Rehabilitation Psychology

Measuring Posttraumatic Growth and Depreciation After Spinal Cord Injury: A Rasch Analysis

Simon Kunz, Carolina Fellinghauer, and Claudio Peter

Online First Publication, August 26, 2019. http://dx.doi.org/10.1037/rep0000288

CITATION
Kunz, S., Fellinghauer, C., & Peter, C. (2019, August 26). Measuring Posttraumatic Growth and Depreciation After Spinal Cord Injury: A Rasch Analysis. *Rehabilitation Psychology*. Advance online publication. http://dx.doi.org/10.1037/rep0000288

American Psychological Association

Rehabilitation Psychology

© 2019 American Psychological Association
ISSN: 0090-5550

http://dx.doi.org/10.1037/rep0000288

Measuring Posttraumatic Growth and Depreciation After Spinal Cord Injury: A Rasch Analysis

Simon Kunz, Carolina Fellinghauer, and Claudio Peter
Swiss Paraplegic Research, Nottwil, Switzerland, and University of Lucerne

On behalf of The SwiSCI Study Group

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Purpose: Individuals with spinal cord injury (SCI) may experience both positive (posttraumatic growth, PTG) and negative (posttraumatic depreciation, PTD) psychological changes following the injury. PTG and PTD were assessed using the 10-item short form of the Posttraumatic Growth Inventory (PTGI-SF) and 10 matched negatively worded items for PTD (selected from the PTGI-42) within the Swiss Spinal Cord Injury Cohort Study (SwiSCI). This item selection is henceforth called PTG/D-SF. The objective of this study was to test the metric properties of the PTG/D-SF to determine the best strategy to derive reliable sum scores and to test the validity of several different structural conceptualizations. ***Method:*** Using cross-sectional data ($N = 278$), a series of unidimensional and multidimensional Rasch analyses of the PTG/D-SF ($N = 20$) were performed. Rasch analyses were conducted separately for the items or by domains to investigate dimensionality, monotonicity, item and model fit, and local item dependency of the instrument. ***Results:*** The separate PTG and PTD items or their domains can be summated to form a unidimensional scale. Aggregation into domains improved the score distribution and increased the scope of the instruments. The reliability of the sum score for PTG was good (Person Separation: 0.81); the one for PTD was admissible (Person Separation: 0.77). ***Conclusion:*** PTG and PTD should be understood as distinct constructs rather than two ends of a continuum. Findings support the use of a PTG total score and to some degree the PTD total score. Future work could adapt the PTD items to improve the performance of the scale.

Impact and Implications

The current study is the first to examine the metric properties and dimensionality of a measure for posttraumatic growth (PTG) and depreciation (PTD) in spinal cord injury using modern test theory. Higher reliability is achieved with a separate scoring of the PTG and PTD dimensions, which therefore must be understood as two distinct constructs. Clinicians and rehabilitation professionals should monitor in parallel, both positive and negative perceived life changes after the onset of a spinal cord injury. Both PTG and PTD items can be aggregated into overall sum scores and meaningfully interpreted, although the measurement precision of the PTG sum score can be expected to be higher than the one of the PTD sum score.

Keywords: posttraumatic growth, spinal cord injuries, psychometrics, Rasch analysis, rehabilitation

Simon Kunz, Empowerment, Participation, and Social Integration Unit, Swiss Paraplegic Research, Nottwil, Switzerland, and Department of Health Sciences and Health Policy, University of Lucerne; Carolina Fellinghauer, Rehabilitation Services and Care Unit, Swiss Paraplegic Research, and Department of Health Sciences and Health Policy, University of Lucerne; Claudio Peter, Empowerment, Participation, and Social Integration Unit, Swiss Paraplegic Research, and Department of Health Sciences and Health Policy, University of Lucerne.

The members of the SwiSCI Steering Committee are: Xavier Jordan (Clinique Romande de Réadaptation, Sion); Michael Baumberger, Hans Peter Gmünder (Swiss Paraplegic Center, Nottwil); Armin Curt, Martin Schubert (University Clinic Balgrist, Zürich); Margret Hund-Georgiadis, Kerstin Hug (REHAB Basel, Basel); Thomas Troger (Swiss Paraplegic Association, Nottwil); Daniel Joggi (Swiss Paraplegic Foundation, Nottwil); Hardy Landolt (Representative of persons with SCI, Glarus); Nadja Münzel (Parahelp, Nottwil); Mirjam Brach, Gerold Stucki (Swiss Paraplegic Research, Nottwil); Christine Fekete (SPF Coordination Group at Swiss Paraplegic Research, Nottwil).

Simon Kunz and Carolina Fellinghauer contributed equally to the study. This study has been financed in the framework of the Swiss Spinal Cord Injury Cohort Study (SwiSCI, https://www.swisci.ch/en), supported by the Swiss Paraplegic Foundation.

Correspondence concerning this article should be addressed to Simon Kunz, PhD, Empowerment, Participation, and Social Integration Unit, Swiss Paraplegic Research, Guido A. Zäch-Strasse 4, CH-6207 Nottwil, Switzerland. E-mail: simon.kunz@paraplegie.ch

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Introduction

Spinal cord injury (SCI) is a severe life event leading to chronic disability (World Health Organization, 2013). SCI can result in permanent paralysis and loss of sensation corresponding to the level of the spinal lesion. It affects bladder, bowel, and sexual functions and can lead to secondary health conditions, such as spasticity, chronic pain, pressure sores, cardiovascular disease, or osteoporosis (Lin, 2003). These severe physical consequences reverberate on the level of everyday activities and societal participation. Hand and arm use can be impaired, leading to limitations in eating, drinking or self-care. Work and leisure activities are often negatively influenced; work reeducation or usage of specialized transport services may be necessary (Kirshblum, Campagnolo, & DeLisa, 2002). Further, SCI may also exert a negative impact on mental health. The risk for anxiety disorders, poor quality of life, substance abuse, and suicide is elevated for people with SCI compared to the general population (Craig, Tran, & Middleton, 2009; Post & van Leeuwen, 2012).

In spite of the serious physical, social, and psychological consequences, several studies showed that persons with SCI may also experience positive psychological changes following the injury, such as an increased sense of personal strength or a higher appreciation of life (e.g., Kunz, Joseph, Geyh, & Peter, 2017; McMillen & Cook, 2003). Different terms have been used to refer to this phenomenon (e.g., stress-related growth, adversarial growth), but "posttraumatic growth" (PTG) is viewed as describing best its underlying meaning (Tedeschi & Calhoun, 2004; Zoellner & Maercker, 2006). PTG has not only been observed in persons with SCI, but in many persons who have experienced a severe life event, including violent assaults or loss of a significant other (e.g., Barskova & Oesterreich, 2009; Linley & Joseph, 2004; Zoellner & Maercker, 2006).

One of the most widely used instruments to assess PTG is the Posttraumatic Growth Inventory (PTGI; Tedeschi & Calhoun, 1996). The PTGI has 21 items comprising the five domains "Relating to others," "New possibilities in life," "Personal strength," "Spiritual change," and "Appreciation of life." Besides the original PTGI, different versions of this instrument have been developed and used in research. For example, a short form consisting of 10 items (with two items each per domain) has been constructed (Cann, Calhoun, Tedeschi, Taku et al., 2010) to reduce participant burden within large data collections. Furthermore, as a response to the critique that using the PTGI may lead to biased findings because only "positive" psychological changes are surveyed, Baker, Kelly, Calhoun, Cann, and Tedeschi (2008) constructed the PTGI-42. Next to the original 21 positively framed PTG-items, the PTGI-42 adds 21 matched but negatively worded items (example item: I have less of an appreciation for the value of my own life) allowing respondents to report also about negative psychological changes, termed *posttraumatic depreciation* (PTD). By assessing positive and negative changes in each domain with separate items rather than using one bipolar item, the PTGI-42 takes into account that both may coexist (even within the very same domains). Assessing both PTG and PTD can give insights not only into the resources but also into the problems and challenges that a person experiences posttrauma. Both may be relevant to plan and perform targeted psychological interventions and to support the person in the rehabilitation process. To investigate this potential clinical relevance of both, PTG and PTD, in individuals with SCI and aiming to reduce participant burden, an abbreviated version of the PTGI-42, henceforth labeled PTG/D-SF, has been used in the Swiss Spinal Cord Injury Cohort (SwiSCI) Study. This 20-item measure consists of the 10-item PTGI-SF for PTG and the 10 matched negatively worded items for PTD taken from the PTGI-42.

The scale properties of the PTGI and of its short form (both assessing PTG only) have received considerable attention in the past, without yielding clear evidence concerning dimensionality. Results of studies examining the factorial structure in various populations typically suggest that both the five-factor model (corresponding to the five domains) as well as a five-factor model with a second-order factor offer acceptable fit regarding the PTGI (e.g., Linley, Andrews, & Joseph, 2007; Maercker & Langner, 2001; Purc-Stephenson, 2014; Saltzman, Easton, & Salas-Wright, 2015; Taku, Cann, Calhoun, & Tedeschi, 2008) and its short form (e.g., Cann, Calhoun, Tedeschi, Taku et al., 2010; Kaler, Erbes, Tedeschi, Arbisi, & Polusny, 2011; Prati & Pietrantoni, 2014). In sum, the results of these studies leave it open whether the domain scores need to be examined separately (as suggested by the five-factor solution without a second-order factor) or whether they can also be aggregated into a total score (as suggested by the second-order factor solution).

Considering positive and negative changes, as it is done with the PTGI-42, adds a further question regarding dimensionality, that is, whether PTG and PTD represent opposite poles of a single construct (i.e., posttraumatic life changes with a continuum from high positive to high negative change) or two separate constructs (i.e., two separate dimensions each with a continuum of no change to high positive or negative change, respectively; Joseph & Linley, 2008b). Clear-cut evidence regarding this question is lacking so far since the dimensionality of the PTGI-42 has not been tested yet. Correlational research revealed that PTG and PTD can be experienced in parallel (Linley & Joseph, 2004; Wortman, 2004), in the same domains (e.g., Baker et al., 2008; Cann, Calhoun, Tedeschi, & Solomon, 2010), and independently of each other (Frazier, Conlon, & Glaser, 2001; Solomon et al., 1999; Tedeschi & Calhoun, 2004; Updegraff, Taylor, Kemeny, & Wyatt, 2002). This suggests that PTG and PTD, even in the same domains, seem to be independent dimensions and not two ends of the same continuum. Supporting this assumption further, a hierarchical model with two higher-order factors (PTG and PTD dimensions) and each with five lower-order factors representing the respective domains reached an acceptable fit for the PTG/D-SF used in the SwiSCI study (Kunz et al., 2017).

The metric evaluations described above have commonly used classical test theory (CTT) to investigate the characteristics of the measure. However, in order to construct a measurement, scale calibration methodologies from the field of probabilistic measurement are more appropriate means to determine if an instrument possesses the metric properties required for valid and reliable measurement (Petrillo, Cano, McLeod, & Coon, 2015; Tennant & Conaghan, 2007).

The Rasch analysis is a probabilistic approach from the field of modern test theory that was first introduced by George Rasch in 1966 in the field of educational sciences (Rasch, 1960). In Rasch's theory, responses to a measurement scale are expected to follow a certain pattern, the Guttmann pattern, where the probability of a response is a function of the item's difficulty and the person's ability.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Rasch-based analysis has several advantages over CTT (Andrich, 1988; Tesio, 2003; Wright & Linacre, 1989). First, contrary to CTT, ordinal data that fits the Rasch model can be reliably aggregated into interval scale scores, which is required for further statistical, parametric testing or the measurement of change. Second, many methodologies are data dependent and aim to fit models to the data; the mathematical formulation of the Rasch model fits the data to the model to obtain information regarding metric properties. Third, Rasch analysis is a probabilistic methodology that places sample and test-independent estimates for the person and the items on one continuum providing hereby sample independent reliability estimates. In contrast, CTT-based reliability estimates are not robust to factors such as the test length and the distribution of the sample. Nowadays, methods from the field of modern test theory are considered to be the gold standard to determine metric properties in assessment tools as they build on more theoretically sound fundamental measurement principles and have "greater potential to solve practical measurement problems" than CTT (Embretson & Reise, 2000, p.3).

Current Study

The overall objective of the current project is to evaluate the metric properties of the PTG/D-SF and to determine the best strategy to derive reliable summary scores for future quantitative analyses by using Rasch analysis. The specific aims are:

1. To test several different structural conceptualizations of the PTG/D-SF including a unidimensional, two unidimensional, and a two-dimensional Rasch model with either the items or domains.

2. To examine the metric properties of the different conceptual structures with Rasch and to determine its reliability at scale and item level for measurement.

In doing so, the current study aims to contribute in particular to a clarification of the questions whether PTG and PTD are best conceptualized as a unidimensional construct or as two distinct constructs and whether the corresponding domains can be meaningfully aggregated into one total score. Based on a previous analysis of PTG/D-SF data in a subsample of the SwiSCI study sample, we expect PTG and PTD to be two distinct but not totally unrelated dimensions with moderate-to-strong correlation and good-to-excellent reliability of the respective total scores.

Method

Participants and Procedure

We used data collected within the ongoing inception cohort of the SwiSCI study (Post et al., 2011). The SwiSCI study collects clinical and questionnaire data (in German, French, and Italian) on individuals newly diagnosed with a traumatic or nontraumatic SCI. Eligible individuals must be admitted for clinical rehabilitation to one of the four national SCI rehabilitation centers (Spinal Cord Injury Center of the Balgrist University Hospital, Zürich; Centre for Spinal Cord Injury and Severe Head Injury, REHAB Basel; Clinique Romande de Réadaptation, Sion; and the Swiss Paraplegic Centre, Nottwil), aged 16 years or above, and permanently residing in Switzerland. Excluded are individuals with congenital conditions leading to SCI, new diagnoses of SCI in the context of palliative care, and neurodegenerative disorders such as multiple sclerosis. The Switzerland was formally approved by the principal ethics committee on research involving humans from northwest and central Switzerland (covering the collaboration centers in Nottwil and Basel), the Ethics Committee Vaud (covering the center in Sion), and the Ethics Committee Zürich (covering the center in Zürich). All participants gave written informed consent.

In the inception cohort of the SwiSCI study data is collected at four measurement time points during clinical rehabilitation: 1, 3, and 6 months after injury diagnosis and at rehabilitation discharge. For our secondary data analysis, we only used cross-sectional data from the discharge assessment. All SwiSCI participants who completed their clinical rehabilitation until May 29, 2017 were considered for the analysis. However, not all eligible individuals participated in the SwiSCI study and some dropped out before the discharge assessment. The corresponding participant flow is depicted in Appendix A. The study's reporting is based on the STROBE statement (von Elm et al., 2007).

Measures

PTG. As part of the PTG/D-SF, PTG was measured with the short form of the Posttraumatic Growth Inventory (PTGI-SF, Cann, Calhoun, Tedeschi, Taku et al., 2010) in the SwiSCI study. The PTGI-SF consists of 10 items that ask respondents to report the degree to which they perceive positive changes resulting from SCI. Two items each refer to one of five domains: Relating to others (items: distance and people), New possibilities in life (items: way and life), Personal strength (items: difficulty and strong), Spiritual change (items: religion and belief), and Appreciation of life (items: priority and esteem). The questions of the PTGI-SF that correspond to the labels used in the brackets can be found in Appendix B. The response options for these items range from 0 (*I did not experience this change*) to 5 (*I experienced this change to a very great degree*).

In previous research, sum scores for each of the five PTGI-SF domains (each having a possible range of 0 to 10) and an overall sum score (possible range from 0 to 50) have been used. Relying on CTT, admissible reliability (i.e., Cronbach's alpha $> .70$) of the domain scores (despite consisting of only two items each) and good reliability of the overall score (i.e., $\alpha > .80$) was reported (Cann, Calhoun, Tedeschi, Taku et al., 2010).

PTD. PTD was assessed with 10 negatively worded items corresponding to the 10 positively worded items of the PTGI-SF (see Appendix B for specific wording). Accordingly, we used the same labels as for the PTG items to refer to these items that were selected from the broader PTGI-42 (Baker et al., 2008). Relying on CTT, admissible reliability (i.e., $\alpha > .70$) of all the PTD domain sum scores (consisting of two items each), except for the reliability of the relating to others score ($\alpha = .61$), and good reliability (i.e., $\alpha > .80$) of the PTD overall sum score (consisting of 10 items) was reported (Kunz et al., 2017).

Language versions in the SwiSCI study. The PTGI (Tedeschi & Calhoun, 1996) and its variants were originally developed in English. In the SwiSCI study, existing validated German, French, and Italian versions of the PTG measurement instruments were

used (Lelorain, Bonnaud-Antignac, & Florin, 2010; Maercker & Langner, 2001; Prati & Pietrantoni, 2014). Concerning PTD, items in German, French, and Italian were not available and therefore were translated from the English original scale (Baker et al., 2008) using a forward translation procedure. Next, the resulting three language versions of the PTG/D-SF were harmonized in parallel in group sessions by bilingual persons, because both validated PTG items and translated PTD items were not necessarily consistent, although based on the same English original measure (Baker et al., 2008). Minor revisions consisted of deleting or adding some single item subsets or word replacements. The English original measure served as point of reference in this harmonization process.

Data Analysis

In response to the inconsistent findings concerning dimensionality, a series of Rasch analyses were conducted (see Figure 1). The items of the PTG/D-SF were analyzed with the Partial Credit Model (PCM; Masters, 1982), a special type of Rasch model that is used with polytomous rating scales. The PCM assumes that the distances between thresholds of adjacent response options can vary within and across rating scales. All analyses were conducted in R (R Core Team, 2018), using the package eRm (Mair & Hatzinger, 2007) for the unidimensional Rasch analyses, and the package TAM (Robitzsch, Kiefer, & Wu, 2018) for the multidimensional Rasch analyses.

First (Step 1), the 20 items making up the PTG/D-SF were submitted conjointly to unidimensional Rasch analyses using two different conceptualizations, an analysis of the 20 items as such (Model 1a) and an analysis of the domain scores (Model 1b), which were built by summing up the item scores from a common domain (see Measures section), as pairwise associations of items from the common domains (e.g., Relating to others) within the PTG and the PTD dimension were expected due to their specific conceptual overlap. Second (Step 2), two separate unidimensional PCMs were tested, with PTG representing one and PTD the other potentially distinct dimension (Model 2a). Next, the items from common domains from each potential dimension of the PTG/D-SF (i.e., PTG and PTD, respectively; Model 2b) were aggregated and submitted to separate unidimensional Rasch analyses. Third (Step 3), two multidimensional Rasch analyses with either items or domains were performed. The multidimensional Rasch analysis accounted for the two potential dimensions of the PTG/D-SF. Multidimensional Rasch analysis can be used when several known, but not totally independent, dimensions are expected within a latent construct. The multidimensional Rasch analysis will then test if, to some extent, PTG and PTD could be represented by a higher-level construct, such as; for example here, posttraumatic life change. Analogous to the previous Steps 1 and 2, the first multidimensional model (Model 3a) used the items, the second model again aggregated the items by domains (Model 3b). A graphical illustration of our modeling approach is depicted in Figure 1.

When doing a unidimensional Rasch analysis, a series of metric assumptions, which would negatively impact the validity of a scale for measurement if not taken into account, have to be verified. Besides the item and the model fit, assumptions such as the dimensionality, response monotonicity, person–item targeting, local item dependency, and differential item functioning need to be tested.

Dimensionality of a scale can be assessed through different means. In the present analysis, a principal component analysis of the standardized Rasch residuals will support the analysis of the dimensionality of the items. First eigenvalues >2 are considered as substantial and indicative of multidimensionality (Raîche, 2005), unidimensionality is supported with first eigenvalues <1.5, which is a more critical cut-off (Linacre & Tennant, 2009). Additionally, items can be grouped according to their positive or negative loading on the first residual PCA factor. These two subgroups of items are then submitted separately to a Rasch analysis where person estimates, and their measurement errors are then compared

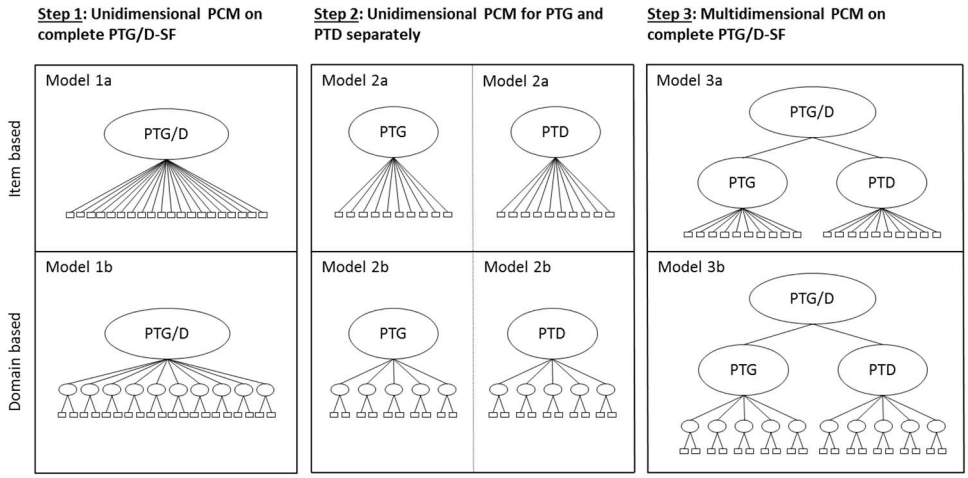


Figure 1. Conceptual steps of the PTG/D-SF Rasch model based analyses. Step 1 = unidimensional analyses of the PTG/D-SF items or by domains. Step 2 = separate unidimensional analyses of the items or domains from each PTG/D-SF dimensions (PTG and PTD). Step 3 = multidimensional Rasch analyses of the items or domains of the PTG/D-SF with PTG and PTD as dimensions.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

individually using dependent *t* tests. The expected percentage of significant *t* tests due to chance lies at 5%. A percentage and upper confidence interval (CI) below 5% are expected to support the unidimensionality of the scale (Smith, 2002).

Monotonicity of the rating scales assumes that response options appear strictly ordered from 0 meaning that the person did not perceive a certain change to 5 meaning that the person perceived change to a very high extent after SCI. The PCM analysis computes the response thresholds, which are the equal probability points between adjacent response options. In the presence of ordered thresholds, one can assume that the monotonicity of a rating scale is supported. When, for some reason, thresholds appear disordered the adjacent levels of a rating scale can be collapsed and the PCM analysis rerun until all rating scales of the instrument present a monotonic ordering.

Targeting: A well-targeted metric presents a mean item difficulty and mean person ability close to zero on the continuum of the construct, indicating that the measurement instrument has the right scope to assess the population in question well. Further, the proportion of persons with abilities below the smallest item difficulty or above it should not exceed 15% to meet standards and indicate a good targeting of the model (McHorney & Tarlov, 1995).

Local item dependency (LID) indicates response dependency between items, which may bias the item and model fit estimates (Yen, 1993) and impact on the dimensionality (Marais & Andrich, 2008). LID is often caused by response redundancies in an assessment with items addressing similar aspects of a latent trait. Correlations of standardized item residuals above .2 are indicative of a local dependency between items. In presence of locally dependent items, a testlet strategy could be adopted that creates one single item in aggregating the correlated items by summing their respective scores. Our domain-based approach also aggregates the items from a common domain. However, these are not strictly speaking testlets, as the respective items are not expected to correlate statistically above a fixed threshold but are aggregated based on a conceptual reasoning only. With testlets that aggregate dependent items, ordering of thresholds is no longer expected (Andrich, 2006).

Differential Item Functioning (DIF) implies that the item difficulties are not invariant across sample characteristics. In the present study we investigated DIF for injury characteristics (completeness and level of injury) as well as person characteristics (sex, age, and language). In the presence of DIF, the response probability differs systematically for a given person ability. This is often considered a measurement bias, which may indicate favoritism in a sample's subgroup (Holland & Wainger, 1993). DIF adjustment often requires to split items, that is, creating items where the difficulty gets adjusted for the significant sample characteristic (Andrich & Hagquist, 2015; Hagquist, Bruce, & Gustavsson, 2009). However, considering that DIF is a conditional property where causal pathways between the group factor and an item are not always clear, scale preservation can be prioritized against group-specific scale adjustments to preserve the homogeneity of the scale and its applicability across the entire population.

Item and model fit are expected to support the validity of a metric. The fit of the items is given with the infit statistic, which is a less outlier-sensitive fit statistic derived from the analysis residuals. More specifically the infit statistic corresponds to the mean squared standardized residuals. Good fitting items are expected to present infit values close to 1, at least between 0.8 and 1.2 (Wright & Linacre, 1994).

To determine the fit of the models, the internal consistency of the unidimensional and multidimensional Rasch models will be examined based on their reliability, which is determined (a) by the person separation reliability (PSR), which gives the reliability of the overall model basing on the Rasch ability estimates and their variance, and (b) by the Warm's weighted likelihood estimator, which provides the reliability of the Rasch estimates in each dimension. Both indices range from 0 to 1 (Wright & Stone, 1979) and can be interpreted in the same way as Cronbach's alpha. The minimum acceptable PSR value is 0.7 for the use of a metric at group level. For measurement at individual level, a PSR of at least 0.85 is expected (Tennant & Conaghan, 2007). Further, the fit of the unidimensional and multidimensional models will also be described based on deviations of the expected from the true observations using the root mean squared deviation (RMSD). The RMSD can also be used to compare the fit of a multidimensional Rasch model with the fit of a nested unidimensional model (Adams, Wilson, & Wang, 1997). RMSD values $< .05$ indicate a good model fit, $.05 < \text{RMSD} < .08$ value indicate moderate model fit, and $\text{RMSD} > .08$ a poor model fit. RMSD change in fit can be compared across nested models with an ANOVA. The RMSD gives an estimate of the degree of fit of the data to the Rasch assumptions, which can in turn be used to compare nested models in order to determine the best fitting modeling approach.

Persons with at least 20% responses to the PTG/D-SF scale or dimension (i.e., PTG and PTD) entered the analysis. However, the percentage of persons with more than 50% of missing was low (2%). Remaining missing values were not imputed. One of the most important properties of the Rasch analysis is the specific objectivity, which assures that all estimated difficulty parameters are sample independent (item parameter invariance) and all latent trait-related parameters are independent of the items used for estimation (person parameter invariance). In that sense it can be expected that Rasch estimation is consistent even on an incomplete dataset, whatever the type of missing data (Hardouin, Conroy, & Sébille, 2011).

Results

The sample counted 342 participants. A total of 278 participants with at least 20% responses to the PTG/D-SF were included in the analyses (see Appendix A). Of these, 81.7% filled in the German, 14.7% the French, and 3.6% the Italian version of the SwiSCI questionnaire. Sociodemographic and lesion-related characteristics of the analyzed sample can be found in Table 1. The proportion and percentage of responses, including missing responses for the items measuring PTG and PTD are shown in Appendix B.

Table 2 shows the results at model level, including the information about the number of observations entered in the analysis, the number of dimensions, the targeting (item and person mean, threshold range, floor and ceiling effects), model reliability, dimensionality, and model fit. More detailed information about the difficulty, fit, difficulty rank, threshold ordering, results of the principal component analysis and local item dependencies are shown in Appendix C.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Table 1
Descriptive Statistics of the Analyzed Sample (N = 278)

Sociodemographic information	*M* (*SD*)
Age (years)	54.11 (16.56)
Months since SCI at discharge	5.26 (2.86)
	n (%)
Gender	
Male	187 (67.3)
Injury level and type	
Complete paraplegia	27 (10.9)
Complete tetraplegia	11 (4.5)
Incomplete paraplegia	124 (50.2)
Incomplete tetraplegia	74 (30.0)
Intact	9 (3.6)
Unknown	2 (.8)
SCI cause	
Nontraumatic	118 (42.4)
Traumatic	157 (56.5)
Unknown	3 (1.1)

Step 1

Model 1a: Item-based unidimensional Rasch analysis of the PTG/D-SF.

Dimensionality. The results of the PCM analysis of the PTG/D-SF including all the items indicated strong multidimensionality with 17.0% of significant *t* tests. The PC1 loadings emphasized and confirmed the two dimensions of the PTG/D-SF, where PTG items' PC1 loadings were positive and most PTD items presented negative PC1 loadings. The only exception was the "religion" item of the PTD dimension, which loaded positively on the PTG dimension. However, this item's PC1 loading was close to zero (PC1 loading = .02).

Monotonicity. The analysis of the PTG/D-SF indicated disordered thresholds for all items. At this stage, no response option recoding strategy was undertaken, as it could be expected that the scale is multidimensional, and a unidimensional co-calibration of all items of the two dimensions would not be further supported. Further, it is known that threshold disordering is often caused by the multidimensionality and item dependencies (Sideridis, 2011; Yen, 1993).

Targeting. The mean item difficulty and person ability were about half a logit away. Five persons presented the lowest possible score when using all items for calculating the row scores. After the Rasch analysis the percentage of persons with abilities below the easiest item difficulty was 11.9%, indicating a small floor effect, and a higher proportion of participants reporting to perceive no or very small change in any direction as a result of their SCI.

Local item dependency. Several locally dependent items with residual correlations >.2 were found. However, no LID was observed across PTG/D-SF dimensions, only within. The PTG questions for "esteem," "priority," "way," "life," and "difficulty" correlated and the PTD questions for "religion" and "belief" correlated. The correlational structure and the strength of the associations are shown in Figure 2.

Item fit. The PCM analysis of the items resulted in poor fit; that is, infit >1.2, for the esteem (PTG) item.

Reliability. The person separation reliability was good in the analysis with all the items (α = .89, PSR = .88).

Table 2
Model Fit Statistics Including the Information About the Data Entered in the Analysis and Estimation Algorithm, Item Location, Person Location, Threshold Range, Floor and Ceiling, Reliability, Dimensionality Test and Model Fit

Analysis step	Model	Conceptualization	*n*	Number of dimensions	Number of items	Coding strategy	Item location		Person location		Threshold range		Targeting		Reliability		Unidimensionality paired *t*-tests	Model fit
							M	*SD*	*M*	*SD*	Min	Max	Floor	Ceiling	PSR	Alpha	% Sig *t*-test	RMSD
Step 1	1a	PTG/D-SF item analysis	278	1	20	0 1 2 3 4 5	.00	.70	−.60	.60	−1.4	2.07	11.87%	.00%	.88	.89	17.01% [15.11%: 17.98%]	.04
	1b	PTG/D-SF domain analysis	278	1	10	0 1 2 3 4 5	.05	.62	−.41	.44	−1.7	2.14	2.88%	.00%	.85	.84	24.26% [22.53%: 25.14%]	.03
Step 2	2a	PTG	278	1	10	0 1 2 3 4 5	.06	.75	−.32	.69	−1.2	2.33	11.87%	.00%	.84	.86	6.62% [4.47%: 7.72%]	.03
	2a	PTG recoded	278	1	10	0 0 1 1 1 2	.46	1.63	−.72	1.47	−2.5	2.66	20.86%	1.80%	.81	.84	0% [0%[a]: 1.54%]	.05
	2b	PTG domain analysis	278	1	5	0 1 2 3 4 5	.12	.67	−.21	.53	−1.5	2.31	2.88%	.00%	.81	.82	1.35% [0%[a]: 2.25%]	.02
	2a	PTD	277	1	10	0 1 2 3 4 5	.03	.57	−.79	.70	−1	1.27	44.77%	.36%	.83	.86	1.68% [0%[a]: 2.92%]	.04
	2a	PTD recoded	277	1	10	0 0 1 1 1 2	.34	1.19	−1.39	1.20	−1.4	1.96	60.65%	.36%	.75	.82	2.35% [0%[a]: 3.82%]	.02
	2b	PTD domain analysis	278	1	5	0 1 2 3 4 5	.08	.56	−.57	.50	−1	1.76	28.06%	.00%	.77	.80	2.07% [0%[a]: 3.19%]	.04
Step 3	3a	PTG	278	2	20	0 1 2 3 4 5	−.08	.10	−.03	.68	−1.6	1.65	1.80%	1.08%	.80	*na*	*na*	.07
		PTD					.12	.13	−.03	.84	−1	1.23	15.11%	4.32%	.60	*na*	*na*	
	3a	PTG Recoded	278	2	20	0 0 1 2 2 2	.53	.38	.01	1.12	−.9	1.28	23.38%	12.59%	.75	*na*	*na*	.06
		PTD Recoded					1.16	.26	.24	1.00	.64	1.81	66.55%	6.12%	.52	*na*	*na*	
	3b	PTG domain analysis	278	2	10	0 1 2 3 4 5	−.02	.03	.03	.54	−1.4	1.67	1.80%	.36%	.77	*na*	*na*	.05
		PTD domain analysis					.06	.07	.09	.56	−1.1	1.53	.00%	.36%	.50	*na*	*na*	

Note. *na* = not applicable; PSR = person separation reliability; RMSD = root mean squared deviation; PTG/D-SF = Posttraumatic Growth/Depreciation–Short Form.
[a] negative lower confidence interval bounds were set to zero.

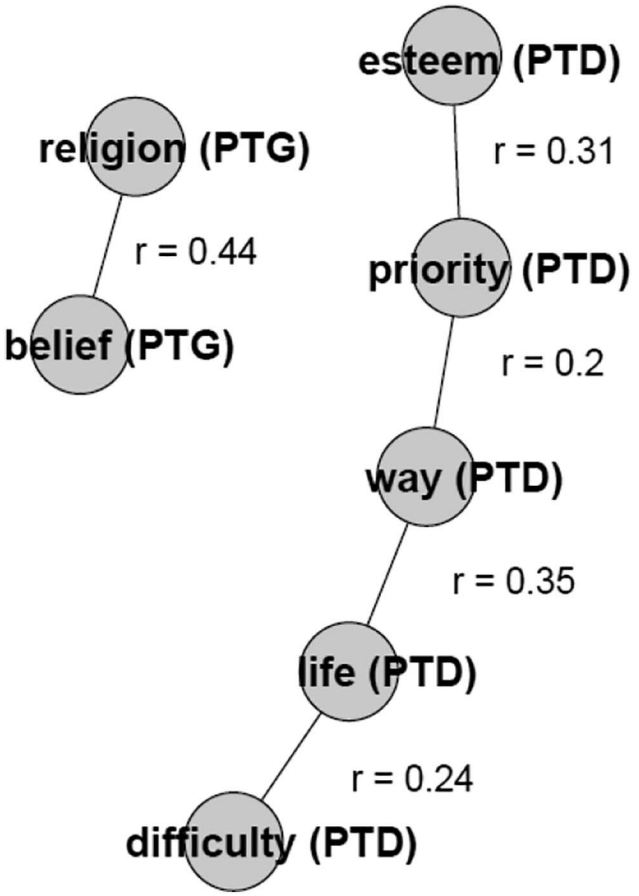


Figure 2. Local item dependencies in Model 1a (unidimensional analyses of the PTG/D-SF items).

DIF. Uniform-DIF for person or injury characteristics was not found.

Model 1b: Domain-based unidimensional Rasch analysis of the PTG/D-SF.

Dimensionality. The multidimensionality issue, as indicated by 24.3% of significant *t* tests, remained, even increased, in the analysis of the PTG/D-SF using the domains. Here also, the loadings on the first component confirmed the dimensional structure of the instrument. One exception were the Spiritual change domain items of the PTG dimension, which showed loadings close to 0 on this dimension.

Targeting. The mean item difficulty and person ability were about half a logit away. After the Rasch analysis the percentage of persons with abilities below the easiest item difficulty was only 2.9%, supporting a better targeting and the absence of any floor effect when item scores were aggregated by domains.

Local item dependency. Most of the local dependencies found in the previous Model 1a got absorbed when aggregating the items into domains. Still, the Personal strength and New possibilities in life domains of the PTD dimension were locally dependent with $r = .27$.

Item fit. Domain-based analysis presented only good fitting domains with infit values within the expected boundaries.

Reliability. The person separation and the reliability were good in the analysis with domains (PSR = .85; $\alpha = .84$). Recoding of items improved the scope and the reliability of the metric. However, interpretations at this stage are biased by the significant multidimensionality of the item and domain analyses (Baghaei, 2008).

DIF. Uniform-DIF for person or injury characteristics was not found.

Step 2

Model 2a: Item-based unidimensional Rasch of each PTG/D-SF dimension.

Dimensionality. The lower CI-bound of the *t* tests addressing the dimensionality question were all <5% and the first eigenvalues were below 2, which supports the unidimensionality of the PTG and the PTD dimension, respectively.

Monotonicity. Disordering of thresholds was an issue in both dimensions and concerned all the items. One recoding strategy leaving three response thresholds instead of six was applicable to both PTG/D-SF dimensions (0 = >0, 1 = >0, 2 = >1, 3 = >1, 4 = >1, 5 = >2) and solved the disordering for all items across both dimensions (see Figure 3).

Targeting. Both, the PTG and the PTD dimension presented a floor effect before and after the recoding of the items. The difference between mean item difficulty and mean person ability was below 0.5 logit in the nonrecoded analyses of the PTG dimension and above one with recoded items (logit difference = 1.18). With regards to the PTD dimension, the recoding of items also increased the difference between the mean item difficulty and the mean person ability, the difference being above 1.5 logit (logit difference = 1.73). Recoding of the items affected the targeting and increased the number of persons with a lowest possible score, and thereby the number of observed floor effects after the PCM analysis, especially in the PTD dimension. In both dimensions, these effects were always in the direction of no perceived changes after the SCI. Recoding of items improved the scope of the metric.

Local item dependency. Some residual correlation was found between the belief and religion items of the PTG dimension ($r = .44$) as well as in the PTD dimension ($r = .26$). For both dimensions, the recoding strategy, which aimed to solve the disordering with one single strategy, had no effect on the LID; the belief and religion items remained locally dependent in both the PTG and the PTD dimension.

Item fit. The item fit in the PTG dimension was good for all items and only one item of the PTD dimension, people (infit = 1.33), presented an underfit beyond the boundaries for acceptable fit. The misfit observed in the PTD dimension for people remained in the analysis with recoded items (infit = 1.31).

Reliability. The analysis of the PTG dimension resulted in good reliability when keeping the original item encoding (PSR = .84, $\alpha = .86$) and with recoding of the response options (PSR = .81, $\alpha = .84$). For the PTD dimension, the reliability measured by the PSR and the Cronbach's alpha was only good in the analysis with the unrecoded items (PSR = .83 and $\alpha = .86$). The Cronbach's alpha was also good for the recoded model ($\alpha = .82$) but the PSR was only admissible (PSR = .75).

DIF. The difficulty item of the PTG dimension showed uniform language DIF (French against German translation of the

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

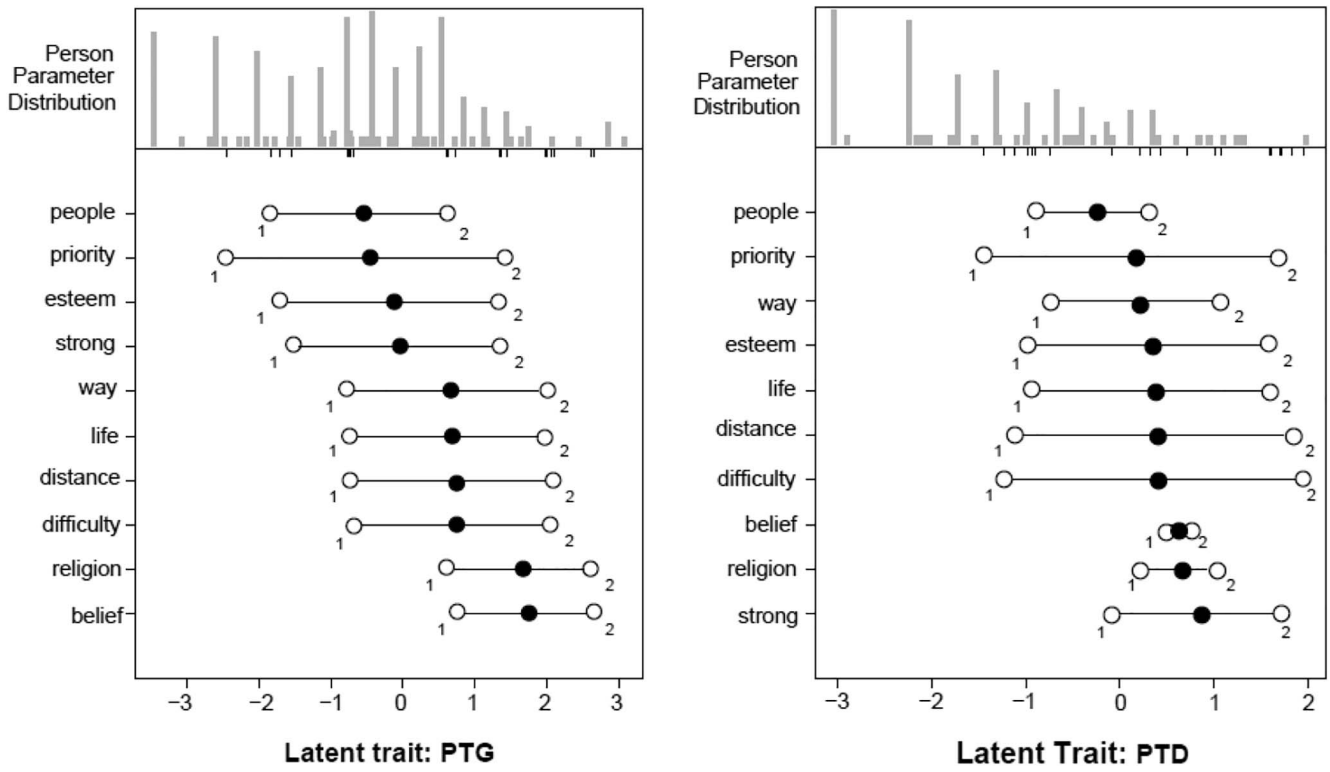


Figure 3. Person item map for the individual Rasch analysis of PTG and PTD with recoded items.

item). The language DIF did not occur anymore in the analysis with recoded items. All other person or injury characteristics included in the DIF analysis; that is, gender, age, injury completeness and injury level, did not affect the functioning of the PTG/D-SF items.

Model 2b: Domain-based unidimensional Rasch of each PTG/D-SF dimension.

Dimensionality. When calibrated by domains, the proportion of significant *t* test was <5% and the first eigenvalues were <2, supporting the unidimensionality of the PTG and the PTD dimension, respectively.

Targeting. The use of the domains instead of the items clearly improved the targeting of the PTG dimension, from 11.9% detected participants with abilities below the lowest difficulty in the item analysis to 2.9% in the analysis with the domains. Such an improvement was also observed in the PTD dimension. Nonetheless, a significant floor effect remained in this latter dimension even after aggregation by domains, as indicated by 28.1% of the participants showing abilities below the lowest item difficulty. The targeting of the scales was good for the analysis of the PTG dimension with domains since differences between the mean item difficulty and mean person ability were below 0.5 logit. The targeting in the PTD dimension was a little less favorable with differences of 0.65 logit, indicating again a higher percentage of participants experiencing no changes after their SCI. The biggest change among PTG and PTD domains was reported for the Appreciation of life and the least for Spiritual changes. The analysis with domains instead of items improved the scope of the metric.

Local item dependency. No remaining LID was found between domains of the PTG or PTD analyses.

Item fit. Also, the analyses by domains resulted in good fit for all the domains and in both dimensions.

Reliability. The analysis of the PTG dimension resulted in good reliability in the domain-based model (PSR = .81, α = .82). For the PTD dimension, the reliability measured by the PSR and the Cronbach's alpha was good (α = .80) but the PSR was only admissible (PSR = .77). Here again, it can be expected that the low PSR was due to the skewed distribution of the scores with floor effects when aggregating the items from a domain.

DIF. No DIF was observed in the analysis with domains.

Step 3

Model 3a: Item-based multidimensional Rasch of the PTG/D-SF.

Monotonicity. The multidimensional Rasch analysis of the PTG/D-SF scale with two separate dimensions resulted in threshold disordering for all items. The disordering could not be solved by applying one common recoding strategy across items. The best strategy, different from the strategy applied in Step 2, was 0 = >0, 1 = >0, 2 = >1, 3 = >2, 4 = >2, 5 = >2. However, seven items, with one exception, all from the PTD dimension, still presented disordered thresholds: religion (PTD), distance (PTD), difficulty (PTD), life (PTD), belief (PTD and PTG), strong (PTD).

Targeting. The differences between the mean item difficulties and the mean person abilities was below 0.5 logit in the model without recoding, indicating good targeting. However, the floor effects did not disappear in the multidimensional context and the proportion of persons in the extremes of the PTD dimension

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

remained high (15.1%) and increased for both dimensions with the recoding of the items (PTG: 23.4%; PTD: 66.6%).

Item fit. The two-dimensional analysis with items resulted in underfit only in one of the 20 items. The PTD people item, with original coding and when applying the recoding strategy showed an infit >1.2, that is, 1.32 and 1.22, respectively.

Reliability. The reliability for each dimension in the multidimensional models is depicted in Table 2. The PTG dimension presented a better person separation reliability. While the reliability of the PTG dimension was admissible to good without and with recoding of the item thresholds (PSR = .80; PSR recoded = .75), the PTD dimension presented inadmissible to poor person separation reliability (PSR = .6; PSR recoded = .52).

Model fit. The model fit was moderate for the multidimensional conceptualization with the 20 items (RMSD = .07) and their recoded version (RMSD = .06). The correlation between the item-based PTG and PTD dimensions was $r = .64$ before and $r = .67$ after recoding.

Comparing the unidimensional model with all items in Step 1 to the corresponding multidimensional model with two dimensions in Step 3 revealed a significant difference in model fit, as the ANOVA test comparing the two models based on a likelihood ratio test was significant, $\chi^2(2) = 287.69$, $p < .001$. The change in the RMSD, however, indicated a deterioration of the quality of the model fit when applying the multidimensional model instead of the unidimensional model.

Model 3b: Domain-based multidimensional Rasch of the PTG/D-SF.

Targeting. The targeting was good and the aggregation by domains did not lead to high proportions of person ability estimates below the lowest threshold after the two-dimensional Rasch analysis.

Item fit. The two-dimensional analysis with domains resulted in low fit for the Spiritual change domain, in both the PTG and the PTD dimension; that is, infit values of 1.36 and 1.31.

Reliability. With the domain aggregation, the reliability of the PTG dimension was admissible (PSR = .77), but the person separation reliability of the PTD dimension further dropped to an inadmissible level (PSR = .45).

Model fit. The model fit was good for the multidimensional conceptualization with domains (RMSD = .05). The domain-based PTG and PTD dimensions correlated with $r = .61$.

Comparing the unidimensional model with domains in Step 1 to the corresponding multidimensional model with two dimensions in Step 3 resulted also in a significant change in the model fit, as the ANOVA test comparing the two models based on a likelihood ratio test was significant, $\chi^2(2) = 224.94$, $p < .001$. However, the direction of the change was in favor of the item-based analysis, not toward the multidimensional conceptualization.

Discussion

The present study examined the psychometric properties of the PTG/D-SF (i.e., an item set corresponding to the PTGI-SF and 10 matched negatively phrased items selected from the broader PTGI-42) in a sample of individuals with SCI by testing and comparing a series of Rasch models. The results of these Rasch analyses supported our hypothesis that treating PTG and PTD as two different concepts (Step 2) reflects the structure of the PTG/D-SF better than assuming a common latent trait for PTG and PTD. A unidimensional analysis of both the PTG and the PTD items together (Step 1) results in multidimensionality with the items loading distinctly on either the PTG or the PTD dimension. However, although the PTG and PTD dimension correlated at least moderately ($r > .6$), accounting for the correlation in a multidimensional Rasch approach (Step 3) resulted in poor reliability and a lower model fit as compared to the separate calibration of the two dimensions. This finding supports and expands previous research indicating that PTG and PTD should be understood as distinct constructs rather than two ends of a continuum. Together, these findings also support Baker et al. (2008), who created the PTGI-42 in such a way that individuals are enabled to independently report PTG and PTD in the same domains.

The finding that PTG and PTD are best conceptualized as separate dimensions is also consistent with the organismic valuing theory of PTG (Joseph & Linley, 2005, 2008a). This theory proposes that an individual can process trauma-related information in different ways with regards to the various facets of his or her self-structure and worldviews. Accordingly, it is possible that some of these facets are positively altered, whereas other facets are negatively altered or remain unchanged as a result of the coping process. Therefore, the presence of PTG in one of the domains should not necessarily be taken as an indication for the absence of PTD, or vice versa, because both can coexist at the same time in the same individual. Consequently, a comprehensive assessment of an individual's reactions to potential trauma in clinical research and practice requires that both PTG and PTD are considered separately (Linley & Joseph, 2004).

Overall, the results of the present study lend some support for the use of the PTG/D-SF to accomplish such a comprehensive assessment of reactions to potential trauma like SCI onset. The results of the separate PCMs for the PTG and the PTD dimension suggested that for both PTG and PTD the items or the domains can be summated to form a unidimensional scale. Aggregation into domains improved the score distribution and increased the scope of the instruments with a bigger range of threshold difficulties (Model 2b). The analysis of the PTG dimension by domains also improved the unidimensionality and solved the local dependency between the belief and religion items. Dimensionality of the PTD dimension was good in all analyses. The domain-based analysis of the PTD dimension presented good fit statistics unlike the item-based analysis where the people item was not fitting. The reliability of the item analysis may seem better but could be expected to be artificially inflated due to the local item dependencies (Baghaei, 2008). As such, our findings support previous work (e.g., Cann, Calhoun, Tedeschi, Taku et al., 2010; Linley et al., 2007) suggesting that the individual domains of PTG (and PTD) can be meaningfully aggregated into an overall total score for each.

The results of the DIF analyses revealed that the PTG/D-SF items or domains generally discriminated equally across different sample characteristics (i.e., across categories of injury completeness and level, sex, age, and language of the questionnaire). This suggests that the measure does not systematically favor specific subgroups. The only exception was that the PTG difficulty item showed uniform language DIF (French against German) in one of the tested models. It is possible, that this result could be caused by a little variation in the formulation of the item.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Nonetheless, several issues need to be mentioned. First, while the reliability (as indicated by the PSR) of the sum score for PTG was good, the one for PTD was only admissible. The skewness of the person ability distributions with a high frequency of participants reporting that they did not perceive any change in most of the PTD items can be one reason for the low reliability. The presence of such skewed distributions may result in inflated error variance due to the high number of extreme scores that then affects the computation of the PSR more than the Cronbach's alpha, which remains more constant (Andrich, Salatino, Converti, & Saruggia, 2015). In addition, it has been argued that the PTD scale may perform worse than the PTG scale because the items were created in the original PTGI-42 by simply mirroring the PTG-items linguistically but not based on individual narratives, literature reviews, or clinical expertise (Oshiro et al., 2019). These potential shortcomings in the creation of the PTD items may also serve as an explanation for why high PTD scores were seldom observed in the current study and also in previous work with other populations (e.g., Baker et al., 2008; Barrington & Shakespeare-Finch, 2013; Kroemeke, Bargiel-Matusiewicz, & Kalamarz, 2017; Michélsen, Therup-Svedenlöf, Backheden, & Schulman, 2017).

A second notable issue was that, with regard to both the PTG and the PTD scale, some local item dependencies were detected. In particular, the items referring to religious and spiritual changes were locally dependent in both scales. This suggests that these items measure something specific that cannot be explained by the common latent PTG or PTD trait. These results lend empirical support to a theoretical critique that positive changes in religion and spirituality should not be conceptualized as part of the PTG construct (Joseph, 2011). More specifically, Joseph (2011) recommended to exclude changes in spirituality and religion from the PTG concept because their inclusion leads to a confusion over the direction of change that is experienced as growthful; for some individuals increases in religion and spirituality may be considered as PTG, whereas others consider decreases in religion as PTG. Supporting this notion and corroborating our results, a recent study examining Japanese students demonstrated that in contrast to all other PTG items, which were judged as positive by the vast majority, a substantial proportion (31%) of the individuals judged the item "I have a stronger religious belief" as representing a negative change. Similarly, 35% judged the item "I have a weaker religious faith" as a positive change. In sum, it may indeed be advisable to exclude religious and spiritual changes from the PTG and PTD constructs. In doing so, it may be particularly interesting to consider a recent updated version of the PTGI (Tedeschi, Cann, Taku, Senol-Durak, & Calhoun, 2017), in which the original Spiritual change domain was enriched by adding four items that refer to existential changes (e.g., "I have greater clarity about life's meaning") rather than tapping spiritual change in a more traditional, religious sense such as the original two PTGI items do. Accordingly, these four new items may perform better in secular cultures like the one in Switzerland. However, further research in different cultures is needed to strengthen such a claim.

Limitations

This study is subject to several limitations. It is based on PTG/D-SF ratings from 278 persons with SCI. Though good enough to conduct Rasch analysis, it may have led to very unequal group distributions when examining DIF (e.g., lesion type, language groups), with findings that are potentially not robust at some group levels. Second, our focus was on an SCI sample, and the generalizability to other populations experiencing different critical life events will require further investigation. However, this study was the first adopting a modern test theory approach with Rasch analysis when examining the metric criteria of a PTGI-related measure. Therefore, a more in depth understanding of the "behavior" of the PTG/D-SF items can be expected as well as strengths and weaknesses in the use of the PTG/D-SF can be anticipated. Third, convergent and divergent validity (e.g., associations with indicators of mental health or well-being) were not investigated, since this was part of a previous study at our institution (Kunz et al., 2017).

Conclusion

This is the first study examining the metric quality of the PTG/D-SF measure using a modern test theory approach. The study complements investigations that have so far relied upon a CTT approach when investigating the properties of the different versions of the PTGI. Overall, findings support the use of a PTG total score and to some degree the PTD total score. Hence, more research may be needed to improve the PTD scale. To do so, future work could adapt the PTD items by considering individual narratives and reviewing the literature. Also, the inclusion of the belief and religion items into both the PTG and the PTD scales may need to be reconsidered.

References

Adams, R. J., Wilson, M., & Wang, W. (1997). The multidimensional random coefficients multinomial logit model. *Applied Psychological Measurement, 21,* 1–23. http://dx.doi.org/10.1177/0146621697211001

Andrich, D. (1988). *Rasch models for measurement*. Newbury Park, CA: Sage. http://dx.doi.org/10.4135/9781412985598

Andrich, D. (2006). Item discrimination and Rasch-Andrich thresholds revisited. *Rasch Measurement Transactions, 20,* 1055–1057.

Andrich, D., & Hagquist, C. (2015). Real and artificial differential item functioning in polytomous items. *Educational and Psychological Measurement, 75,* 185–207. http://dx.doi.org/10.1177/0013164414534258

Andrich, R., Salatino, C., Converti, R. M., & Saruggia, M. (2015). Cost-effectiveness of powered wheelchairs: Findings of a study. *Studies in Health Technology and Informatics, 217,* 84–91.

Baghaei, P. (2008). Local dependency and Rasch measures. *Rasch Measurement Transactions, 21,* 1105–1106.

Baker, J. M., Kelly, C., Calhoun, L. G., Cann, A., & Tedeschi, R. G. (2008). An examination of posttraumatic growth and posttraumatic depreciation: Two exploratory studies. *Journal of Loss and Trauma, 13,* 450–465. http://dx.doi.org/10.1080/15325020802171367

Barrington, A., & Shakespeare-Finch, J. (2013). Posttraumatic growth and posttraumatic depreciation as predictors of psychological adjustment. *Journal of Loss and Trauma, 18,* 429–443. http://dx.doi.org/10.1080/15325024.2012.714210

Barskova, T., & Oesterreich, R. (2009). Posttraumatic growth in people living with a serious medical condition and its relations to physical and mental health: A systematic review. *Disability and Rehabilitation, 31,* 1709–1733. http://dx.doi.org/10.1080/09638280902738441

Cann, A., Calhoun, L. G., Tedeschi, R. G., & Solomon, D. T. (2010). Posttraumatic growth and depreciation as independent experiences and predictors of well-being. *Journal of Loss and Trauma, 15,* 151–166. http://dx.doi.org/10.1080/15325020903375826

Cann, A., Calhoun, L. G., Tedeschi, R. G., Taku, K., Vishnevsky, T., Triplett, K. N., & Danhauer, S. C. (2010). A short form of the Posttraumatic Growth Inventory. *Anxiety, Stress, & Coping, 23,* 127–137. http://dx.doi.org/10.1080/10615800903094273

Craig, A., Tran, Y., & Middleton, J. (2009). Psychological morbidity and spinal cord injury: A systematic review. *Spinal Cord, 47,* 108–114. http://dx.doi.org/10.1038/sc.2008.115

Embretson, S. E., & Reise, S. P. (2000). *Item response theory for psychologists*. Mahwah, NJ: Erlbaum.

Frazier, P., Conlon, A., & Glaser, T. (2001). Positive and negative life changes following sexual assault. *Journal of Consulting and Clinical Psychology, 69,* 1048–1055. http://dx.doi.org/10.1037/0022-006X.69.6.1048

Hagquist, C., Bruce, M., & Gustavsson, J. P. (2009). Using the Rasch model in nursing research: An introduction and illustrative example. *International Journal of Nursing Studies, 46,* 380–393. http://dx.doi.org/10.1016/j.ijnurstu.2008.10.007

Hardouin, J. B., Conroy, R., & Sébille, V. (2011). Imputation by the mean score should be avoided when validating a Patient Reported Outcomes questionnaire by a Rasch model in presence of informative missing data. *BMC Medical Research Methodology, 11,* 105. http://dx.doi.org/10.1186/1471-2288-11-105

Holland, P. W., & Wainger, H. (1993). *Differential item functioning*. Hillsdale, NJ: Erlbaum.

Joseph, S. (2011). Religiosity and posttraumatic growth: A note concerning the problems of confounding in their measurement and the inclusion of religiosity within the definition of posttraumatic growth. *Mental Health, Religion & Culture, 14,* 843–845. http://dx.doi.org/10.1080/13674676.2011.609162

Joseph, S., & Linley, P. A. (2005). Positive adjustment to threatening events: An organismic valuing theory of growth through adversity. *Review of General Psychology, 9,* 262–280. http://dx.doi.org/10.1037/1089-2680.9.3.262

Joseph, S., & Linley, P. A. (2008a). Positive psychological perspectives on posttraumatic stress: An integrative psychosocial framework. In S. Joseph & P. A. Linley (Eds.), *Trauma, recovery, and growth: Positive psychological perspectives on posttraumatic stress* (pp. 3–20). Hoboken, NJ: Wiley. http://dx.doi.org/10.1002/9781118269718.ch1

Joseph, S., & Linley, P. A. (2008b). Psychological assessment of growth following adversity: A review. In S. Joseph & P. A. Linley (Eds.), *Trauma, recovery, and growth: Positive psychological perspectives on posttraumatic stress* (pp. 21–36). Hoboken, NJ: Wiley. http://dx.doi.org/10.1002/9781118269718.ch2

Kaler, M. E., Erbes, C. R., Tedeschi, R. G., Arbisi, P. A., & Polusny, M. A. (2011). Factor structure and concurrent validity of the Posttraumatic Growth Inventory–Short Form among veterans from the Iraq War. *Journal of Traumatic Stress, 24,* 200–207. http://dx.doi.org/10.1002/jts.20623

Kirshblum, S., Campagnolo, D. I., & DeLisa, J. A. (2002). *Spinal cord medicine*. Philadelphia, PA: Lippincott Williams & Wilkins.

Kroemeke, A., Bargiel-Matusiewicz, K., & Kalamarz, M. (2017). Mixed psychological changes following mastectomy: Unique predictors and heterogeneity of posttraumatic growth and posttraumatic depreciation. *Frontiers in Psychology, 8,* 1245. http://dx.doi.org/10.3389/fpsyg.2017.01245

Kunz, S., Joseph, S., Geyh, S., & Peter, C. (2017). Posttraumatic growth and adjustment to spinal cord injury: Moderated by posttraumatic depreciation? *Psychological Trauma: Theory, Research, Practice and Policy, 9,* 434–444. http://dx.doi.org/10.1037/tra0000164

Lelorain, S., Bonnaud-Antignac, A., & Florin, A. (2010). Long term posttraumatic growth after breast cancer: Prevalence, predictors and relationships with psychological health. *Journal of Clinical Psychology in Medical Settings, 17,* 14–22. http://dx.doi.org/10.1007/s10880-009-9183-6

Lin, V. W. (2003). *Spinal cord medicine: Principles and practice*. New York, NY: Demos.

Linacre, J. M., & Tennant, A. (2009). More about critical eigenvalue sizes (variances) in standardized residual principal components analysis (PCA). *Rasch Measurement Transactions, 23,* 1228.

Linley, P. A., Andrews, L., & Joseph, S. (2007). Confirmatory factor analysis of the Posttraumatic Growth Inventory. *Journal of Loss and Trauma, 12,* 321–332. http://dx.doi.org/10.1080/15325020601162823

Linley, P. A., & Joseph, S. (2004). Positive change following trauma and adversity: A review. *Journal of Traumatic Stress, 17,* 11–21. http://dx.doi.org/10.1023/B:JOTS.0000014671.27856.7e

Maercker, A., & Langner, R. (2001). Persönliche reifung (personal growth) durch belastungen und traumata: Validierung zweier deutschsprachiger fragebogenversionen. [Posttraumatic personal growth: Validation of German versions of two questionnaires]. *Diagnostica, 47,* 153–162. http://dx.doi.org/10.1026//0012-1924.47.3.153

Mair, P., & Hatzinger, R. (2007). Extended Rasch modeling: The eRm package for the application of IRT models in R. *Journal of Statistical Software, 20,* 1–20. http://dx.doi.org/10.18637/jss.v020.i09

Marais, I., & Andrich, D. (2008). Formalizing dimension and response violations of local independence in the unidimensional Rasch model. *Journal of Applied Measurement, 9,* 200–215.

Masters, G. N. (1982). A Rasch model for partial credit scoring. *Psychometrika, 47,* 149–174. http://dx.doi.org/10.1007/BF02296272

McHorney, C. A., & Tarlov, A. R. (1995). Individual-patient monitoring in clinical practice: Are available health status surveys adequate? *Quality of Life Research, 4,* 293–307. http://dx.doi.org/10.1007/BF01593882

McMillen, J. C., & Cook, C. L. (2003). The positive by-products of spinal cord injury and their correlates. *Rehabilitation Psychology, 48,* 77–85. http://dx.doi.org/10.1037/0090-5550.48.2.77

Michélsen, H., Therup-Svedenlöf, C., Backheden, M., & Schulman, A. (2017). Posttraumatic growth and depreciation six years after the 2004 tsunami. *European Journal of Psychotraumatology, 8,* Article 1302691. http://dx.doi.org/10.1080/20008198.2017.1302691

Oshiro, R., Kopitz, J., Soejima, T., Kibi, S., Kamibeppu, K., Sakamoto, S., & Taku, K. (2019). Perceptions of positive and negative changes for posttraumatic growth and depreciation: Judgments from Japanese undergraduates. *Personality and Individual Differences, 137,* 17–21. http://dx.doi.org/10.1016/j.paid.2018.07.040

Petrillo, J., Cano, S. J., McLeod, L. D., & Coon, C. D. (2015). Using classical test theory, item response theory, and Rasch measurement theory to evaluate patient-reported outcome measures: A comparison of worked examples. *Value in Health, 18,* 25–34. http://dx.doi.org/10.1016/j.jval.2014.10.005

Post, M. W., Brinkhof, M. W., von Elm, E., Boldt, C., Brach, M., Fekete, C., . . . Stucki, G. (2011). Design of the Swiss Spinal Cord Injury Cohort Study. *American Journal of Physical Medicine and Rehabilitation, 90,* S5–S16. http://dx.doi.org/10.1097/PHM.0b013e318230fd41

Post, M. W., & van Leeuwen, C. M. (2012). Psychosocial issues in spinal cord injury: A review. *Spinal Cord, 50,* 382–389. http://dx.doi.org/10.1038/sc.2011.182

Prati, G., & Pietrantoni, L. (2014). Italian adaptation and confirmatory factor analysis of the full and the short form of the Posttraumatic Growth Inventory. *Journal of Loss and Trauma, 19,* 12–22. http://dx.doi.org/10.1080/15325024.2012.734203

Purc-Stephenson, R. J. (2014). The Posttraumatic Growth Inventory: Factor structure and invariance among persons with chronic diseases. *Rehabilitation Psychology, 59,* 10–18. http://dx.doi.org/10.1037/a0035353

Raîche, G. (2005). Critical eigenvalue sizes (variances) in standardized residual principal components analysis. *Rasch Measurement Transactions, 19,* 1012.

Rasch, G. (1960). *Probabilistic models for some intelligence and attainment tests*. Copenhagen, Denmark: Danish Institute for Educational Research.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

R Core Team. (2018). R: A language and environment for statistical computing (Version 3.5.0) [Computer software]. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from http://www.R-project.org/

Robitzsch, A., Kiefer, T., & Wu, M. (2018). TAM: Test analysis modules (Version 2.13–15) [Computer software]. Retrieved from https://CRAN.R-project.org/package=TAM

Saltzman, L. Y., Easton, S. D., & Salas-Wright, C. P. (2015). A validation study of the Posttraumatic Growth Inventory among survivors of clergy-perpetrated child sexual abuse. *Journal of the Society for Social Work and Research, 6,* 305–315. http://dx.doi.org/10.1086/682728

Sideridis, G. D. (2011). The effects of local item dependence on estimates of ability in the Rasch model. *Rasch Measurement Transactions, 25,* 1334–1336.

Smith, E. V., Jr. (2002). Detecting and evaluating the impact of multidimensionality using item fit statistics and principal component analysis of residuals. *Journal of Applied Measurement, 3,* 205–231.

Solomon, Z., Waysman, M. A., Neria, Y., Ohry, A., Schwarzwald, J., & Wiener, M. (1999). Positive and negative changes in the lives of Israeli former prisoners of war. *Journal of Social and Clinical Psychology, 18,* 419–435. http://dx.doi.org/10.1521/jscp.1999.18.4.419

Taku, K., Cann, A., Calhoun, L. G., & Tedeschi, R. G. (2008). The factor structure of the Posttraumatic Growth Inventory: A comparison of five models using confirmatory factor analysis. *Journal of Traumatic Stress, 21,* 158–164. http://dx.doi.org/10.1002/jts.20305

Tedeschi, R. G., & Calhoun, L. G. (1996). The Posttraumatic Growth Inventory: Measuring the positive legacy of trauma. *Journal of Traumatic Stress, 9,* 455–471. http://dx.doi.org/10.1002/jts.2490090305

Tedeschi, R. G., & Calhoun, L. G. (2004). Posttraumatic growth: Conceptual foundations and empirical evidence. *Psychological Inquiry, 15,* 1–18. http://dx.doi.org/10.1207/s15327965pli1501_01

Tedeschi, R. G., Cann, A., Taku, K., Senol-Durak, E., & Calhoun, L. G. (2017). The Posttraumatic Growth Inventory: A revision integrating existential and spiritual change. *Journal of Traumatic Stress, 30,* 11–18. http://dx.doi.org/10.1002/jts.22155

Tennant, A., & Conaghan, P. G. (2007). The Rasch measurement model in rheumatology: What is it and why use it? When should it be applied, and what should one look for in a Rasch paper? *Arthritis and Rheumatism, 57,* 1358–1362. http://dx.doi.org/10.1002/art.23108

Tesio, L. (2003). Measuring behaviours and perceptions: Rasch analysis as a tool for rehabilitation research. *Journal of Rehabilitation Medicine, 35,* 105–115. http://dx.doi.org/10.1080/16501970310010448

Updegraff, J. A., Taylor, S. E., Kemeny, M. E., & Wyatt, G. E. (2002). Positive and negative effects of HIV infection in women with low socioeconomic resources. *Personality and Social Psychology Bulletin, 28,* 382–394. http://dx.doi.org/10.1177/0146167202286009

von Elm, E., Altman, D. G., Egger, M., Pocock, S. J., Gøtzsche, P. C., & Vandenbroucke, J. P. (2007). The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: Guidelines for reporting observational studies. *The Lancet, 370,* 1453–1457. http://dx.doi.org/10.1016/S0140-6736(07)61602-X

World Health Organization. (2013). *International perspectives on spinal cord injury*. Geneva, Switzerland: WHO Press.

Wortman, C. B. (2004). Posttraumatic growth: Progress and problems. *Psychological Inquiry, 15,* 81–90.

Wright, B. D., & Linacre, J. M. (1989). Observations are always ordinal; measurements, however, must be interval. *Archives of Physical Medicine and Rehabilitation, 70,* 857–860.

Wright, B. D., & Linacre, J. M. (1994). Reasonable mean-square fit values. *Rasch Measurement Transactions, 8,* 370–371.

Wright, B. D., & Stone, M. H. (1979). *Best test design*. Chicago, IL: Mesa Press.

Yen, W. M. (1993). Scaling performance assessments: Strategies for managing local item dependence. *Journal of Educational Measurement, 30,* 187–213. http://dx.doi.org/10.1111/j.1745-3984.1993.tb00423.x

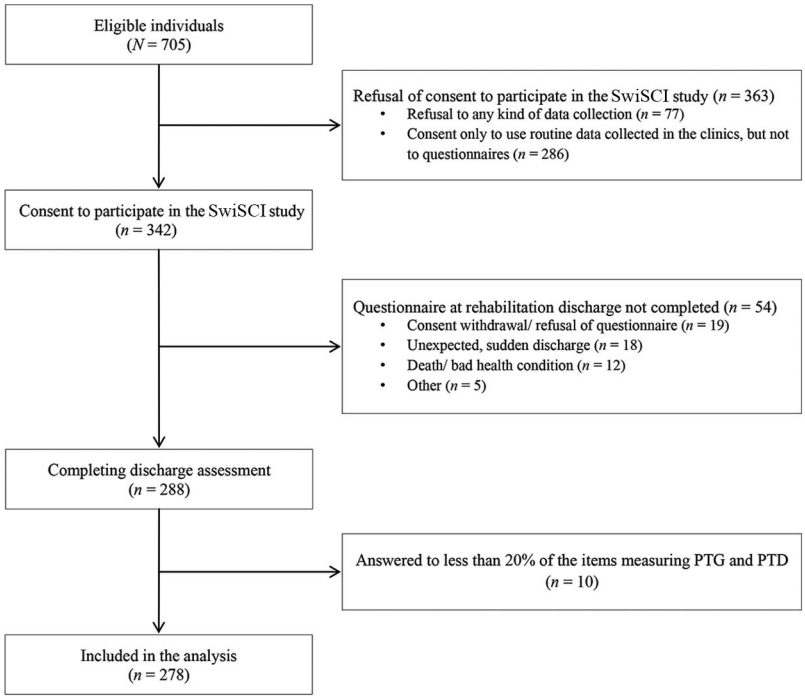
Zoellner, T., & Maercker, A. (2006). Posttraumatic growth in clinical psychology—A critical review and introduction of a two component model. *Clinical Psychology Review, 26,* 626–653. http://dx.doi.org/10.1016/j.cpr.2006.01.008

(*Appendices follow*)

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Appendix A

Participation in the Study



(*Appendices continue*)

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Appendix B

Frequencies and Percentages of Responses Regarding All PTG/D-SF Items

Response options	Overall *n* (%) PTG 342	Overall *n* (%) PTD 342
Priority:	I changed my priorities about what is important in life	I find it difficult to clarify priorities about what is important in life
0 = I did not perceive this change as a result of my SCI	37 (10.8)	117 (34.2)
1 = I perceived this change to a very small extent as a result of my SCI	25 (7.3)	52 (15.2)
2 = I perceived this change to a small extent as a result of my SCI	36 (10.5)	27 (7.9)
3 = I perceived this change to a certain extent as a result of my SCI	61 (17.8)	40 (11.7)
4 = I perceived this change to a high extent as a result of my SCI	78 (22.8)	25 (7.3)
5 = I perceived this change to a very high extent as a result of my SCI	39 (11.4)	9 (2.6)
Missing values	66 (19.3)	72 (21.1)
Esteem:	I have a greater appreciation for the value of my own life	I have less of an appreciation for the value of my own life
0 = I did not perceive this change as a result of my SCI	68 (19.9)	154 (45.0)
1 = I perceived this change to a very small extent as a result of my SCI	20 (5.8)	32 (9.4)
2 = I perceived this change to a small extent as a result of my SCI	31 (9.1)	21 (6.1)
3 = I perceived this change to a certain extent as a result of my SCI	55 (16.1)	33 (9.6)
4 = I perceived this change to a high extent as a result of my SCI	56 (16.4)	19 (5.6)
5 = I perceived this change to a very high extent as a result of my SCI	38 (11.1)	9 (2.6)
Missing values	74 (21.6)	74 (21.6)
Religion:	I have a better understanding of spiritual matters	I have a poorer understanding of spiritual matters
0 = I did not perceive this change as a result of my SCI	174 (50.9)	201 (58.8)
1 = I perceived this change to a very small extent as a result of my SCI	25 (7.3)	24 (7.0)
2 = I perceived this change to a small extent as a result of my SCI	20 (5.8)	12 (3.5)
3 = I perceived this change to a certain extent as a result of my SCI	27 (7.9)	13 (3.8)
4 = I perceived this change to a high extent as a result of my SCI	19 (5.6)	10 (2.9)
5 = I perceived this change to a very high extent as a result of my SCI	9 (2.6)	9 (2.6)
Missing values	68 (19.9)	73 (21.3)
Way:	I established a new path for my life	I have a less clear path for my life
0 = I did not perceive this change as a result of my SCI	90 (26.3)	148 (43.3)
1 = I perceived this change to a very small extent as a result of my SCI	39 (11.4)	42 (12.3)
2 = I perceived this change to a small extent as a result of my SCI	29 (8.5)	18 (5.3)
3 = I perceived this change to a certain extent as a result of my SCI	47 (13.7)	22 (6.4)
4 = I perceived this change to a high extent as a result of my SCI	39 (11.4)	20 (5.8)
5 = I perceived this change to a very high extent as a result of my SCI	21 (6.1)	12 (3.5)
Missing values	77 (22.5)	80 (23.4)
Distance:	I have a greater sense of closeness with others	I have a greater sense of distance from others
0 = I did not perceive this change as a result of my SCI	105 (30.7)	148 (43.3)
1 = I perceived this change to a very small extent as a result of my SCI	26 (7.6)	32 (9.4)
2 = I perceived this change to a small extent as a result of my SCI	31 (9.1)	26 (7.6)
3 = I perceived this change to a certain extent as a result of my SCI	40 (11.7)	31 (9.1)
4 = I perceived this change to a high extent as a result of my SCI	44 (12.9)	20 (5.8)
5 = I perceived this change to a very high extent as a result of my SCI	19 (5.6)	7 (2.0)
Missing values	77 (22.5)	78 (22.8)
Difficulty:	I know better that I can handle difficulties	I am less certain that I can handle difficulties
0 = I did not perceive this change as a result of my SCI	99 (28.9)	139 (40.6)
1 = I perceived this change to a very small extent as a result of my SCI	36 (10.5)	35 (10.2)
2 = I perceived this change to a small extent as a result of my SCI	28 (8.2)	33 (9.6)

(*Appendices continue*)

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Appendix B (*continued*)

Response options	Overall *n* (%) PTG 342	Overall *n* (%) PTD 342
3 = I perceived this change to a certain extent as a result of my SCI	37 (10.8)	29 (8.5)
4 = I perceived this change to a high extent as a result of my SCI	48 (14.0)	17 (5.0)
5 = I perceived this change to a very high extent as a result of my SCI	19 (5.6)	6 (1.8)
Missing values	75 (21.9)	83 (24.3)
Life:	I am able to do better things with my life	I am less capable of doing better things with my life
0 = I did not perceive this change as a result of my SCI	93 (27.2)	154 (45.0)
1 = I perceived this change to a very small extent as a result of my SCI	35 (10.2)	32 (9.4)
2 = I perceived this change to a small extent as a result of my SCI	33 (9.6)	24 (7.0)
3 = I perceived this change to a certain extent as a result of my SCI	34 (9.9)	28 (8.2)
4 = I perceived this change to a high extent as a result of my SCI	44 (12.9)	17 (5.0)
5 = I perceived this change to a very high extent as a result of my SCI	20 (5.8)	8 (2.3)
Missing values	83 (24.3)	79 (23.1)
Belief:	I have a stronger religious faith	I have a weaker religious faith
0 = I did not perceive this change as a result of my SCI	184 (53.8)	203 (59.4)
1 = I perceived this change to a very small extent as a result of my SCI	12 (3.5)	21 (6.1)
2 = I perceived this change to a small extent as a result of my SCI	25 (7.3)	13 (3.8)
3 = I perceived this change to a certain extent as a result of my SCI	15 (4.4)	9 (2.6)
4 = I perceived this change to a high extent as a result of my SCI	18 (5.3)	6 (1.8)
5 = I perceived this change to a very high extent as a result of my SCI	8 (2.3)	9 (2.6)
Missing values	80 (23.4)	81 (23.7)
Strong:	I discovered that I'm stronger than I thought I was	I discovered that I'm weaker than I thought I was
0 = I did not perceive this change as a result of my SCI	75 (21.9)	175 (51.2)
1 = I perceived this change to a very small extent as a result of my SCI	18 (5.3)	34 (9.9)
2 = I perceived this change to a small extent as a result of my SCI	31 (9.1)	16 (4.7)
3 = I perceived this change to a certain extent as a result of my SCI	53 (15.5)	20 (5.8)
4 = I perceived this change to a high extent as a result of my SCI	50 (14.6)	5 (1.5)
5 = I perceived this change to a very high extent as a result of my SCI	37 (10.8)	5 (1.5)
Missing values	78 (22.8)	87 (25.4)
People:	I learned a great deal about how wonderful people are	I learned a great deal about how disappointing people are
0 = I did not perceive this change as a result of my SCI	55 (16.1)	143 (41.8)
1 = I perceived this change to a very small extent as a result of my SCI	24 (7.0)	37 (10.8)
2 = I perceived this change to a small extent as a result of my SCI	22 (6.4)	17 (5.0)
3 = I perceived this change to a certain extent as a result of my SCI	49 (14.3)	27 (7.9)
4 = I perceived this change to a high extent as a result of my SCI	55 (16.1)	15 (4.4)
5 = I perceived this change to a very high extent as a result of my SCI	61 (17.8)	23 (6.7)
Missing values	76 (22.2)	80 (23.4)

Note. PTG = posttraumatic growth; PTD = posttraumatic depreciation; SCI = spinal cord injury.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

(*Appendices continue*)

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Appendix C

Rasch Analysis Item Fit Statistics

Analysis step	Conceptualization	Dimension	Item	Infit	Location	Difficulty rank	Threshold ordering	Disordered	Eigenvalue	Cumulative eigenvalue in %	PC1 loading	LID
Step 1: Model 1a	All items	PTG	priority	1.07	−.69	1	3 → 1 → 2 → 4 → 5	X	3.26	16.32	.10	
			esteem	***1.24***	−.48	3	5 → 1 → 2 → 3 → 4	X	1.40	38.98	.31	
			religion	.80	.27	9	5 → 2 → 1 → 3 → 4	X	1.21	45.05	.04	belief (PTG)
			way	***.89***	−.20	5	4 → 2 → 1 → 3 → 5	X	1.07	56.12	.22	
			distance	1.02	−.13	8	4 → 1 → 2 → 3 → 5	X	.91	70.36	.17	
			difficulty	.95	−.15	7	4 → 3 → 1 → 2 → 5	X	.78	78.59	.23	
			life	.88	−.19	6	4 → 2 → 3 → 1 → 5	X	.75	82.35	.27	
			belief	.82	.30	10	5 → 1 → 3 → 2 → 4	X	.59	91.90	.02	religion (PTG)
			strong	.98	−.43	4	5 → 1 → 2 → 3 → 4	X	.57	94.75	.30	
			people	1.19	−.68	2	5 → 2 → 1 → 3 → 4	X	.03	100.00	.19	
		PTD	priority	.98	.11	2	2 → 3 → 1 → 4 → 5	X	1.70	24.81	−.30	esteem (PTD); way (PTD)
			esteem	.97	.22	4	5 → 2 → 1 → 3 → 4	X	1.44	31.99	−.30	priority (PTD)
			religion	.79	.32	8	5 → 4 → 1 → 2 → 3	X	1.14	50.77	.02	
			way	.95	.15	3	5 → 3 → 1 → 2 → 4	X	1.00	61.12	−.30	priority (PTD); life (PTD)
			distance	.91	.26	6	4 → 2 → 1 → 3 → 5	X	.94	65.82	−.19	
			difficulty	.91	.28	7	4 → 1 → 2 → 3 → 5	X	.87	74.71	−.30	life (PTD)
			life	1.05	.25	5	5 → 2 → 1 → 3 → 4	X	.68	85.75	−.34	way (PTD); difficulty (PTD)
			belief	.70	.33	9	5 → 2 → 3 → 4 → 1	X	.64	88.96	−.02	
			strong	.91	.44	10	4 → 3 → 1 → 5 → 2	X	.52	97.37	−.25	
			people	1.04	−.01	1	5 → 3 → 1 → 4 → 2	X	.49	99.84	−.05	
Step 1: Model 1b	All domains	PTG	Relating to others	.94	−.20	2	*not applicable*		2.53	25.31	−.27	
			New possibilities in life	.84	−.10	4			1.24	37.70	−.36	
			Personal strength	.91	−.16	3			1.15	49.25	−.40	
			Spiritual change	.84	.28	5			1.09	60.14	.01	
			Appreciation of life	1.07	−.41	1			.92	69.36	−.33	
		PTD	Relating to others	.89	.22	3	*not applicable*		.91	78.43	.22	
			New possibilities in life	1.00	.20	2			.84	86.87	.40	strength (PTD)
			Personal strength	.82	.26	4			.64	93.29	.41	possibilities (PTD)
			Spiritual change	.74	.30	5			.62	99.50	.02	
			Appreciation of life	1.02	.12	1			.05	100.00	.39	

(*Appendices continue*)

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Appendix C (*continued*)

Analysis step	Conceptualization	Item	Infit	Location	Difficulty rank	Threshold ordering	Disordered	Eigenvalue	Cumulative eigenvalue in %	PC1 loading	LID
Step 2: Model 2a	PTG	priority	1.07	−.43	1	3 → 1 → 2 → 4 → 5	X	1.84	18.43	−.21	
		esteem	1.03	−.21	3	4 → 1 → 2 → 3 → 5	X	1.32	31.64	−.21	
		religion	.98	.61	9	5 → 2 → 1 → 3 → 4	X	1.26	44.26	.61	belief
		way	.79	.09	5	3 → 2 → 1 → 4 → 5	X	1.23	56.51	−.17	
		distance	.97	.17	8	4 → 1 → 2 → 3 → 5	X	1.10	67.48	.05	
		difficulty	.89	.14	7	4 → 3 → 1 → 2 → 5	X	.96	77.08	−.19	
		life	.76	.11	6	4 → 1 → 3 → 2 → 5	X	.88	85.92	−.21	
		belief	1.00	.67	10	5 → 1 → 3 → 2 → 4	X	.83	94.23	.61	religion
		strong	.80	−.16	4	5 → 1 → 2 → 3 → 4	X	.55	99.73	−.22	
		people	1.13	−.42	2	5 → 2 → 1 → 3 → 4	X	.03	100.00	−.08	
Step 2: Model 2a	PTG recoded items	priority	1.05	−.51	2	1 → 2		1.67	16.75	−.07	
		esteem	.99	−.18	3	1 → 2		1.34	30.11	−.16	
		religion	1.04	1.62	9	1 → 2		1.28	42.87	.64	belief
		way	.82	.61	5	1 → 2		1.22	55.06	−.09	
		distance	.87	.69	7	1 → 2		1.13	66.38	−.02	
		difficulty	.89	.70	8	1 → 2		1.03	76.71	−.20	
		life	.80	.63	6	1 → 2		.89	85.58	−.10	
		belief	1.06	1.70	10	1 → 2		.83	93.91	.61	religion
		strong	.74	−.09	4	1 → 2		.61	100.05	−.30	
		people	1.10	−.60	1	1 → 2		−.01	100.00	−.21	
Step 2: Model 2b	PTG domain analysis	Relating to others	.85	.02	2	*not applicable*		1.39	27.87	−.49	
		New possibilities in life	.65	.14	4			1.32	54.26	.45	
		Personal strength	.72	.06	3			1.19	78.04	.15	
		Spiritual change	1.13	.57	5			1.03	98.74	−.53	
		Appreciation of life	.91	−.21	1			.06	100.00	.50	
Step 2: Model 2a	PTD	priority	.90	−.14	2	2 → 3 → 1 → 4 → 5	X	1.77	17.66	−.29	
		esteem	.80	.00	4	4 → 2 → 1 → 3 → 5	X	1.38	31.50	−.15	
		religion	1.07	.17	8	5 → 4 → 1 → 3 → >2	X	1.35	44.98	.39	belief
		way	.84	−.07	3	3 → 4 → 1 → 2 → 5	X	1.12	56.17	−.32	
		distance	.94	.04	6	4 → 2 → 1 → 3 → 5	X	1.01	66.32	.31	
		difficulty	.84	.04	7	3 → 1 → 2 → 4 → 5	X	.96	75.93	−.31	
		life	.88	.03	5	4 → 2 → 1 → 3 → 5	X	.92	85.09	−.41	
		belief	.94	.17	9	5 → 2 → 3 → 4 → 1	X	.82	93.32	.36	religion
		strong	.87	.26	10	4 → 3 → 1 → 5 → 2	X	.68	100.11	−.03	
		people	***1.33***	−.25	1	4 → 3 → 1 → 5 → 2	X	−.01	100.00	.38	
Step 2: Model 2a	PTD recoded items	priority	.88	.13	2	1 → 2		1.69	16.88	−.26	
		esteem	.77	.30	4	1 → 2		1.47	31.59	−.08	
		religion	1.00	.62	9	1 → 2		1.38	45.41	.35	belief
		way	.85	.17	3	1 → 2		1.16	57.02	−.36	
		distance	.97	.36	6	1 → 2		1.01	67.09	.33	
		difficulty	.88	.36	7	1 → 2		.99	76.97	−.32	
		life	.95	.33	5	1 → 2		.89	85.84	−.44	
		belief	.85	.58	8	1 → 2		.73	93.19	.32	religion
		strong	.92	.82	10	1 → 2		.70	100.17	−.07	
		people	***1.31***	−.29	1	1 → 2		−.02	100.00	.41	
Step 2: Model 2b	PTD domain analysis	Relating to others	.98	.06	3	*not applicable*		1.54	30.88	−.61	
		New possibilities in life	.75	.05	2			1.29	56.65	.48	
		Personal strength	.69	.12	4			1.20	80.73	.38	
		Spiritual change	1.09	.20	5			.95	99.72	−.40	
		Appreciation of life	.77	−.05	1			.01	100.00	.29	

(*Appendices continue*)

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Appendix C (*continued*)

Analysis step	Conceptualization	Dimension	Item	Infit	Location	Difficulty rank	Threshold ordering	Disordered
Step 3: Model 3a	2-Dimensional	PTG	priority	1.13	−.26	1	3 → 4 → 1 → 2 → 5	X
			esteem	1.13	−.12	2	3 → 5 → 1 → 2 → 4	X
			religion	1.04	.07	9	5 → 4 → 2 → 1 → 3	X
			way	.92	−.07	8	5 → 3 → 2 → 1 → 4	X
			distance	1.06	−.09	7	4 → 5 → 1 → 2 → 3	X
			difficulty	1.00	−.11	3	5 → 4 → 3 → 1 → 2	X
			life	.86	−.10	4	5 → 4 → 1 → 3 → 2	X
			belief	1.07	.08	10	4 → 5 → 1 → 3 → 2	X
			strong	.93	−.09	6	4 → 5 → 1 → 2 → 3	X
			people	1.19	−.09	5	2 → 5 → 3 → 1 → 4	X
		PTD	priority	.98	−.04	1	5 → 2 → 3 → 1 → 4	X
			esteem	.91	.05	4	5 → 4 → 2 → 1 → 3	X
			religion	1.16	.23	8	5 → 4 → 2 → 1 → 3	X
			way	.97	.08	6	5 → 4 → 3 → 1 → 2	X
			distance	1.00	.00	2	5 → 4 → 2 → 1 → 3	X
			difficulty	.94	.01	3	5 → 3 → 1 → 2 → 4	X
			life	.99	.06	5	5 → 4 → 2 → 1 → 3	X
			belief	1.07	.34	10	5 → 4 → 1 → 2 → 3	X
			strong	.99	.28	9	5 → 3 → 2 → 1 → 4	X
			people	***1.32***	.20	7	5 → 3 → 2 → 1 → 4	X
Step 3: Model 3a	2-Dimensional recoded items	PTG	priority	1.10	−.09	1	1 → 2	
			esteem	1.13	.24	2	1 → 2	
			religion	.92	1.17	10	1 → 2	
			way	.94	.59	7	1 → 2	
			distance	1.01	.58	6	1 → 2	
			difficulty	1.00	.65	8	1 → 2	
			life	.92	.53	5	1 → 2	
			belief	.89	1.07	9	2 → 1	X
			strong	.91	.29	3	1 → 2	
			people	1.12	.32	4	1 → 2	
		PTD	priority	.99	.87	2	1 → 2	
			esteem	.94	1.09	5	1 → 2	
			religion	1.06	1.57	10	2 → 1	X
			way	.98	1.20	7	1 → 2	
			distance	.99	.96	3	2 → 1	X
			difficulty	.94	.82	1	2 → 1	X
			life	.97	1.03	4	2 → 1	X
			belief	1.00	1.55	9	2 → 1	X
			strong	1.07	1.37	8	2 → 1	X
			people	***1.22***	1.17	6	1 → 2	
Step 3: Model 3b	2-Dimensional domain analysis	PTG	Relating to others	1.06	−.06	1	*not applicable*	
			New possibilities in life	.93	.03	5		
			Personal strength	1.02	−.03	2		
			Spiritual change	***1.36***	−.02	4		
			Appreciation of life	1.13	−.03	3		
		PTD	Relating to others	1.16	−.04	1	*not applicable*	
			New possibilities in life	1.06	.02	2		
			Personal strength	.93	.13	5		
			Spiritual change	***1.31***	.13	4		
			Appreciation of life	1.05	.08	3		

Note. PTG = posttraumatic growth; PTD = posttraumatic depreciation. Boldfaced and italicized values are indicating underfit.

Received April 8, 2019
Revision received June 18, 2019
Accepted July 1, 2019