High (4&5)	12.0	12.0		12.4	14.2	
Employment Status			**<.001**			**<.001**
Unemployed (w / and w/o subsidy)	28.6	22.5		24.4	13.5	
Employed	47.1	64.6		37.8	77.9	
Disability	18.9	9.5		29.1	6.5	
Retired	5.4	3.4		8.7	2.1	
Living arrangements			ns			**<.001**
Alone	11.4	10.2		23.7	9.5	
Family	82.7	83.2		68.4	85.7	
Non-Family	5.9	6.6		7.9	4.8	
Children			ns			ns
Yes	53.7	54.1		51.4	58.2	
No	46.3	45.9		48.6	41.7	

Table 2.

	Women			Men		
	Suicide attempters (N=303)	**Psychiatric Inpatients (N=112)**	**P value**	**Suicide attempters (N=175)**	**Psychiatric Inpatients (N=85)**	**P value**
Axis I disorders (Any mental disorder)	%	%		%	%	
Alcohol dependence	6.1	6.3	ns	25.8	17.7	ns
Alcohol abuse	6.7	1.0	.03	14.1	7.1	ns
Substance dependence	5.1	2.7	ns	16.6	16.5	ns
Substance abuse	4.7	0.9	ns	7.7	2.4	ns
Psychotic disorder (current)	8.7	45.0	<.001	14.2	52.9	<.001
Major Depressive Episode (current)	53.7	24.8	<.001	58.6	21.2	<.001
Major Depressive Episode (recurrent)	30.3	9.1	<.001	30.3	11.9	.<05
Dysthymia	10.7	6.2	ns	5.3	0.0	ns
Panic disorder (current)	6.4	8.1	ns	5.3	1.2	ns
Agoraphobia	5.7	2.9	ns	4.1	2.4	.<05
Social Phobia	8.1	0.0	.<05	6.8	0.7	.<05
Generalized Anxiety disorder	17.1	16.1	ns	13.6	15.3	ns

Table 3.

Dataset	Measure	FLDA	Traditional psychometric approach	Mean difference*	CI 95%
Validation	Specificity	83.1%	88.2%	-5.1%	-4.8 - -5.5
Validation	Sensitivity	74.5 %	44.6%	29.8%	29.2-30.4
Validation	Positive predictive value	75.3%	72.7%	2.6%	2.3-3.0
Validation	Likelihood ratio	4.4	3.8	0.6	0.3-0.9
Validation	Accuracy	79.6%	70.6%	9.0%	8.9-9.1
Validation	AUC	0.849	0.779	0.07	0.069-0.071
Test	Specificity	81.9%	87.6%	-5.7%	-5.4 - -6.1
Test	Sensitivity	72.6%	43.7%	28.8%	28.2-29.5
Test	Positive predictive value	73.7%	71.3%	2.4%	2.1-2.7
Test	Likelihood ratio	4.0	3.5	0.5	0.3-0.7
Test	Accuracy	78.1%	69.9%	8.2%	8.1-8.4
Test	AUC	0.849	0.778	0.071	0.069-0.072

*All differences were statistically significant ($p<0.05$)

Table 4.

SRRS items	% of suicide attempters showing this life event	% of controls showing this life event	ULC*	Traditional Ranking	FLDA Ranking (Males)	FLDA Ranking (Females)	FLDA Ranking (Both genders)
Death of spouse or husband	1.5	0.7	100	1	4	34	36
Divorce	1.2	0	73	2	21	36	24
Marital separation	28.7	7.2	65	3	3	3	3
Imprisonment	0.2	0.1	63	4	37	22	37
Death of close family member	13.6	8.8	63	5	11	10	10
Personal injury or illness	27.2	6.5	53	6	1	6	2
Marriage	1.2	3.3	50	7	40	41	39
Dismissal from work	9.2	4.0	47	8	10	9	9
Marital reconciliation	0.6	0.1	45	9	20	20	26
Retirement	1.7	0.6	45	10	7	29	34
Change in health of family member	12.1	26.2	44	11	42	40	41
Pregnancy	2.7	1.6	40	12	23	42	40
Sexual difficulties	2.3	0.4	39	13	38	11	7

Addition of a new family member	34.1	12.2	39	14	6	5	6
Business readjustment	0.4	0.8	39	15	35	21	17
Change in financial status	19.0	7.8	38	16	14	16	14
Death of a close friend	1.9	1.7	37	17	39	33	35
Change to different line of work	9.6	5.4	36	18	12	18	15
Change in frequency of arguments	38.1	5.1	35	19	2	1	1
Major mortgage	0.2	0.0	31	20	19	25	23
Foreclosure of mortgage or loan	1.9	0.6	30	21	8	13	11
Change in responsibilities at work	1.9	1.3	29	22	5	37	42
Child leaving home	3.1	1.1	29	23	30	8	5
Trouble with in-laws	3.1	0.5	29	24	16	7	13
Outstanding personal achievement	0.0	1.1	28	25	43	31	38
Spouse/husband starts or stops work	0.4	0.4	26	26	26	19	18
Begin or end school	7.1	6.3	26	27	32	17	27
Change in living conditions	0.0	0.3	25	28	22	28	25
Revision of personal habits	14.2	3.4	24	29	9	2	4

Trouble with boss	2.3	1.7	24	30	15	39	12
Change in working hours or conditions	17.4	13.0	20	31	17	12	16
Change in residence	19.2	13.7	20	32	33	35	33
Change in schools	0.0	0.1	20	33	29	24	30
Change in recreation	0.2	0.0	19	34	34	26	22
Change in church activities	0.0	0.4	19	35	28	30	28
Change in social activities	11.7	7.5	18	36	13	38	21
Minor mortgage or loan	0.0	0.0	17	37	27	23	31
Change in sleeping habits	0.8	0.4	16	38	36	14	20
Change in number of family reunions	0.2	1.3	15	39	31	32	32
Change in eating habits	3.6	0.1	15	40	25	4	8
Vacation	1.0	0.4	13	41	18	15	19
Christmas	0.6	0.0	10	42	24	27	29
Minor violation of law	6.1	3.3	11	43	41	43	43

* Life events are ranked according to the Units of Life Change (ULC) described by the scale's authors.

Figure 1. Graphical representation of the Fisher Linear Discriminant Analysis (FLDA)

In this figure, we represent the scores obtained by eight subjects (4 Suicide Attempters: black circles; and 4 Non-Suicide Attempters: gray circles) in two hypothetical polychotomous items (ranging from 0 to 5). Imagine that we were interested in summarizing all the responses of a given individual in a single value (e.g., the responses of a subject to all SRRS items). This value can be calculated in several ways, depending on the weight (relevance) of each item (life event, in this study). Two possible ways of calculating the item weight are represented in the figure: 1) Projection 1 (FLDA; black line): the FLDA algorithm allocates a weight (score) to each item in order to better differentiate between classes (suicide attempters vs. non-suicide attempters in this study); and 2) Projection 2 (traditional psychometric approach, red line), which obtains the global score (Social Readjustment Index, SRI) by simply adding the scores of all individual items using the units of change (ULC). The scores of each subject can be represented in both projection 1 and projection 2. Please, notice how suicide attempters and non-suicide attempters are better separated in Projection 1 as compared with Projection 2.

Figure 2. Comparison of the Receiver Operating Characteristic (ROC) curves obtained using the continuous scores from the SRRS using the two methods (FLDA and the traditional psychometric approach). A ROC curve is a plot of the true positive rate (sensitivity) against the false positive rate (1-specificity) for the different possible cut-off points of a diagnostic test.

Figure 1.

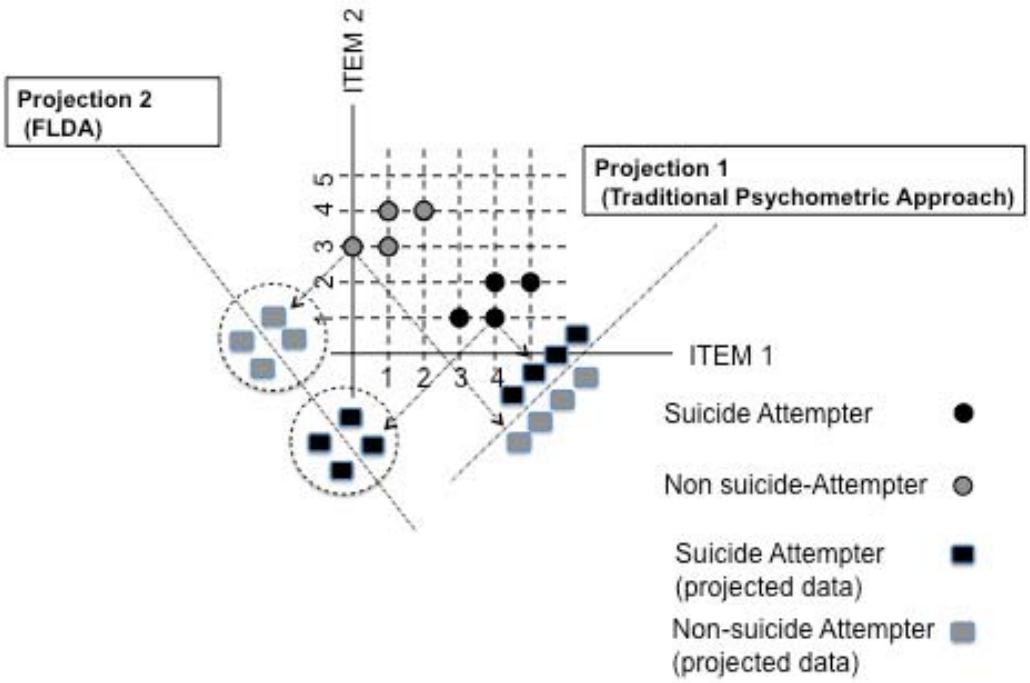
Projection 2
(FLDA)
ITEM 2
Projection 1
(Traditional Psychometric Approach)
ITEM 1
1 2 3 4 5
1 2 3 4
Suicide Attempter
Non suicide-Attempter
Suicide Attempter
(projected data)
Non-suicide Attempter
(projected data)

Figure 2.