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Dynamic Factor Analysis of Worldviews/Religious Beliefs and Well-Being among Older Adults

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Abstract Intraindividual patterns of time-lagged relationships among self-reports of worldviews/religious beliefs, self-concept, and physical and psychological well-being were investigated. Participants were older adults (mean age = 77 years) who were measured weekly covering a total of 25 weeks. Dynamic Factor Models were fitted to multivariate repeated measures data pooled over subsets of participants. The results showed significant time-lagged cross-factor relationships suggesting that worldviews/religious beliefs had a significant direct effect on self-concept and physical health over 2 weeks. For each factor series, there were substantial autoregressive effects indicating persisting effects of factors on themselves over 1 or 2 weeks. A link between worldviews/religious beliefs and physical health was found in the time-lagged structure of within-person variability. The findings underscore the need to study both intraindividual change and interindividual differences in intraindividual variability to obtain a better understanding of behavior and behavioral development.

Keywords Intraindividual variability · Dynamic factor analysis · Worldviews/religious beliefs · Well-being

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Introduction

Research on behavior and behavior change has focused heavily on the study of stable behavior traits and individual differences in gradual, more or less irreversible developmental changes. Studies of aging have been mostly cross-sectional and preoccupied with investigating simple averages aggregated across individuals; information that can hardly answer questions about interindividual differences in the aging process or intraindividual change over time. However, empirical evidence and conceptual arguments are increasingly suggesting that fundamental aspects of behavior and behavioral change need to be defined in more dynamical, change-oriented terms rather than static, equilibrium-oriented terms (e.g., Cattell 1963; Horn 1972; Larsen 1987; Nesselroade 1991, 2004). Within the dynamics of adaptation and selective optimization of gains and losses over the life span (Baltes et al. 1998), intraindividual variability, rather than stability, may offer a more promising way to characterize the "base" conditions of living organisms (Nesselroade and Featherman 1997). From a measurement standpoint, intraindividual variability, as a given condition of the organism, contributes to differences found among persons at any given occasion of measurement. Given the theoretical and methodological implications, studying intraindividual variability and interindividual differences (and similarities) in intraindividual variability is key to obtaining a fuller understanding of behavior and behavioral development.

Relatively few studies have investigated intraindividual changes in psychological and psychosocial factors that contribute to the well-being of older people. The specific aim of this study is to examine the relationships among worldviews/religious beliefs, self-concept, and physical and psychological well-being from an intraindividual

process perspective. Religious beliefs appear to have a significant stress-buffering effect for physical and mental health, especially for older adults (e.g., Antonucci and Akiyama 1993; Ellison et al. 2001; George et al. 2002; Krause 1992). Self-concept or self-esteem may well be an intervening factor that mediates the associations between worldviews/religious beliefs and well-being (e.g., Pearlin and Schooler 1978; Krause 1992).

Worldviews/Religious Beliefs and Well-Being of Older Adults

Religion has long been thought to become more important to people as they age (Blazer 1982). Religious activities and attitudes are commonly reported coping behaviors among persons of all ages, but especially among older people (e.g., Koenig et al. 1988). Empirical research has found that religious beliefs is integrally related to physical and psychological health, fostering the well-being of older people (e.g., George et al. 2002). Religious beliefs has been shown to be significantly related to older persons' subjective health, fewer symptoms of physical ill health, and lower mortality (Clark et al. 1999; Hannay 1980; Krause 1998; Levin and Markides 1985; Strawbridge et al. 1997; Zuckerman et al. 1984; also see Powell et al. 2003 for a review). Previous research also has documented the impact of religious beliefs on mental health or psychological well-being in later life. Evidence from previous cross-sectional studies shows that there is a positive association between religious beliefs and subjective well-being indicators including life satisfaction and happiness (Blazer and Palmore 1976; Diener and Clifton 2002; Ellison et al. 1989; Frazier et al. 2005; Hunsberger 1985). Along similar line, belief in a just world (Lerner 1980) is positively related to a better well-being in old age (Dzuka and Dalbert 2006). Unfortunately, previous studies have failed to specify possible underlying mechanisms linking worldviews/religious beliefs to physical and psychological well-being; further study is needed to understand the processes by which worldviews/religious beliefs influence the well-being of older adults.

Self-Concept as a Mediator of the Associations Between Worldviews/Religious Beliefs and Well-Being of Older Adults

Most research on the relationship between religious beliefs and well-being is concerned with the direct effects of religious beliefs on physical health and psychological well-being of older adults. Although these studies have made a valuable contribution toward the development of a knowledge base, it is important to identify the intervening mechanisms that may link these constructs so that researchers can better understand how religious beliefs are related to physical and psychological well-being in later life. Previous research has shown that self-esteem and mastery, two critical aspects of self-concept, are important psychological resources in coping with stressful life events (Krause 1987; Pearlin et al. 1981; Pearlin and Schooler 1978). Self-esteem and mastery may play an important role in linking worldviews/religious beliefs to well-being. Worldviews/religious beliefs may be associated with positive self-concept, which in turn contributes to physical and psychological well-being of older adults. The examination of such indirect effects can provide valuable insight into the relationships among these constructs.

Hood et al. (1996) have delineated three significant roles of religious beliefs and practices: offering meaning in life, enhancing one's sense of personal control, and building self-esteem. Older people with higher religious commitment report having more hope, sense of purpose, self-esteem, and security (Ellison 1991; Holt and Dellmann-Jenkins 1992; Jenkins and Pargament 1988; Krause 1992, 1995). For example, based on a nationwide survey among older Blacks, Krause and Tran (1989) found that religious beliefs tends to counterbalance or offset the undesirable effects of life events by bolstering and maintaining positive self-esteem and feelings of mastery. The findings of past research, therefore, suggest that individuals with strong religious beliefs are more likely to believe that, with the help of God, difficult life stressors and their sequelae can be controlled and overcome.

Growing evidence indicates that self-esteem and perceived mastery are related to physical and psychological well-being. High self-esteem is associated with minor or few health problems and perceptions of good health, whereas low self-esteem is associated with severe or numerous health problems and perceptions of poor health (Antonucci and Jackson 1983; Antonucci et al. 1989; Duffy and MacDonald 1990; Krause 1987; Seeman and Seeman 1983). Perceived mastery is also related to higher levels of subjective health and fewer and less severe symptoms (Lachman 2006; Lachman and Weaver 1998; Pudrovska et al. 2005; Rodin et al. 1985). Rodin and McAvay (1992) found that a decline in feelings of self-efficacy, which reflected perceived mastery over several domains of living, was significantly related to negative changes in health among older adults. Greater levels of self-esteem and perceived mastery are associated with greater life satisfaction and lower depressive symptoms (Diener and Diener 1995; Lachman and Weaver 1998; MacInnes 2006; Okun et al. 1984; Pudrovska et al. 2005; Tran et al. 1991).

In summary, the existing research literature suggests that religious beliefs may be significantly related to physical and psychological well-being of older adults. Although research on the well-being of older people lacks a clearly articulated understanding of the mechanisms through

which worldviews/religious beliefs influence the well-being of the individual, there is evidence that worldviews/religious beliefs are positively related to self-esteem and feeling of mastery which, in turn, are associated with physical and psychological well-being.

Intraindividual Variability and Intraindividual Change Patterns

Much adult development and aging research has used general dimensions of more or less stable interindividual differences to classify older persons into diagnostic groups, predict longevity and mortality, and more broadly, to understand the nature of development and change. Less attention has been paid to intraindividual change patterns, including those associated with adult development and aging. Nevertheless, researchers have increasingly turned their attention to using intraindividual designs for studying process and change (e.g., Nesselroade 2004; Nesselroade and Featherman 1991; Nesselroade and Salthouse 2004) and have shown that intraindividual variability adds significant contribution in predicting important variables for understanding adaptive processes in aging. For example, intraindividual fluctuation in sensorimotor functioning had a unique contribution in accounting for individual differences in verbal and spatial memory among older adults (Li et al. 2001).

It has been argued that religious attitudes tend to remain stable into old age (e.g., Markides et al. 1987). In addition, religious coping has been conceptualized in terms of dispositions or traits that describe the extent and manner in which an individual's faith becomes involved in the problem-solving process. However, a previous study found systematic intraindividual variation in worldviews/religious beliefs of older adults, the structure of which showed considerable resemblance to structures reported from cross-sectional data (Kim et al. 1996). Although feelings of subjective well-being and self-concept have most often been conceptualized and measured in static terms as if they were a stable property of an individual, this may not be truly the case. The literature on subjective well-being reveals evidence that momentary mood influences participants' responses to subjective well-being questions. For example, Schwarz and Clore (1983) found that momentary affective states (e.g., those produced by the weather) influenced happiness and satisfaction judgment. While some might contend that self-esteem, a large component of self-concept, is relatively stable (e.g., Rosenberg 1979), other researchers have shown that it is significantly influenced by a variety of factors such as daily events (Butler et al. 1994; Sherkat and Reed 1992). In addition, Kling et al. (1997) reported that self-concept shifts in response to changes experienced during a life transition.

Overall, findings of past research on intraindividual variability (in physiological and psychological attributes) suggest that it predicts important outcomes and is a contributing factor to successful aging (e.g., Rowe and Kahn 1997). These findings warrant further examination of short-term intraindividual variability and the dynamic relationships among worldviews/religious beliefs, self-esteem, and physical and psychological well-being in later life.

Dynamic Factor Analysis: Description and Rationale

Understanding the relationships between changes (based on longitudinal information) and differences (based on cross-sectional information) is a central concern of developmental research (e.g., Baltes et al. 1977). Accordingly, it is critical for research on developmental processes to provide direct information on developmental change within the individual (Molenaar 2004; Wohlwill 1973). There has been growing interest in using variants of P-technique factor analysis[1] (Cattell 1963) to analyze patterns of intraindividual variability or intraindividual change (e.g., Lebo and Nesselroade 1978; McArdle 1982; Nesselroade and Ford 1985; Shifren et al. 1997; Wood and Brown 1994; Zevon and Tellegen 1982). Dynamic factor analysis (DFA) was subsequently developed (Brown and Zhang 2006; Molenaar 1985; Nesselroade et al. 2002) to remedy some of the deficiencies of conventional P-technique. Variants of the DFA model provide ways to accommodate time-lag information into the modeling of multivariate repeated measures which offers a promising way to study process. DFA and variants (Browne and Nesselroade 2005; Nesselroade et al. 2002) are especially useful to study the "structure of process" (Jones and Nesselroade 1990).

The Present Study

The focus of this study is to investigate intraindividual patterns of time-lagged relationships among worldviews/religious beliefs, self-concept, and physical and psychological well-being of older adults. Conceptual models are proposed indicating that the effects of worldviews/religious beliefs on well-being operate directly and indirectly through psychological components of self-concept. The principal aim of the present study is to investigate contributions of worldviews/religious beliefs and self-concept to physical health and psychological well-being of older adults as reflected in concurrent and time-lagged relationships among those variables manifested in a weekly measurement protocol.

[1] P-technique factor analysis involves fitting the common factor model that is usually applied to cross-sectional studies of individuals to one individual's repeated multivariate measures data.

Method

The data used in the present analysis were drawn from the Cornwall Manor Project (e.g., Kim et al. 1996), which was conducted as part of the John D. & Catherine T. MacArthur Foundation Studies of Successful Aging. The Cornwall Manor Project was designed to study the magnitude and nature of short-term, intraindividual variability and stability manifested by older adults in a wide array of variables.

Sample

The participants were 57 volunteers who resided at Cornwall Manor, a retirement community in Cornwall, Pennsylvania, USA. Members of the sample, which was comprised of a well-functioning group of 39 women and 18 men who were on average 77 years of age ($SD = 7.23$). In general, the health status of the participants was reasonably good as indicated by self-rating of health which averaged between good and very good ($M = 3.45$, $SD = 0.95$ on 1–5 rating scale). The educational level of participants was relatively high ($M = 13.8$ years).

Procedures

Apprehending the nature of intraindividual variability requires intensive-measurement (many variables, many occasions) designs. Participants were divided randomly, as much as possible given scheduling and time conflicts, into two groups: a longitudinal group ($n = 32$) and a retest-control group ($n = 25$). The longitudinal group was measured weekly for a total of 25 weeks (occasions). Due to holiday breaks, 27 weeks were required to obtain the 25 measurements. The retest-control group was measured only twice: at the first week and at the last week of longitudinal group measurement. When the results from the retest-control group were used to assess the design effects of repeated testing (e.g., a learning or practice effect) in the longitudinal group, no patterns suggesting practice effects were evident (Nesselroade and Featherman 1991). Retention of participants in the study was high. One retest-control group member died before the post-test interview, two withdrew for personal reasons, and one interview failed to record on the computer. Only one subject out of 32 longitudinal group members withdrew from the study.

Measures

The measures used in the Cornwall Manor study spanned the biomedical, physical, cognitive performance, activity, mood/state, and attitudinal domains. Some of the measures were adapted from a test battery developed under the auspices of the MacArthur Foundation Research Program on Successful Aging (Berkman et al. 1993), and other measures were taken from a survey instrument of the Americans' Changing Lives study (Herzog et al. 1989). Worldviews/religious beliefs and gait variables were measured bi-weekly over 13 occasions. All other variables involved in the present study were measured weekly over 25 occasions. Descriptions of the items and descriptive statistics for the measures are presented in the Appendix. Items were coded so that a high score reflects greater degree of the measured attribute.

Worldviews/Religious Beliefs

Nine attitudinal measures were used to assess worldviews/religious beliefs. The items tended to factor into two dimensions identifiable as (1) *fatalism*, concerning belief in a world that is governed by external forces, such as fate or an active God, and (2) *justice*, representing a belief that people generally get what they deserve (Rubin and Peplau 1975). The response format was a 4-point Likert scale with response alternatives ranging from *strongly disagree* to *strongly agree*.

Self-esteem and Mastery

The self-concept was operationalized with two dimensions: self-esteem and mastery feeling. Self-esteem was assessed by three items from the Rosenberg Self-Esteem scale (Rosenberg 1965), which asked global feelings of self-worth and self-acceptance. Three items of perceived mastery were used to measure the extent to which one regards one's life-chances as being under one's own control (Pearlin and Schooler 1978). A 4-point Likert response scale was used ranging from *strongly disagree* to *strongly agree*.

Physical Health

Three factors of physical functioning were identified. The first factor of Gait consisted of three measures: (1) Normal Walking—time required for the participant to walk 10 feet at a normal speed; (2) Fast Walking—time required for the participant to walk 10 feet at a rapid pace; and (3) Walking Circle—time required for the participant to walk around the perimeter of a visible circle. The second factor involved systolic and diastolic blood pressure measures which were administered five times within each interview session and averaged to a single weekly score: (1) two systolic blood pressure (SBP) scores that were measured when the participant was sitting and standing, respectively, and (2) two diastolic blood pressure (DBP) scores that were measured when the participant was sitting and standing, respectively. Finally, the third factor of subjective health was

constructed based on participants' answers to three questions about (1) satisfaction with their health, (2) their own health rating, and (3) the extent to which their activities were limited by their health or health-related problems. The response format for those three items was a 5-point Likert scale.

Psychological Well-Being

Four positive measures of psychological well-being were used to assess cognitive and affective dimensions of subjective well-being in older adults. The items were adapted from the Life Satisfaction Scales (Neugarten et al. 1961). Indicators of *cognitive* states (e.g., overall life satisfaction) typically involve implicit comparisons of ideal and real life circumstances, which are believed to represent relatively stable evaluations of various domains of life experience (Diener 1984). In contrast, indicators of *affective* states (e.g., personal happiness) reflect relatively spontaneous responses that tap mainly transient assessments of life quality. The responses were rated on a 4-point Likert scale which ranged from *strongly disagree* to *strongly agree.*

Data Analytic Procedures

The primary goal of this study is to examine intraindividual variability in the measures of worldviews/religious beliefs, self-concept, physical health and psychological well-being, and further investigate the nature of concurrent and lagged relationships between physical and psychological well-being outcomes and the contributing factors (i.e., worldviews/religious beliefs and self-concept). A dynamic factor model (DFM) was fitted to lagged covariance functions of multiple individuals' short time-series data. Figure 1 illustrates a schematic representation of a diagram for a three-factor, two-lag DFM (see Nesselroade et al. 2002 for discussion of model fitting issues). In Fig. 1, the DFM includes autoregressions and cross-lag regressions among the latent factors, to capture the "dynamics" within and among factors over time. Specifically, an explanatory latent factor (Fa) affects an outcome latent factor (Fc) directly and indirectly through its influence on an intervening latent factor (Fb). Similar to the traditional common factor model (e.g., Spearman 1904), the DFM is specified without correlations between the unique series. That is, the time series of unique variances are autocorrelational but cross-correlational structure is assumed to be zero both within and across occasions. Furthermore, the DFM used in this study contains an invariant factor measurement component in which all factor loadings are constrained to be identical over multiple occasions. These invariant common factor loadings are the basis for the continuity of the latent construct and imply that the same construct is measured at each occasion.

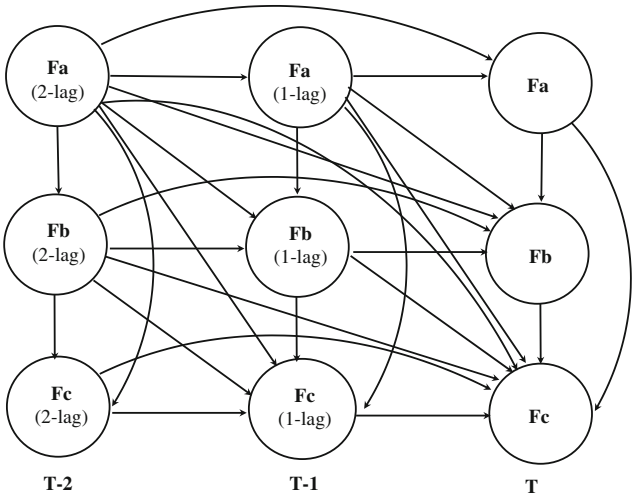

Fig. 1 A diagram for a three-factor two-lag dynamic factor model. For clarity of presentation, manifest variables and unique variances are not shown

Models were evaluated for adequacy of fit using several criteria: Ratios of chi-square to degrees of freedom of less than 3 (Bollen 1989), values of comparative fir index (CFI) of greater than .90, and a root mean square error of approximation (RMSEA) value of .08 or lower (Browne and Cudeck 1993). Relative fit indices involved incremental fit measures based on the differences in likelihood ratio test statistics (i.e., χ^2) resulting from comparison of a particular model under consideration relative to a more parsimonious model. The LISREL 8 statistical program (Jöreskog and Sörbom 1993), with a maximum-likelihood estimation method, was used to fit the confirmatory DFMs to the data along the lines described by Nesselroade and Molenaar (1999).

Results

Preliminary Analyses: Longitudinal Factor Analysis on the First and Last Occasion Data

In a preliminary examination of the factor structure of the variables and longitudinal change in the factor structure, longitudinal factor analytic models were fitted to the covariance matrices of the responses on the first and last occasions of measurement of the whole sample ($N = 57$). The longitudinal factor analysis also aimed at evaluating the appropriateness of assuming that the measurement battery was measuring the same thing across the 25 weeks of measurement, because measuring repeatedly for 25 weeks may raise concerns about the nature of the scores and the meaningfulness of analytic operations performed on them. In the present analysis, factor invariance over

time was tested based on inter-individual differences data with respect to both configural and metric invariance assumptions as described in several previous studies (Horn and McArdle 1992; McArdle and Cattell 1994; McArdle and Nesselroade 1994). Accordingly, alternative model comparisons involved (1) a *null* model in which all loadings of the factors on the manifest variables and all correlations among the factors are set equal to zero, and the uniquenesses are allowed to covary between the corresponding variables across the two time points, (2) a *metric invariance* model in which the pattern and the loadings of the factors are forced to be equal across the two occasions, and (3) a *configural invariance* model in which the pattern of salient versus nonsalient loadings is forced to be equivalent at the two occasions but not necessarily the magnitudes of the loadings. The null model assumes that there are no underlying common factors. Both the metric and the configural invariance models, however, estimate factor loadings and factor correlations within and across occasions. For all three models, correlations were estimated between uniquenesses for the corresponding variables across the two occasions.

For some of the variables, parcels of items or composites (linear combinations) were used to reduce the number of parameters to be estimated which was helpful in model fitting with a relatively small sample size. A composite was produced by summing a couple of randomly chosen items from the subset of items assessing the same latent construct, according to the method which was proposed by Kishton and Widaman (1994). No item was assigned to more than one composite. When a common factor involves two pairs of composites (or items) with each pair representing different dimensions of the latent factor, uniquenesses of the related composites within a pair were allowed to be correlated to obtain a significantly better fit.

A two-factor longitudinal model was fitted to an 8×8 covariance matrix of the Occasion 1 and Occasion 25 worldviews/religious beliefs data, involving four composites: (1) Fatalism_A = mean of SWW and SWT, (2) Fatalism_B = mean of APG and BMB, (3) Just_A = mean of SFF and DWG, and (4) Just_B = mean of MBO, GPR, and WGF (item abbreviations are shown in Appendix). Model fitting comparisons for the worldviews/religious beliefs data revealed that the metric invariance model produced a better fit compared with the null and configural invariance models (see Table 1). Similarly, a two-factor longitudinal model was fitted to the covariance matrix of the Occasion 1 and Occasion 25 self-concept data. At each time point, four composites were used, consisting of two composites reflecting self-esteem and two composites reflecting perceived mastery: (1) Esteem_A = PAN, (2) Esteem_B = mean of TNG and AFF, (3) Mastery_A = CDA, and (4) Mastery_B = mean of SFP and NSP. Model fitting results indicated that the null model did not fit the data well. The metric invariance model fit the data reasonably well on the basis of the chi-square to degrees-of-freedom ratio, and the fit was significantly better than that of the configural invariance model. As for the life satisfaction data, the metric invariance model yielded a significantly better fit compared to the null model. The configural invariance model produced only a slightly better fit than the metric invariance model.

For the Occasion 1 and Occasion 25 subjective health data, a two-factor longitudinal model was constructed based on three indicators (i.e., HS, OHR and AL) at each occasion. The results indicated that the metric invariance model was the best fitting model compared to the null and configural invariance models (see Table 1). For the blood pressure measures, a two factor longitudinal model was defined on four composite scores at each time point: (1) SIT_SYS = mean of three measurements of sitting systolic blood pressure of the week, (2) STN_SYS = mean of three measurements of standing systolic blood pressure of the week, (3) SIT_DIA = mean of three measurements of sitting diastolic blood pressure of the week, and (4) STN_DIA = mean of three measurements of standing diastolic blood pressure of the week. Again, the metric invariance model fit significantly better than the null and configural invariance models. The results of fitting a two-factor longitudinal model to the gait measures (using 3-item scores) indicated that the fit of the metric invariance model improved significantly over the null model. Although the fit of the configural invariance model was significantly better than that of the metric invariance model, a closer inspection of the results for the configural invariance model revealed that the factor loadings and the standard errors were not greatly discrepant between corresponding variables across time.

To summarize the results of the longitudinal factor model fittings, for most of the variables, the metric invariance model was the best fitting model, compared to the null model and configural invariance models. In the cases of life satisfaction and gait measures, although the fit statistics of the configural invariance model were significantly better than that of the metric invariance model, the corresponding parameter estimates of factor loadings were comparable across the two occasions. In general, the (test–retest) stability of the factor scores between Occasion 1 and Occasion 25 factors were significant ($t > 1.96$). For the life satisfaction and self-concept measures, the stability estimates approached significance ($t = 1.74$ and 1.65, respectively). Results of the metric invariance model fitting indicate that factor loadings were equivalent across time. The test of the equality of factor loadings affirms that the same factor was measured across time. Ultimately, the findings of the longitudinal factor analyses indicate the

Table 1 Comparative fit statistics for alternative models

Model	Goodness-of-fit				Step-down goodness-of-fit		
	df	χ^2	GFI	RMSEA	Δdf	$\Delta\chi^2$	*p*(d)
1. Worldviews/religious beliefs							
Null	20	101.07	.66	.27			
Metric Inv	14	25.29	.90	.12 (.035; .190)	6	75.78	<.05
Configural Inv	11	25.14	.90	.15 (.073; .230)	3	0.15	ns
2. Self-concept							
Null	24	67.63	.78	.18			
Metric Inv	18	31.58	.88	.12 (.041; .180)	6	36.05	<.05
Configural Inv	15	30.58	.89	.14 (.065; .210)	3	1.00	ns
3. Life satisfaction							
Null	22	56.20	.81	.17			
Metric Inv	16	27.66	.90	.11 (.031; .180)	6	28.54	<.05
Configural Inv	13	19.63	.92	.10 (.000; .180)	3	8.03	<.05
4. Subjective health							
Null	12	127.57	.64	.41			
Metric Inv	7	3.49	.98	.00 (.000; .096)	5	124.08	<.05
Configural Inv	5	0.76	1.00	.00 (.000; .000)	2	2.73	ns
5. Blood pressure							
Null	24	264.83	.51	.42			
Metric Inv	14	21.50	.92	.10 (.000; .180)	10	243.33	<.05
Configural Inv	11	18.60	.93	.12 (.000; .210)	3	2.90	ns
6. Gait							
Null	11	274.51	.45	.65			
Metric Inv	9	22.08	.90	.16 (.077; .248)	2	252.43	<.05
Configural Inv	7	8.33	.96	.06 (.000; .181)	2	13.75	<.05

Bold type indicates the best fitting model

Metric Inv Metric Invariance model, *Configural Inv* Configural Invariance model, *df* degrees of freedom, *GFI* goodness-of-fit index, *RMSEA* root mean square error of approximation, Δdf difference in degrees of freedom, $\Delta\chi^2$ difference in χ^2, *p(d) p* value for the difference

invariance over time of the latent structure of the variables included in this study.

Pooling Lagged Covariance Matrices

Because each variable incorporated a relatively small number of occasions of measurement (e.g., 13 occasions), the individual time-series are not long enough to be analyzed as separate time-series. So, applying a clustering procedure described by Nesselroade and Molenaar (1999), homogeneous subsets of participants whose data presumably manifest similar lagged structures were identified. Then, the data of the homogeneous group of multiple participants were pooled and used for DFM. Some participants were excluded because of insufficient variation on some items (i.e., zero variance with regard to one or more of the item scores or composite scores) which would have jeopardized the modeling procedures. Because worldviews/religious beliefs (a main predictor) were measured bi-weekly, all other variables needed to be adjusted into a bi-weekly format (by using data from the occasions when worldviews/religious beliefs were assessed). The number of participants available for testing for homogeneity of lagged covariance matrices varied according to the variables under consideration in a specific model and whether the model is based on weekly measures or bi-weekly measures. The lack of variability of scores on the repeated measures forced the exclusion of 2–15 participants, depending on the subset of variables. For dynamic factor analyses, a missing data point for an individual was imputed with the mean of the two adjacent occasion scores. If the first occasion score was missing, the second occasion score was substituted for the missing score. If the last occasion score was missing, the missing score was replaced with the second to last score.

Fitting Dynamic Factor Models

DFMs were fitted to the aggregated data from the identified homogeneous subsamples. To determine the appropriate

number of lags for a given data set, DFMs with a lag length varying from 0 to 2 lags were fitted and their fit measures were compared. Because of the restriction of available numbers of sample size and occasion, the number of possible lags this DFM can entertain was 0, 1, or 2. A zero-lag DFM involved only concurrent relationships among latent factors, and one-lag and two-lag autocorrelations between uniquenesses for corresponding variables across time. No cross-lag factor relationships were estimated. A one-lag DFM added lagged relationships among latent factors only from t (time or occasion) to $t + 1$. Finally, a two-lag DFM further added lagged relationships among factors from t to $t + 2$.

One or two sets of latent factors which involve no manifest indicators (phantom latent factors, Rindskopf 1984) were included to properly estimate lagged factor regressions for one-lag DFM or two-lag DFM, respectively. Figure 1 illustrates a schematic representation of dynamic relationships among latent factors with 0-, 1-, and 2-lags when including the phantom latent factor series. Following the procedures suggested by Nesselroade et al. (2002), block-toeplitz matrices were constructed from the data to estimate the DFMs.

Dynamic Factor Model Fittings for Worldviews/Religious Beliefs and Physical and Psychological Well-Being

In Table 2, the first column summarizes results of DFM analyses on worldviews/religious beliefs, self-concept, and life satisfaction data. These DFM analyses were performed on 13 occasions of data with a 2-week interval from eight participants, making a total of 104 person/occasion measurement units. The one-lag DFM provided a better fit compared to the zero-lab DFM. The two-lag DFM did not provide significant improvement in model fit compared to the one-lag DFM, suggesting that the one-lag DFM yielded the best fit to the data. The results of the best fitting model revealed a significant concurrent relationship linking self-concept to life satisfaction indicating that higher levels of self-concept were related to higher levels of life satisfaction. Autoregressive factor regressions were significant for all three factors. There were significant positive autoregressive lagged factor influences over one lag (2 weeks) for the worldviews/religious beliefs and self-concept factors. For the life satisfaction factor, the lagged effect of the preceding factor on itself over 2 weeks was in the negative direction.

Models for worldviews/religious beliefs, self-concept, and subjective health concerned data from nine participants who were repeatedly measured over 13 occasions with a two-week interval (117 person/occasion units of measurement). The DFM with one lag was the best fitting model. As can be seen in Table 2, results of the one-lag DFM analysis showed that there was a significant concurrent relationship between self-concept and subjective health suggesting that higher scores on the self-concept measures were associated with higher scores on the subjective health measures at the concurrent time. Worldviews/religious beliefs and self-concept had significant positive autoregressive effects over 2 weeks, whereas subjective health had a significant negative autoregressive effect at 2 weeks. DFM analyses of worldviews/religious beliefs, self-concept, and blood pressure variables were conducted using data from six participants over 13 occasions with a 2-week interval (78 person/occasion units of measurement). According to the results of the one-lag DFM, which was the best fitting model, there were significant positive autoregressive factor influences for the factor scores of worldviews/religious beliefs and self-concept at one lag (2 weeks).

The last column of Table 2 reports the results of DFM analyses for worldviews/religious beliefs, self-concept, and gait based on data from six participants measured at 13 bi-weekly occasions (78 person/occasion units of measurement). The one-lag DFM yielded a significantly better fit than the zero-lag model. Estimates of the parameters for the two-lag DFM, however, failed to converge. Model fitting results of the one-lag DFM (the best-fitting model, see also Fig. 2) revealed a significant concurrent relationship between worldviews/religious beliefs and self-concept, unexpectedly linking a higher score of worldviews/religious beliefs to a lower score of self-concept. Several significant cross-factor lagged relationships were obtained at one lag. Unlike the concurrent relationship but consistent with what was hypothesized, the worldviews/religious beliefs factor had a positive effect on the self-concept factor over 2 weeks. Furthermore, worldviews/religious beliefs positively predicted physical performance on the next occasion. There were significant autoregressions for the three factors of worldviews/religious beliefs, self-concept, and gait, indicating that each factor score positively predicted the next occasion factor score.

Discussion

Longitudinal and dynamic factor analysis models were used to investigate the patterns of within-individual short-term changes and the patterns of functional relationships among worldviews/religious beliefs, physical health, and psychological well-being variables over time. The DFA outcomes revealed many idiosyncratic factor relationship patterns that are not evident in the analyses based on interindividual differences data (e.g., raw correlations functions among the variables). The findings also indicated

Table 2 Results of DFM fittings to worldviews/religious beliefs, self-concept, and well-being

Model parameter	Life satisfaction	Subjective health	Blood pressure	Gait
Concurrent factor regressions				
Worldviews/RB => Self-concept	−.04 (.10)	.25 (.18)	−.01 (.03)	−5.80 (2.79)[a]
Worldviews/RB => Well-being	.14 (.14)	−.43 (.35)	−.10 (.12)	−1.89 (1.03)
Self-concept => Well-being	1.04 (.51)[a]	2.21 (.58)[a]	−2.39 (3.07)	−.06 (.06)
Autoregressive factor regressions				
Worldviews/RB => Worldviews/RB	.62 (.06)[a]	.79 (.11)[a]	1.02 (.12)[a]	.74 (.06)[a]
Self-concept => Self-concept	.25 (.09)[a]	.69 (.19)[a]	1.07 (.27)[a]	.39 (.11)[a]
Well-being => Well-being	−.22 (.06)[a]	−.36 (.14)[a]	−.05 (.15)	.27 (.10)[a]
One-lag cross-factor regressions				
Worldviews/RB => Self-concept	−.12 (.09)	−.35 (.19)	.13 (.05)	4.66 (2.03)[a]
Worldviews/RB => Well-being	.72 (.56)	.55 (.31)	.04 (.05)	1.62 (.79)[a]
Self-concept => Well-being	4.48 (2.86)	.40 (.56)	−.11 (.39)	.07 (.04)

Goodness-of-fit indices

Model	Goodness-of-fit				Step-down goodness-of-fit		
	df	χ^2	GFI	RMSEA	Δdf	$\Delta\chi^2$	*p*(d)
Life satisfaction							
Zero-lag	333	468.11	.84	.065			
One-lag	327	426.76	.84	.057	6	41.35	<.05
Two-lag	321	421.91	.84	.058	6	4.85	ns
Subjective health							
Zero-lag	278	338.72	.86	.045			
One-lag	272	287.06	.88	.023	6	51.66	<.05
Two-lag	266	281.06	.88	.023	6	6.00	ns
Blood pressure							
Zero-lag	333	462.75	.79	.074			
One-lag	327	389.03	.82	.052	6	73.72	<.05
Two-lag	321	379.73	.82	.051	6	10.00	ns
Gait							
Zero-lag	278	398.66	.79	.078			
One-lag	272	369.02	.80	.071	6	29.64	<.05
Two-lag	No convergence						

Bold type indicates the best fitting model. The numbers in parentheses are standard errors

Worldviews/RB worldviews/religious beliefs, *df* degrees of freedom, *GFI* goodness-of-fit index, *RMSEA* root mean square error of approximation, *Δdf* difference in degrees of freedom, $\Delta\chi^2$ difference in χ^2, *p(d) p* value for the difference

[a] Parameter that is larger than 1.96 times its standard error

that more complex DFA models showed better fit than traditional P-technique models.

Empirical research has suggested that religious beliefs has a positive influence on physical and psychological health and serves an important role in the well-being of older people (e.g., Idler 1987; George et al. 2002). We hypothesized that worldviews/religious beliefs may not only have direct effects on physical and psychological well-being but also have indirect effects mediated through its influences on self-concept. The present data demonstrated that worldviews (i.e., belief in a just world) and religious beliefs were positively related to self-concept and physical health over one lag (2 weeks). No indirect effect of worldviews/religious beliefs on physical and psychological well-being was found in concurrent or lagged relationships. The significant direct effect of worldviews/religious beliefs on physical performance measures is in line with previous research findings that showed a significant positive relationship between religious beliefs and physical health but failed to show a significant relationship between religious beliefs and psychological well-being among older adults (e.g., Courtenay et al. 1992; Hannay

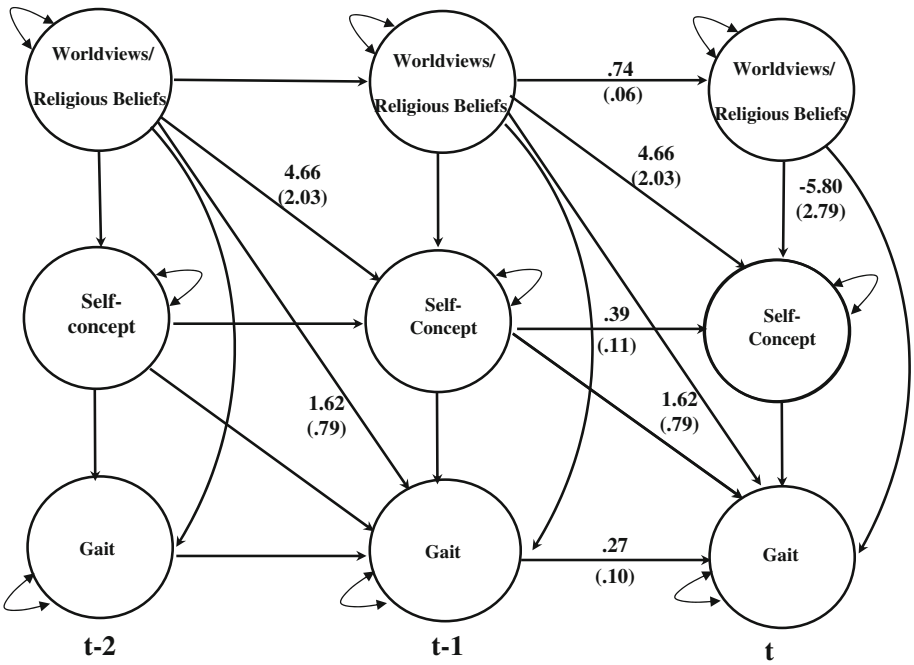

Fig. 2 Latent variable relationships in a dynamic factor model of worldviews/religious beliefs, self-concept, and gait

1980; Koenig et al. 1996; Levin and Markides 1986; Okun and Stock 1987). These results are inconsistent with some prior studies showing that individuals with higher levels of religious beliefs reported greater psychological well-being (e.g., Ellison 1991; Levin et al. 1995). As will be discussed in the following section, our DFA findings indicate that intraindividual patterns for the dynamic relationships among worldviews/religious beliefs, self-concept and well-being are complex.

There were substantial autoregressive effects for the factors over time. These autoregressive effects were not necessarily positive at one lag. This finding was different from what was expected from the ordinary stability coefficients that are almost always in the positive direction. Specifically, DFA results based on intraindividual data revealed that positive one-lag autoregressive effects were present for the factors of worldviews/religious beliefs, self-concept, and gait. The positive lagged effects within a factor indicate that a higher factor score at a given occasion tends to induce a higher factor score for the same factor in the following occasion. In contrast, negative one-lag autoregressive effects were found for the factors of life satisfaction and subjective health. In the case of the negative autoregressive effect, a higher factor score at one time significantly predicts a lower factor score at a later time. This may reflect the nature of a self-regulatory system in the maintenance of psychological homeostasis. Negative autoregressive effects were found more often with respect to psychological attributes such as life satisfaction or psychologically processed attributes such as subjective rating of health, rather than with respect to physical performance (e.g., gait) or physiological attribute (e.g., blood pressure). It may be true that psychological processes (or at least the self-reports concerning them), compared to behavioral or physiological processes, are more likely to organize dynamic relationships across time which involve some kind of compensatory systems of short-term fluctuations. Overall, whether negative or positive, these autoregressive effects appear to represent significant organization within a factor over time.

DFA results further revealed substantial lagged relationships as well as concurrent relationships across factors. Self-concept was a significant predictor of life satisfaction and subjective health at the concurrent time. As hypothesized, greater positive self-concept was related to higher levels of life satisfaction and subjective health. In the model for worldviews/religious beliefs and gait, worldviews/religious beliefs had a negative effect on self-concept concurrently; however, the significant lagged relationships supported the hypotheses showing that worldviews/religious beliefs had positive effects on self-concept and gait measures at one lag. That is, although worldviews/religious beliefs seemed to be negatively related to self-concept at the concurrent time, it had positive lingering effects on self-concept and physical health over a 2-week period. These seemingly incongruent relationships between concurrent time and a 2-week lag reinforce the importance of studying the patterns across time to ascertain the nature of lagged effects. If one had not looked at time lagged relationships across factors, as in ordinary P-technique analyses, this pattern would have been missed.

It should also be noted that some of the factor loadings in the DFA models were not significant. The magnitude of factor loadings indicates the extent to which the items have

covaried together on an occasion-to-occasion basis. Given that all estimated factor loadings in the longitudinal factor analyses were significant, the findings imply that relative salience of factor loadings based on intraindividual variability data are different from those based on interindividual differences data. This is not surprising; the literature on P-technique factor analysis has often reported discrepancies with respect to the factors extracted from group data and the factors emerging from individual data (e.g., Hooker 1991; Hurlburt and Melancon 1987). As Nesselroade and Featherman (1997) pointed out, such discrepancies raise as much doubt about the validity of between persons analyses as they do concerning within persons ones.

In the present research, the one-lag DFM provided a much richer picture and a better fit than the zero-lag DFM. This finding suggests that DFA would better explain the processes of changes for the factors across time than the traditional P-technique factor analysis when significant lagged relationships exist. It seems that the increased precision afforded by modeling lagged relationships within and across factors resulted in a better description of within-person changes and dynamic relationships among the variables over time. Applications of DFMs to multivariate time series data appear to be valuable tools for understanding complex developmental processes in aging and adult development (Kim and Nesselroade 2003; Nesselroade 2004).

The current study has some limitations which must be acknowledged. First, the sample of individuals and the numbers of occasions repeatedly measured for an individual were relatively small. Specifically, the patterns of intraindividual variability were identified on subsets of an already small sample. In our view, however, this speaks to the diversity and complexity of intra-individual variability (lack of it in some cases) and underscores the need for further investigation of such phenomena. Second, individuals in this sample were relatively healthy and high-functioning older adults who volunteered to participate. For future studies, different sampling strategies could broaden the basis of comparison by involving participants of larger functional ranges. Quite possibly, it may be the case that high-functioning subgroups and low-functioning subgroups show different patterns of dynamic time-lagged relationships among the factors. Finally, according to the DFA results reported here, the magnitude of relationships between the constructs seems to differ depending on the number of time lags. However, we were not able to test more than three lags (i.e., zero-, one-, and two-lags) because of the limited numbers of data points due to relatively small sample size and number of occasions. Therefore, future research should examine optimal numbers of lags for the DFMs to best represent the observed lagged covariances.

In conclusion, our results support the notion that the link between worldviews/religious beliefs and physical health may not be captured well by looking only at concurrent indications of relationships. Rather, meaningful structure and organization may lie in more complicated, time-lagged relationships (e.g., Nesselroade and Molenaar 1999). It is likely that the structural patterns of intraindividual variabilities are not fully identical to those of interindividual differences. The differences between intraindividual variabilities and interindividual differences will not be precisely reflected by interindividual analyses obtained from cross-sectional data. This study extends one of the possible advanced methodological tools that are available to study both intraindividual change and interindividual differences in change patterns to additional classes of variables. We hope our analyses will inspire more interests in patterns of intraindividual variabilities and the value of such patterns for understanding dynamic processes of behavioral development.

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Appendix

See Table 3.

Table 3 Descriptive statistics for measures of the worldviews/religious beliefs, self-concept, subjective health, and life satisfaction

Construct/variable	Occasion 1			Occasion 25		
	N	Mean	SD	*N*	Mean	SD
Worldviews/religious beliefs						
Not wonder why (NWW)	57	2.74	0.92	52	2.77	0.78
Die when's the time (DWT)	57	2.84	1.13	53	2.68	0.89
All plan of God (APG)	57	2.89	1.11	51	2.94	0.86
Sacrificed for future (SFF)	57	2.51	0.97	51	2.39	1.00
Bad things meant to be (BMB)	57	2.07	1.02	52	2.29	0.89
Deserve what to get (DWG)	57	2.16	0.88	53	2.23	0.95
Misfortune brought on (MBO)	57	3.00	0.76	53	2.79	0.74
Good people rewarded (GPR)	57	3.18	0.73	52	2.85	0.87
Work hard good future (WGF)	57	2.19	0.85	51	2.27	0.80
Self-concept						
Positive attitude toward myself (PAM)	57	3.58	0.65	53	3.55	0.54
Think no good (TNG)	57	3.23	0.95	53	3.51	0.70
All in all, feel as a failure (AFF)	57	3.81	0.40	53	3.87	0.39
Can do anything (CDA)	57	2.95	0.81	53	3.13	0.62
Sometimes feel pushed (SFP)	57	3.39	0.90	53	3.38	0.71

Table 3 continued

Construct/variable	Occasion 1			Occasion 25		
	N	Mean	SD	*N*	Mean	SD
No way to solve the problems (NSP)	56	3.25	0.87	52	3.12	0.86
Subjective health						
Health satisfaction (HS)	57	3.56	0.96	54	3.53	0.88
Own health rating (OHR)	57	3.58	0.91	54	3.52	0.90
Activities limited (AL)	57	4.09	1.18	54	3.98	1.20
Life satisfaction						
Life could be happier (LCH)	56	2.45	0.99	53	2.58	0.89
Best years of my life (BYL)	56	2.52	0.93	53	2.49	0.78
Look back satisfied (LLS)	57	3.49	0.71	52	3.31	0.58
Not change my past life (NCP)	57	2.88	1.04	53	2.72	0.93

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