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Application of Novel Statistical Methods
in Suicide Research

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DI (FH) Mag. Ingo Nader

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Introduction

Suicide is an important public health issue. According to the World Health Organization (WHO), approximately one million people die from suicide every year (WHO, 2012). As a consequence, much research is performed regarding epidemiology of suicides (e. g., Gunnell, Bennewith, Hawton, Simkin, & Kapur, 2005) and also in the field of suicide prevention (e. g., see Mann et al., 2005, for a review of suicide prevention strategies).

The fields and topics of suicide research are very diverse and heterogeneous. These topics include medical, psychological, and demographic risk factors in the general population (e. g., Logan, Hall, & Karch, 2011) or in high-risk populations like adolescents (e. g., Gutierrez, 2006; Portzky, Audenaert, & Heeringen, 2005), the elderly (e. g., Osvath, Kovacs, Voros, & Fekete, 2005), or prison inmates (e. g., Fazel, Cartwright, Norman-Nott, & Hawton, 2008). They also include the impact of media reporting on suicide rates (e. g., Sisask & Värnik, 2012) or even the impact of sport events on suicide rates (e. g., Encrenaz et al., 2012), to name only a few examples.

The three specific topics of interest for this doctoral thesis are the distribution of suicides over the span of the year (i. e., seasonality of suicides), the assessment of attitudes toward suicide, and the assessment of knowledge about suicide. Seasonality of suicides is a long-known phenomenon (Kevan, 1980) pertaining to the fact that more suicides occur in spring compared to the other seasons (Preti, 2002), but recently it has been discussed whether or not seasonality is decreasing or even vanishing (Ajdacic-Gross et al., 2005; Rihmer, Rutz, Pihlgren, & Pestality, 1998; Yip, Chao, & Chiu, 2000).

Attitudes toward suicide describe how people perceive suicide (Yamanaka, 2008) and people who have attempted suicide (Suokas, Suominen, & Lonnqvist, 2008), which is related to stigma (Witte, Smith, & Joiner, 2010), and also to increased planning of suicides in adolescents (Joe, Romer, & Jamieson, 2007). Knowledge about suicide is often part of scales that measure attitudes toward suicide, but should rather be treated as a separate construct. In evaluation of suicide prevention programs, knowledge about suicide is often assessed as a distal outcome to measure effectiveness (Isaac et al., 2009).

Owing to the diversity in this field of research, also the statistical methods applied are very heterogeneous. This is true not only across different topics, but also within specific areas of suicide research. As an example, eight different methods were identified in a review regarding statistical techniques in studies of suicide seasonality (Hakko, Räsänen, Tiihonen, & Nieminen, 2002). These techniques ranged from very simple statistical techniques like χ^2 tests to time-series-specific methods of analysis like spectral analysis (Warner, 1998). However, none of these techniques allowed for the continuous assessment of seasonality, which would be beneficial to answer the question of whether or not seasonality is decreasing.

Regarding the assessment of attitudes toward and knowledge about suicide, the methodological diversity is much smaller. Most studies on scales that measure those constructs use standard techniques like exploratory or confirmatory factor analyses and related methods of classical test theory. More modern methods like those in the framework of item response theory (IRT) are used only very infrequently, especially in assessing personality features (Reise & Waller, 2009) like attitudes toward suicide. These IRT methods have significantly affected

and improved the development of ability and achievement measures, and using them for refinement of personality measures ought to result in better science (Thomas, 2011).

Generally, the application of state-of-the-art methods could help gaining additional insights and resolving controversial issues. This is not only true for the development and analysis of scales to assess, for example, attitudes or knowledge about suicide, but also for every other part of suicide research. The better the method of analysis, the better patterns in the data will be visible and the easier it should be to draw valid conclusions to improve the understanding of suicide.

Outline

This doctoral thesis is aimed at introducing novel methods to the field of suicide research, and also at bringing to mind some methods that are already available but hardly ever used in practice. The three studies that form this doctoral thesis cover a wide field of topics in suicide research, but they share the application of new or underused methods that can provide additional insights into the research topic in question.

The first study is a time-series analysis and investigates the changes of seasonality during a thirty-nine-year period. It uses complex demodulation (Bloomfield, 2000), which is a method of analysis usually used to analyze short-term signals in medicine (e.g., cardiorespiratory dynamics, Lipsitz, Hayano, Sakata, Okada, & Morin, 1998; cardiac interbeat intervals, Yeragani, Pohl, & Balon, 2004).

The second study presents an analysis of a scale to assess attitudes toward suicide (Eskin, 2004). Research regarding the dimensionality of that scale was inconclusive, as two previous related studies using exploratory factor analysis to investigate the dimensionality found six- (Eskin, 2004) as well as seven- (Eskin, Voracek, Stieger, & Altinyazar, 2011) factor solutions for this scale. In the current study, Mokken scale analysis (Mokken, 1971; Sijtsma & Molenaar, 2002) was applied to resolve this question. This method of analysis is situated in the framework of non-parametric item response theory (IRT). Although it is not a new method, it is hardly ever applied. To make the interpretation of results easier, confirmatory factor analysis (CFA) was used to test the fit of the resulting models. This facilitates the interpretation of the results by using widely known and well-established fit statistics.

The third and last study of this doctoral thesis reports on the construction of a new scale to assess knowledge about suicide postvention (i. e., support for the bereaved after the suicide of a loved one). The items of the scale were analyzed by means of Rasch tree analyses (Strobl, Kopf, & Zeileis, 2011), a newly developed method of item response theory that facilitates the identification of differential item functioning (DIF), i. e., identifying subgroups of respondents for which specific items of the scale are more (or less) difficult. This allows to infer which aspects of knowledge about suicide postvention need to be emphasized for a certain subgroup to enable effective suicide prevention.

These three studies are presented in more detail below. Furthermore, the final versions of the studies are appended after the main part of this document.

Study 1. Suicide Seasonality: Complex Demodulation as a Novel Approach in Epidemiologic Analysis

Introduction. Seasonality of suicides is a well-known phenomenon that has already been investigated as early as 1825 (Kevan, 1980). Contrary to common belief, most suicides occur in spring, and least suicides occur in autumn. However, these seasonal fluctuations of the number of suicides have been suspected to be diminishing already in 1981 (Meares, Mendelsohn, & Milgrom-Friedman, 1981). This finding has been replicated for other countries, e. g., Finland (Hakko, Räsänen, & Tiihonen, 1998), Denmark (Yip, Yang, & Qin, 2006), or Switzerland (Ajdacic-Gross et al., 2005). However, seasonal variation has been found to increase in other countries like the United States of America (Bridges, Yip, & Yang, 2005) or Australia (Rock, Greenberg, & Hallmayer, 2003).

Most (if not all) of these studies used statistical methods that did not allow for continuous estimation of the amplitude (i. e., the strength of the seasonality effect in the time series). Instead, the time series usually was split in two or more parts, and the periodic patterns were analyzed for each time segment separately. This segmentation of the time series usually is arbitrary and not based on any theoretical assumption, and it might mask important aspects or introduce spurious findings (comparably to dichotomization of continuous variables).

Furthermore, it has been suspected (Voracek, Fisher, Yip, & Zonda, 2004) and also partly confirmed (Oravec, Sisti, Rocchi, & Preti, 2007; Rocchi, Sisti, Miotto, & Preti, 2007) that the amplitude of seasonal variation is related to

the absolute number of suicides. This hypothesis is easy to investigate when seasonality is assessed continuously.

Methods. To assess time trends in the strength of suicide seasonality, complex demodulation (Bloomfield, 2000) was applied. This method transforms the original time series into two new time series: the amplitude of the original series (i. e., the strength of seasonality), and the phase of the original series (i. e., the location of the maximum number of suicides during the period of the seasonality). Both of these new series vary over time, hence they describe temporal changes (time trends) in amplitude and location of peak. Described more technically, the original time series

$$x_t = A_t \cos(\omega t + \phi_t) + z_t \quad (1)$$

contains an oscillating signal of frequency ω with amplitude A_t , a peak at location ϕ_t and some random noise z_t . The frequency is fixed at a certain value, but amplitude, location of peak, and random noise vary over time. The oscillating signal (i. e., the cosine) can be rewritten as imaginary numbers, based on the formula $\cos(x) = \frac{1}{2}(e^{ix} + e^{-ix})$, which results in

$$x_t = \frac{1}{2}A_t (e^{i(\omega t + \phi_t)} - e^{-i(\omega t + \phi_t)}) + z_t \quad . \quad (2)$$

This time series is then multiplied by $e^{-i\omega t}$, resulting in a demodulated time series

$$y_t = x_t e^{-i\omega t} \quad (3)$$

$$= \left(\frac{1}{2}A_t (e^{i(\omega t + \phi_t)} - e^{-i(\omega t + \phi_t)}) + z_t \right) e^{-i\omega t} \quad (4)$$

$$= \underbrace{\frac{1}{2}A_t e^{i\phi_t}}_{(a)} + \underbrace{\frac{1}{2}A_t e^{-i(2\omega t + \phi_t)}}_{(b)} + \underbrace{z_t e^{-i\omega t}}_{(c)} \quad . \quad (5)$$

In equation 5, term (a) is the term of interest. It varies slowly over time, with frequencies below ω . Term (b) varies at frequency 2ω , and term (c) is the random noise term (that does not contain any power at frequency ω by definition of equation 1). Terms (b) and (c) have to be removed from the time series, in order to be able to extract the time series of amplitude and location of peak that are contained in term (a). This is called filtering and is an inherent feature of complex demodulation. In the study presented in this doctoral thesis, this was achieved by applying a 13-month centered moving average (as described in more detail in the study itself). The theoretical result is

$$\hat{y}_t = \frac{1}{2}A_t e^{i\phi_t} \quad . \quad (6)$$

After filtering, the amplitude \hat{A}_t and the location of the peak $\hat{\omega}_t$ of the time series at any time point t can be calculated by

$$\hat{A}_t = 2|\hat{y}_t| = 2\sqrt{\Re(\hat{y}_t)^2 + \Im(\hat{y}_t)^2} \quad (7)$$

$$\hat{\omega}_t = \arctan\left(\frac{\Im(\hat{y}_t)}{\Re(\hat{y}_t)}\right) \quad (8)$$

with $\Re(\hat{y}_t)$ being the real part and $\Im(\hat{y}_t)$ being the imaginary part of the demodulated and filtered time series \hat{y}_t . This can be understood as the polar representation of imaginary numbers. When the real part is represented on the x -axis, and the imaginary part on the y -axis, the arctangent is the angle of the point in this coordinate system, i. e., the relative location of the peak in the period (in this case, in the one-year cycle).

Results and Discussion. The present study examined the hypotheses regarding decreasing seasonality and regarding the association of strength of season-

ality with absolute suicide numbers in Austrian data on suicides for the years 1970 to 2008 ($N = 67,741$). Results of the study showed that the strength of seasonality was related to absolute suicide numbers, and that the strength of seasonality was stable when this association was taken into account. This finding might explain the seemingly heterogeneous and directionally opposite findings concerning changes in suicide seasonality that were found for different countries. Changes in seasonality found in prior related investigations might be smaller than currently is believed when this association is taken into account.

Study 2. Investigating Dimensionality of Eskin's Attitudes toward Suicide Scale with Mokken Scaling and Confirmatory Factor Analysis

Introduction. Attitudes toward suicide are an important factor in research regarding suicide. They include the view of suicidal behavior as a mental illness or the opinion that suicidal problems should be discussed openly. These attitudes are important for nurses and doctors treating suicidal patients (Anderson & Standen, 2007), and they also might be linked to actual suicidal behavior, although it is still a matter of debate on which pathways attitudes influence suicidal behavior (Beautrais, Horwood, & Fergusson, 2004). However, more positive attitudes toward suicide seem to be moderating the effect of hopelessness on suicidal ideation, at least in men, as suicidal ideation increases with hopelessness only when suicide is considered an acceptable option (Gibb, Andover, & Beach, 2006). Also, higher acceptability of suicide might be related to higher suicide rates (Salander Renberg, Hjelmeland, & Kuposov, 2008).

A review identified 18 different scales for measuring attitudes toward suicide, and for most of these scales, investigations of psychometric properties were un-

satisfactory (Kodaka, Postuvan, Inagaki, & Yamada, 2010). Furthermore, some of these scales also include items regarding factual knowledge about suicide, which strictly speaking should not be considered an attitude. One measure that does not contain items assessing knowledge is the scale of Eskin (2004). It has a very narrow focus on attitudes, it is short and still comprehensive. However, some contradictory evidence exists regarding the factor structure of this instrument, as prior research has identified a six- (Eskin, 2004), as well as a seven- (Eskin et al., 2011) factor solution, both by means of exploratory factor analyses.

Methods. In the present study, Mokken scale analysis (Mokken, 1971; Sijtsma & Molenaar, 2002) was used to clarify the factor structure of this instrument. This is a non-parametric method in the IRT framework and has some major advantages over classical methods like factor analysis. First, the assumptions made by IRT models are empirically testable (as opposed to classical test theory, where they are axiomatic). Second, this method of analysis can be used to automatically select items that fit in a common scale, which is comparable to a factor analysis or principal component analysis. However, not all items need to be part of the resulting scales. This enables Mokken scale analysis to construct scales instead of just data transformations (as is the case with principal component analysis; Wismeijer, Sijtsma, Assen, & Vingerhoets, 2008). Third, the construction of unidimensional scales is based on a criterion that specifies how well the items have to fit into the common scale. The strictness of that criterion can be varied and is increased stepwise in the course of the analysis, resulting in more clear-cut scales (and more items that are dropped). Thereby, the dimensionality of the instrument in question can be inspected and

additional insights can be gained. The method of analysis is explained in more detail in the study itself.

However, as the method is not widely used, results are not easily comparable to prior research. To amend this drawback, confirmatory factor analysis (CFA) was applied to assess the fit of models resulting from Mokken scale analysis. This allows to use well-established fit indices (Hu & Bentler, 1999) that provide a more familiar way to present results on the dimensionality of a questionnaire.

Results and Discussion. Results of the study revealed that the additional seventh factor found by Eskin et al. (2011) seemed to result from a more prominent view of suicide as a solution to life's problems, which might also be regarded as a facet of acceptability of suicide as found in the six-factor solution (Eskin, 2004). Moreover, results indicated that the factor *open reporting of suicide* has unsatisfactory psychometric properties, as the items it contains assess rather different constructs (i. e., open reporting of suicide in the media vs. open discussion of suicides among friends).

In summary, Eskin's scale seems to be a promising instrument. Furthermore it could be demonstrated how the joint use of Mokken scale analysis and CFA can lead to additional insights into the dimensionality of a questionnaire.

Study 3. Development of a Scale to Assess Knowledge about Suicide Postvention using Item Response Theory

Introduction. Knowledge about suicide postvention is an important distal outcome in the evaluation of suicide prevention programs that focus on the bereaved (Isaac et al., 2009; Szumilas & Kutcher, 2011). However, most scales

used for this purpose are specifically tailored to the evaluation study in question (Bean & Baber, 2011) and most of these scales use subjective self-ratings of perceived (as opposed to actual) knowledge (Clark, Matthieu, Ross, & Knox, 2010). Moreover, psychometric properties are scarcely investigated. For one scale that was used to assess knowledge about suicide postvention, it was attempted to construct a standardized instrument, the Preparing for Crisis Knowledge Test (PFC-KT), but psychometric properties were unsatisfactory (Mackesy-Amiti, Fendrich, Libby, Goldenberg, & Grossman, 1996). The aim of the last study of this doctoral thesis was to construct a scale measuring knowledge about suicide postvention.

Methods. Items were generated by screening the scientific literature, and item content was discussed with experts in the field of suicide research and paraprofessionals working in the field of crisis intervention (who also offer counseling for the bereaved after suicide).

For item analysis and item selection, methods of item response theory were used. As knowledge scales are known to be rather heterogeneous (e. g., Voracek et al., 2008), a newly developed method was used: Rasch trees (Strobl et al., 2011). This method is based on the Rasch model (Rasch, 1960), which ensures that the scale is unidimensional and that the sum score is a fair measure of the ability that is to be measured. Fit of the Rasch model is usually tested by comparing the item difficulty parameters (i. e., the estimated difficulties resulting from the Rasch model) of two or more subgroups. If they are not similar, the response behavior to the item in question is different for the subgroups and the item is said to show differential item functioning (DIF).

Using the Rasch trees method allows to identify subgroups of people that respond differently to certain items. One major advantage of this method is that the subgroups are defined by external criteria like age, sex, education, prior experience with suicide in friends or family, or any other criterion that was assessed. The method identifies the most important criteria by means of parameter instability tests, i. e., by analyzing for which groupings the estimated item parameters differ the most between subgroups.

For continuous external criteria like age, the method identifies the optimal cut point for that criterion by analyzing the score contribution (which can be derived from the conditional likelihood from the Rasch model) of each subject based on the external criterion. By a formal statistical test, the generalized M-fluctuation test (Zeileis & Hornik, 2007), it chooses the point for which the individual score contribution changes the most, thereby avoiding problems of arbitrarily splitting continuous variables (Strobl, Kopf, & Zeileis, 2010). Furthermore, the method also identifies subgroups by combining the specified external split criteria. This is achieved by recursively testing for parameter instability. First, all specified split criteria are tested in the complete sample. If DIF is found, the sample is split in regard to the criterion that was found to promote DIF, and the parameter instability tests are performed again in each subsample (until no more significant differences arise or the subsample is too small).

The fact that the grouping is based on external criteria facilitates interpretation of the results, as the constituting criteria that form subgroups are clearly defined, which is often not the case in other methods like cluster analysis, latent class analysis, or the mixed Rasch model. This can be used to gain additional

insight into the construct that is to be measured, in this case, knowledge about suicide postvention.

Results and Discussion. The most important subgroups identified by the Rasch tree analysis were age and sex. Also, education was found to be important in one sample, but this influence could not be replicated in a second independent sample. Marital status did not affect the response behavior to the items in the scale, nor did experience with suicidal behavior in close friends or family.

Although subgroups with different response behavior were identified by means of IRT analyses, factor analyses attested unidimensionality. Hence, as has been claimed before, presence of item-level DIF does not necessarily lead to biased scale scores (Reise & Waller, 2009). Moreover, for most items the item parameters were rather similar in the subgroups.

Only for some items, stronger differences in item difficulty (i. e., DIF) were found. For example, item 7 of the scale (anger is a normal reaction) was found to be more difficult for younger respondents, and item 5 (touching the deceased is medically safe) was found to be more difficult for young men. This could be used for suicide preventive measures. For example, making clear that touching the deceased is not dangerous from a medical point of view might be a way to encourage coping with the loss, particularly for younger men. In summary, the measure shows satisfactory properties for assessing knowledge about suicide postvention and could be used to evaluate suicide prevention or postvention programs more effectively.

General Discussion

The aim of this doctoral thesis was to contribute to suicide research by exemplifying the benefits of the application of novel or underused statistical methods. In each of the studies it could be shown that differences or even contradictions in prior related research might be more understandable or even resolved when investigated with different methodology.

Study one showed how different results of prior related studies regarding the changes in suicide seasonality might be explained by taking into account the relation to absolute suicide numbers. This was facilitated by applying complex demodulation, a method to continuously estimate the amplitude (i. e., strength) of suicide seasonality over the study period, avoiding the need to arbitrarily split the time series into two (or more) time segments and to compare results obtained with standard methods for each of these segments. This segmentation might be compared to dichotomizing a continuous variable. In this context, it is widely known that results might be obscured or that even spurious results can arise due to arbitrarily categorizing a continuous variable (e. g., Cohen, 1983; Fitzsimons, 2008; Maxwell & Delaney, 1993). However, despite a huge amount of evidence against this practice, dichotomization of variables remains very common in practical applications (DeCoster, Iselin, & Gallucci, 2009). It can only be hoped that the example of this study will motivate other researchers to refrain from arbitrarily splitting time series for analyzing changes in the amplitude of time series in general and for analyzing strength of suicide seasonality in particular.

In study two, a novel combination of two methods was applied to clarify

results regarding the factor structure of a questionnaire measuring attitudes toward suicide. It could be shown that different results regarding the dimensionality of the questionnaire might be explained by applying Mokken scale analysis, as this method allows to specify a criterion for how well the items have to fit into a common scale (i. e., a criterion for the quality of the scale). By increasing this criterion, the structure of the scale was revealed. It became clear that the additional seventh factor *suicide as a solution* splits off from the factor *acceptability of suicide*, when the strictness of the criterion increases. To make results more comparable with prior research, CFA was used to obtain well-known and widely used measures of fit (Hu & Bentler, 1999).

Study three presented the construction of a novel scale to measure knowledge about suicide postvention. After item construction and discussion of item content with experts from research and practical counseling, item analysis was performed with a new method of item response theory that allows to identify subgroups of persons with different response behavior for certain items (i. e., DIF). This was used to gain additional insights into the construct of knowledge about suicide postvention. For example, item 7 (anger is a normal reaction) was more difficult for younger respondents, which might indicate that they have less experience with grief in general and with their emotions in particular. Also, item 5 (touching the deceased is medically safe) was especially difficult for younger men. Using these findings, it may be possible to target suicide preventive measures more specifically. Making clear that touching the deceased is not dangerous from a medical point of view might be a way to encourage coping with the loss, particularly for younger men, and effective coping can reduce contagion effects or lower the risk for psychological problems in survivors that

have been exposed to suicide (Mackesy-Amiti et al., 1996).

The studies presented in this doctoral thesis have some limitations. All of these studies presented methods (or combinations of methods) that were new to the field of research. Although the results indicated that the methods worked well and could produce useful information, this has to be replicated in other samples.

A specific limitation of study one is the relatively limited study period. Although the time span comprised thirty-nine years, there are studies that analyze time series dating back more than one-hundred years (e.g., Ajdacic-Gross et al., 2005). Hence, the suggestion that seasonality is decreasing is (at least in part) based on a longer time series than the series that was used for the current study, and it might well be possible that the changes in the last thirty-nine years (i.e., the non-changing seasonality) do not reflect changes in the longer period. This might also indicate that the changes in the strength of suicide seasonality are non-linear, which could be easily investigated with complex demodulation in future research.

In study two, CFA models were used to test the fit of the scales resulting from the Mokken scale analysis. Although this strategy was aimed to make results comparable to prior research by using well-known fit indices (Hu & Bentler, 1999), using confirmatory analyses in the same sample might lead to overfit. In future investigations it would be profitable to use independent samples for Mokken and CFA analyses. Another shortcoming of study two is the fact that only dimensionality of the Eskin (2004) scale was investigated, but not its validity. However, as this was not the goal of the study, further studies need to address aspects of validity more thoroughly.

A specific limitation of study three is the fact that the Rasch tree analysis is, in fact, a data mining strategy. Comparable to model tests based on the mixed Rasch model (Rost, 1990), this method identifies the groups of persons for which the item difficulties vary the most. This has two consequences. First, investigating the fit of the model on this grounds is a very rigorous test of the Rasch model, in the course of which some items might be excluded that would not be excluded with conventional analyses. Of course, this also should lead to a questionnaire of high quality. Second, data mining strategies are generally very dependent on the sample they are used in. Hence, despite the fact the two independent samples were used for the study, replication in other samples is still highly warranted.

In summary, this doctoral thesis presented three statistical techniques that could be useful in suicide research. The techniques offer a view from a new perspective on some research questions, answering some, and providing the possibility to generate new hypothesis. For the research questions covered in this thesis the techniques proved beneficial, and it is hoped that they are also adapted for future research.

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Study 1

Nader, I. W., Pietschnig, J., Niederkrotenthaler, T., Kapusta, N. D., Sonneck, G., & Voracek, M. (2011). Suicide seasonality: Complex demodulation as a novel approach in epidemiologic analysis. *PLoS ONE*, *6*, e17413.

Suicide Seasonality: Complex Demodulation as a Novel Approach in Epidemiologic Analysis

Ingo W. Nader^{1*}, Jakob Pietschnig¹, Thomas Niederkrotenthaler^{2,3}, Nestor D. Kapusta⁴, Gernot Sonneck^{3,5}, Martin Voracek¹

1 Department of Basic Psychological Research, School of Psychology, University of Vienna, Vienna, Austria, **2** Department of General Practice and Family Medicine, Center for Public Health, Medical University of Vienna, Vienna, Austria, **3** Department of Medical Psychology, Center for Public Health, Medical University of Vienna, Vienna, Austria, **4** Department of Psychoanalysis and Psychotherapy, Medical University of Vienna, Vienna, Austria, **5** Ludwig Boltzmann Institute for Social Psychiatry, Vienna, Austria

Abstract

Background: Seasonality of suicides is well-known and nearly ubiquitous, but recent evidence showed inconsistent patterns of decreasing or increasing seasonality in different countries. Furthermore, strength of seasonality was hypothesized to be associated with suicide prevalence. This study aimed at pointing out methodological difficulties in examining changes in suicide seasonality.

Methodology/Principal Findings: The present study examines the hypothesis of decreasing seasonality with a superior method that allows continuous modeling of seasonality. Suicides in Austria (1970–2008, $N=67,741$) were analyzed with complex demodulation, a local (point-in-time specific) version of harmonic analysis. This avoids the need to arbitrarily split the time series, as is common practice in the field of suicide seasonality research, and facilitates incorporating the association with suicide prevalence. Regression models were used to assess time trends and association of amplitude and absolute suicide numbers. Results showed that strength of seasonality was associated with absolute suicide numbers, and that strength of seasonality was stable during the study period when this association was taken into account.

Conclusion/Significance: Continuous modeling of suicide seasonality with complex demodulation avoids spurious findings that can result when time series are segmented and analyzed piecewise or when the association with suicide prevalence is disregarded.

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* E-mail: ingo.nader@univie.ac.at

Introduction

Seasonality of suicides is a long-known and well-established phenomenon, with investigations published as early as 1825 [1]. Research showed that the pattern of seasonality is sex-specific: For men, studies showed an annual cycle with a single peak in spring, while for women, most (but not all) studies also revealed an additional biannual cycle with a smaller second peak in autumn [2,3]. Furthermore, seasonality has been found to be confined to violent suicide methods (i.e., all methods except poisoning [4]), specifically to hanging and drowning [5], and sometimes to jumping from high places [6].

Already in 1981, seasonal fluctuations in suicidality were suspected to be diminishing in Britain [7]. More recently, seasonality of suicide was reported to be decreasing in Finland [8], Denmark [9], the Swedish island of Gotland [10], England and Wales [11], and Switzerland [5]. Other studies found no decrease in seasonality in Italy [12], and even an increase in Australia [13] and the USA [14]. It was hypothesized that absolute suicide numbers are related to the strength of seasonality in suicides [15], which, from a mathematical point of view, is a

logically consistent assumption: When the absolute suicide frequency is higher, seasonal variation increases. This hypothesis has been partly confirmed by two previous studies [16,17].

Another, less disputed (but also not as intensively investigated) change in suicide seasonality relates to the location of the peak in the annual cycle. Although it is generally accepted that suicide rates are highest in spring or early summer, a Danish study reported that the peak occurs earlier now than a hundred years ago [18].

Research into suicide seasonality has employed a variety of statistical methods [19], ranging from simple Chi-squared tests to more complex methods such as harmonic analysis or spectral analysis. These latter two procedures are standard methods for the analysis of seasonal time-series data and aim to identify the contributions of different frequencies (cycles per year) in the periodic patterns in the time-series data. They are well suited for this purpose, but are unable to assess changes in cyclic patterns over time. Therefore, most studies have investigated changes in seasonality by arbitrarily splitting time series into two or more parts and comparing the respective findings. This entails serious drawbacks. First and foremost, splitting the time series is not based

on any theoretical assumption. Moreover, doing so might obscure important aspects or produce spurious findings.

A much more appropriate way is to employ statistical techniques that allow continuous estimation of the relevant variable (e.g., amplitude), like complex demodulation [20]. This method estimates amplitude and phase (location of peak) of a time series for each time point of the study period. To the authors' knowledge, complex demodulation has not yet been applied in the field of suicide seasonality research.

We aimed at demonstrating the benefits of this technique by applying it to suicide statistics of the Austrian population. We explored potential shifts in the location of the peak and possible changes in the strength of suicide seasonality (amplitude), taking into account a possible relation of amplitude and absolute suicide numbers.

Methods

Study Sample

We obtained daily suicide data in the period from January 1, 1970, to December 31, 2008, from Statistics Austria. In this period, 67,741 suicides were recorded (71.4% vs. 28.6% by men vs. women). Suicide method was coded by ICD-8, ICD-9, and ICD-10, depending on the date of the recorded death.

Data Preparation

From the daily suicide data, we calculated monthly suicide numbers. To account for the unequal length of months, these were adjusted to a standard month of 30.44 (365.25/12) days. For analysis, the time series' trend had to be removed. As the trend changed within the study period (increasing suicide rates until 1986, whilst decreasing rates thereafter; see Figure 1), we estimated the yearly trend by means of a thirteen-month centered moving average [21]. This procedure was chosen for ease of interpretation, as using an even number of months would induce a shift of the resulting average by half a month. The first month (e.g., first year's January) and the thirteenth month (e.g., second year's January) were weighted with 0.5; thus, all twelve months of the year had the same weights and the resulting average can be interpreted as the average monthly suicide frequency in a one-year period around the respective month.

Data Analysis

To assess the relative contributions of all possible frequencies in suicide seasonality, a periodogram analysis [22] was performed. This method estimates the amount of variance explained by every possible frequency in the time series (and is the unsmoothed variant of spectral analysis). We used Fisher's *g* test [23] to check for significant seasonality, and relevant frequencies (explaining significant parts of the overall variation) were revealed by using the tables of Russell [24]. In accordance with previous studies (e.g., [6,25]), this was performed for the whole sample, for men and women separately, and finally for different suicide methods (hanging, drowning, shooting, jumping from high places, poisoning, cutting, and other methods) for men and women, respectively.

When significant one-year cycles were found, we used complex demodulation to assess changes in amplitude and phase (location of peak). Complex demodulation may be regarded as a local version of harmonic analysis [20], whereby the frequency is fixed at a certain value (in this case, one cycle per year) and amplitude and phase are allowed to vary. This yields two new time series: one for the amplitude at each time-point of the study period, and another one for the phase. These resulting time series are per

definition rough and fluctuating and thus have to be filtered; hence, smoothing is an inherent feature of this data-analytic method. This was accomplished by applying another thirteen-month centered moving average. Furthermore, the smoothed amplitude and phase time series may be used to reconstruct (i.e., remodulate) the key features of the original time series. This remodulated time series can then be compared to the original data to assess fit.

To evaluate whether amplitude and phase changed over time, we used linear regression models. As the amplitude has been found [12,16] to be associated with absolute suicide numbers, suicide frequency was included as a predictor. Because assumptions of the linear model are generally violated in time-series data due to autocorrelated residuals, significance testing was performed using an appropriate covariance estimator [26,27]. All analyses were performed in the statistical software package R (Version 2.10.1) [28].

Results

Overview

The first subsection presents an overall analysis of seasonality, without taking into account possible changes during the study period. We used periodogram analysis [22] to explore general patterns in suicide seasonality in the Austrian population.

The second subsection aims at revealing dynamic changes in suicide seasonality. This is achieved by complex demodulation [20], which estimates amplitude and location of peak continuously from the original time series of monthly suicide frequencies. To assess time trends in these variables, we applied regression models.

Periodogram Analysis of Seasonality

In the total sample, an annual cycle explained 29.8% of variance. We found seasonal patterns to be stronger for men: In men, 26.1% of variance was explained by an annual cycle, whereas in women, seasonality was less pronounced. The annual cycle explained 14.3% of variance, and, consistent with previous research [7], an additional biannual cycle was found, explaining further 4.6%. Moreover, we found a periodic component with a frequency of 6 cycles per year in the total sample and in women, as well as some significant non-seasonal frequencies at non-integer frequencies, but each of them accounted for less than 2.7% of variance (Table 1).

For men, only the methods hanging and drowning showed significant annual seasonality. Annual cycles explained 27.2% of variance for the method of hanging. No significant biannual cycle was found, but there were a number of non-seasonal frequencies (Table 2). Drowning also revealed marked annual cycles (17.8%), and no other frequencies contributed significantly. For shooting, jumping from high places, poisoning, cutting, and other suicide methods, no significant annual cycles were found for men.

For women, annual patterns of seasonality were found for the methods of hanging, drowning, and (in contrast to men) jumping from high places. Seasonality was strongest for drowning, where the annual cycle explained 9.0% of the variance. For hanging and jumping from high places, annual patterns explained 5.9% and 6.8%, respectively.

Women who died by hanging were the only subgroup that showed a significant biannual cycle (4.4%). We found no significant annual or biannual seasonality for shooting, poisoning, cutting, or other methods (Table 2).

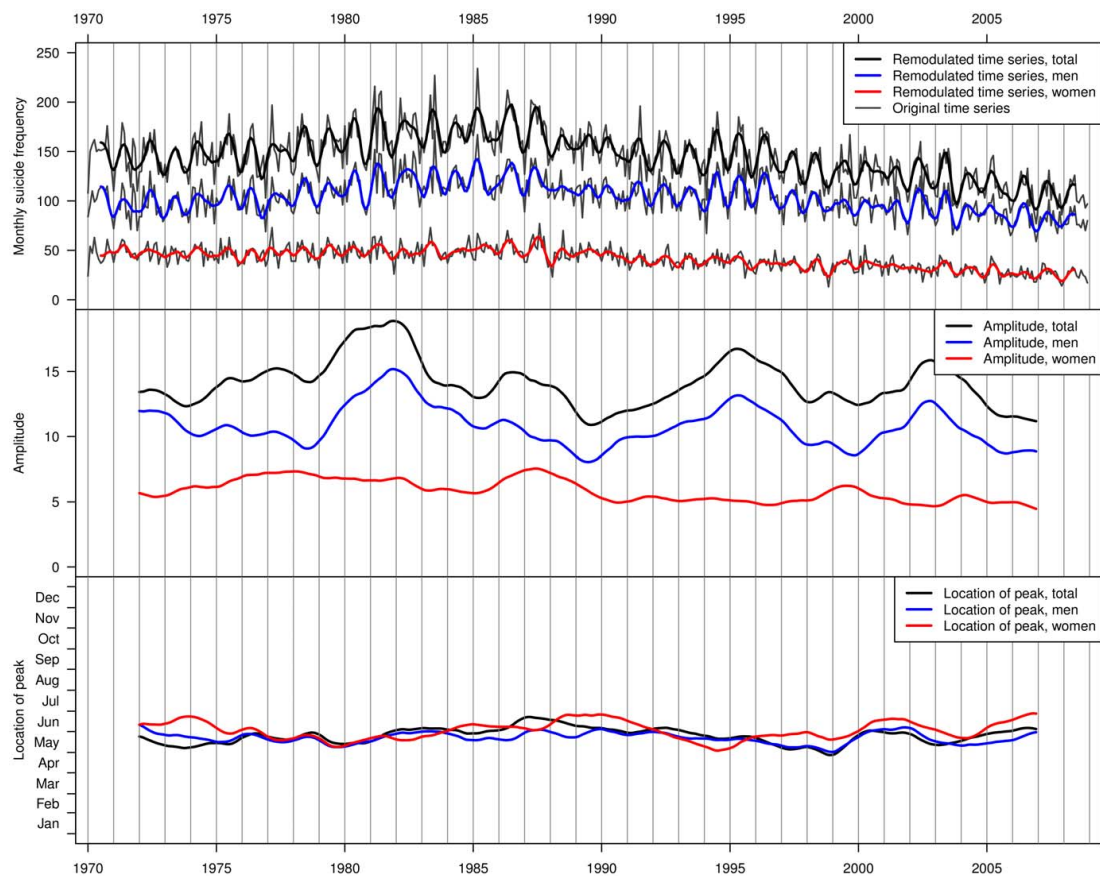


Figure 1. Monthly suicide numbers and complex demodulation results. Upper panel shows the remodulated and original time series of absolute suicide frequencies for the total sample, men, and women. Middle panel depicts the amplitude as a function of time; amplitude is the difference of monthly suicide numbers from the deseasonalized yearly trend at a specific point in time. Lower panel shows the location of the peak (phase) as a function of time. For clarity of presentation, amplitude and phase plots are additionally smoothed by a 37-month centered moving average.

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As expected, hanging was found to be the most common suicide method in our sample, and suicide incidence was much higher for men (Table 3). Therefore, seasonal patterns of the total sample were most likely to be driven by the method of hanging, especially in men.

Complex Demodulation of Seasonality

Although the cyclic pattern is only explained by a single frequency (i.e., an annual cycle), the remodulated time series captured the main features of the original time series adequately (Figure 1, upper panel). Percentage of explained variance ranged from 48.4% for the total sample to 26.3% for hanging in women (Table 4, first column).

Trends of amplitude and phase (location of peak) are also shown in Figure 1 (middle and lower panel). Amplitude is the deviation of monthly suicide numbers from the deseasonalized yearly trend at a specific time. The difference of lowest and highest suicide frequencies in the course of a year therefore equals twice the amplitude.

The amplitude of the total sample was markedly unstable during the study period and mainly driven by men. The latter is not surprising, since suicide incidence was much higher in men as compared to women. The amplitude was lower in women, showing less variation over time. Mere visual inspection suggested a relation between absolute suicide numbers and amplitude: When comparing the yearly trend of the original series with the amplitude obtained from complex demodulation (Figure 1, upper panel), it is obvious that the strength of suicide seasonality (i.e., amplitude) was higher when absolute suicide numbers were high, and that the amplitude decreased when absolute suicide numbers went down. Correlations between amplitude and deseasonalized yearly trend of absolute suicide numbers ranged from $r = .32$ to $r = .54$ in subsamples where adequate annual seasonality was identified by periodogram analysis (Table 4, second column).

For a more formal approach, we applied linear regression models, where the amplitude was predicted by two explanatory variables: absolute suicide frequency (deseasonalized yearly trend,

Table 1. Suicide seasonality for the total sample, men and women (all methods).

	Frequency	Variance explained	<i>p</i> value
Total sample	1.00	29.8%	<0.001
	6.00	2.7%	
Men	1.00	26.1%	<0.001
	5.23	2.6%	
Women	1.00	14.3%	<0.001
	2.00	4.6%	
	1.74	2.6%	
	6.00	2.2%	
	1.59	2.1%	

Results of periodogram analysis (significant frequencies and the proportion of variance explained by that frequency) and Fisher's *g* test of significant seasonality against the null hypothesis of no seasonality. Frequency is the number of cycles per year, *p* values are one-sided.
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estimated by 13-month centered moving average) and time. Results showed that absolute suicide numbers were related to the amplitude in the total sample as well as in all other subsamples

with significant annual seasonality (Table 4), except in the subsample of women that used hanging as suicide method. In this subgroup, no trend was present. Consequently, significance of the relation between amplitude and absolute suicide numbers could not be assessed due to lack of variation in the explanatory variable.

Regarding time trends in the strength of suicide seasonality (that is, amplitude), no decreasing or increasing seasonality was found in the total sample and also in most subsamples. The only subgroups that showed a slight, but nominally significant, decrease of seasonality were men who died by drowning and women who used the method of hanging.

Regarding time trends in the location of the peak, similar regression models were fitted, including time as explanatory variable. We found no significant changes in the location of maximum suicide incidence in any subsample (only subsamples with significant annual seasonality were considered; all *p*s > 0.08, further results omitted for brevity). Despite showing no significant time trends, location of the peak showed considerable variation during the study period, ranging from mid-March to August. Figure 1, which was smoothed for clarity, still shows variation from late April to late June. On average, the peak location was in late May.

Discussion

The major goal of this study was to investigate the hypothesis of decreasing seasonality with new and appropriate methodology. We showed that continuous modeling of amplitude, obtained by complex demodulation, is an adequate and

Table 2. Suicide seasonality for specific suicide methods for men and for women.

	Men			Women		
	Frequency	Variance explained	<i>p</i> value	Frequency	Variance explained	<i>p</i> value
Hanging	1.00	27.2%	<0.001	1.00	5.9%	<0.001
	1.36	3.6%		2.00	4.4%	
	2.85	2.4%		1.58	4.2%	
	5.23	2.2%		1.31	2.4%	
Drowning	1.00	17.8%	<0.001	1.00	9.0%	<0.001
				6.00	3.4%	
Shooting			0.071	1.41	3.7%	0.037
Jumping			0.004			<0.001
	1.67	4.7%		1.00	6.8%	
	1.23	4.1%		3.97	2.9%	
	1.00	3.4%		1.08	2.6%	
	1.28	2.6%		4.18	2.4%	
Poisoning			0.005	1.21	2.1%	0.730
	1.38	4.4%				
	3.00	2.8%				
Cutting			0.708		0.357	
Other			0.260		0.556	

See Table 1.
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Table 3. Frequencies (absolute and relative) of specific suicide methods in Austria.

Method	Men		Women		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Hanging	24356	50.4%	7056	36.4%	31412	46.4%
Drowning	1341	2.8%	2159	11.1%	3500	5.2%
Shooting	9609	19.9%	507	2.6%	10116	14.9%
Jumping	3072	6.4%	2853	14.7%	5925	8.7%
Poisoning	5980	12.4%	4951	25.6%	10931	16.1%
Cutting	1060	2.2%	369	1.9%	1429	2.1%
Other	2954	6.1%	1474	7.6%	4428	6.5%

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convenient way of investigating changes in strength of suicide seasonality. We also demonstrated that the strength of seasonality is associated with absolute suicide numbers. When this association was taken into account, no changes in strength of suicide seasonality were found.

Methodological Aspects in Suicide Seasonality Research

In our study, we used complex demodulation to obtain a continuous estimate of amplitude during the study period. Other studies segmented their time series and compared the results for different time periods. In most (if not all) cases, this segmentation was performed arbitrarily and was not theoretically founded. Furthermore, this approach has methodological disadvantages. On the one hand, it might obscure important aspects because it is not fine-grained enough, and on the other hand it might produce spurious findings when fluctuations in amplitude are large (as was seen in our results) or when segments of the time series are too short.

Moreover, a continuous estimate of amplitude over time, as obtained by complex demodulation, facilitates taking into account possible associations of strength of seasonality (amplitude or ratio of seasonal variation) with absolute suicide numbers. This effect has been disregarded in the majority of studies examining changes in suicide seasonality, which in turn might also have led to artificial results. This does not only apply to the amplitude of seasonal

variation obtained from complex demodulation, but also to another method frequently used in suicide seasonality research: In harmonic analysis, the fraction of variance attributed to seasonal patterns is known to be proportional to the overall mean in the specific period [29]. Hence, changes in seasonality are influenced by changes in absolute suicide numbers and might give rise to spurious results.

Association of Amplitude and Absolute Suicide Numbers

The present study supported the hypothesized association of suicide seasonality strength and absolute suicide numbers in the Austrian population. This link has also been demonstrated in other studies [12,16]. Therefore it seems reasonable that this is a generalizable finding and that this effect is also present in other countries.

As our findings indicate a moderate correlation of up to .54 between the amplitude and absolute suicide numbers, a substantial fraction of suicides do not seem to show seasonal variation. This has already been hypothesized by prior research: Possible explanations include that only suicides related to psychiatric illness are seasonal [9] and that the decrease in seasonality of suicides corresponds to an increase in antidepressant prescription numbers [10]. However, we found no decrease in seasonality despite documented strong increases of antidepressant prescriptions in Austria [30]. Seasonality of suicides has also been shown to

Table 4. Relation of amplitude to absolute suicide numbers and time trends in amplitude of suicide seasonality.

	Variance explained	$r_{amp,abs}$	Regression			
			Absolute number	p	Time	p
Total sample	48.4%	0.33	0.060	0.026	0.011	0.769
Men, all methods	47.4%	0.32	0.060	0.023	-0.026	0.381
Men, hanging	45.2%	0.53	0.214	<0.001	0.051	0.154
Men, drowning	36.3%	0.52	0.326	<0.001	-0.009	0.040
Women, all methods	30.3%	0.48	0.076	0.045	-0.001	0.959
Women, hanging	26.3%	0.46	0.000	1.000	-0.043	0.025
Women, drowning	30.4%	0.54	0.225	0.001	-0.002	0.794
Women, jumping	25.4%	0.47	0.240	<0.001	0.004	0.227

Variance explained is the squared correlation of the (detrended) original time series and the remodulated time series from complex demodulation. $r_{amp,abs}$ is the correlation of amplitude and absolute suicide frequency (deseasonalized yearly trend, estimated by 13-month centered moving average). Absolute number is the change in amplitude (in absolute number of suicides) when the absolute suicide frequency (deseasonalized yearly trend) increases by one suicide. Time is the linear change in amplitude per year (in absolute number of suicides) when absolute monthly suicide frequency is held constant.

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be more pronounced in rural than in urban contexts [5], offering another potential explanation. The present study cannot confirm or disprove any of these possible explanations, but the results do strengthen the hypothesis that only a proportion of suicides show seasonal variation.

Changes in the Strength of Suicide Seasonality

Seasonality of suicides has been shown to decrease in most [5,8–11], but not all, countries [13,14]. Furthermore, the amplitude of seasonal variation has repeatedly been shown to be associated with absolute suicide numbers [12,16], which also held with the present data. This latter effect may well account for the inconclusive evidence from comparisons of different countries. In Finland, where a slight decrease in seasonality was found, absolute suicide numbers also decreased for violent suicides in the last years of the study period. The authors of that study already suspected these facts to be related, but did not address this matter in further analysis [8]. Similar patterns have been reported in other studies [5,9–11,31]. In Australia, on the other hand, both seasonality and absolute suicide numbers increased [13], as well as in the USA [14].

Therefore, the association of seasonal variation and absolute suicide numbers might be an adequate link to integrate seemingly heterogeneous and directionally opposite findings concerning changes in suicide seasonality across countries. We hypothesize that changes in suicide seasonality may turn out to be smaller and much more consistent across different nations than currently is widely believed, once this association is considered.

Suicide Seasonality in Austria

Putting the results of this study into the context of other findings requires some explication, as prior related studies used a variety of distinctly different methods. Chi-squared tests do not report explained variance and for this reason are not comparable with more advanced methods. In harmonic analysis, the total variance is split into seasonal harmonics (integer frequencies), non-seasonal harmonics (non-integer frequencies), and random variation. Contributions of specific frequencies (e.g., a one-year cycle) are sometimes reported analogously to the results of periodogram analysis, but at other times as percentage within seasonal harmonics, which themselves are a percentage of total variance. In this case, the contribution of a certain frequency is obtained by multiplication of the two percentages, which can then be compared to the present study's results.

One-year cycles explained 29.8% of variance in our sample, which is comparable to the findings of other studies (e.g., 31 to 44% in the USA [14]). For men vs. women, we found the one-year cycle to explain 26.1 vs. 14.3% of variance, respectively, which is also comparable to results of other countries (e.g., 16 to 39% vs. 11 to 37% in Italy [12], and 20 to 39% vs. 3 to 18% in Slovenia [32]). We found seasonality to be confined to hanging and drowning (in men and women) and jumping from high places (in women only), which similarly is consistent with studies analyzing specific suicide methods [5,6]. Also conforming to prior research, we detected a biannual cycle in women [7], and we found this biannual cycle only for hanging.

Our results did not support a shift in the peak of suicide incidence. It has to be noted that our study period was limited to 39 years, whilst the study advancing this hypothesis [18] cited data stemming from more than one century apart. Therefore, the present results do not contradict the hypothesis of a progressively earlier-occurring peak in the past, but they indicate that any such development does not seem to be ongoing, at least in the Austrian population. Despite lacking any time trend, the

location of the peak showed considerable (albeit unsystematic) variation over the study period. This might, on the one hand, be a result of using only moderate smoothing. On the other hand, it might offer an explanation for varying results of prior research concerning the exact location of the highest suicide incidence within the annual cycle.

For the reasons elaborated above, we consider our data set as quite typical. This applies also to our results, with one exception: Strength of suicide seasonality was found to be stable when the association with absolute suicide numbers was corrected for. This association was found in all subsamples, except for hanging in women where it could not be assessed due to lack of a trend in absolute suicide numbers. Only two subgroups showed marginal decreases in amplitude, namely men who died by drowning, and women who used the method of hanging. Drowning is a very uncommon method and therefore not a main contributor to overall suicide seasonality. Hanging in women did not show strong seasonality; hence, annual seasonality is mainly driven by men who take their lives by hanging. Since no time trends were found for this latter method, seasonality seems to be a stable phenomenon, at least in the Austrian population.

Furthermore, the amplitude of seasonal patterns showed considerable variation over the study period. Previous research did not assess the strength of seasonality continuously. Instead, time series were split into intervals, and the interval-specific results also showed considerable variation (as can be seen from the range of numbers mentioned above). We therefore assume that both variation in the strength of seasonality and an association of strength with absolute suicide numbers might also be found in other populations.

Study Limitations

The present findings are based on population statistics of a single country. This is true for most studies in suicide seasonality research; the only comprehensive cross-national study was performed in 1995 [33]. Although we found sample characteristics to be comparable to those of other countries, it still remains to be shown that the current conclusions hold for other countries.

Implications

It has been argued in previous studies that decreases in suicide seasonality might indicate that some interventions are able to reduce the risk of suicide at times of high risk [34] or that such decreases might be related to a smaller proportion of depressive suicides [10]. This was not confirmed by our results, as there was evidence that the seemingly decreasing strength of seasonality might be a result of its association with absolute suicide numbers. Therefore, a possibly lowered rate of depressive suicides would lower absolute suicide numbers, but not the strength of suicide seasonality.

In summary, our study demonstrates the usefulness of complex demodulation to assess the strength of suicide seasonality. This method allows a continuous estimation of amplitude during a given study period, which facilitates incorporating the association of strength of seasonality with absolute suicide numbers. We could show this association to be significant, and, when considering this fact, we demonstrated that seasonality of suicides seems to be stable in Austria. Although replications in other countries are needed to assess the generalizability of these findings, incorporating the methodological approach of this study seems to have potential to yield a clearer understanding of changes in seasonal patterns of suicide incidence.

Author Contributions

Conceived and designed the experiments: IWN MV JP. Analyzed the data: IWN. Contributed reagents/materials/analysis tools: JP TN NDK GS.

Wrote the paper: IWN. Literature review: IWN JP MV. Interpretation of results: IWN JP TN NDK GS MV. Critical review and revision of manuscript: IWN JP TN NDK GS MV.

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Study 2

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Investigating Dimensionality of Eskin's Attitudes toward Suicide Scale with Mokken Scaling and Confirmatory Factor Analysis

Ingo W. Nader, Ulrich S. Tran, Patricia Baranyai, and Martin Voracek

Attitudes toward suicide are often investigated by means of questionnaires, most of which are overly long or of low psychometric quality. Eskin's (2004) Attitudes Towards Suicide Scale is short and first investigations suggest good psychometric properties, but its factor structure has scarcely been explored. Hence, we examined this instrument by a data-analytic approach that combines Mokken scaling and confirmatory factor analysis (CFA). Results revealed 6 factors, of which 1 possessed only weak measurement properties. CFAs indicated only borderline fit of models found in prior research, but adequate fit for the scale structures revealed by Mokken scaling. Psychometric properties of these scales were satisfactory. Both the instrument as well as the methodological approach presented here can be recommended for further research.

Keywords attitudes, confirmatory factor analysis, dimensionality, item response theory, Mokken scaling, suicide

Attitudes toward suicide are complex and multi-faceted, including the view of suicidal behavior as a mental illness, the opinion that suicidal problems should be discussed openly, or the thought that suicide will be punished after death. These attitudes have been investigated in a great variety of contexts, for example among nurses and doctors (e.g., Anderson & Standen, 2007) as well as among medical (e.g., Wallin & Runeson, 2003) and psychology students (e.g., Hjelmeland, Akotia, Owens et al.,

2008), with regard to survivors' views on suicide (Yamanaka, 2008), or regarding effects of death in the family (Zhang & Jia, 2009), as well as in terms of their role in ethnocultural differences regarding suicide (for a review, see Colucci & Martin, 2007). Another line of research has investigated associations of attitudes toward suicide and actual suicidal behavior, although both the extent as well as the actual pathways of how attitudes influence suicidal behavior are still a matter of extensive but

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unresolved debate (Beautrais, Horwood, & Fergusson, 2004). More positive attitudes toward suicide have been found to moderate the effect of hopelessness on suicidal ideation (i.e., among men, suicidal ideation increases with hopelessness only when suicide is considered an acceptable option; Gibb, Andover, & Beach, 2006), and higher acceptability of suicide has been linked to increased planning of suicidal actions in adolescents (Joe, Romer, & Jamieson, 2007). Furthermore, higher acceptability of suicide has also been suspected to be associated with higher suicide rates, although this finding remains debated (Salander Renberg, Hjelmeland, & Kuposov, 2008).

In summary, attitudes toward suicide are an important factor in research regarding suicide and, due to a potential link to actual suicidal behavior, suicide prevention (Li & Phillips, 2010). This entails the question of how to effectively measure attitudes toward suicide. Survey-based investigations of attitudes are probably the most commonly used method in research today, despite an increasing amount of qualitative research (e.g., Knizek, Akotia, & Hjelmeland, 2010).

A variety of questionnaires for assessing attitudes toward suicide are available. A recent review identified 18 different scales, for most of which investigations of psychometric properties were found lacking (Kodaka, Postuvan, Inagaki et al., 2010). Probably the most widely used is the Suicide Opinion Questionnaire (Domino, Gibson, Poling et al., 1980), which is rather lengthy (100 items) and factorially complex (Anderson, Lester, & Rogers, 2008). Another instrument is the Multi-Attitude Suicide Tendency Scale (Orbach, Milstein, Har-Even et al., 1991), which aims at measuring intentions related to actually engaging in suicidal behavior (as opposed to attitudes related to suicidal behavior in general). The Suicide-Attitude Questionnaire (SUIATT; Diekstra &

Kerkhof, 1988) is a thoroughly constructed scale measuring cognitive, affective, and instrumental aspects regarding suicide of different supposed actors (self, beloved one, people in general), but the authors themselves admit that it is too long and complicated for clinical purposes (Diekstra & Kerkhof, 1989). Other measures include the Attributions of Causes to Suicide Scale (Lester & Bean, 1992), which measures the extent to which suicide is causally attributed to three theoretically founded, but mutually related domains (intrapsychic problems, interpersonal conflicts, and societal pressures; Voracek, Loibl, & Lester, 2007), or the Attitudes Towards Suicide Scale (Salander Renberg & Jacobsson, 2003), for which only low internal consistencies have been found. Furthermore, some items of this instrument seem to rather assess knowledge about suicide instead of attitudes (e.g., whether asking someone about suicidal thoughts can invoke such thoughts).

The multitude of available questionnaires on this topic might be related to difficulties to accurately define attitudes toward suicide. Attitudes can be defined as “a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor” (Eagly & Chaiken, 1993, p. 1). Research can target attitudes toward suicidal behavior itself, toward possible causes of suicide, or toward other aspects of suicidality. Sometimes attitudes appear to be confused with knowledge about suicide or suicidal behavior. In this context, knowledge is to be understood as an all or nothing matter, which does not involve a degree to which something can be known or not: A person either has knowledge about some fact, or does not (BonJour, 2010). Hence, when investigating attitudes toward suicide, restricting the item content to a more clear-cut construct would clearly be profitable.

Yet another measure of attitudes toward suicide is the scale of Eskin (2004),

which is short while still comprehensive. It comprises 24 items and measures 6 factors. These investigate, among others, the respondent's opinion on whether people have the right to kill themselves or whether suicidal behavior should be hidden from others. Hence, this scale has a more narrow focus on attitudes as defined above.

However, some contradictory evidence exists regarding the factor structure of this instrument. Instead of the six factors, an investigation in a German-speaking sample resulted in a seven-factor solution that yielded the view of suicide as a solution to life's problems as an additional factor (Eskin, Voracek, Stieger, & Altinyazar, 2011). Apart from factor loadings, no other psychometric properties were reported.

The goal of the present study was two-fold. First, we aimed to clarify the factor structure of this instrument and to report on psychometric properties, in order to improve on the scarce number of thoroughly investigated attitude measures (Kodaka, Postuvan, Inagaki et al., 2010) and to add information on an instrument with a clearly defined focus on attitudes toward suicide. Second, in doing so we outlined a methodological approach that combines the benefits of (exploratory) nonparametric item response theory and parametric methods related to classical test theory: We conjointly applied Mokken scaling and confirmatory factor analysis (CFA), using the former to explore the facets of the questionnaire, and the latter to investigate the fit of resulting models.

METHODS

Participants

The sample consisted of 571 German-speaking volunteers (212 men and 359 women; 74.5% Austrian, 20.0% German, 0.7% Swiss, and 4.8% other nationality). Mean age was 30.0 years ($SD = 12.8$ years).

In terms of highest education, 7.2% had completed primary education, 18.6% had an apprenticeship diploma, 53.2% had completed secondary education, 20.5% had a university degree, and 0.5% did not state their highest education.

Measure

Eskin's (2004) scale consists of 24 statements which are rated on 5-point scales, ranging from 1 (*completely disagree*) to 5 (*completely agree*). Factors measured by the scale are: (1) acceptability of suicide; (2) suicide as a sign of mental illness; (3) the belief that persons who commit suicide will be punished after death; (4) the opinion that suicidal people should communicate their problems; (5) the intention to hide past suicidal behavior; and (6) the opinion that suicide should be discussed and reported openly among friends or in the news.

A seventh factor has been found through exploratory factor analysis in a German-speaking sample (Eskin, Voracek, Stieger et al., 2011), namely (7) the view of suicide as a solution, including items of the former factors acceptability of suicide and communication about suicidal problems.

Procedure

Participants were identified by personal contacts of the researchers and by word of mouth, were recruited opportunistically and approached personally. All participants gave informed consent, took part on a voluntary basis, and were not remunerated for participation. They were assured that participation was entirely anonymous and confidential. After completion of the questionnaire, all participants were debriefed using a standardized debriefing text containing information about the study and

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contact information of institutions which offer help for people in need of counseling.

230 To further increase heterogeneity in this community sample, the questionnaire was also presented as an online version. Participants were recruited by posting the link to the online questionnaire in social
235 media sites and Internet message boards (not related to suicide topics).

Almost two-thirds (62.4%) of the total sample completed the paper-pencil form of the questionnaire, whereas 37.6% were
240 recruited online. The online sample differed slightly in terms of sex (58.8% vs. 69.6% women in paper-pencil vs. online sample) and education (educational level was more heterogeneous in the online sam-
245 ple), but not regarding age or attitudes toward suicide (results omitted for brevity).

Scale Assessment Procedure

Mokken scaling (Mokken, 1971; Sijtsma & Molenaar, 2002) is a non-
250 parametric method for constructing unidimensional scales of dichotomous or polytomous items within the framework of item response theory (IRT). The method assumes a unidimensional latent trait, local
255 independence of responses, and monotonicity (i.e., the higher the latent trait, the more an item will be endorsed). If these assumptions are satisfied, higher sum scores correspond to higher values on the
260 latent trait (that is, respondents can be reliably ordered on the latent trait by their score).

One of the major advantages of IRT models in general and Mokken scaling in
265 particular is that these assumptions are empirically testable. Monotonicity can be inspected and tested via the item response function, and unidimensional scales generally have substantial positive covariances
270 between all pairs of items. From these covariances, the so-called scalability coefficients (Loevinger's H) are calculated. They

are calculated for each item pair (H_{ij} ; com-
parable to item covariances and indicating
275 how well two items fit in a common scale), for each item in a scale (H_i ; comparable to an item discrimination parameter in relation to the scale the item is a part of), and for a total scale (H ; Sijtsma, Meijer, & van der Ark, 2011). This H coefficient
280 indicates the scale's quality in terms of ordering the respondents on the latent dimension. Numerically quantifying a scale's ability to order individuals by means of coefficient H is one of the major stren-
285 gths of Mokken scaling. Commonly, the value of H is desired to exceed $H=.3$. Values of .3–.4 indicate a weak scale, .4–.5 a moderate scale, and values of $>.5$ are evidence of a strong scale (Sijtsma & Molenaar, 2002).
290

Although Loevinger's H can be used as a measure of internal consistency, it has
295 somewhat different properties than Cronbach's coefficient α . A more comparable measure in the framework of Mokken scaling is the Molenaar-Sijtsma ρ coefficient (Molenaar & Sijtsma, 1988), which can take values between 0 and 1. A value
300 of .7 is generally recommended for a scale to be acceptable.

In exploratory Mokken scaling, scale construction is performed by an automated
305 algorithm which selects items with high pairwise scalability coefficients H_{ij} into scales, as long as these coefficients exceed a specified minimal value $\min H_i$ (usually .3). If this is not the case, the algorithm attempts to construct a second unidimen-
310 sional scale from the remaining items. The algorithm stops when no item satisfies the above mentioned criteria, possibly leaving some unscalable items that do not fit into any of the scales. Following Sijtsma and Molenaar (2002), the $\min H_i$ value
315 should be varied from 0 to .55, partitioning the items into an increasing number of more and more clear-cut scales, thereby revealing the dimensionality of the instru-
320 ment in question.

Additionally, we fitted CFA models. Mokken scaling has already been used jointly with principal component analysis (Wismeijer, Sijtsma, van Assen et al., 2008), and investigating the dimensionality of a scale with Mokken scaling and CFA might yield additional insights. First, models resulting from Mokken scaling can be tested in terms of their data fit with CFA, using fit indices and benchmarks that are well-established (Hu & Bentler, 1999). Second, CFA results allow for direct comparisons with prior research. Mokken scaling was performed in R (R Development Core Team, 2010), using the Mokken package (van der Ark, 2007), and CFA was carried out in Mplus Version 6.1 (Muthén & Muthén, 2008).

already three Mokken scales resulted, and for $\min H_i = .20$, four scales were found. All scales corresponded either to single factors reported by Eskin (2004) or were combinations thereof. One scale, for example, consisted of the items of the two factors Punishment after Death and Hiding Suicidal Behavior (which are undoubtedly related in content; Table 1).

For the recommended value of $\min H_i = .30$ (Sijtsma & Molenaar, 2002), six Mokken scales resulted. These scales matched the scales originally found by Eskin (2004), with the only exception of Item 16, which was found to be unscalable. Owing to item content heterogeneity, the scale Open Reporting of Suicide was found to be a weak scale with $H = .31$, with low internal consistency (Molenaar-Sijtsma $\rho = .46$). All other scales were strong (all $H > .5$, but most of them exhibiting considerably higher values of up to $H = .89$) and of high internal consistency (all $\rho \geq .86$, reaching values of $\rho = .94$; Table 2), indicating that raw scale scores are highly suited for ordering the respondents regarding their respective attitude.

RESULTS

Mokken Scaling

Dimensionality of Eskin's attitudes toward suicide scale was assessed by means of the automated item-selection procedure. Starting with a minimum value $\min H_i = 0$,

TABLE 1. Item Numbers for Selected Scales of Exploratory Mokken Analysis

$\min H_i$	Sc. 1	Sc. 2	Sc. 3	Sc. 4	Sc. 5	Sc. 6	Unscalable
.00-.05	11-15, 21, 22 (.44)	9, 10, 16-20 (.28)	1-8, 23 (.47)				24
.10-.15	11-15, 21, 22 (.44)	9, 10, 17-20 (.38)	1-8 (.59)	23,24 (.31)			16
.20	12-15, 21, 22 (.54)	9-11 (.83)	17-20, 24 (.46)	1-8 (.59)			16, 23
.25	12-15, 21, 22 (.54)	9-11 (.83)	17-20 (.61)	1-8 (.59)	23, 24 (.31)		16
.30	12-15 (.82)	9-11 (.83)	21, 22 (.89)	17-20 (.61)	1-8 (.59)	23, 24 (.31)	16
.35-.45	12-15 (.82)	9-11 (.83)	21, 22 (.89)	17-20 (.61)	1-8 (.59)		16, 23, 24
.50	12-15 (.82)	9-11 (.83)	21, 22 (.89)	17-20 (.61)	1-4, 7, 8 (.67)	5, 6 (.56)	16, 23, 24
.55	12-15 (.82)	9-11 (.83)	21, 22 (.89)	18-20 (.69)	1-4, 7, 8 (.67)	5, 6 (.56)	16, 17, 23, 24

Note. Numbers in cells are item numbers, and numbers in parentheses are the respective scales' scalability coefficients H . $\min H_i$ = minimum item scalability for an item to be selected to a scale. Sc = Mokken Scale.

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TABLE 2. Item Text and Scale Characteristics from Mokken Scaling

Scales/items	H_i
Scale 1: Acceptability of suicide ($H = .59$; $\rho = .91$; $\alpha = .89$)	
1. Someone who has gone bankrupt has the right to kill him/herself.	.59
2. Someone who is tired of living has the right to kill him/herself.	.67
3. Someone who dishonored his/her family has the right to kill him/herself.	.61
4. Someone suffering from an incurable illness has the right to kill him/herself.	.61
5. Suicide can be a solution to some problems.	.50
6. Suicide can be the only way out of life's problems.	.47
7. People have the right to kill themselves.	.66
8. Killing oneself by committing suicide is a right behavior.	.58
Scale 2: Suicide as a sign of mental illness ($H = .83$; $\rho = .93$; $\alpha = .92$)	
9. People who attempt suicide are mentally ill.	.83
10. People who kill themselves by committing suicide are mentally ill.	.87
11. People who think and plan suicide are mentally ill.	.80
Scale 3: Punishment after death ($H = .82$; $\rho = .94$; $\alpha = .93$)	
12. People who attempt suicide are going to be punished in the other world.	.85
13. People who kill themselves are going to be punished in the other world.	.86
14. People who think and plan suicide are going to be punished in the other world.	.84
15. People who kill themselves by committing suicide are sinful.	.73
16. There is a life after death. (excluded from analysis)	—
Scale 4: Communicating psychological problems ($H = .61$; $\rho = .86$; $\alpha = .84$)	
17. A person who thinks and plans suicide should tell this to his/her friends and thereby ask for help.	.53
18. People should tell their psychological problems to their friends.	.60
19. Young people should tell their psychological problems to their parents.	.66
20. A young person who thinks and plans suicide should tell this to his/her parents.	.65
Scale 5: Hiding suicidal behavior ($H = .89$; $\rho = .91$; $\alpha = .90$)	
21. Families whose daughter or son attempts suicide should hide this from their neighbors.	.89
22. Families who lose a daughter or son from suicide should hide this from their neighbors.	.89
Scale 6: Open reporting and discussion of suicide ($H = .31$; $\rho = .46$; $\alpha = .42$)	
23. Suicide news should be written openly in the newspapers.	.31
24. The matter of suicide should be discussed openly among friends.	.31

Note. Factor names were taken from the six-factor solution of Eskin (2004). Item 16 was found to be unscalable and therefore excluded from analysis, but is still listed in the table. H = Loevinger's scalability coefficient for the complete scale; H_i = Loevinger's scalability coefficient for a single item (i.e., item discrimination); α = Cronbach α ; ρ = Molenaar-Sijtsma ρ .

375 For higher values of $\min H_i$, the extracted scales remained essentially the same, but an increasing number of items were found to be unscalable (Table 1). First, the scale corresponding to the factor Open Reporting of Suicide (Items 23 and 24) was found to be unscalable for $\min H_i = .35$.

This five-scale structure remained unchanged, until for a value of $\min H_i = .50$ the scale corresponding to the factor Acceptability of Suicide (Items 1–8) was split into two scales of 6 and 2 items. The latter of these two scales largely corresponded to the factor of Seeing Suicide as a 380

385 Solution, which was the additional seventh
 factor found by Eskin, Voracek, Stieger
 et al. (2011). In that earlier report, this fac-
 tor also contained Item 17, which was
 unscalable for the strictest criterion of min-
 390 $H_i = .55$ and therefore dropped. Hence, this
 solution consisted of six factors, namely (1)
 acceptability of suicide, (2) suicide as a solu-
 tion, (3) suicide as a sign of mental illness,
 (4) the belief that persons who commit sui-
 395 cide will be punished after death, (5) the
 opinion that suicidal people should com-
 municate their problems, and (6) the inten-
 tion to hide past suicidal behavior.

Confirmatory Factor Analyses

400 As the quality of scales resulting from
 Mokken scaling is not straightforwardly
 comparable to prior research, we analyzed
 some of the resulting models with CFA.
 This method also offers the possibility to
 405 assess the fit of the different models by
 means of well-established benchmarks.
 Following Hu and Bentler (1999), for a
 model to fit very well (or adequately,
 respectively), the comparative fit index
 410 (CFI) and the Tucker-Lewis index (TLI)
 should exceed .95 (or .90), the root-mean-
 square error of approximation (RMSEA)
 should be below .06 (or .08), and the stan-
 415 dardized root-mean-square residual (SRMR)
 below .08 (or .10, respectively).

We compared the fit of six models.
 Starting with models found in prior related
 research, we fitted the seven-factor solu-
 tion (Eskin, Voracek, Stieger et al., 2011;
 referred to as Model 1) and the six-factor
 420 solution (Eskin, 2004; referred to as Model
 2). Furthermore, we fitted models result-
 ing from Mokken scaling, including the solu-
 tions for $\min H_i = .30$ (six factors with Item
 16 excluded; Model 3), $\min H_i = .35$
 425 (additionally excluding the factor Open
 Reporting of Suicide; Model 4), $\min H_i =$
 $.50$ (splitting the factor Suicide as a
 Solution from the factor Acceptability of
 Suicide; Model 5), and $\min H_i = .55$
 430 (additionally excluding Item 17; Model 6).
 In all solutions, factors were allowed to
 correlate.

Models 1 to 4 were almost indiscern-
 ible concerning their fit indices (Table 3)
 435 and showed only borderline fit, with fit
 indices hardly satisfying benchmarks of an
 average fit (except for the SRMR). Only
 for Models 5 and 6, wherein the factor
 Suicide as a Solution was split from the
 440 factor Acceptability of Suicide, the fit
 increased markedly. All indices attested at
 least average fit (with the exception of the
 RMSEA, which was slightly too high for
 all models), and Model 6 showed the best
 445 fit. This model satisfied the strictest cri-
 terion in terms of Mokken scalability, and
 excluded the factor Open Reporting on

TABLE 3. Fit Indices from Confirmatory Factor Analyses for Competing Models

Model	Factors	Items excluded	Split	χ^2	df	TLI	CFI	RMSEA	SRMR
1	7	–	no	1138.5	231	.881	.901	.082 [.077, .087]	.068
2	6	–	no	1137.4	237	.885	.902	.081 [.076, .085]	.061
3	6	16	no	1077.4	215	.888	.905	.083 [.078, .088]	.060
4	5	16, 23, 24	no	1004.1	179	.892	.908	.089 [.083, .094]	.062
5	6	16, 23, 24	yes	973.1	174	.902	.919	.085 [.079, .090]	.055
6	6	16, 17, 23, 24	yes	743.6	155	.917	.932	.081 [.075, .086]	.052

Note. Split = Splitting the factor Suicide as a Solution from the factor Acceptability of Suicide (yes or no); $\chi^2 = \chi^2$ value of model fit; df = degrees of freedom; TLI = Tucker-Lewis index; CFI = comparative fit index; RMSEA = root-mean-square error of approximation; SRMR = standardized root-mean-square residual; numbers in brackets are 95% confidence intervals for the RMSEA.

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450 Suicide as well as two problematic items (Items 16 and 17). Hence, the solution revealed by exploratory Mokken scaling was also confirmed by means of CFA.

DISCUSSION

455 This study investigated the dimensionality of Eskin's (2004) attitudes toward suicide scale by means of Mokken scaling and CFA. Mokken scaling offers an intuitive way of exploring the factor structure of an instrument, whereas CFA can be used 460 to assess the fit of the resulting models. The combination of these methods identified five factors with satisfactory psychometric properties (one of which should probably be split in two), and one factor with only unsatisfactory psychometric properties.

Inconclusive results of prior research concerning the factor structure of a questionnaire are generally clarified by employ- 470 ing CFA. However, the additional utilization of Mokken scaling can permit further insights into the dimensionality of an instrument. By specifying how well a single item has to fit into a scale (i.e., by 475 increasing $\min H_i$), we were able to investigate the stability of different scales. In our case, the Mokken scales resulting from lower values of $\min H_i$ (i.e., with lower scaling quality) were combinations of dif- 480 ferent factors found by Eskin (2004). For example, items from the two factors Punishment after Death and Hiding Suicidal Behavior were allocated to a common scale. Obviously, these factors are related: 485 When expected to be punished for a behavior, hiding it is a logical consequence.

For the recommended strictness of a scale's quality ($\min H_i = .30$), the Mokken scales exactly matched the six factors 490 reported by Eskin (2004), with the exception of one item that clearly measured an attitude not necessarily related to suicide ("There is a life after death"), and therefore

should be dropped. Hence, this six-factor solution is a replication of the factor struc- 495 ture found by Eskin (2004), achieved with a different, IRT-based methodology, in a different sample, and also in another country and culture.

Moreover, Mokken scaling also 500 revealed that the scale Open Reporting of Suicide is rather unreliable, as both items of this scale became unscalable for stricter criteria. Seemingly, the two items of this scale tap different constructs. On the one 505 hand, open discussion of suicide among friends (Item 24) is usually seen as relief and support (e.g., Park, Cho, & Moon, 2010; Topol & Reznikoff, 1982), while on the other hand, open reporting of suicide 510 in the news (Item 23) decidedly is controversial: Copycat effects following newspaper reports on suicide are well known (for a review, see Stack, 2005), although 515 media reporting might also have beneficial effects if certain rules are followed (Papageno effect; Niederkrotenthaler, Voracek, Herberth et al., 2010). For investigating these two constructs, the two items might 520 be interpreted on their own, or more items could be constructed to form two new scales. However, in this form of the questionnaire, these items do not form a common scale.

What is more, the item regarding open 525 reporting of suicide might be questionable in terms of whether it actually assesses an attitude. As stated above, copycat effects are widely known, although probably more 530 among experts than among lay people. Even journalists do not seem to be fully aware of possible contagion effects through media reporting (Collings & Kemp, 2010). However, it might still be 535 argued that this item investigates knowledge rather than attitudes, which makes this item questionable not only in regard to its psychometric properties, but also in regard to its content.

The view of suicide as a mental illness 540 may be seen to reflect both an attitude and

actual knowledge. Among experts, suicide is generally not regarded as a mental illness (McManus, 2005; Shneidman, 1993, p. 55).
 545 However, mental illness and suicide are strongly interrelated (Lönqvist, 2009), which might explain why lay people may interpret suicide as a mental illness. We argue that the questionnaire assesses this view, that may be regarded as an attitude, and not the actual knowledge. Moreover, from a methodological point of view, the scale possessed good measurement properties.

555 It could furthermore be shown that the factor Acceptability of Suicide might contain another subscale, namely seeing suicide as a solution to one's problems. This might be regarded as a facet of acceptability, as suicide is commonly seen as an escape from or a solution to overwhelming problems (e.g., Kraft, Jobes, Lineberry et al., 2010). Hence, this subscale can be interpreted on its own, but it can also be seen as part of a broader construct of acceptability of suicide. This might explain why different factor structures have been found in prior research, as sample characteristics or cultural differences might have altered the relative importance of seeing suicide as a solution.

Based on the above findings, we conclude that Items 16 (from the factor Punishment after Death), 17 (from the factor Communicating Suicidal Problems), 23, and 24 (i.e., the complete factor Open Reporting of Suicide) should be excluded when using this questionnaire. Depending on the researcher's interest, a five-factor solution (with a broader definition of acceptability of suicide) or a six-factor solution (with an additional factor of seeing suicide as a solution) is recommended.

585 Compared to other questionnaires assessing attitudes toward suicide, Eskin's scale has some advantages. For one thing, Eskin's (2004) scale focuses more clearly on attitudes and opinions about suicide, as opposed to knowledge about suicide

(e.g., some items in the Attitudes Towards Suicide Scale) or theories about assumed causes, as for example Lester and Bean's (1992) scale. Another advantage that distinguishes Eskin's scale from other measures is its good psychometric quality and its clear-cut factorial structure, as shown by results of the current study. Items were found to be suited to order respondents on the measured latent trait (i.e., the respective attitude). Furthermore, both classical as well as IRT-based measures of internal consistency were satisfactory. A limitation of Eskin's scale is that it is short. As a consequence, some scales consist only of two items and therefore cannot be used to investigate attitudes toward suicide in full detail. However, short scales can be valuable in longer surveys, for screening purposes, or in clinical settings (Diekstra & Kerkhof, 1989).

Some limitations of the present study have to be noted. The sample used in this study is a convenience sample and may not be representative. However, our Mokken scaling results replicate the two different factorial structures found in previous research, and we therefore believe that possible non-representativity did not affect our results or the outlined method of analysis.

Furthermore, we did not assess aspects of validity of Eskin's scale. Items have face validity, and prior research showed that higher acceptability is related to lower religiosity (Eskin, Voracek, Stieger, et al., 2011), which is an indication for validity of this facet. However, further investigation of validity is advisable for future research, especially when considering that the relation of attitudes to actual suicidal behavior is still a matter of ongoing debate (Beautrais, Horwood, & Fergusson et al., 2004).

In summary, Eskin's (2004) Attitudes Towards Suicide scale seems to be a promising research instrument, owing to its relatively narrow focus on attitudes, as well as

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to its good psychometric properties and clear-cut factor structure. Thus, it also might prove beneficial for investigating the relation of attitudes toward suicide to actual suicidal behavior, which in turn can contribute to prevention of suicides. Furthermore, the combination of Mokken scaling and CFA presented here might prove beneficial to reveal other instruments with good psychometric properties, thereby increasing the quality of measurement also in other fields of research.

AUTHOR NOTE

Ingo W. Nader, Ulrich S. Tran, Patricia Baranyai, and Martin Voracek, Department of Basic Psychological Research and Research Methods, School of Psychology, University of Vienna, Vienna, Austria.

Correspondence concerning this article should be addressed to Ingo W. Nader, University of Vienna, School of Psychology, Department of Basic Psychological Research and Research Methods, Liebiggasse 5, A-1010 Vienna, Austria. E-mail: ingo.nader@univie.ac.at

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Study 3

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**Development of a Scale to Assess Knowledge about Suicide Postvention
using Item Response Theory**

INGO W. NADER, MSc, MEng, THOMAS NIEDERKROTENTHALER, MD, PhD, MMSc,

ANNE H. E. SCHILD, MSc, INGRID KOLLER, PhD, ULRICH S. TRAN, DSc, MSc,

NESTOR D. KAPUSTA, MD, PhD, GERNOT SONNECK, MD, AND

MARTIN VORACEK, DSc, DMSc, PhD

INGO W. NADER, ANNE H. E. SCHILD, INGRID KOLLER, ULRICH S. TRAN, MARTIN VORACEK,
Department of Basic Psychological Research and Research Methods, School of
Psychology, University of Vienna, Austria; THOMAS NIEDERKROTENTHALER, Department of
General Practice and Family Medicine, Center for Public Health, Medical University of
Vienna, Austria, and Department of Medical Psychology, Center for Public Health, Medical
University of Vienna, Austria; NESTOR D. KAPUSTA, Department of Psychoanalysis and
Psychotherapy, Medical University of Vienna, Austria; GERNOT SONNECK, Department of
Medical Psychology, Center for Public Health, Medical University of Vienna, Austria, and
Crisis Intervention Center and Ludwig Boltzmann Institute for Social Psychiatry, Vienna,
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Address correspondence to Ingo W. Nader, University of Vienna, School of Psychology,
Department of Basic Psychological Research and Research Methods, Liebiggasse 5, A-
1010 Vienna, Austria. E-mail: ingo.nader@univie.ac.at

ABSTRACT

Knowledge about suicide postvention is an important distal outcome in the evaluation of suicide prevention programs that focus on the bereaved. However, most scales are specifically tailored to the evaluation study in question and psychometric properties are often unsatisfactory. Therefore, we developed the Knowledge about Suicide Postvention (KSPV) scale. Scale properties were investigated with Rasch trees, a newly developed method in the framework of item response theory. Additionally, we provide cues for convergent validity. In summary, the scale shows satisfactory properties for assessing knowledge about suicide postvention and could be used to evaluate suicide postvention programs more effectively.

Keywords: knowledge, suicide postvention, suicide prevention, Rasch tree, differential item functioning, item response theory

Many countries have established suicide prevention plans (Beautrais, 2005; Taylor, Kingdom, & Jenkins, 1997). One suggested measure in these plans is education, i.e., providing knowledge about suicidal behavior and about how to identify and support people in suicidal crises (e.g., Isaac et al., 2009). Furthermore, acquisition of knowledge is an important goal in preparing caregivers for their work in suicide prevention (Ramsay, 2004).

Most suicide prevention programs assess changes in knowledge about suicide, at least as a distal outcome (Isaac et al., 2009). However, evaluation studies of suicide prevention programs often use subjective self-ratings of perceived (as opposed to actual) knowledge (e.g., Clark, Matthieu, Ross, & Knox, 2010) or ad-hoc scales tailored to a specific program (e.g., Bean & Baber, 2011). Hardly any evaluation study used a scale with established psychometric properties, and many of the specifically tailored scales assess knowledge about epidemiological facts. These facts can be relevant for recognizing warning signs at population level, but are less suitable when it comes to offer support for people at risk at the individual level, like in tertiary prevention (i.e., suicide postvention). The latter is an important part of suicide prevention because of known contagion effects and the increased risk of psychological problems in survivors that have been exposed to suicide (Mackesy-Amiti, Fendrich, Libby, Goldenberg, & Grossman, 1996).

A recent review on the effectiveness of suicide postvention programs also reports knowledge as an important part of the program evaluation (Szumilas & Kutcher, 2011). For one of the scales used to quantify knowledge about suicide postvention (Grossman et al., 1995), an attempt was made to develop a stand-alone instrument, the Preparing for Crisis Knowledge Test (PFC-KT), but psychometric properties were unsatisfactory (Mackesy-Amiti et al., 1996). Moreover, the scale focuses on school-based programs and many items relate to structural prerequisites in schools that should facilitate postvention after suicides, hence the PFC-KT is only suitable for this specific population.

The most widely used scale on knowledge about suicide is perhaps the Revised Facts on Suicide Quiz (RFOS; Hubbard & McIntosh, 1992). However, this scale focuses on knowledge about suicide in general and not on suicide postvention specifically. It contains a number of questions that relate to epidemiological facts about suicide (e.g., the most frequently used method). It is hardly ever used in studies that evaluate suicide prevention or postvention programs.

To the best of our knowledge, there is no scale assessing knowledge about suicide postvention that has satisfactory psychometric properties. Hence, the aim of this study was to develop a scale measuring knowledge about suicide postvention, specifically focusing on support for the bereaved by suicide. As knowledge scales are known to be heterogeneous in content, we applied a new method of analysis in the framework of item response theory, the so-called Rasch trees (Strobl, Kopf, & Zeileis, 2011). This method allows for identification of differential item functioning (DIF) in specific subgroups defined by sociodemographic criteria, i.e., it allows to identify subgroups of participants who respond differently to specific items compared to other groups. This information can be used to gain additional insight into the construct of knowledge about suicide postvention. We also investigate cues for validity of the newly constructed measure.

METHODS

Participants

For the construction of the Knowledge About Suicide Postvention (KSPV) scale, three independent samples were used. In the first sample, a preliminary version of the scale was tested, the second sample was used for item selection, and the third sample was used for confirmatory analyses and cross-validation.

Sample 1. The first sample consisted of 620 German-speaking volunteers (60.2% women, 2.3% missing). In terms of nationality, 74.5% were Austrian, 19.8% were German,

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and 3.2% had other nationality (2.4% missing). Mean age was 30.2 years ($SD = 13.0$ years). Regarding education, 7.3% reported primary education as their highest education, 19.4% had an apprenticeship diploma, 52.7% had completed secondary education, and 20.2% had a university degree (0.5% missing). About 47.7% of the sample reported knowing someone who had engaged in suicidal behavior (see Demographics).

Sample 2. This sample consisted of 626 German-speaking volunteers (61.3% women, 0.2% missing). Participants were mainly Austrian (66.3%), 18.8% were German, and 12.8% reported other nationality (2.1% missing). Mean age was 29.5 years ($SD = 12.3$ years). Regarding their highest educational degree, 7.0% had primary education, 13.7% reported an apprenticeship diploma, 61.0% completed secondary education, and 17.3% reported having a university degree (1.0% missing). Of the sample, 48.6% knew someone who had engaged in suicidal behavior.

For the Rasch-tree analyses, participants who answered all items of the KSPV scale correctly or incorrectly were excluded (they conveyed no information on how difficult the items are in relation to each other). Also, participants with missing values had to be excluded due to computational reasons. Hence, the final sample for these analyses consisted of 589 participants.

Sample 3. For the confirmatory analyses, we aimed at achieving a balanced sample regarding sex ($n = 681$; 49.9% women, 5.9% missing). Nationality was 81.2% Austrian, 7.8% German, and 4.4% other nationality (6.6% missing). Mean age was 31.7 years ($SD = 13.4$ years). For highest education, 4.4% reported primary education, 10.3% had an apprenticeship diploma, 53.2% completed secondary education, and 25.8% had a university degree (6.3% missing). About 47.7% of the participants knew someone who had engaged in suicidal behavior. With the same exclusion criteria as for sample 2, the sample for the Rasch-tree analyses comprised 593 participants.

Measures

Knowledge about Suicide Postvention (KSPV). The first version of the KSPV scale consisted of 10 items. Item content was developed by IWN by screening the scientific literature and then discussed among all authors and with further experts in the field of suicide research and crisis intervention (who also offer counseling for bereaved by suicide). Relating to item content, the main aim was to provide items practically relevant to the counseling of individuals bereaved by suicide. For that reason, questions about epidemiological facts were not part of the questionnaire. After initial analyses in the first sample, items were rephrased where necessary and additional items were constructed, resulting in a 21-item version. Starting from this version, items were excluded based on their content and psychometric properties (see Data Analysis). The final version of the KSPV consisted of 15 items, with three response options each: true, false, don't know. The answer "don't know" was treated as incorrect. For a complete list of items see Table 1. Psychometric properties are discussed in detail in the Results section.

Items were constructed and validated in German and later translated into English by IWN, AHES, and TN using the parallel blind technique (Behling & Law, 2000). The resulting translations were discussed with native English speakers from the field of public health, and wording of items was adapted and revised accordingly.

Revised Facts on Suicide Quiz (RFOS). For assessing general knowledge about suicide and to validate the KSPV scale, the Revised Facts on Suicide Quiz was used (RFOS; Hubbard & McIntosh, 1992; German form: Voracek, Tran, & Sonneck, 2008). This measure consists of 32 items assessing various facts about suicide and suicidal behavior including epidemiological facts. All items have three response categories (either true/false/don't know, or three possible answers). The answer "don't know" was treated as incorrect in the analyses. Cronbach α in the three samples was .47, .62, and .60,

respectively. In spite of the relatively low values, this was comparable to prior research (e.g., Kőlves, Tran, & Voracek, 2007; Voracek, Loibl, et al., 2008; Voracek, Fisher, Loibl, Tan, & Sonneck, 2008).

Demographics. Participants were asked to provide demographic information on their age, sex, marital status, highest educational qualification, as well as about their field of study (for students; samples 2 and 3) and their occupation (sample 3 only). The latter two were later recoded into two categories (related to caring profession vs. other), which were used for group comparisons to validate the KSPV scale. Additionally, participants were asked whether they had any experience with family members or close friends engaging in suicidal behavior (i.e., completed or attempted suicide), as knowledge has been found to be higher in that group (MacDonald, 2007).

Procedure

In all samples, participants were recruited opportunistically by research assistants. All participants provided informed consent, took part voluntarily, and were not remunerated for participation. They were ensured that they remained absolutely anonymous and data were treated confidentially. After completion of the questionnaire, participants were debriefed using a standardized debriefing page with information about the study goals as well as contact information of institutions which offer counseling.

For samples 1 and 3, the questionnaire was also presented online, and 37.8% and 31.5% of these samples completed the online version, respectively. Participants were recruited via social media sites and internet message boards unrelated to suicide topics.

Data Analysis

Additionally to standard means, i.e. investigating internal consistency (Cronbach α) and factor structure, we applied methods of item response theory (IRT) to assess the quality of items and the dimensionality of the scale. We used the Rasch model (Fischer &

Molenaar, 1995; Rasch, 1960), which ensures that the scale is unidimensional and that the person sum score is an appropriate measure. Furthermore, item difficulty parameters (i.e., estimated difficulty resulting from the Rasch analysis) are not confounded by the latent ability (in this case, knowledge) of the participants, which is a major advantage over classical methods of analysis.

The fit of the Rasch model is usually tested by comparing the item difficulty parameters of two or more groups. If they are similar, all items of the scale have comparable properties in the two samples and the test is fair. If item parameters differ, the affected items are said to show differential item functioning (DIF). DIF means that items work differently for participants of different groups, even when they have the same latent ability (knowledge). This is usually tested with global likelihood ratio (LR) tests (Andersen, 1973). The groups are defined by external or internal split criteria. External split criteria can be chosen freely, with participants' sex, education, or age as probably the most common. Regarding internal split criteria, the raw score is both the most common and rigorous one.

When the Rasch model does not fit for the whole dataset, it can be investigated whether it fits for certain subgroups of the sample. One mean of identifying groups is to use mixture Rasch models (Rost, 1990) in which groups are identified automatically by means of latent class analysis. However, it is often difficult to interpret DIF, as it remains unknown what constitutes the latent classes in which the response behavior is different.

Recently, a new method has been proposed to elude this drawback. Rasch trees (Strobl et al., 2011) can be used to automatically identify subgroups of persons who differ in their response behavior based on external split criteria. Moreover, the method also considers combinations of these criteria. This facilitates identification of DIF and, due to the known subgroups, the reasons for DIF can be investigated more easily (Reise & Waller, 2009), which can be used to gain additional insight into the measured construct.

For item selection, Rasch-tree analyses and model tests of the Rasch model in the identified subgroups were performed iteratively. First, homogenous subgroups were identified by a Rasch-tree analysis using the external criteria sex, age, education, marital status, and whether or not participants had any experience with suicidal behavior in relatives or close friends. To confirm the fit of the Rasch model in the identified subgroups, we performed global LR tests using the internal split criterion (raw score median split) and, in sample 3, additionally one external criterion (online vs. paper-pencil testing). Furthermore, we used Wald tests (Fischer & Molenaar, 1995) to identify items that did not satisfy the Rasch model and applied Martin-Löf tests (Martin-Löf, 1973) in the identified subgroups, to examine unidimensionality of the scale. For the Martin-Löf test, it is standard practice to compare a group of easy items to a group of difficult items. For the model tests, we used a significance level of $\alpha = .01$ (to correct for multiple testing). After exclusion of unfitting items, these steps were repeated until the LR and Martin-Löf tests indicated that the Rasch model was valid in all subgroups identified by the Rasch-tree analysis.

Factor analyses were conducted in MPlus (Muthén & Muthén, 2008) using an estimator based on polychoric correlations, which is appropriate for analyzing dichotomous data (weighted least squares mean and variance adjusted [WLSMV] estimator). All other analyses were performed in R 2.15.0 (R Development Core Team, 2012), using packages eRm (Mair, Hatzinger, & Maier, 2011) and psychotree version 0.12-1 (Strobl et al., 2011).

RESULTS

Analyses in Sample 1

Cronbach α of the first version of the KSPV scale was .66, which was higher than that of the RFOS in the same sample (Cronbach $\alpha = .47$), in spite of the fact that this version of the KSPV scale consisted of 10 items only. Discriminatory power (correlations of single items and total score with the respective items excluded) ranged from $r_{it} = .23$ to

.40 (mean $r_{it} = .33$). The rates of correct answers to the items ranged from .34 to .89.

Regarding factor structure, an exploratory factor analysis was performed. The scree plot indicated a one-factor solution to be most suitable. The mean total score was 5.99, indicating no floor or ceiling effects. Total scores correlated moderately with RFOS scores ($r = .37, p < .001$).

Analyses in Sample 2 with all KSPV items

Internal consistency of the 21-item version of the KSPV was $\alpha = .72$, which again was higher than that of the RFOS in the same sample ($\alpha = .62$). However, discriminatory power of some of the newly constructed items was low (around $r_{it} = .10$ for items 14 and 20) and zero for item 13 ($r_{it} = -.04, p = .33$; Table 1). An exploratory factor analysis revealed seven eigenvalues greater than one, but the scree plot suggested a one-factor solution. As a next step, item selection was performed by means of Rasch-tree analyses.

Item Selection by Means of Item Response Theory

According to the strategy of analysis described above, the following items were excluded (in that order): 13, 14, 20, 19, 9, and 1. Item 13 may be considered an epidemiological fact less relevant for practical counseling and therefore was excluded. Items 14 and 19 might be problematic because of the term “shock” (which can be understood in a psychological or in a physical sense). In item 9, the term “playing normally” might be problematic, because respondents could think differently about what is considered “normal” after a traumatic event. For items 1 and 20, the correct answer may depend on the situation. Hence, these items were excluded.

The final scale consisted of 15 items. The subgroups identified in the Rasch-tree analysis for this version of the scale are depicted in Figure 1. Age was the most important criterion, followed by education and sex. Marital status did not affect the response behavior to the items in the scale, and neither did experience with suicidal behavior in friends or

family. LR tests in these subgroups were not significant (all $ps \geq .019$), and neither were the Martin-Löf tests (all $ps \geq .15$).

Analysis of the Final Version of the KSPV in Sample 2

For the final 15-item version of the KSPV, Cronbach α was .72. Discriminatory power of items was between $r_{it} = .16$ and .50 (mean $r_{it} = .33$). The percentage of correct answers to the items ranged from .31 to .84. In an exploratory factor analysis, the scree plot indicated a one-factor solution (33.1% variance explained by first factor, 9.6% by second factor). Additionally, a confirmatory factor analysis indicated an acceptable fit of a one-factor solution (root mean square error of approximation RMSEA = .046 [CI: .038; .054]; comparative fit index CFI = .923; standardized root mean square error SRMR = .078). The Martin-Löf test for unidimensionality was also not significant at $\alpha = .01$ ($p = .027$).

Confirmatory Analyses in Sample 3

A Rasch-tree analysis with LR tests for model fit (as performed in sample 2) yielded subgroups that were similar to those in sample 2, except that education was not replicated as an important factor for DIF (Figure 1). A confirmatory factor analysis yielded, again, an acceptable fit of a one-factor model (RMSEA = .043 [.035, .051], CFI = .910, SRMR = .079), and the Martin-Löf test attested unidimensionality ($p = .352$).

Using DIF to Investigate Response Behavior

The Rasch tree analyses identified subgroups of persons that responded differently to certain items (Figure 1). For example, item 21 (bereaved should generally take tranquilizers) was more difficult for younger men compared to older participants. It could be speculated that this group is generally less willing to deal with intense negative emotions, and therefore believes that the use of tranquilizers is generally recommended. A similar argument might apply to item 5 (touching the deceased is medically safe) which is also more difficult for younger men. Touch can be a very intense and intimate gesture,

hence accepting this as a possibility might be difficult when less willing to deal with intense emotions. Items 6 and 7 (all people react the same way; anger is a normal reaction) were more difficult for younger respondents, maybe because they have less experience with grief in general. For most items, however, item difficulties were rather similar (overlapping confidence intervals, Figure 1).

Validity

As a first cue for convergent validity, scores of the final (15-item) version of the KSPV scale were correlated with the RFOS. This measure is already validated, but it measures knowledge about suicide in general and is therefore less specific than the KSPV. The scores of the two measures correlated moderately in two independent samples (samples 2 and 3; $r = .53$ and $r = .46$, both $ps < .001$), indicating that the KSPV scale measures a related, but not identical construct.

Furthermore, sum scores of the KSPV scale were compared between different subgroups of participants (again, in two independent samples). First, groups of students were compared. The focal group consisted of students in disciplines related to caring professions (e.g., psychology, medicine, teaching, social work; $n = 173$ and $n = 104$, for samples 2 and 3, respectively), and was compared to all other students ($n = 167$ and $n = 160$, respectively). Participants in the focal group scored significantly higher in the KSPV scale, both in sample 2 ($t_{(338)} = 6.71$, $p < .001$, $d = 0.73$) and in sample 3 ($t_{(262)} = 4.12$, $p < .001$, $d = 0.52$). Effects were of medium-to-large size and comparable to those of the RFOS ($d = 0.56$ and 0.70 for samples 2 and 3, respectively).

Second, groups in different occupational fields were compared. This comparison was only performed for sample 3, as occupation was not part of the survey for sample 2. Again, the focal group consisted of participants working in fields related to caring professions (e.g., psychologists, therapists, teachers, social workers, paramedics; $n = 82$).

Performance of this group was compared to the remaining participants that were employed ($n = 301$). Again, participants in the focal group scored higher on the KSPV scale ($t_{(381)} = 4.69, p < .001, d = 0.59$). This medium-sized effect was slightly higher than when the RFOS was used to compare these subgroups ($d = 0.44$).

Third, we compared participants who had experience with suicidal behavior in friends or family ($n = 304$ and $n = 325$ for samples 2 and 3, respectively) with those who had no such experience ($n = 320$ and $n = 316$, respectively). For the KSPV scale, effects were small but significant in sample 2 ($t_{(622)} = 4.02, p < .001, d = 0.33$) as well as in sample 3 ($t_{(639)} = 3.20, p = .001, d = 0.25$). For the RFOS, effects were smaller in sample 2 ($d = .16$) and not-existent in sample 3 ($t_{(639)} = 1.69, p = .09, d = 0.13$).

DISCUSSION

In this study, we report on the construction and analysis of a new measure for assessing knowledge about suicide postvention. Both classical as well as IRT-based analyses suggest that measurement properties are satisfactory, and first cues of validity indicate that the measure is suitable for assessing knowledge about suicide postvention.

As the newly constructed KSPV scale correlated with an already established measure of knowledge about suicide in general (RFOS), it seems safe to assume that it possesses convergent validity. Furthermore, scale scores were higher for participants who likely had more knowledge about suicide postvention, either due to their field of study or due to their occupation. Moreover, KSPV scores of individuals who had experience with suicidal behavior in friends or family were higher compared to the rest of the sample, which corresponds to prior research (MacDonald, 2007). Effects were not only comparable, but even slightly higher for the KSPV compared to the RFOS. Hence, the KSPV scale seems to be a valid measure of knowledge about suicide postvention.

The IRT analyses identified subgroups with different response behavior (DIF).

However, for most items, item parameters were not extremely different in the subgroups identified in the Rasch-tree analysis as indicated by overlapping confidence intervals for most items. As the items of a knowledge test are usually not exchangeable (each item assesses a related, but different aspect of knowledge), it is only natural that some subgroups perform differently on certain items. Also, presence of item-level DIF does not necessarily lead to biased scale scores (Reise & Waller, 2009). Furthermore, both factor analyses and IRT analyses suggested that a one-factor solution was adequate to describe the data, especially given the fact that knowledge scales are typically diverse in content (e.g., Voracek, Fisher, et al., 2008).

For some items, different response behavior was identified for specific subgroups (non-overlapping confidence intervals). Sex and age seem to be important predictors for the difficulty of these items. For example, making clear that touching the deceased is not dangerous from a medical point of view (item 5) might be a way to encourage coping with the loss, which could act in a suicide-preventive way particularly for younger men.

Knowing someone who was engaged in suicidal behavior was not identified as a significant influence on DIF, although it was found to influence knowledge in the current study and in prior research (MacDonald, 2007). Hence, response behavior for these two groups is similar for all items and the test is a fair measure to compare these groups.

Education was found to be a factor that influences response behavior only in sample 2, but this was not replicated in sample 3. This indicates that the Rasch-tree method is rather sensitive to sample characteristics. For instance, sample 3 contained fewer participants with lower education, which might be why the influence of education was not replicated in that sample. This sample dependency is one of the limitations of this study. The Rasch-trees method is very sensitive in identifying DIF. Hence, replication of results in different samples is needed. Another limitation of this study is that the Rasch model is

rather rigorous in its assumptions. However, it was possible to identify subgroups for which these assumptions hold, even though knowledge is known to be a rather heterogenous concept (e.g., Voracek, Fisher, et al., 2008). Furthermore, we could show that item difficulties in these subgroups were not very different for most items. In case of larger differences of item difficulties for specific groups of participants, the Rasch-trees method allows for investigation of possible causes in differences of the response behavior.

We showed that DIF analyses can be used to gain more insight about both the instrument, as well as the measured construct. This could facilitate the identification of specific target groups for education campaigns, primary prevention, intervention, as well as for postvention.

In summary, we demonstrated that the constructed scale is a suitable measure of knowledge about suicide postvention. The KSPV scale might provide a means for a more rigorous outcome evaluation in evaluation studies (at least for the distal outcome of knowledge), as was demanded in prior research (Mann et al., 2005).

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TABLES

TABLE 1.

Items and psychometric properties of the KSPV scale. Instructions: "The following statements refer to facts from research regarding support for the bereaved by suicide. Please tick the answer that you think is correct."

Item text	Sample 2		Sample 3	
	%c	r_{it}	%c	r_{it}
(1) Bereaved should better not see the deceased person before the funeral. (F)	.51	–	.48	–
2 Bereaved should not be contacted by crisis intervention teams shortly after the death. (F)	.69	.30	.67	.29
3 Avoiding to talk about the suicide of a family member/friend is a good coping strategy. (F)	.84	.44	.85	.35
4 Pharmacological treatment (tranquilizers) in the first hours after the bereavement should be avoided by all means. (F)	.42	.19	.45	.27
5 Touching the body of a deceased person is safe from a medical point of view. (T)	.41	.24	.50	.29
6 All people react the same way to a sudden and unexpected death. (F)	.78	.34	.78	.24
7 Anger with the deceased is a normal reaction. (T)	.56	.35	.53	.32
8 Children should not, by any means, see the deceased person. (F)	.31	.26	.31	.31
(9) Children playing normally right after the death is a sign of traumatization. (F)	.42	–	.43	–
10 Children playing „being dead“ or „funeral“ after a suicide is a sign of traumatization. (F)	.42	.29	.44	.35
11 Suicide should be concealed from children. (F)	.61	.43	.60	.43
12 It is best to cope with the suicide of a loved one or friend on your own. (F)	.83	.37	.80	.38
(13) The younger a child is at the time of a loved one's suicide, the higher the child's suicide risk. (T)	.10	–	.09	–
(14) The shock phase after a suicide lasts at least a week. (F)	.18	–	.14	–
15 Media interviews of the bereaved immediately after the suicide are a first step in coping with the death. (F)	.69	.38	.70	.27
16 Grief after suicide should be shared with children. (T)	.71	.44	.72	.43
17 Farewell rituals (e.g., lighting a candle, talking to the deceased, ...) are unbearable after a suicide. (F)	.79	.50	.85	.40
18 In the days after a loved one's suicide it is beneficial for children to maintain their usual daily routines. (T)	.69	.16	.63	.17
(19) In the shock phase after a suicide, the risk of a suicide is highest. (F)	.25	–	.26	–
(20) It is a good coping strategy to divert a bereaved person (e.g., by reminding him/her of good times). (F)	.15	–	.15	–
21 The bereaved should, generally, take tranquilizers in the first hours after the death. (F)	.43	.23	.48	.20

Note. T = True; F = False; %c = Percentage of correct answers; r_{it} = item-restscore correlation (not given for excluded items; item numbers of excluded items are given in parenthesis).

FIGURES

Figure 1

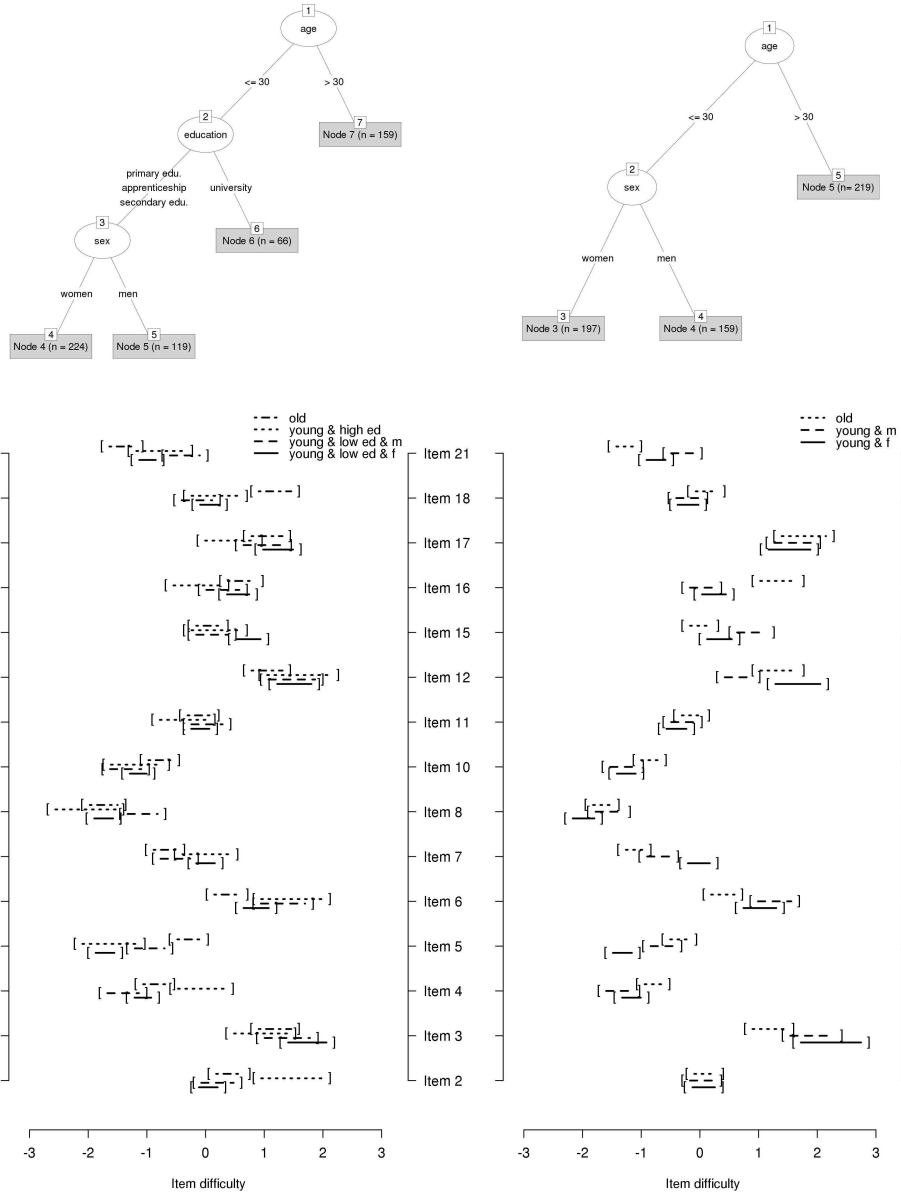


FIGURE CAPTIONS

Figure 1. Groups of respondents identified by Rasch tree analysis and item difficulties in these groups with 95% confidence intervals (left: sample 2; right: sample 3). Only items of the final version of the KSPV are depicted.

Abstract

The topics of suicide research are very diverse and heterogeneous, and so are the methods employed in this field of research. Often, the choice of method simply depends on convenience, or on which methods have been used in previous related studies. This doctoral thesis aims at presenting three methods in three different topics of suicide research. By using each of the methods, research questions may be answered more profoundly than with the methods that were used in past related research.

Study one addressed the question whether or not seasonality of suicides is decreasing. By using complex demodulation, a statistical method that allows continuous estimation of the strength of seasonality over the study period, it could be shown that the seasonality of suicides remained stable over the study period when the association with absolute suicide numbers was taken into account.

Study two investigated the dimensionality of a questionnaire measuring attitudes towards suicide. For this scale, the evidence regarding factor structure was somewhat mixed in prior research. Dimensionality was investigated by means of Mokken scale analysis. Because this method is used only seldomly, confirmatory factor analyses were used to quantify the fit of the resulting models, allowing to compare the results to prior research more easily.

Study three reports on the construction of a new scale to assess knowledge about suicide postvention. The scale was analyzed by means of Rasch trees, a new method of item response theory that allows to automatically identify subgroups of respondents with different response behavior for certain items.

Result might be used for more effective planning of suicide preventive measures.

In summary, the statistical methods presented in this thesis offer a view from a new perspective on different research questions. For the three topics presented, the methods proved beneficial, and it is hoped that they are adapted for future research.

Zusammenfassung

Forschung zu Suizid ist ein sehr heterogenes Feld, und genauso heterogen sind auch die statistischen Methoden, die zur Beantwortung der Forschungsfragen herangezogen werden. Die Wahl der statistischen Methode beruht oft auf Bequemlichkeit oder wird mit der Anwendung in bereits vergangenen Studien begründet. Ziel dieser kumulativen Dissertation ist es, die Anwendung dreier Methoden zu präsentieren, die einige Forschungsfragen gründlicher beleuchten können als bisher verwendete Methoden.

Die erste Studie beschäftigte sich mit der Frage, ob die Saisonalität der Verteilung der Suizide über den Jahresverlauf abnimmt oder nicht. Durch die Verwendung von komplexer Demodulation (complex demodulation) kann die Stärke der Saisonalität während der Studienperiode kontinuierlich geschätzt werden. Die Ergebnisse zeigen, dass diese nicht abnimmt, wenn der Einfluss der absoluten Suizidhäufigkeit mit in Betracht gezogen wird.

In der zweiten Studie wurde die Dimensionalität eines Fragebogens zur Erfassung von Einstellungen zu Suizid untersucht, zu der widersprüchliche Ergebnisse gefunden wurden. Dazu wurde einerseits die Mokken Analyse verwendet, und die resultierenden Modelle wurden mittels konfirmatorischer Faktorenanalyse auf ihre Passung zu den Daten untersucht, um die Ergebnisse leichter mit bisheriger Forschung vergleichbar zu machen.

Die dritte Studie präsentiert die Konstruktion eines neuen Fragebogens zum Wissen über Suizid-Postvention. Die Skalenanalyse erfolgte mittels Rasch Trees, einer neuen Methode der Item Response Theorie. Diese Methode erlaubt es, Personengruppen mit unterschiedlichem Antwortverhalten zu identifizieren,

und dies kann für die Planung von suizidpräventiven Maßnahmen verwendet werden.

Die statistischen Methoden, die in dieser Dissertation präsentiert wurden, können einen neuen Blickwinkel auf verschiedene Forschungsfragen bieten. Die Anwendung dieser Methoden in drei verschiedenen Gebieten der Suizidforschung scheint vorteilhaft, und es bleibt zu hoffen, dass die Anwendung dieser Methoden auch für zukünftige Forschung gewinnbringend ist.

Curriculum Vitae

Mag. DI (FH) Ingo Nader

General Information

name Ingo NADER
degree Mag. DI (FH) [about equivalent to: MSc., MEng.]
office address Liebiggasse 5
A-1010 Vienna
AUSTRIA
phone +43 (0) 1 4277 47129
email ingo.nader@univie.ac.at
date of birth October 19, 1978



Education

since Dec 15, 2008 **Doctoral Program** at the University of Vienna
Title of Dissertation: Application of Novel Statistical Methods in Suicide Research

Oct 1, 2002 to Oct 30, 2008 **Diploma: Psychology** at the University of Vienna (graduated with honors)
Major: Clinical Psychology
Diploma Majors: **Methodology** and **Research Methods and Evaluation**
Title of Diploma Thesis: Conditional Logistic Regression and Odds Ratio Multifactor Dimensionality Reduction for the Analysis of Interactions of Environmental Risk Factors and the 5-HT_{2A}-1438 G/A Polymorphism in Anorexia Nervosa

Oct 1, 1998 to Jun 29, 2002 **University of Applied Sciences for Production and Automation Engineering**, Vienna (graduated with honors)

Sept 4, 1989 to Jun 29, 1997 **Secondary School with Emphasis on Informatics** in Stockerau (graduated with honors)

Work Experience

since Dec 15, 2008 **University assistant (prae doc) at the Department of Basic Psychological Research and Research Methods, School of Psychology, University of Vienna**
Doctoral Program (see above), other autonomous research, collaboration with research conducted at the department, teaching (see publications / teaching experience)

Dec 1, 2011 **Introductory course for the statistical software R**
Introduction to basic functionality and selected statistical methods for researchers of the School of Psychology at the University of Vienna (duration: 1 day)

Jan 23 and Feb 20, 2010	Introductory course for the statistical software R Introduction to basic functionality and selected statistical methods for researchers of the Ludwig Boltzmann Institute for Health Promotion Research (duration: 2 days)
Oct 1 to Dec 14, 2008	Lecturer at the University of Vienna, Department of Basic Psychological Research Course: Laboratory of Psychological Methodology and Statistics
Oct 1, 2003 to Oct 30, 2008	Student assistant at the Department of Basic Psychological Research at the University of Vienna Weekly sessions for accompanying the course <i>Laboratory of Psychological Methodology and Statistics</i> , assisting with research projects
Nov 2006 to May 2008	Evaluation project: Jung.Alt.Werden coordinated by Univ.-Ass. Mag. Dr. Karin Waldherr compiling a standardized interview, data collection, data analysis, research report
Feb 2007 to Sep 2007	Freelance statistical consulting for Knoll & Szalai OEG Introduction to SPSS and data analysis for a mobility research project
Feb 1, 2005 to Mar 1, 2005	Project collaborator for University of Vienna and the DISCimus club data analysis for the „Computerkids“ project (Study led by Ao. Univ.-Prof. Doz. Dr. phil. Georg Gittler)
Oct 1, 2001 to Jan 31, 2002	TGM VAAE (Versuchsanstalt für Elektrotechnik und Elektronik) Internship during University of Applied Sciences for Production and Automation Engineering Tasks: Development of a controller for a test antenna (coding a PIC16F876 microprocessor application); development of a measuring device for temperature and humidity for long-term recording and transfer to the PC (PIC16F876 microprocessor)
Mar 6, 2000 to Jun 30, 2000	Renault Automation Comau, Evry, France semester abroad during University of Applied Sciences for Production and Automation Engineering Tasks: database programming; data transfer; system documentation.

Additional Education

May, Jun 2012	Course at Vienna University of Economics: Advanced Data Analysis in R
Nov 26, 2011 Jan 14, 2012 May 19, 2012	Courses at Vienna University of Economics: Generalized Linear Models I and II Lecturer: Ao. Prof. Reinhold Hatzinger
Jan 30, 2009	Workshop: eRm-Package „extended Rasch modelling“ Using R for data analysis with Rasch models (Lecturer: Mag. Herbert Poinstingl)
Oct 2007 to Jan 2008	Courses at Vienna University of Economics: Programming in R and Advanced Programming Lecturer: Prof. Kurt Hornik (Member of the R Development Core Team)
Sep 22, 2006 to Sep 24, 2006	Congress for Crisis Intervention: KIT-Tage⁰⁶, University of Innsbruck, Austria University of Innsbruck, Austrian Red Cross and alpS (center for natural disasters management)
Sep 23, 2006 to Sep 25, 2006	Congress for Crisis Intervention: KIT-Tage⁰⁵, University of Innsbruck, Austria

Jan 14, 2006	Seminar for Crisis Intervention: Group measures for relief forces after stressful deployment 12-hour training course in defusing and debriefing in group settings. (Lecturer: Mag. Dr. Manfred Krampf)
Sep 24, 2004 to Sep 26, 2004	Congress for Crisis Intervention: KIT-Tage⁰⁴, University of Innsbruck, Austria
Sep 26, 2003 to Sep 28, 2003	Congress for Crisis Intervention: KIT-Tage⁰³, University of Innsbruck, Austria
Feb 27, 2003	Seminar for Crisis Intervention: Death in the family [„Keiner stirbt für sich allein – Tod im Spannungsfeld der Familie“] (Lecturer: Peter Fässler-Weibel)
Oct 11 to 13 and Nov 15 to 17, 2002	Education and preparation for working in a Red Cross crisis Intervention team for the Austrian Red Cross

Additional skills

<i>Languages</i>	German (mother tongue) English (very good, level C2) French (good, level B2)
<i>time spent abroad</i>	semester abroad during University of Applied Sciences for Production and Automation Engineering (May 6 to Jun 30, 2000) at Renault Automation Comau, Evry, France (see <i>work experience</i>)
<i>skills</i>	excellent skills in statistics and methodology work experience, mathematical education in University of Applied Science, Diploma majors excellent knowledge of the statistical software package R skilled in SPSS skilled in LaTeX document markup language for scientific manuscripts and reports, allowing for automatic integration of R results via SWeave ; can be used for preparing presentations (Beamer) basic skills in programming languages C, C++, Fortran, Delphi, Turbo Pascal, Basic basic skills in SQL Structured Query Language (SQL) for accessing and manipulation of data base entries familiar with Linux (Kubuntu / Ubuntu) familiar with applications like Microsoft Office (Word, Excel, Access, Powerpoint), OpenOffice (Writer, Calc, Impress), Eclipse, ...
<i>voluntary work</i>	crisis intervention for the Austrian Red Cross Nov 2002 to Aug 2010; tasks: crisis intervention, personal counselling of bereaved in the first hours after bereavement

Publications

In press

Nader, I. W., Pietschnig, J., & Voracek, M. (in press). Academic workload, research productivity, and end of life: A single-case historiometric study. *Psychological Reports*.

Nader, I. W., Tran, U. S., Baranyai, P., & Voracek, M. (in press). Investigating Dimensionality of Eskin's Attitudes towards Suicide Scale with Mokken Scaling and Confirmatory Factor Analysis. *Archives of Suicide Research*.

2012

Adambejan, M., Wagner, G., **Nader, I. W.**, Fernandez-Aranda, F., Treasure, J., & Karwautz, A. (2012). Internalizing and externalizing behaviour problems in childhood contribute to the development of anorexia and bulimia nervosa – a study comparing sister-pairs. *European Eating Disorders Review*, *20*, 116-120.

Niederkröthenthaler, T., Sonneck, G., Dervic, K., **Nader, I. W.**, Voracek, M., Kapusta, N. D., Etzersdorfer, E., Mittendorfer-Rutz, E., & Dorner, T. (2012). Predictors of suicide and suicide attempt in subway stations: A population-based ecological study. *Journal of Urban Health*, *89*, 339-353.

Pietschnig, J., **Nader, I. W.**, & Gittler, G. (2012). Pheromone Exposure Impairs Spatial Task Performance in Young Men. *Canadian Journal of Behavioural Science*, *44*, 93-98.

Swami, V., **Nader, I. W.**, Pietschnig, J., Stieger, S., Tran, U. S., Voracek, M. (2012). Personality and individual difference correlates of attitudes toward human rights and civil liberties. *Personality and Individual Differences*, *53*, 443-447.

Swami, V., Pietschnig, J., Stieger, S., **Nader, I. W.**, & Voracek, M. (2012). Beautiful as the chance meeting on a dissecting table of a sewing machine and an umbrella! Individual differences and preference for surrealist literature. *Psychology of Aesthetics, Creativity, and the Arts*, *6*, 35-42.

Swami, V., Stieger, S., Harris, A. S., **Nader, I. W.**, Pietschnig, J., Voracek, M., & Tovée, M. J. (2012). Further investigation of the validity and reliability of the Photographic Figure Rating Scale for body image assessment. *Journal of Personality Assessment*, *94*, 404-409.

Swami, V., Stieger, S., Pietschnig, J., **Nader, I. W.**, & Voracek, M. (2012). Using more than 10% of our brains: Examining belief in science-related myths from an individual differences perspective. *Learning and Individual Differences*, *22*, 404-408.

2011

Karwautz, A. F. K., Wagner, G., Waldherr, K., **Nader, I. W.**, Fernandez-Aranda, F., Estivill, X., Holliday, J., Collier, & D. A., Treasure, J. L. (2011). Gene-environment interaction in anorexia nervosa: Relevance of non-shared environment and the serotonin transporter gene. *Molecular Psychiatry*, *16*, 590-592.

Nader, I. W., Pietschnig, J., Niederkröthenthaler, T., Kapusta, N. D., Sonneck, G., & Voracek, M. (2011). Suicide seasonality: Complex demodulation as a novel approach in epidemiologic analysis. *PLoS ONE*, *6*, e17413.

Nader, I. W., Tran, U. S., & Formann, A. K. (2011). Sensitivity to initial values in full nonparametric maximum likelihood estimation of the two-parameter logistic model. *British Journal of Mathematical and Statistical Psychology*, *64*, 320-336.

2010

Nader, I. W., Gittler, G., Waldherr, K., & Pietschnig, J. (2010). Chew on this: No support for facilitating effects of gum on spatial task performance. *Archives of Oral Biology*, *55*, 712-717.

Conference Presentations (talks):

Nader, I. W., Tran, U. S., Baranyai, P., & Voracek, M. (2012). Investigating Dimensionality by means of Mokken Analysis and Confirmatory Factor Analysis. Psychoco 2012: International Workshop on Psychometric Computing, February 9-10, 2012, Innsbruck.

Nader, I. W., Pietschnig, J., Niederkrothenthaler, T., Kapusta, N. D., Sonneck, G., & Voracek, M. (2010). Seasonal changes in suicide frequency: What biology can learn from epidemiology. 22nd Annual Meeting of the Society for Light Treatment and Biological Rhythms, July 1-3, 2010, Vienna.

Nader, I. W., Tran, U. S., & Formann, A. K. (2010). Startwertabhängigkeit von Itemparametern im Zwei-Parameter logistischen Modell. 9. Tagung der Österreichischen Gesellschaft für Psychologie, 8.-10. April 2010, Salzburg.

Nader, I. W., & Pietschnig, J. (2010). Saisonalität von Suiziden: Zunehmend – abnehmend – gleichbleibend? Symposium anlässlich der Emeritierung von o. Prof. Gernot Sonneck, 9. Oktober 2010, Wien.

Conference Presentations (posters):

Nader, I. W., Pietschnig, J., Niederkrothenthaler, T., Kapusta, N. D., Sonneck, G., & Voracek, M. (2010). Trend analysis of suicide seasonality by complex demodulation. 13th European Symposium on Suicide and Suicidal Behaviour, September 1-4, 2010, Rome.

Nader, I. W., Baranyai, P., & Voracek, M. (2011). Akzeptanz von Suizid: Einfluss von Persönlichkeit und suizidbezogenen Einstellungen. 11. Arbeitstagung der Fachgruppe für Differentielle Psychologie, Persönlichkeitspsychologie und Psychologische Diagnostik, 26.-28. September, 2011, Saarbrücken.

Ephemera:

Burger, C., Edl, M., Koch, S., **Nader, I. W.**, Pietschnig, J., Stieger, S., & Voracek, M. (2011, April). Anton K. Formann [biographical item]. Available at: http://en.wikipedia.org/wiki/Anton_Formann

Voracek, M., Stieger, S., **Nader, I. W.**, & Pietschnig, J. (2012, January). Anton K. Formann Memorial Pages [biographical item]. Available at: <http://www.antonformann.at>

Reviewing

Reviewing for:

- British Journal of Mathematical and Statistical Psychology
- Psychiatry and Clinical Neurosciences
- Suicidology Online

Media

Karwautz, A. F. K., Wagner, G., Waldherr, K., **Nader, I. W.**, Fernandez-Aranda, F., Estivill, X., Holliday, J., Collier, D. A., & Treasure, J. L. (2011). Gene-environment interaction in anorexia nervosa: Relevance of non-shared environment and the serotonin transporter gene. *Molecular Psychiatry*, *16*, 590-592.

- Media report in Webstandard (17.12.2010). „Magersucht entsteht durch Gen-Umwelt-Interaktion.“
- Media report in Kurier (20.12.2010). “Magersucht: Umwelt und Gene spielen zusammen.”
- Media report in in Presse (01./02.01.2011). “Magersucht: Der Einfluss von Genen und Umgebung.”

Niederkrotenthaler, T., Sonneck, G., Dervic, K., **Nader, I. W.**, Voracek, M., Kapusta, N. D., Etzersdorfer, E., Mittendorfer-Rutz, E., & Dornier, T. (in press). Predictors of suicide and suicide attempt in subway stations: A population-based ecological study. *Journal of Urban Health*.

- Media report in Webstandard (14.02.2012). “Risikofaktoren für U-Bahn-Suizide”.
<http://derstandard.at/1328507693724/Analyse-Risikofaktoren-fuer-U-Bahn-Suizide>

Teaching Experience

Courses:

Bachelorthesis I (empirical laboratory course); seminar, University of Vienna.

winter term 2010/2011, summer term 2011, winter term 2011/2012, summer term 2012

Supervised Orientation Tutorium (SOT); laboratory course, University of Vienna.

winter term 2011/2012

Laboratory of Psychological Methodology and Statistics I; laboratory course, University of Vienna.

winter term 2008/2009, winter term 2009/2010, winter term 2010/2011

Laboratory of Psychological Methodology and Statistics II; laboratory course, University of Vienna.

summer term 2009, summer term 2010

Laboratory of Statistics; laboratory course, University of Vienna.

summer term 2011, summer term 2012

Additional responsibilities:

- coordination for all courses „**Laboratory of Psychological Methodology and Statistics**“ (winter term 2010/2011)
- all responsibilities for the course „**Test Theory and Test Construction**“ after death of Prof. Formann (compilation and execution of exams, exam meetings, etc.)

Memberships and Affiliations

- Wiener Werkstätte for Suicide Research

Administrative Functions

Coordination of the Exposition for Psychology studies of the University of Vienna at the Job, Training, and Education Fair (BEST3) March 2010, March 2011, and March 2012.