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The Temporal Factor of Change in Stressor–Strain Relationships: A Growth Curve Model on a Longitudinal Study in East Germany

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Several theoretical models describing how stressor–strain relationships unfold in time (e.g., M. Frese & D. Zapf, 1988) were tested with a longitudinal study, with 6 measurement waves, using multivariate latent growth curve models. The latent growth curve model made it possible to decompose trait and state components of strains and to show that both trait and state components are affected by work stressors. Because East Germany constitutes a high-change environment, it is an appropriate setting in which to study the relationship between work stressors and strains. The results showed that both the state and trait components of strains were affected by stressors. For example, individual trends in uncertainty (stressor) and worrying (strain) were related, whereas worrying also showed a short-term relationship with time pressure (another stressor). In particular, the decomposition into trait and state components was only possible with the growth curve method that was used.

In this article, we examine the stressor–strain relationships using longitudinal data (six measurement points) in a radical change situation—the situation in East Germany after the collapse of communism in 1990. This article contributes to the literature in the following ways: First, the stress literature is vast, but there is a lack of longitudinal studies (Zapf, Dormann, & Frese, 1996). Many authors have called for longitudinal studies. Second, stress effects unfold in time. However, stress research has not been explicit in discussing this process. In this article, we discuss alternative models on time lags necessary for stressors to have an effect on strain. Third, there has been a call in stress research to look for intraindividual differences in these processes (Frese & Zapf, 1988). In this article, we make a first attempt to focus on the relationships between within-person changes in stressors and within-person changes in strain. For example, some individuals may react to a decrease of a stressor with an immediate decline in their strain level, whereas others take a much longer time to react. Fourth, the focus on intraindividual changes over a long time frame enabled us to decompose changes in slow moving trendlike changes and short-term statelike fluctuations. Fifth, to do this, we had to use a methodological procedure not frequently applied in stress research: the growth curve model. Sixth, Kasl (1978) argued that stress research should capitalize on naturally occurring events that have an impact on stress. East German society and workplaces changed completely from socialism to capitalism after the introduction of the West German D-Mark in mid 1990. This is a natural starting point for stressor changes. Finally, this study used a representative sampling procedure, so that the stress process in multiple worksites or industries and the role of occupational self-selection and drift can be studied (as recommended by Murphy, Hurrell, & Quick, 1992).

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Stressor–Strain Models

The issue of how stressor–strain relationships unfold in time is of fundamental importance for stress research, although it has not been studied systematically. The theoretical framework for our models was inspired by the stressor–strain models presented by Frese and Zapf (1988) and the interpretation of change by Nesselroade (1991). Nesselroade (1991, p. 96) distinguished three kinds of variability: (a) intraindividual variability (relatively rapid, more or less reversible changes, such as *states*), (b) intraindividual change (relatively slow changes reflecting processes, such as development, labeled as *trait change*), and (c) interindividual variability (highly stable, even over long periods, denoted as *traits*). The stressor–strain models of Frese and Zapf (1988) explain the various ways exposure to stressors may lead to psychological and psychosomatic dysfunctioning in the course of time.

From these two sources we distilled six theoretical models that were tested in this study; they are summarized in Table 1. Table 1 also presents differences between the models with regard to their predictions, time perspectives, and causal agents. The last column on statistical predictions is described in more detail later. These predictions range from perfect stability to very short-term effects of stressors on strain. An additional model is the reverse causation model, which argues for the opposite direction of strain effects on stressors.

Strain Stability Model

There are two types of stability. One relates to the stability of the means of stressors and strains (mean stability). The other one is the stability of individual differences. The stability of individual differences implies that the relative position of the participant's scores does not change over time. For instance, all people can move in the same direction, which implies a mean change, but the relative position of persons might remain unaltered. Theoretically, it has been argued that strain is a function of negative affectivity and that negative affectivity is genetically determined (Brief, Burke, George, Robinson, & Webster, 1988; Burke, Brief, & George, 1993; Spector, Zapf, Chen, & Frese, 2000). In its strong form, this hypothesis implies that strain is completely stable both in terms of means and in terms of individual differences. This means that a person's psychological health is not affected by changes in the outside world; strain is conceptualized as a stable trait despite changing circumstances.

On the stressor side, we hypothesized changes because East Germany is in a radical change situation, which should translate into changes in the levels of stressors. This implies that there should be clear changes in the means and probably in the individual differences, because not all people are equally affected by the shifts in stressor levels.

Table 1
Characteristics of and Statistical Predictions for Theoretical Models

				Model used in testing			
Model	Prediction	Time perspective	Causal agent	Spurious	Latent growth	Measurement	Hybrid
Strain stability							
Mean stability	Stable means of strains, but stressors' means change	Long time stability for strains	Stable trait			Equality constraints for means	
Stability of individual differences	No change in the relative position of strain scores	Long time stability for strains	Stable trait			High stability coefficients	
Interindividual differences	Stable parts of stressors and strains are related	Long time period	Stable trait	One perfectly stable latent variable explains the covariances of all stressors and strains			
Stressor–strain trend	Continuous influence of stressors on strains	Trends over a long time period	Stressors		Positive correlation between stressor slope factors and strain slope factors		
Reverse causation	Long-term influence of strains on stressors	Lagged	Strains		Correlation between strain intercept factors and stressor slope factors		
Sleeper-effect	Long-term influences of stressors on strains	Lagged	Stressors		Positive correlation between stressor intercept factors and strain slope factors		
Short-term reaction	Short-term continuous effects of stressors on strains	Synchronous	Stressors				Significant positive covariates

Interindividual Differences Model

In contrast to the strain stability model, the interindividual differences model predicts that stressors and strains should be related. Furthermore, the interindividual differences model does not expect the strains to be completely stable, although this model refers to the stable component in the strains. In addition, this model argues that there is also a stable component in the stressors and that the stable parts of stressors and strains should be related. We call it the interindividual differences model because the covariation between stressors and strains in all measurement waves can be fully explained by differences between people. Two processes may be responsible for the relationship between stressors and strains. First, there may be a fit between personal characteristics (e.g., strain) and situational parameters (e.g., stressors) that are constantly adjusting to each other. This leads to a highly stable, mutually reinforcing equilibrium that would imply that relationships between variables do not change. Second, the model may also come about because one underlying ultrastable personality trait causes both stressors and strains. This could be a result of negative affectivity (Brief et al., 1988; Burke et al., 1993). Negative affectivity implies that a stable negative affectivity trait produces spurious correlations between reports of stressors and strains (Brief et al., 1988). Thus, equilibrium processes or a stable third variable could cause high stability of interindividual differences in both stressors and strains.

Stressor–Strain Trend Model

In contrast to the previous models, this model does not refer to the completely stable components, but instead to the relatively slow moving changes in stressors and strains. The stressor–strain trend model implies that long-term changes in one stressor lead to corresponding changes in the strain variables. Thus, the trends of stressors and strain are related. This is, for example, the case when time pressures in the job gradually increase. People do not react immediately to the accompanying daily fluctuations in time pressure, but instead gradually develop visible psychosomatic symptoms. This model allows for a waxing and waning in the symptoms as well, which might be related to the daily fluctuations in stress levels.

Reverse Causation Model

Most stress models focus on the effects of stressors, but some models argue for a reverse causation: Initial strain levels may determine later exposure to stressors. Two mechanisms can explain the impact on later stressors: selection and direct effects. Selection effects can have benign or detrimental effects on later stressors. Kohn (1973) and Frese (1985) have argued that one legitimate hypothesis is that people with a high degree of strain tend to fall back to less desirable jobs or get assigned more stressful tasks within their jobs (drift model). The reason is that they either cannot cope well with the job and, therefore, do not receive more desirable assignments, or, because of a high degree of absenteeism, are relegated to more stressful tasks (or, vice versa, those who can cope better get better tasks). However, initial strain levels may also have opposite effects on later stressor levels: The selection mechanism with an opposite outcome is the refuge model. Employees suffering from high strain may seek new jobs (or different tasks within the same job) so that they can reduce their stress level. This kind of selection effect is called the refuge model, because employees retreat from the tough jobs and look for the less stressful jobs (and the other way around, some people may look for challenges when their strain level is low). The drift model and the refuge model differ in their prediction for the development of later stressors. The drift model predicts a positive relationship between initial strain and later stressors, because of the worsening of the working conditions, whereas a refuge model predicts a negative relationship, because workers are successful in reducing the level of stress to which they are exposed. Direct effects can also be either positive or negative. The extent to which coping efforts are successful is crucial. Positive effects can be expected if problem-focused coping reduces chronic stressors. An example of negative effects is the true strain–stressor[1] hypothesis (Zapf, Dormann, & Frese, 1996). For instance, software designers who cannot cope with time pressure may become too anxious, resulting in reduced cognitive abilities, and this may result in more errors. Correcting these errors increases the workload even further.

Sleeper-Effect Model

A sleeper effect occurs when stressors do not have an immediate effect but need some incubation time (Nesselroade, 1991; Frese & Zapf, 1988). An analogy is posttraumatic stress disorder (American Psychiatric Association, 1994) or burnout (Glass & McKnight, 1996; Maslach, 1998). For our purposes, the question is whether there are long-term lagged effects of stressors that appear much later. For example, social stressors may lead to a cautious and even hostile attitude toward colleagues that contributes to later depression. In this case, the hostile attitude acts like a slow-acting virus. An alternative mechanism for this effect is the accumulation model with a threshold. Such a model has been argued for the results of night work and shift work (Frese & Okonek, 1984). Only after a certain threshold (breaking point) is reached do long-term effects of shift work appear. These effects do not disappear even with the cessation of the shift work.

Short-Term Reaction Model

Stressors can have an immediate direct effect on strain (Frese & Zapf, 1988, refer to this as an initial impact model). Thus, assuming no further exposure, there is an immediate reaction to a stressor that may subside shortly thereafter if there is no exposure to this stressor any longer. Thus, strain fluctuates directly with the level of stressors involved. Although this model sounds like a simple stimulus–response model and, therefore, is reminiscent of the stress–strain models of the stress research in the 50s and 60s, it is also possible to posit some intermediate coping processes (Lazarus & Folkman, 1984). However, in contrast to the sleeper effect, these processes should occur relatively quickly.

In summary, the first two models (the strain stability model and the individual differences model) can be regarded as personality models and therefore predict high stability in strains. The differ-

[1] In the context of negative affectivity, a similar hypothesis is called the *stressor creation hypothesis* (Spector, Zapf, Chen, & Frese, in press).

ence between the strain stability model and the individual difference model is that the first treats the measurement of the stressors as reflecting objective characteristics of the work environment, which can change, of course, although these changes do not affect the strains. In contrast, the individual differences model treats the stressor reports as strongly confounded with personality and does not predict that the residual changes (thus, after the stable trait has been partialled out) in stressors and strains are related to each other. The reverse causation model and the sleeper-effect model are both lagged models, but they differ in their causal direction: Initial strain predicts later stressor levels or, vice versa, earlier levels of stressors have a lagged effect on strains. The sleeper-effect model, the stressor–strain trend model, and the short-term reaction model are traditional stress models in the sense that they consider stressors as the causal agents. The last two models differ because they focus on different aspects of the data: The slow moving systematic changes versus the rapid fluctuations. An analogy is the long-term effects of air pollution on climate versus the short-term effects of air pollution on weather conditions.

The Situation in East Germany

Our approach in looking at growth curves is particularly interesting in a country that has changed dramatically in terms of working conditions and social makeup. All East European countries share this dramatic change. We concentrate on East Germany during the 5 years after unification.

Table 2 shows a few dates to emphasize the historical context in which our study was done. As the short description in Table 2 shows, the economic situation in East Germany changed most radically in late 1990–1991. Democracy and capitalism came to East Germany in mid-1990. Because workplaces did not become more democratic until late 1990 and in 1991, our Time 1 data were collected at a time when socialist practices were still widespread in state-run companies. Although all respondents knew that changes were imminent, most did not anticipate the quality and level of the impending changes to come.

With regard to the stressors, the following hypotheses are plausible. Under socialism, unemployment was virtually unknown. This was still the case in 1990, during the first wave of our study (we only included employed people at Time 1 in our sample). People were aware that the introduction of capitalism would mean layoffs. Moreover, they had few illusions about the competitive strength of their companies. It was obvious to everyone how badly work was organized and how many investments were needed to bring productivity and product quality up to modern standards. Thus, they knew that many jobs would be lost. However, at the same time optimism with regard to the labor market prevailed. People expected that even if they lost their jobs, it would be easy

Table 2
Historical Context in East Germany

Time	Historical event	Study wave
October–November 1989	Mass demonstrations in Leipzig, Dresden, and Berlin	
November 1989	The Berlin wall opens	
March 1990	First free election in East Germany	
July 1990	Economic unification; the deutsche mark is introduced in East Germany; the first changes appear at the work places; East German companies start to be sold off, mainly to West German firms; workplaces are still very much like they were under socialism	T1
October 1990	Political unification	
November 1990	Workplaces start to change	T2
December 1990	First general election in all of Germany	
1991	Serious economic crisis in East Germany; many work-related education programs started by government	
August–September 1991	Dramatic changes in workplaces; many people change jobs	T3
1992–1993	The economic crisis in East Germany deepens; wages increase to 70–80% of Western level; many government programs to stimulate growth; more and more resentment toward West German managers among East Germans	
August–September 1992		T4
August–September 1993		T5
1994–1995	The economic situation in East Germany stabilizes on a low level; unemployment is high, in some towns approaching 50%; pockets of very high productivity in the East; however, average productivity of East German workers is about 70% of those in the West; most industrial jobs have been lost; West Germany slides into an economic recession with high unemployment	
August–September 1995		T6

Note. T = time.

to find new ones. We hypothesized that fear of unemployment would peak at Time 3 and then level off. Unemployment increases were higher in the beginning years of economic change, particularly 1991, because the firms had to lay off staff to trim their companies and make them ready for sale (nearly all state-owned companies were sold until 1995). Although the rate of unemployment still continued to increase, those who had a job in 1993 could feel much more secure than in 1991.

At Time 1, work life was still socialist, which implied that people could easily leave the workplace to go shopping and that work was slow and comparatively nondemanding. However, there were many organizational problems: obtaining needed supplies, trying to complete tasks with inadequate tools, etc. In other words, time pressure was low and organizational problems were high. It was our hypothesis that during the 5 years of our study, time pressure would increase because of the work pressures of modern management systems. On the other hand, organizational problems would decrease as the tools of production became more modern and the introduction of supplies became better planned.

Socialist East Germany has been described as a *niche society*, in which friendships were very important and where comradeship at work was high. Newspaper reports and psychotherapists (e.g., Maaz, 1992) have argued that with the introduction of capitalism the social climate has become rougher because competition has increased (e.g., for workplaces, for better jobs, for a career). This would suggest that in 1990, social stressors should be lower and that they should increase linearly with time.

Work requirements were not clearly laid down in socialist times; thus, it was not quite clear which job requirements one had to fulfill and which ones not (Pearce, Branyicki, & Bukacsi, 1994). It is reasonable to assume that this led to role ambiguity and role conflicts. We assume that the modern management methods introduced in 1991 would gradually give the employees a clearer sense of what was expected of them, thus reducing uncertainty (which is a conglomerate of role ambiguity and conflict).

One could interpret the radical change situation as a stressful life event. Although many changes were, of course, most welcome, others might be perceived to be negative. The social atmosphere would become harder and more competitive—the niche society could not be upheld. On the other hand, the introduction of modern management would lead to the decrease of organizational problems and uncertainty. Thus, we hypothesized that some of the work stressors would increase, whereas others would decrease, and that the combined effects of all the work stressors would produce a more or less constant level of strain during the period of our study.

Method

The data in this study were gathered in the AHUS project. AHUS is a German acronym for "active actions in a radical change situation." The goal of the project was to study the effects of the drastic changes that took place after the unification of East and West Germany, and one of the research questions was which people could cope better with the many stressors they encountered. This study used all six waves over a 5-year time period. Other publications of this study concentrated on personal initiative (Frese, Kring, Soose, & Zempel, 1996; Frese, Fay, Hilburger, Leng, & Tag, 1997; Frese, Garst, & Fay, 1998) and social support as a moderator of stressors (Dormann & Zapf, 1999). None of the data reported here have been published before.

Sample

A representative sample was drawn in Dresden, a large city in the south of East Germany. It is the capital of Saxonia, houses a large technical university, and is relatively well-off (e.g., compared with cities in the north of East Germany). The sampling was done by randomly selecting streets, then selecting every third house, and then in each house, every fourth apartment (in smaller houses every third one). All people between the ages of 17 and 65 with full-time employment at Time 1 participated (thus, we sometimes had more than one participant per family). The refusal rate of 33% was quite low for a study of this kind. Confidentiality was assured; if participants preferred anonymity, they were assigned a personal code word.

At Time 1 (July 1990), 463 people participated in Dresden. At Time 2 (November and December, 1990), 202 additional people were asked to participate.[2] At Time 3 (September 1991), the N was 543; at Time 4 (September 1992), the N was 506; at Time 5 (September 1993), $N = 478$; at Time 6 (September 1995), $N = 489$. Experimental mortality did not change the makeup of the sample. There were no significant differences in the stressor variables between dropouts from Time 1 to Time 3 and full participants. The sample is representative of the Dresden population on the relevant parameters (e.g., for age, social class, male and female percentage at work). Fifty-three percent of the participants were men and 47% were women. At Time 3, ages ranged from 17 to 65 years ($M = 39$, $SD = 11.4$). Most participants worked in public or private services (36%), followed by those who were employed in trade or manufacturing enterprises (31%). Of the office workers in the study, 19% had jobs that required minimal qualifications, whereas 27% were either managers or professionals, positions calling for higher qualifications. Higher level public servants, mostly employed in schools and universities, made up 13% of the participants. The study group also included skilled (17%) and unskilled (15%) blue-collar workers. At the start of the study, none of the participants were unemployed, but the unemployment figures for the subsequent waves were $n = 42$ (7%) at Time 2, $n = 59$ (11%) at Time 3, $n = 38$ (8%) at Time 4, $n = 35$ (8%) at Time 5, and $n = 37$ (8%) at Time 6. After the first wave, some of the participants had no job for reasons other than involuntary unemployment (e.g., retirement, schooling, parental leave). The items on the stressor scales were not administered to those people who did not have a job at the time of the assessment.

Measures

All stressor and strain measures were ascertained with a questionnaire.

Strain Variables

The strain measures, for depression, psychosomatic complaints, irritation, and worrying, are adaptations of Mohr's (1986) scales—a group of well-validated scales that are used frequently in Germany.

The measure for depression (four items) was originally adapted from Zung (1965), and all of those items that referred to physical problems (e.g., not being able to sleep) were excluded to reduce the overlap with psychosomatic complaints. Sample items were "A good deal seems senseless to me" and "I have sad moods." A 7-point Likert-type scale was used, and the extreme response categories were described as 1 (*almost always*) to 7 (*never*).

The measure for psychosomatic complaints (eight items) was originally adapted from Fahrenberg (1975) and related to aches and other negative bodily sensations that are commonly regarded as strain symptoms. The respondents can easily detect the symptoms, and no medical assistance is needed for its diagnosis. The contents of some items were: "Do you feel

[2] Additional people were added to ascertain whether repeated participation had an influence on the variables of the questionnaire. This was not the case.

pain in your shoulders?" and "Do you have feelings of dizziness?" A 5-point Likert-type scale was used with response categories, ranging from 1 (*almost daily*) to 5 (*never*).

The irritation (five items) and worrying (three items) measures were both derivatives of the scale of irritation and strain developed by Mohr (1986), because preliminary analysis indicated that two (only moderately correlated) factors could be distinguished.

Worrying referred to the preoccupation of work-related problems in one's spare time ("Even during holidays I think a lot about problems at my work"). The scope of the original Irritation scale was narrowed down to feelings of irritation and nervousness ("I'm easily agitated"). A 7-point Likert-type scale was used.

Stressors

The stressors measure used a 5-point Likert-type answer scale and have all been adapted from Semmer (1982, 1984) and Zapf (1991), with the exception of social stressors (Frese & Zapf, 1987). The scale development of the stressors was influenced by Caplan, Cobb, French, van Harrison, and Pinneau (1975). All of these scales are frequently used in German studies and have been well validated.

The measure for job insecurity (four items) asked about how secure the job was. Questions referred to the probability of becoming unemployed or of the chance of finding a new job in case one became unemployed.

The time pressure measure (five items) included several aspects of mental efforts (concentration, vigilance, long working hours, and time pressure; e.g., "How often do you experience time pressure?").

The scale for organizational problems (eight items) was longer than the original Semmer (1982, 1984) scale, because we wanted to include more items specific to East Germany. It measured whether the material, the supplies, and the tools were adequate so that work could be done without interruptions. In a prior study it had been shown to be one of the stressors most strongly related to psychosomatic complaints (Semmer, 1984). The construct is similar to the organizational constraints described in Peters, O'Connor, and Rudolf (1980, p. 79). They defined the construct as "facilitating and inhibiting conditions not under the control of the individual," and they found a relation not only with performance but also with affective responses.

Social stressors (six items) referred to several aspects of work relationships, (e.g., a negative group climate, conflicts with coworkers and supervisors, and social animosities).

Uncertainty (five items) combined role conflict and role ambiguity by asking for unclear and conflicting commands and the problem that a mistake may lead to damages.

Modeling Strategy

Our modeling strategy consisted of two steps. In the first step we tested the measurement models. The second step was used to test the structural models (Anderson & Gerbing, 1988).

Measurement Models

Strain variables. The strategy of the measurement modeling involved three basic steps. In the first step (Model 1) a longitudinal measurement model was tested.

The assumption that the same construct was measured across all time points is crucial (Kenny & Campbell, 1989; Plewis, 1996). Therefore, Steps 2 and 3 tested measurement invariance (Little, 1997; Meredith, 1993). The second step (Model 2) tested for equality of factor loadings over time. Changes in relationships of the latent construct and the items over time is an indication of a gamma change (Golembiewski, Billingsley, & Yeager, 1976), which implies a change in the respondent's interpretation of the item content (Oort, 1996). If there is a sizeable gamma change, comparisons of the relevant constructs over time are impossible. In a third step (Model 3), the equivalence of item intercepts over time was tested. If all factor loadings are equal, a change in the item intercepts indicates a general change in the level of the item response. This implies that the item is more or less attractive and that this shift cannot be explained by a change in the latent trait. This phenomenon is called beta change (also called a response shift) and occurs if a respondent changes his or her meaning of the item response scale's value (Oort, 1996). Some authors (Byrne, Shavelson, & Muthén, 1989; Pentz & Chou, 1994) have argued that in practice a few violations can be tolerated and that partial measurement invariance is a more realistic goal.

Stressors. The stressor variables were not fitted with a confirmatory factor analysis, and internal consistencies were not calculated. The reason for this is that we prefer to see the stressor items as a mixture of causal and effect indicators[3] (Bollen & Lennox, 1991; Cohen, Cohen, Teresi, Marchi, & Velez, 1990; MacCallum & Browne, 1993; Spector & Jex, 1998). In general, variables can be conceived either as causes or as effects of a latent construct (Blalock, 1967, pp. 163–164). In a factor model, the latent construct is conceived as the cause for the observed variables (e.g., responses to the items of a questionnaire) that are called effect indicators. In contrast, a causal indicator model assumes that the observed variables determine the latent construct. However, sometimes both models seem to be at least partly valid, and this poses a problem for constructing a measurement model. This was the case in our study, where the stressor variables were based upon a questionnaire, in which the items focused on external events the respondent encountered. Semmer, Zapf, and Greif (1996) showed that our measures of the stressors were at least partly related to the objective work situation. Therefore, it is best to consider the stressor variables as representing both subjective and objective features of the work situation (Ilgen & Hollenback, 1992; Spector, 1998, p. 161). However, the subjective and the objective interpretations have different implications for both the direction of the paths between the latent construct and the indicators, as well as the form of the covariance matrix of the indicators of the stressor scales. For practical purposes, a reasonable solution is the use of an equal weighting scheme for the items, because no information is available about more appropriate weighting (McDonald, 1996).

One could argue that the same reasoning would also apply to some of the strain measures, for example, for psychosomatic complaints. Although there are pros and cons for both views, we preferred the effect indicator model because we did not want to measure psychosomatic symptoms per se, but the underlying strain which manifests itself in various forms of bodily discomfort. We acknowledge that for each single complaint there are manifold causes, but one common cause is the strain level of the person.

The measurement models were also used to test the strain stability model (cf. Table 1). As described in Table 1, mean stability required that the latent means of the strain variables were restricted to be equal in the measurement models. This can be tested with a chi-square difference test because this is a nested model (Bollen, 1989). The stressors were not modeled as latent variables, and hence we used paired t tests to test for the equality of means. The stability of the individual differences model is correct, if the correlations of the latent constructs are very high and are equally high across two adjacent time points and five time points (for example, Time 1–Time 2 stability should be similarly as high as the Time 1–Time 6 stability; again, for the strain variables we used the latent constructs, for the stressors variables, the observed constructs).

Structural Models

To test the structural models, it was necessary to fit separate models for each combination of a strain and a stressor variable. Both restrictions of the

[3] Causal indicators are also known as *formative* indicators, and effect indicators are often called *reflective* indicators.

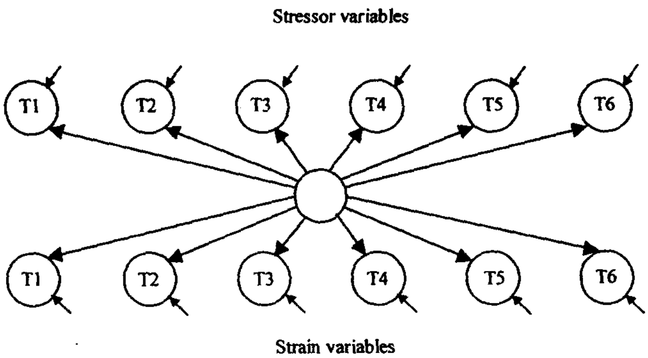

Figure 1. Spurious model; one perfectly stable construct explains all the covariation between stressors and strain variables. T = time.

software and the limited sample size (Bentler & Chou, 1987) forced us to use this modeling strategy. Table 1 explains the relationship between the theoretical models and the statistical tests. As previously described, the strain stability model was tested by imposing constraints on the measurement models.

The interindividual differences model was tested with the spurious model. This is a one-factor model for all the stressor and strain variables. This factor represents a stable construct that explains all the covariation between all the stressor and the strain variables (see Figure 1).

To test all the other models in Table 1, we needed to use growth curve models (compare the Appendix for a short introduction to the growth curve modeling), although they are not typically used in the stress literature. Briefly, growth curve models focus on intraindividual changes and interindividual differences in change patterns. Therefore, they allow us to test stressor trend–strain trend correlations (slope–slope correlations) and correlations between initial values (intercepts) and change patterns (slopes). In addition, we also used one hybrid model (to be explained later).

The next model in Table 1—the stressor–strain trend model—was tested within a specific growth curve model. This growth curve model can either be linear or nonlinear (depending on which one has the best fit). If growth cannot be considered as linear over time, some of the slope factor loadings can be estimated (more on this in the Appendix). This can be done for both the stressors and the strain variables. A convenient strategy (Meredith & Tisak, 1990; McArdle, 1988) is to fix the slope factor loading for the first measurement wave to the value 0 and for the second measurement wave to the value of 1. The other factor loadings are then estimated. From these growth models, we derived the slope–slope correlations. Figure 2 explains this. There are two factors for both strains and stressors: slope and intercept. The slope factor *S* is a latent construct that represents the slope coefficients for each individual (as deviations from the mean slope). A high factor score for *S* means that the slope for that individual deviates strongly from the mean slope. If the mean slope is zero (no mean changes over time), a high positive (negative) factor score implies a strong positive (negative) change for that person and a low positive (negative) value means that there is little positive (negative) change. Thus, *S* tells us something about the interindividual differences in change processes (more on this in the Appendix). The correlation between the two slopes of stressors and strain tells us something about how individual differences in the stressor trajectories are related to individual differences in strain trajectories. In the case that the common fixation scheme is used (fixing the first slope factor

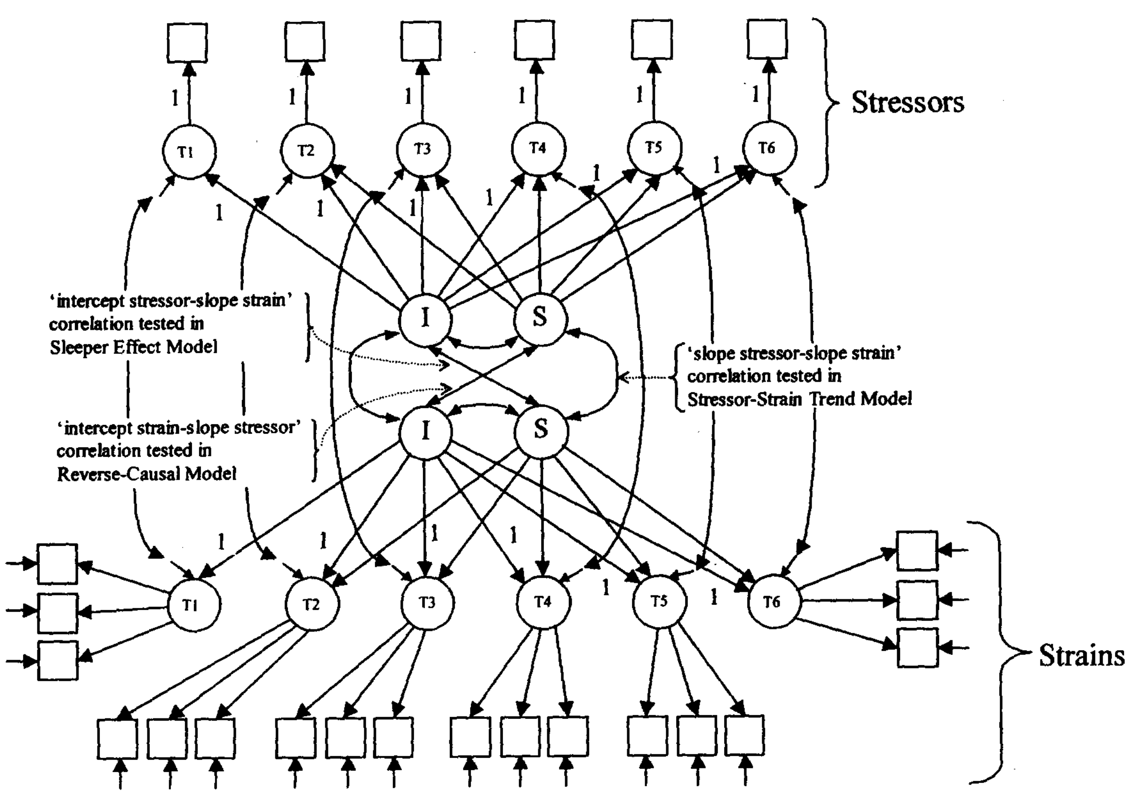

Figure 2. Nonlinear growth curve model of stressors and strain with a measurement model included for the strain variables. Autocorrelations between unique factors of strain items are not shown. T = time; I = intercept; S = slope.

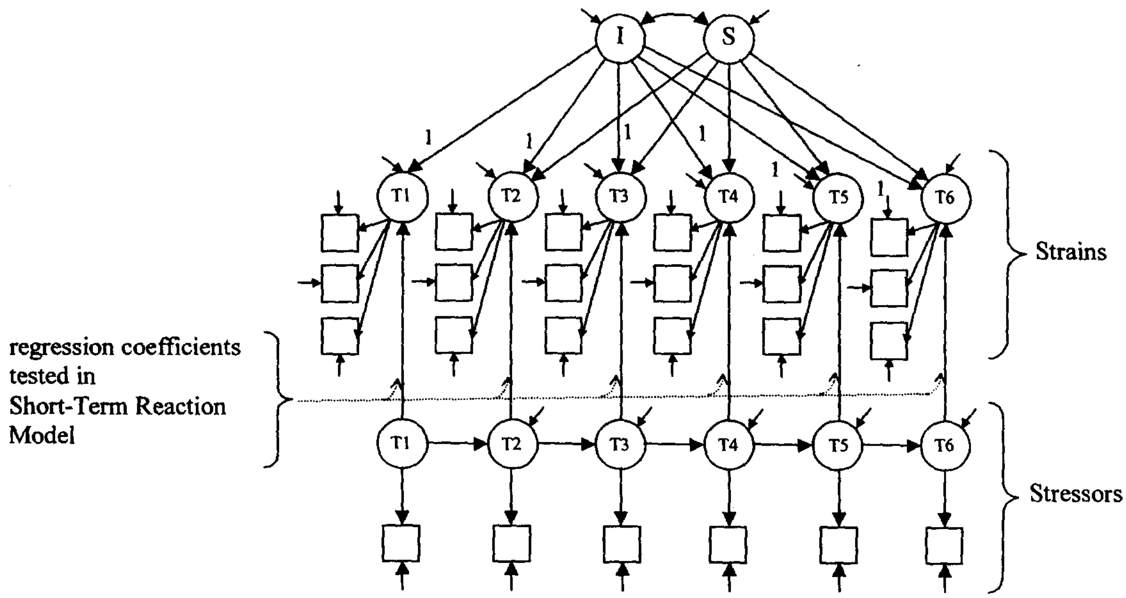

Figure 3. Hybrid model; combination of nonlinear growth curve model (above) for the strain variables (measurement model included) and a first order autoregressive model (below) for the stressor variables. Autocorrelations between unique factors of strain items are not shown. T = time; I = intercept; S = slope.

to the value zero), then the intercept factor scores can be interpreted as representing the expected values for the first measurement wave (starting points of growth curves; see Appendix). A high positive (negative) factor score on the intercept factor (denoted as "I" in Figure 2) means that the growth curve starts at a higher (lower) initial value than the average growth curve. A positive intercept–intercept correlation means that people with higher (lower) initial values on one variable also tend to have higher (lower) initial values on the other variable.

The fourth model in Table 1—reverse causation model—was tested by looking at how strongly earlier levels of strains were predictive of later developmental trajectories of stressors. We fixed the slope factor loading for the first measurement wave to the value 0 (cf. Figure 2), and we could then interpret the intercept factor score as the expected initial value (Time 1) for a particular subject. The reverse causation model was tested by the intercept–slope correlation of strain and stressors within the linear or nonlinear growth curve model (depending on which one had the best fit).

The sleeper-effect model was tested with the same statistical procedure as the reverse causation model (cf. Figure 2); however, this time we looked for the relationship between earlier levels of stressor on later strain developments. Technically, this means that the stressor intercept factor is correlated with the strain slope factor.

The final model in Table 1—the short-term reaction model—was tested with a hybrid model that is a combination of a latent growth curve model and an autoregressive model.[4] (The autoregressive model assumes that the immediately preceding variable has a path on the next without regard to time. This means that stressors at the first measurement point predict the stressors at the next measure.) This combination is more appropriate for the short-term reaction effect because it allows synchronous effects from stressors on strain (unlike a combination of two growth curve models). Figure 3 describes this model. The introduction of time-varying covariates will change the interpretation of the growth curve itself: The growth curve describes the adjusted values after the influence of the covariates (the stressors) is taken into account. Or, equivalently, the stressor explains the state variance in the strain, because the trendlike changes are already partialled out. In the hybrid model, the covariates are unrelated to the intercept and slope factor and the time-specific residual (cf. Figure 3). Thus, the variance of each strain variable can be partitioned into three nonoverlapping components: explained variance by the growth curve, the covariate, and a time-specific residual.

All of the described models were tested against a maximal model that did not place any constraints on the structural relations of the variables; this is called the correlated model, and is used as a baseline model.

To evaluate all the models, covariance matrices and means were estimated with the computer program NORMS (Schafer, 1997), and these matrices and mean vectors were used as input for LISREL (Version 8.14, Jöreskog & Sörbom, 1993). The NORMS program is specifically designed for handling missing data problems. We used the EM algorithm of NORMS. The EM algorithm (Dempster, Laird, & Rubin, 1977) is a general technique for finding maximum-likelihood estimates for models with partial missingness. It is based on the assumption that data are missing at random (MAR), which is a much milder assumption than the assumption that missing values occur completely at random (MCAR). "MAR is less restrictive than MCAR because it requires only that the missing values behave like a random sample of all values within subclasses defined by observed data" (Schafer, 1997, p. 11). The sample size used for a particular LISREL analysis was calculated by the mean of the different sample sizes of the input matrix (N = 448 for depression; N = 445 for psychosomatic complaints; N = 447 for irritation; N = 447 for worrying).

To evaluate the overall fit of the models, we report the chi-square statistic, the Akaike Information Criterion (AIC; Akaike, 1987), and the comparative fit index (CFI; Bentler, 1990). One disadvantage with the chi-square statistic in comparative model fitting is that it always decreases when parameters are added to the model. Therefore, we also report the AIC index, because it takes parsimony (in the sense of as few parameters as possible), as well as fit, into account (Jöreskog & Sörbom, 1993). However, if two models were nested, we report the chi-square difference test

[4] Actually, we also did an extensive comparison of the autoregressive model and the growth curve model for all of the models described in this study. Because of space constraints, this part was omitted. Interested readers may contact Harry Garst to request the technical report.

Table 3
Means, Standard Deviations, and Intercorrelations at Time 1

Subscale	*M*	*SD*	1	2	3	4	5	6	7	8	9
Stressors											
1. Job Insecurity	2.80	0.73	—								
2. Time Pressure	3.10	0.86	.07	—							
3. Organizational Constraints	2.80	0.77	−.04	.11	—						
4. Social Stressors	2.05	0.65	.16*	.22**	.27**	—					
5. Uncertainty Strains	2.42	0.77	.00	.36**	.40**	.41**	—				
6. Depression	2.70	0.90	.31**	.01	.15*	.26**	.15*	—			
7. Psychosomatic Complaints	2.03	0.84	.17*	.24**	.11	.23**	.12	.35**	—		
8. Irritation	3.22	1.29	.20**	.15*	.10	.34**	.23**	.47**	.37**	—	
9. Worrying	3.29	1.48	.16*	.28**	.00	.22**	.18*	.29**	.32**	.51**	—

Note. $N = 179$ (listwise deletion).
$^{*}p < .05.$ $^{**}p < .01.$

(Bollen, 1989). The CFI is based on a comparison of the fit of the hypothesized model to the fit of the null baseline model, and most researchers consider values greater than .90 as an indication for a good fit, although recent research suggests a cutoff value close to .95 (Hu & Bentler, 1999).

To evaluate effect sizes, we report the parameters of interest, the standard errors, and the z values. Unfortunately, in the multivariate nonlinear latent growth curve models (with freely estimated factor loadings), we could not test the significance of several growth curve parameter estimates. The reason is that the z values for those estimates are not invariant under different fixation schemes (more about this in the Appendix).

Results

Descriptive Data

In Tables 3–8, the means, standard deviations, and cross-sectional intercorrelations of the summated scores of the stressor and strain scales for each measurement wave are presented separately.

In Table 9, the zero-order intercorrelations of the strains and stressors scale scores for all time periods are shown. Many of the correlations between stressors and strains are small to moderate in size.

Strain Measurement Models

The goodness-of-fit measures of the measurement models are shown in Table 10. The null model assumes complete independence between the items. The unconstrained model (Model 1) is a longitudinal measurement model that is unconstrained, allowing different factor loadings and item intercepts over time. Model 2 is a restricted model, with equal factor loadings over time. Model 3 is more restrictive and, additionally, assumes equal item intercepts over time. Model 4 is discussed later and tests for equal means of the latent constructs over time. Measurement invariance across time is one prerequisite interpreting the constructs to be comparable over time. Measurement invariance can be assumed to exist if equal factor loadings and item intercepts do not lead to a significantly worse fit of the model. Only a few parameters needed to be freed for depression and psychosomatic complaints. Although, after these modifications, the results of the chi-square difference tests of irritation and psychosomatic complaints remained significant, further freeing of parameters led to estimates which were only trivially different from the restricted ones.

Thus, for irritation and worrying we found full measurement invariance, and for depression and psychosomatic complaints we found partial measurement invariance. This is not a problem, because partial measurement invariance is sufficient (Byrne et al., 1989; Muthén & Muthén, 1998; Pentz & Chou, 1994). We note that for the modified constrained measurement models, all values of the CFI were above .94, which can be considered a good fit.

Table 4
Means, Standard Deviations, and Intercorrelations at Time 2

Subscale	*M*	*SD*	1	2	3	4	5	6	7	8	9
Stressors											
1. Job Insecurity	3.06	0.78	—								
2. Time Pressure	3.28	0.77	−.08	—							
3. Organizational Constraints	2.34	0.73	.03	.09	—						
4. Social Stressors	2.00	0.70	.10*	.12*	.32**	—					
5. Uncertainty Strains	2.27	0.68	−.02	.29**	.36**	.40**	—				
6. Depression	2.73	0.90	.17**	−.09	.15**	.21**	.11*	—			
7. Psychosomatic Complaints	2.10	0.77	.09*	.10*	.08	.12**	.17**	.46**	—		
8. Irritation	3.19	1.18	.10*	.03	.09	.20**	.16**	.48**	.49**	—	
9. Worrying	3.56	1.50	.13**	.25**	.00	.08	.10*	.22**	.26**	.40**	—

Note. $N = 440$ (listwise deletion).
$^{*}p < .05.$ $^{**}p < .01.$

Table 5
Means, Standard Deviations, and Intercorrelations at Time 3

Subscale	*M*	*SD*	1	2	3	4	5	6	7	8	9
Stressors											
1. Job Insecurity	2.77	0.72	—								
2. Time Pressure	3.36	0.74	−.09	—							
3. Organizational Constraints	2.03	0.69	.14**	−.05	—						
4. Social Stressors	1.98	0.69	.08	.04	.29**	—					
5. Uncertainty	2.26	0.67	−.04	.17**	.26**	.49**	—				
Strains											
6. Depression	2.68	0.93	.22**	−.05	.15**	.27**	.11*	—			
7. Psychosomatic Complaints	2.15	0.78	.12*	.13*	.11*	.09	.10	.40**	—		
8. Irritation	3.28	1.12	.11*	.08	.16**	.25**	.23**	.46**	.49**	—	
9. Worrying	3.77	1.41	.15**	.27**	.01	.07	.09	.24**	.26**	.41**	—

Note. N = 362 (listwise deletion).
$^{*}p < .05$. $^{**}p < .01$.

Structural Models

The goodness-of-fit measures of our model tests are shown in Table 11. The first model (correlated) is an unconstrained structural model that can be used as a baseline for the growth curve models. The second model is the interindividual differences model (spurious model), in which the correlations of all the stressor and strain variables can be explained by one common, unmeasured factor, which is assumed to be perfectly stable over time.

The next two models are latent growth curve models (linear and nonlinear), to test for the relevant parameters for the stressor–strain trend model, reverse-causation model, and sleeper-effect model. The last model is a hybrid model (to test for the short-term reaction model), which combines a latent growth curve model for the strain variables and a first-order autoregressive model for the stressor variables that act as synchronous covariates for the strain variables.

The AIC values displayed in Table 11 show that for the combination of strains with the stressors, job insecurity, time pressure, and organizational problems were better (i.e., lowest) for the hybrid than for the latent growth curve models, although the differences were not high. For social stressors and uncertainty, the nonlinear latent growth curve model yielded the lowest AIC values. There was only one exception: The combination of psychosomatic complaints and uncertainty gave a slightly lower AIC value for the hybrid model, although the difference in AIC with the nonlinear latent growth curve model was negligible. Again, we note that AIC value differences between alternative models were sometimes quite small. In those cases in which the differences between the growth curve and the hybrid models were relatively small, we could continue to test hypotheses with either of those models.

Testing of the Theoretical Models

We now describe how the results bear on the theoretical models that are described in Table 1.

The Strain Stability Model

This model argues that there is no change over time for strains, despite changes in the stressors. The answer to this model can be split into questions of mean and individual differences stabilities.

Mean stability for strain variables. The strain means were rather stable, as one can see in Table 12. However, there were statistical differences for psychosomatic complaints, $\Delta\chi^2$ (5, N = 445) = 25.15, $p < 0.001$, and worrying $\Delta\chi^2$(5, N = 447) = 16.62, p = 0.005, but not for irritation, $\Delta\chi^2$(5, N = 445) = 9.24, p = 0.10, and depression, $\Delta\chi^2$(5, N = 448) = 8.8, p = 0.12. From

Table 6
Means, Standard Deviations, and Intercorrelations at Time 4

Subscale	*M*	*SD*	1	2	3	4	5	6	7	8	9
Stressors											
1. Job Insecurity	2.71	0.73	—								
2. Time Pressure	3.47	0.75	−.16**	—							
3. Organizational Constraints	1.92	0.67	.18**	−.02	—						
4. Social Stressors	1.97	0.72	.19**	.10	.37**	—					
5. Uncertainty	2.19	0.64	−.02	.13*	.34**	.43**	—				
Strains											
6. Depression	2.67	0.98	.30**	−.15**	.23**	.30**	.14*	—			
7. Psychosomatic Complaints	2.21	0.80	.24**	.09	.10	.13*	.06	.36**	—		
8. Irritation	3.23	1.16	.21**	.05	.22**	.24**	.12*	.50**	.48**	—	
9. Worrying	3.84	1.46	.13*	.31**	.01	.12*	.06	.21**	.29**	.41**	—

Note. N = 332 (listwise deletion).
$^{*}p < .05$. $^{**}p < .01$.

Table 7
Means, Standard Deviations, and Intercorrelations at Time 5

Subscale	*M*	*SD*	1	2	3	4	5	6	7	8	9
Stressors											
1. Job Insecurity	2.71	0.67	—								
2. Time Pressure	3.49	0.69	−.05	—							
3. Organizational Constraints	1.81	0.66	.15**	−.04	—						
4. Social Stressors	2.00	0.70	.22**	.14*	.36**	—					
5. Uncertainty	2.18	0.62	.07	.23**	.40**	.39**	—				
Strains											
6. Depression	2.60	0.94	.22**	−.07	.26**	.34**	.23**	—			
7. Psychosomatic Complaints	2.23	0.80	.17**	.13*	.09	.15**	.13*	.42**	—		
8. Irritation	3.17	1.12	.15**	.07	.19**	.27**	.13*	.52**	.48**	—	
9. Worrying	3.87	1.44	.08	.25**	.07	.15*	.10	.23**	.32**	.41**	—

Note. $N = 304$ (listwise deletion).
$^{*}p < .05$. $^{**}p < .01$.

a practical perspective, the differences in means for psychosomatic complaints and worrying were not high.

Mean stability for stressor variables. The stressor variables were measured by the unweighted summated scores, and the hypothesis of the stability of the means was tested by series of paired *t* tests. The results are shown in Table 13. There were no significant differences for social stressors only. For uncertainty, there was a significant result for only the first waves, but if we apply a Bonferroni adjustment to correct for multiple testing, we can conclude that no significant differences could be detected. The most drastic changes were shown in the consistent decrease of organizational problems (see Table 13). It seems there was a leveling off, noting the consistent decrease in mean differences, although the difference between Time 5 and Time 6 was not significant any longer. The means of time pressure increased after the second wave, but after the fourth wave stopped to change significantly. The mean of job insecurity increased in Time 2, which took place 3 months after the start of the study. After this increase there was a downward trend.

Stability of individual differences. The correlations of the latent constructs in Table 14 show that the hypothesis of stability of individual differences is to be rejected. If one compares the last column of Table 14 with all the other columns, it becomes clear that the stabilities across the six waves (a 5-year period) were much lower than the stabilities across adjacent waves.

The stabilities of the stressors are also shown in Table 14. These estimates were derived from the autoregressive models, because these models were the preferred models for the stressors and allowed for taking measurement error into account. Again, a comparison of the one-wave lag with the six-wave lagged stabilities revealed a low degree of stabilities for the stressor variables. In line with our expectation, more changes in organizational problems were present in the first half of our study: In the last 3 years the scores were more stable than in the first 2 years. Changes in social stressors took place in the period from Time 2 to Time 4 and, again, stabilized in the last years. Thus, these results imply that there was little stability in individual differences across a long time frame.

Interindividual Differences Model

The interindividual differences model was tested by the spurious model. In Table 11 the goodness-of-fit measures for the spurious models are shown. In all cases the fit measures were poor. The

Table 8
Means, Standard Deviations, and Intercorrelations at Time 6

Subscale	*M*	*SD*	1	2	3	4	5	6	7	8	9
Stressors											
1. Job Insecurity	2.74	0.67	—								
2. Time Pressure	3.50	0.68	−.02	—							
3. Organizational Constraints	1.77	0.62	.11*	.09	—						
4. Social Stressors	2.02	0.72	.16**	.19**	.33**	—					
5. Uncertainty	2.21	0.64	.05	.33**	.34**	.51**	—				
Strains											
6. Depression	2.59	0.92	.25**	−.03	.24**	.29**	.25**	—			
7. Psychosomatic Complaints	2.19	0.77	.14*	.11	.08	.20**	.15**	.42**	—		
8. Irritation	3.16	1.09	.10	.11*	.25**	.27**	.19**	.42**	.36**	—	
9. Worrying	3.86	1.41	.12*	.24**	.07	.20**	.19**	.28**	.28**	.46**	—

Note. $N = 316$ (listwise deletion).
$^{*}p < .05$. $^{**}p < .01$.

Table 9
Correlation Matrix of Strain With Stressor Variables

		Depression						Psychosomatic complaints						Irritation						Worrying					
Stressor	Time	T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5	T6
Job insecurity	T1	.22*	.15*	.16*	.25*	.26*	.21*	.11*	.10	.11	.11	.11	.05	.17*	.08	.10	.07	.12	.09	.13*	.12*	.15*	.10	.08	.11
	T2	.22*	.19*	.19*	.22*	.22*	.17*	.16*	.12*	.13*	.18*	.14*	.08	.14*	.11*	.17*	.13*	.14*	.08	.14*	.11*	.15*	.10	.08	.09
	T3	.20*	.21*	.24*	.30*	.29*	.22*	.16*	.16*	.14*	.18*	.11*	.08	.17*	.09	.12*	.14*	.14*	.04	.09	.14*	.13*	.08	.03	.06
	T4	.24*	.17*	.15*	.28*	.23*	.17*	.15*	.15*	.13*	.22*	.18*	.13*	.13*	.12*	.14*	.17*	.14*	.08	.09	.10*	.07	.09	.04	.09
	T5	.29*	.16*	.16*	.25*	.24*	.19*	.19*	.13*	.15*	.21*	.17*	.18*	.19*	.06	.15*	.18*	.15*	.12*	.13*	.07	.07	.07	.04	.08
	T6	.23*	.19*	.22*	.26*	.25*	.28*	.14*	.11*	.13*	.18*	.11*	.16*	.12*	.03	.15*	.17*	.12*	.13*	.19*	.04	.08	.08	.02	.07
Time pressure	T1	.00	−.01	−.08	−.12*	−.10	−.07	.15*	.08	.10	.03	.09	−.08	.15*	.08	.05	.07	.08	.08	.31*	.27*	.20*	.23*	.26*	.14*
	T2	−.02	−.10*	−.07	−.09	−.04	.00	.15*	.10*	.14*	.14*	.16*	.09	.12*	.06	.02	.07	.09	.02	.31*	.28*	.27*	.34*	.24*	.18*
	T3	−.02	−.11*	−.09	−.09	−.04	−.06	.10	.06	.10*	.12*	.11*	.09	.10*	.05	.07	.06	.08	.05	.27*	.26*	.28*	.31*	.24*	.15*
	T4	−.07	−.14*	−.10*	−.13*	−.09	−.07	.07	.07	.06	.08	.09	.04	.04	.02	.02	.08	.05	.03	.20*	.18*	.19*	.31*	.23*	.18*
	T5	−.06	−.14*	−.12*	−.15*	−.08	−.12*	.08	.04	.06	.08	.10	.06	.02	−.01	−.05	.01	.05	.00	.17*	.17*	.14*	.24*	.25*	.20*
	T6	−.07	−.15*	−.13*	−.15*	−.15*	−.05	.06	−.02	.02	.04	.06	.07	.01	−.04	−.03	.01	.01	.10	.12*	.13*	.10*	.19*	.14*	.27*
Organizational problems	T1	.17*	.11	.18*	.05	.20*	.18*	.11	.00	.05	−.06	−.04	−.08	.09	.10	.09	.08	.11	.18*	.02	.01	.10	−.04	.05	.04
	T2	.13	.15*	.15*	.15*	.20*	.19*	.13	.08	.11*	.10	.05	.04	.11	.09*	.10	.15*	.11*	.13*	.04	.00	.00	.00	.09	.04
	T3	.08	.11*	.18*	.18*	.20*	.19*	.06	.08	.13*	.08	.11*	.06	.12	.11*	.18*	.19*	.22*	.18*	.11	−.02	.03	.00	.07	.02
	T4	.08	.11*	.19*	.23*	.22*	.22*	.08	.08	.08	.08	.07	.06	.10	.08	.17*	.21*	.19*	.17*	−.03	−.05	.01	.01	.05	.03
	T5	.06	.10*	.16*	.17*	.25*	.25*	.11	.06	.09	.05	.09	.07	.09	.12*	.15*	.15*	.18*	.22*	−.08	−.07	−.08	−.06	.04	.01
	T6	.04	.07	.14*	.15*	.19*	.26*	.08	.01	.10	.09	.03	.08	.14	.07	.14*	.17*	.14*	.25*	.07	.04	.09	.03	.06	.06
Social stressors	T1	.21*	.12*	.17*	.19*	.20*	.07	.21*	.03	.06	−.02	.09	.07	.27*	.16*	.19*	.20*	.14*	.21*	.17*	.10	.09	.14*	.05	.14*
	T2	.20*	.19*	.18*	.16*	.18*	.12*	.18*	.10*	.09	.05	.07	.08	.23*	.21*	.19*	.11*	.09	.11*	.14*	.07	.06	.05	.05	.04
	T3	.20*	.16*	.25*	.22*	.20*	.12*	.18*	.05	.10*	.06	.08	.08	.24*	.17*	.24*	.19*	.16*	.20*	.09	−.03	.06	.07	.04	.05
	T4	.19*	.11*	.25*	.29*	.21*	.19*	.11	.10*	.11*	.11*	.13*	.08	.16*	.12*	.20*	.24*	.17*	.17*	.03	.02	.05	.11*	.05	.07
	T5	.23*	.16*	.27*	.25*	.30*	.23*	.15*	.06	.14*	.11	.15*	.13*	.18*	.14*	.22*	.24*	.27*	.24*	.14*	.02	.08	.08	.14*	.12*
	T6	.25*	.15*	.24*	.25*	.18*	.29*	.18*	.05	.10*	.12*	.13*	.22*	.23*	.15*	.24*	.26*	.17*	.29*	.14*	.10	.15*	.16*	.11	.20*
Uncertainty	T1	.11*	.04	.08	.07	.17*	.14*	.11*	.11*	.08	.03	.10	.08	.21*	.20*	.16*	.17*	.19*	.18*	.23*	.11*	.13*	.08	.14*	.10
	T2	.15*	.08	.09	.09	.14*	.15*	.10	.15*	.12*	.09	.11*	.13*	.18*	.16*	.12*	.05	.06	.10	.21*	.10*	.05	−.01	.01	.06
	T3	.12*	.04	.10*	.11*	.17*	.16*	.09	.11*	.11*	.09	.10	.11*	.19*	.14*	.23*	.16*	.13*	.20*	.12*	.05	.10*	.02	.06	.14*
	T4	.12*	.01	.13*	.13*	.17*	.21*	.08	.10*	.09	.07	.04	.10	.16*	.06	.12*	.15*	.10	.13*	.12	.02	.02	.09	.11*	.15*
	T5	.10	.05	.15*	.07	.20*	.19*	.10	.08	.17*	.07	.10	.12*	.08	.08	.19*	.07	.12*	.13*	.14*	.02	.09	.03	.09	.11*
	T6	.12*	.07	.09	.12*	.16*	.24*	.14*	.03	.14*	.07	.10	.15*	.18*	.13*	.18*	.16*	.12*	.19*	.18*	.07	.13*	.03	.09	.19*

Note. N varies because of missing data (range N = 159–526, mean N = 345). T = time.
* $p < .05$.

Table 10
Goodness-of-Fit Measures for Measurement Models and Mean Stability Model

Model	Depression				Psychosomatic complaints				Irritation				Worrying			
	χ^2	*df*	AIC	CFI	χ^2	*df*	AIC	CFI	χ^2	*df*	AIC	CFI	χ^2	*df*	AIC	CFI
Null	6,908.50	276	7,079.00		16,485.87	1128	16,581.97		9,656.21	435	9,716.21		6,053.92	153	6,089.92	
1. Unconstrained	298.75	177	544.75	.982	1,369.00	699	1,777.00	.944	628.64	315	928.64	.966	125.07	75	317.07	.992
2. Equal factor loadings	311.00	190	531.00	.982	1,409.87	729	1,757.87	.943	652.30	335	912.30	.966	139.78	85	311.78	.991
Difference of 2 and 1	30.28[a]	17			40.87	30			23.66	20			14.71	10		
3. Equal loadings and intercepts	383.07	203	625.07	.973	1,469.29	758	1,843.29	.941	686.55	355	966.55	.964	161.71	95	349.71	.989
Difference of 3 and 2	72.07[a]	13			59.42[a]	29			34.25	20			21.93	10		
Mean stability																
4. Equal latent means	391.87	208	623.87	.972	1,494.44	763	1,858.44	.939	695.79	360	965.79	.964	178.33	100	356.33	.987
Difference of 4 and 3	8.80	5			25.15[a]	5			9.24	5			16.62[a]	5		

Note. $N = 448$ for depression; $N = 445$ for psychosomatic complaints; $N = 447$ for irritation; $N = 447$ for worrying. AIC = Akaike Information Criterion; CFI = comparative fit index.
[a] Chi-square difference test was significant ($\alpha = 0.01$).

hypothesis that all the relationships between stressors and strains can fully be explained by one stable construct has to be rejected.

Stressor–Strain Trend Model

The stressor–strain trend model was tested by the correlation of the stressor slope factor with the strain slope factor in the nonlinear growth model (again, see Figure 2) and the correlations displayed in the first column of Table 15. If we concentrate on the combinations of social stressors and uncertainty with all the strain variables, we notice that there were sizeable slope stressor–slope strain correlations. Out of the eight correlations, six were higher than .20 and two were higher than .30. This means that long-term changes in social stressors and uncertainty were accompanied with corresponding changes in the strain variables. Remarkably, the job insecurity slope factor had no sizeable correlation with any of the strain variable slope factors.

Reverse Causation Model

This model was tested by the correlation of the intercept strain with slope stressor in the nonlinear growth model (see, again, Figure 2). The correlations were by and large rather low (see the second column in Table 15); however, almost all were negative, which is directly counter to the drift model or the true strain hypothesis and in line with the refuge model or models with direct positive effects due to successful problem-focused coping.

Sleeper-Effect Model

This model was tested with the correlations of the intercept of the stressor with the slope of the strain in the nonlinear growth model (see, again, Figure 2), and the correlations are shown in the third column of Table 15. There is little evidence for sleeper effects because nearly all correlations were below .20, and instead of being positive, they were almost all negative.

Short-Term Reaction Model

The short-term reaction model could be well modeled as a hybrid model and could be tested by looking at the synchronous paths from stressors to strain variables. Table 16 shows the standardized regression coefficients of the solution presented in Table 11; many of them were significant. The strongest paths occurred for time pressure and worrying. Social stressors and uncertainty were related to all strain variables with similar magnitude. Organizational problems were related to the strain variables, except to worrying.

Discussion

We tested several stressor–strain models. First, the strain stability model has been shown to be wrong for the stability of individual differences of strains, but there was a high degree of stability of the means of strain variables. As predicted, meaningful differences in stressors could be detected across the 5-year period. Job insecurity peaked somewhat earlier than we predicted (at Time 2 and not at Time 3), but we anticipated the leveling off. After Time 2 job insecurity decreased, to remain at a more or less constant level. One has to keep in mind that job insecurity mea-

Table 11
Goodness-of-Fit Measures for Structural Models

	Depression				Psychosomatic complaints				Irritation				Worrying			
Stressor	χ^2	*df*	AIC	CFI	χ^2	*df*	AIC	CFI	χ^2	*df*	AIC	CFI	χ^2	*df*	AIC	CFI
Job insecurity																
Correlated[a]	669.54	315	1,029.54	.959	1,863.66	974	2,363.66	.936	1,007.06	499	1,413.06	.955	305.68	167	619.68	.982
Spurious[b]	1,413.06	354	1,635.06	.876	3,145.69	999	3,499.69	.846	2,352.33	533	2,618.33	.837	1,438.00	211	1,616.00	.840
Linear[c]	1,005.07	373	1,249.07	.927	2,238.52	1032	2,622.52	.914	1,333.55	557	1,623.55	.931	648.08	225	846.08	.945
Nonlinear[d]	811.64	365	1,071.64	.948	1,992.74	1024	2,392.74	.931	1,134.91	549	1,440.91	.948	431.82	217	645.82	.972
Hybrid[e]	765.11	363	1,029.11	.953	1,937.16	1022	2,341.16	.935	1,066.38	547	1,376.38	.954	362.41	215	580.41	.981
Time pressure																
Correlated	666.55	315	1,026.55	.958	1,947.28	974	2,447.28	.930	973.35	499	1,379.35	.957	268.49	167	582.49	.987
Spurious	1,675.44	367	1,871.44	.843	3,258.62	999	3,612.62	.837	2,328.94	533	2,594.94	.837	1,351.46	211	1,529.46	.851
Linear	837.13	373	1,081.13	.945	2,136.97	1032	2,520.97	.921	1,154.15	557	1,444.15	.946	472.38	225	670.38	.968
Nonlinear	770.34	365	1,030.34	.952	2,052.54	1024	2,452.54	.926	1,059.39	549	1,365.39	.954	367.75	217	581.75	.980
Hybrid	753.00	363	1,017.00	.954	2,029.58	1022	2,433.58	.927	1,035.88	547	1,345.88	.956	356.53	215	574.53	.982
Organizational problems																
Correlated	676.63	315	1,036.63	.956	2,052.97	974	2,552.97	.921	987.52	499	1,393.52	.955	322.68	167	636.68	.979
Spurious	1,441.52	367	1,637.52	.868	3,357.89	999	3,711.89	.827	2,239.29	533	2,505.29	.841	1,463.29	211	1,641.29	.828
Linear	1,172.26	373	1,416.26	.905	2,604.77	1032	2,988.77	.887	1,461.40	557	1,751.40	.917	835.17	225	1,033.17	.919
Nonlinear	796.22	365	1,056.22	.947	2,209.21	1024	2,609.21	.913	1,107.25	549	1,413.25	.948	472.86	217	686.86	.965
Hybrid	745.74	363	1,009.74	.953	2,179.29	1022	2,583.29	.915	1,085.47	547	1,395.47	.950	438.21	215	656.21	.969
Social stressors																
Correlated	663.27	315	1,023.27	.957	1,819.21	974	2,319.21	.937	927.77	499	1,333.77	.960	321.97	167	635.97	.979
Spurious	1,600.02	367	1,796.02	.847	3,089.33	999	3,443.33	.844	2,081.75	533	2,347.75	.854	1,462.15	211	1,640.15	.827
Linear	838.80	373	1,082.80	.943	1,979.97	1032	2,363.97	.929	1,071.41	557	1,361.41	.952	514.91	225	712.91	.960
Nonlinear	748.51	365	1,008.51	.953	1,880.50	1024	2,280.50	.936	982.49	549	1,288.49	.959	409.80	217	623.80	.973
Hybrid	795.27	363	1,059.27	.947	1,882.60	1022	2,286.60	.936	1,000.63	547	1,310.63	.957	439.00	215	657.00	.969
Uncertainty																
Correlated	648.18	315	1,008.18	.958	1,893.29	974	2,393.29	.932	983.17	499	1,389.17	.955	318.14	167	632.14	.979
Spurious	1,474.49	367	1,670.49	.860	3,102.29	999	3,456.29	.843	2,198.82	533	2,464.82	.844	1,405.80	211	1,583.80	.835
Linear	790.75	373	1,034.75	.948	2,051.73	1032	2,435.73	.924	1,137.93	557	1,427.93	.946	506.00	225	704.00	.961
Nonlinear	743.73	365	1,003.73	.952	1,980.67	1024	2,380.67	.929	1,082.57	549	1,388.57	.950	437.47	217	651.47	.970
Hybrid	742.52	363	1,006.52	.952	1,974.50	1022	2,378.50	.929	1,081.33	547	1,391.33	.950	444.38	215	662.38	.968

Note. $N = 448$ for depression; $N = 445$ for psychosomatic complaints; $N = 447$ for irritation; $N = 447$ for worrying. AIC = Akaike Information Criterion; CFI = comparative fit index.
[a] All constructs were allowed to correlate without further restrictions imposed. [b] One-factor model for all stressor and strain variables. [c] Linear growth model for stressor and strain variables. [d] Nonlinear growth model for stressor and strain variables. [e] Nonlinear growth curve for strains with stressors as time-varying covariates with a first order autoregressive structure.

sured the fear of becoming unemployed and should not be equated with the stressor of being unemployed itself. For a particular wave, the people who had lost their jobs, the items of this scale were not included. It might be that for some respondents with initial high scores on job insecurity, their fears turned out to be realistic and they indeed lost their jobs, which resulted in missing values for subsequent waves. Thus, selection effects can partly explain the changes in the means of job insecurity. The means of time pressure increased after Time 2, as expected, because Western production norms soon pervaded job requirements and set the pace at higher standards. The monotonic decrease of the means of organizational problems was also in line with our expectations. Although any transitional period will create its own organizational troubles, apparently the new work systems run more smoothly, and in the first year a decrease in organizational problems can already be detected.

Table 12
Means of Latent Strains for all Measurement Waves

	T1		T2		T3		T4		T5		T6	
Strain	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Depression	2.75	0.053	2.83	0.054	2.87	0.052	2.85	0.053	2.81	0.052	2.80	0.054
Psychosomatic complaints	1.57	0.097	1.62	0.098	1.67	0.100	1.70	0.101	1.67	0.099	1.69	0.100
Irritation	3.09	0.055	3.11	0.053	3.14	0.051	3.11	0.052	3.04	0.051	3.05	0.052
Worrying	3.70	0.080	3.74	0.080	3.92	0.075	3.93	0.075	3.90	0.075	3.92	0.075

Note. T = time.

Table 13
Means, Mean Differences, and t Tests for all Measurement Waves

Stressor and time period	$M\ t_i$	$M\ t_{i+1}$	M difference	SE[a]	t	df	p
Job insecurity							
T1–T2	2.855	3.000	−.140	.039	−4.127	300	.000
T2–T3	3.018	2.746	.273	.032	8.626	380	.000
T3–T4	2.729	2.668	.061	.031	1.987	334	.048
T4–T5	2.644	2.653	−.008	.027	−0.297	316	.766
T5–T6	2.635	2.684	−.049	.028	−1.778	305	.076
Time pressure							
T1–T2	3.215	3.225	−.010	.030	−0.343	335	.732
T2–T3	3.310	3.385	−.075	.031	−2.451	394	.015
T3–T4	3.416	3.508	−.092	.031	−3.021	332	.003
T4–T5	3.534	3.512	.022	.033	0.668	319	.505
T5–T6	3.526	3.545	−.019	.031	−0.608	307	.543
Organizational problems							
T1–T2	2.792	2.480	.312	.048	6.492	169	.000
T2–T3	2.319	2.012	.307	.031	9.837	357	.000
T3–T4	2.016	1.889	.128	.033	3.887	297	.000
T4–T5	1.883	1.794	.088	.030	2.939	289	.004
T5–T6	1.806	1.750	.056	.030	1.868	285	.063
Social stressors							
T1–T2	1.935	1.925	.010	.032	0.315	296	.753
T2–T3	2.000	1.986	.014	.033	0.429	365	.668
T3–T4	1.979	1.971	.008	.037	0.204	303	.839
T4–T5	1.945	1.969	−.024	.034	−0.702	295	.483
T5–T6	1.972	2.022	−.050	.038	−1.319	277	.188
Uncertainty							
T1–T2	2.357	2.279	.079	.036	2.211	293	.028
T2–T3	2.254	2.248	.056	.030	0.187	369	.852
T3–T4	2.263	2.223	.041	.037	1.087	301	.278
T4–T5	2.223	2.182	.043	.035	1.257	295	.210
T5–T6	2.197	2.222	−.025	.034	−0.731	272	.466

Note. T = time.
[a] Standard error of mean difference.

The stability of the means for social stressors was unexpected, because we had originally thought that social cohesion at the workplace would be reduced and competition would increase. The stressor uncertainty showed a small decrease. This was in line with our expectations, because more efficient organizations describe work requirements unambiguously, and this reduces role conflicts and uncertainty.

The mean changes in stressors suggest that East Germany gradually moved in the direction of a Western economy. There were higher work requirements, as indicated by more time pressure, and smoother and more efficient organization and task design, as reflected by lower organizational problems and lower levels of uncertainty. However, there were no signs of higher costs in the sense of higher levels of strains.

The means of the strain variables remained almost stable, but there was no stability of interindividual differences. This means that there were considerable changes in the relative positions of people (as indicated by moderate stability coefficients). Thus, people changed in different ways, with some people improving and some deteriorating (winners and losers of German unification).

The fact that there were mean changes in stressors but not in strain should not be interpreted to mean that there were no causal effects of stressors on strain. Because some stressors increased over time (e.g., time pressure) and others decreased (e.g., organizational problems), the net effect on strain may be the same.

Second, the interindividual differences model could be clearly rejected. There was no stable factor, be it negative affectivity or some other nonmeasured factor, that could explain all common variance between stressors and strains. Because we only tested for a complete interindividual differences model, there may still be some partial impact (e.g., negative affectivity) that was not captured in this model (Spector et al., in press).

Third, the stressor–strain trend model was supported by half of the possible combinations of stressors and strains (see Table 15, first column); uncertainty was related to all the strains (depression, psychosomatic complaints, irritation, and worrying). Uncertainty seems to be one of the most consistent and important stressors; this replicates other reports on the importance of role ambiguity and conflict (Kahn & Byosiere, 1992).

Social stressors showed slope–slope correlations above .20 with psychosomatic complaints and irritation. Time pressure was related to psychosomatic complaints and to worrying, and organizational problems were related to irritation and depression. Interestingly, job insecurity was not related to any of the strains within the constraints of this model.

Some of the slope–slope correlations were quite sizeable, such as social stressors with psychosomatic complaints (.34) and time pressure (.34) and uncertainty (.49) with worrying. More specifically, one can see a fit in the content of stressor and strain relationships. Worrying refers to worrying about work after working time (mood spillover); thus, there is a delayed effect of time pressure and uncertainty. One potential mechanism is that, with time pressure, a person does not have time to worry about things during working hours and, therefore, does it outside of work. Uncertainty was most highly related to worrying. Uncertainty leads to confusion and internal conflict that takes a long time to be resolved and, therefore, carries over into nonwork time.

It is important to note that these correlations cannot be interpreted to be due to some stable third variable (such as negative

Table 14
Stability Coefficients of Strains and Stressors

Strain and stressor	T1–T2	T2–T3	T3–T4	T4–T5	T5–T6	T1–T6
Strains						
Depression	.82	.78	.74	.77	.73	.56
Psychosomatic complaints	.87	.85	.80	.83	.82	.67
Irritation	.70	.72	.76	.70	.74	.59
Worrying	.73	.74	.73	.75	.68	.50
Stressors						
Job insecurity	.82	.75	.87	.94	.88	.44
Time pressure	.97	.88	.86	.87	.90	.58
Organizational problems	.73	.85	.83	.92	.95	.45
Social stressors	.95	.84	.78	.93	.89	.51
Uncertainty	.88	.93	.82	.97	.93	.60

Note. All time lags are 1 year, except T1–T2 lag (4 months) and T5–T6 lag (2 years). T = time.

Table 15
Correlations Between Intercepts and Slopes of Strains and Stressors

Strain and stressor	Slope stressor–slope strain	Intercept strain–slope stressor	Intercept stressor–slope strain
Depression			
Job insecurity	.122	−.007	.058
Time pressure	−.126	.051	−.064
Organizational problems	.267	−.026	−.101
Social stressors	.179	−.021	.065
Uncertainty	.250	−.033	−.067
Psychosomatic complaints			
Job insecurity	.118	−.066	.075
Time pressure	.247	−.124	−.083
Organizational problems	.154	−.247	−.020
Social stressors	.335	−.265	−.059
Uncertainty	.219	−.147	−.069
Irritation			
Job insecurity	.115	−.121	−.033
Time pressure	.143	−.041	−.125
Organizational problems	.207	−.005	−.126
Social stressors	.250	−.133	−.087
Uncertainty	.206	−.163	−.161
Worrying			
Job insecurity	−.086	−.053	−.058
Time pressure	.343	−.180	−.293
Organizational problems	.080	.098	−.107
Social stressors	.158	−.079	−.058
Uncertainty	.493	−.194	−.229

Note. Estimates are taken from the nonlinear latent growth models with correlated residuals.

affectivity), because only the change part of stressors and strains is related in the slope–slope correlation; the constant part is statistically held constant. From this perspective, the size of the correlations is quite high.

An alternative explanation for stressor–strain relations is an overlap in the item content of stressor and strain scales (cf. "the triviality trap"; Kasl, 1978). But an inspection of the items of these scales led to the conclusion that this was not the case.

Fourth, the models that assume reverse causation were tested as latent growth curve and not as hybrid models. The hybrid model, the best fitting model for most stressor–strain combinations, did not allow testing for lagged effects of the intercept parameter of the strain growth curve on the stressor covariates. The drift model was not supported. Reverse causation models, which hypothesized reduced stressors as a result of prior strain levels, were in line with the results. Both positive selection mechanisms as well as positive direct effects can explain this result. Thus, the refuge model was supported. Since there was a radical change situation, many job movements could occur within a short time. Therefore, people with high strain found jobs with less stressors, and people with low strain found jobs with more challenges. Thus, a person with a high degree of psychosomatic complaints attempted to find a job with less social and organizational stressors. However, the effects were quite small and should not be overinterpreted. Additionally, sev-

Table 16
Regression Coefficients for the Regression of the Strain Variables on the Stressors in the Hybrid Models

	Depression						Psychosomatic complaints						Irritation						Worrying					
Stressor	T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5	T6
Job insecurity	.14[a]	.15[a]	.18[a]	.19[a]	.21[a]	.21[a]	.04	.08[a]	.12[a]	.14[a]	.17[a]	.15[a]	.06	.08[a]	.09[a]	.09[a]	.09[a]	.09[a]	.04	.06	.05	.01	−.01	−.01
Time pressure	−.01	.01	−.02	−.05	−.06	−.07	.11[a]	.11[a]	.10[a]	.09[a]	.06	.07[a]	.12[a]	.12[a]	.13[a]	.11[a]	.08	.09[a]	.37[a]	.35[a]	.37[a]	.33[a]	.29[a]	.29[a]
Organizational problems	.17[a]	.20[a]	.22[a]	.25[a]	.24[a]	.23[a]	.10[a]	.12[a]	.15[a]	.16[a]	.14[a]	.14[a]	.10[a]	.13[a]	.15[a]	.17[a]	.17[a]	.15[a]	.04	.05	.07	.05	.03	.04
Social stressors	.17[a]	.20[a]	.23[a]	.28[a]	.30[a]	.31[a]	.16[a]	.19[a]	.22[a]	.24[a]	.24[a]	.25[a]	.18[a]	.24[a]	.25[a]	.26[a]	.30[a]	.30[a]	.13[a]	.13[a]	.17[a]	.18[a]	.17[a]	.18[a]
Uncertainty	.15[a]	.15[a]	.15[a]	.16[a]	.18[a]	.19[a]	.12[a]	.14[a]	.16[a]	.15[a]	.16[a]	.16[a]	.21[a]	.20[a]	.21[a]	.17[a]	.16[a]	.18[a]	.25[a]	.23[a]	.25[a]	.22[a]	.23[a]	.24[a]

Note. Regression coefficients were taken from LISREL's completely standardized solution. N = 448 for depression; N = 445 for psychosomatic complaints; N = 447 for irritation; N = 447 for worrying. T = time.
[a] $z > 1.96$ (based on unstandardized solution).

eral reverse causation mechanisms might be valid only for subgroups, and this contributes to only small correlations.

Fifth, the sleeper-effect model was not supported. A methodological problem in detecting lagged effects is that the presumed causal agents are constantly changing as well. Determining the exact time length of the lagged effects is an unresolved methodological problem in longitudinal research, especially if both short-term and long-term effects are present.

Sixth, the short-term reaction model is well supported by the results of the hybrid models. In nearly every case, there were significant relationships between stressors and strains (the only real exceptions being relationships of time pressure with depression and organizational problems and job insecurity with worrying. For some stressors, the effects were quite high and suggest a specificity effect. For instance, the strongest synchronous effects were detected for the relationship of the stressor time pressure with worrying (with correlations around .33), but time pressure was unrelated to depression. Time pressure does not depress people, but makes them active at work. However, they worry about the job after working hours. General effects on strains were noticeable for social stressors and uncertainty. Note that the latent growth curve was partialled from the strain variables. Thus, the results of Table 16 really present the immediate strain reactions to the stressors, holding the slow moving trait change (the overall trend) for each individual constant.

The overall results can be interpreted in this way: There are two effects side by side. One is the overall relationships between individual trends in stressors and strains (stressor–strain trend model). In a way, this reflects the overall long-term effect of stressors on the slowly changing component of strain (this has been called *trait component* by Nesselroade, 1991). The other effect is the short-term reaction effect, which means that there is a direct and immediate effect of stressors on strains (synchronous). This is unrelated to the general trend and, therefore, is to be interpreted as a clear state effect. This means that both components of strain—in Nesselroade's terminology, state and trait—are affected by the stressors.

As with any study, our research also has some limitations. One relates to the issue of causality. Although we used a longitudinal study, the stressor–strain trend model cannot be convincingly interpreted causally. One prerequisite for interpreting something as causal is the time order effect. However, for example, the slope–slope correlations give up the time order because they look at the general trends of stressors and strain over the full time range. Thus, these correlations can also be the result of a causal effect of strain on stressors or a third variable explaining the variance in both slope factors. The causal argument can be maintained more strongly for the hybrid model that we used to test the short-term reaction model. Here the intercept and the slope factor of the dependent variable strain were partialled out, which means that there is some indication for a causal influence of the stressor on strain even though the effect was synchronous.

A second limitation is that we could not discriminate between subgroups for which differential models may hold (Frese & Zapf, 1988). Although this is true of most studies in the field, it is potentially possible to use growth curve models for multiple groups. However, both sample size limitations and software restrictions forbade using this procedure in this study. Promising software developments have been announced, making it possible to integrate latent class analysis and structural equation modeling (Muthén, in press).

The strengths of this study should not be overlooked. There are very few stressor–strain studies with more than three waves in the literature (Zapf et al., 1996). There is no doubt that this is a unique study in this regard. Another feature is that it took place in a unique historical period. From one perspective this may be a limitation, because it may imply that one cannot generalize the results. But from another perspective it means that one can model complex relationships in a radical change situation more easily because more changes happen overall, therefore speeding up the processes. Thus, similar to the laboratory situation, the manipulation is strong and compressed in time (Moeller & Strauss, 1997).

Another design feature is that we used multiple measures of stressors and strains. This was particularly important for the description of the mean changes of stressors in East Germany, because we could show that there was a characteristic picture of some stressors increasing during the time of the study, some stressors decreasing, and one not changing at all.

Another strength relates to our use of the growth curve models. There are two advantages. We could look at the long-term changes from an overall trend point of view (trait perspective). Moreover, it was possible to differentiate the trait and the state perspective on strain, because we could look at the immediate effects of stressors on strain and at the long-term trends of the relationships between stressors and strains. We found that there were stressor–strain relationships appearing for different time frames side by side. This would have gone undetected with alternative approaches (e.g., with an autoregressive model approach).

Another advantage of the growth curve analysis is that some of the relationships are much stronger than the relationships shown by the zero-order relationships of the stressor and strain variables (although even these relationships were already disattenuated, because the strain variables were latent).

One important contribution of this article is its analysis strategy. To our knowledge, both factor models within a growth curve approach and hybrid models are infrequently or never used in the literature. The use of the factor models made it possible to test for measurement equivalence over time, to ensure that the meaning of the latent constructs remained the same. The advantage of the hybrid model was that we could adjust the growth curves for nontrendlike influences. Introducing time-specific determinants into the model makes latent growth curve modeling a more flexible strategy and partly compensates for the lack of stochastical variation that presumably is a part of many psychological developmental processes (cf. Bock, 1991, p. 127).

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Appendix

Short Introduction of Latent Growth Curve Models

In the past decade, important improvements have been made in the statistical modeling of longitudinal data. One important class is the random coefficient model and the structural equation modeling (SEM) variant, which is called the latent growth curve model.

Good introductions of latent growth curve models already exist (see Curran, in press; MacCallum, Kim, Malarkey, & Kiecolt-Glaser, 1997; Muthén, 1997; Muthén & Curran, 1997; and Willett & Sayer, 1994, 1995). However, a short explanation is given here.

The latent growth curve model distinguishes a within-person level (individual level or Level 1) and a between-person level (group level or Level 2). It is easiest to explain the model by introducing the individual level first. In Figure A1, some data points for an arbitrary participant are plotted. On the *x*-axis, the time dimension is displayed. If a straight line can reasonably approximate the data, we can specify a linear growth curve:

$$\eta_{ti} = \beta_{0i} + \beta_{1i}t + \varepsilon_{ti}, \tag{A1}$$

(Appendix continues)

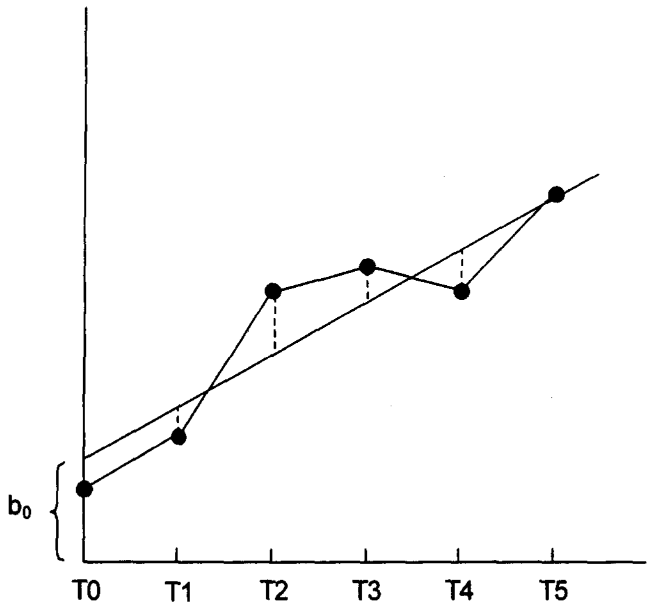

Figure A1. Linear growth curve for a single participant. T = time. b_0 = intercept.

where η_{ti} represents the true score at time t for person i, β_{0i} is the person's intercept, β_{1i} is the person's slope, t is the time of assessment, and ε_{ti} is the person's residual at time t.

If the data are time-structured (both the number and the spacing of all assessments is the same for all participants), we can extend the model to include multiple participants. This is the between-person level of the model. In Figure A2 (top panel), the growth curves for four participants are depicted and the bold line represents the population growth curve. The last lines differ in their starting points as well in their slopes. The introduction of multiple participants also creates variations in which participants differ both in their intercepts and in their slopes. In the SEM framework, the intercepts and slopes are treated as latent variables, and hence, in a linear model the observed scores of each participant can be explained by an intercept factor score, a slope factor score, and a time-specific residual. Accordingly, we change our notation and replace β_{0i} with η_{0i} and β_{1i} with η_{1i} to express that these are treated as latent factors (intercept and slope factor). The individual slopes and intercepts are expressed as deviations from the population intercept (denoted as μ_0) and slope (denoted as μ_1), respectively, and therefore we can write:

$$\beta_{0i} = \mu_0 + \eta_{0i} \tag{A2}$$

and

$$\beta_{1i} = \mu_1 + \eta_{1i}. \tag{A3}$$

By substituting Equations A2 and A3 we can formulate a single equation:

$$\eta_{ti} = \mu_0 + \eta_{0i} + (\mu_1 + \eta_{1i})t + \varepsilon_{ti} \tag{A4}$$

or, equivalently,

$$\eta_{ti} = \mu_0 + \mu_1 t + (\eta_{0i} + \eta_{1i}t + \varepsilon_{ti}). \tag{A5}$$

The last formulation shows that the model can be specified as two additive components: a fixed part (parameters without subject indices) and a random part (subject indices added; denoted as i). If we take the expectancies of Equation A5, we find that these can be expressed by the parameters of the fixed part (the mean intercept and the mean slope). The variances and covariances of Equation A5 refer to the random part, and the parameters are the variance of the intercept factor, the variance of the slope factor, the covariance between both factors, and the variances of the time-specific residuals.

The model described by Equation A5 is essentially a factor model, and in a linear growth model all factor loadings (denoted as ts) are fixed. It is convenient to fix the factor loading for the first measurement occasion at the value of zero. In this case the intercept represents the expected initial value for a particular participant. The other factor loadings are then fixed to values proportional to the time elapsed from the first measurement occasion. A graphical model is shown in Figure A3. Note also that to

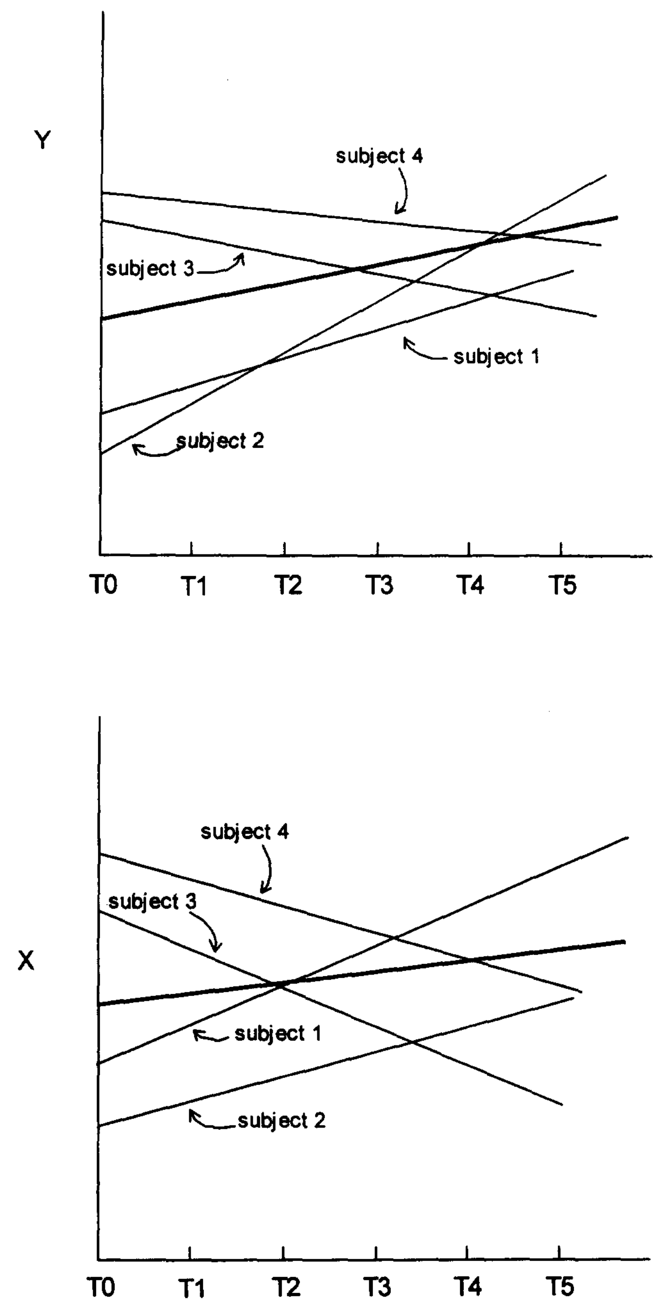

Figure A2. Four individual linear growth curves and the population growth curve (bold) for variable y (shown in top panel) and for variable x (displayed in the bottom panel). T = time.

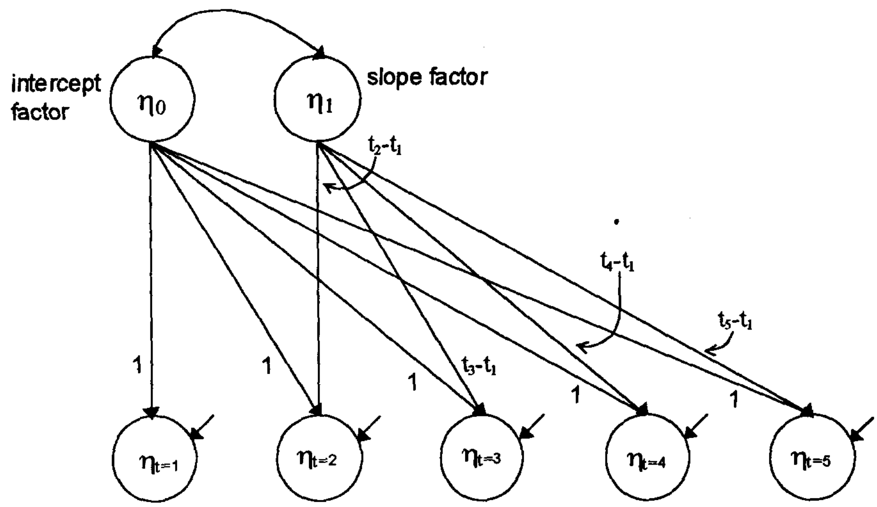

Figure A3. Latent linear growth curve model specified as a factor model with all factor loadings fixed (note that the first slope factor loading is fixed to zero).

estimate the parameters that belong to the fixed part of the model, the vector of observed means has to be supplied along with the covariance matrix.

From the perspective of an applied researcher, it is more interesting to go beyond the description of individual change and include predictors for the differences in individual trajectories. For instance, if two variables have been measured on several occasions, it might be interesting to relate both developments. In these multivariate or crossdomain growth curve models, hypotheses can be formulated in which characteristics of one growth curve may have predictive value for characteristics for another growth curve. For instance, participants who have a steeper slope in variable x may also tend to have higher slopes on variable y. In this case, changes in both processes are related. Alternatively, participants who tend to have higher initial values on variable x may have, on average, higher slopes on variable y. This is displayed in Figure A2 (variable y is displayed in the top panel, and variable x is shown in the bottom panel). Also, constant background variables may be used for explaining differences in growth.

If a linear function is not appropriate to describe the data, quadratic or even higher order polynomials can be used instead. However, Rogosa, Brandt, and Zimowski (1982) and Willett (1989) remarked that in many instances a linear function might be an acceptable approximation. There are several interpretations for the existence of time-specific residuals. First,

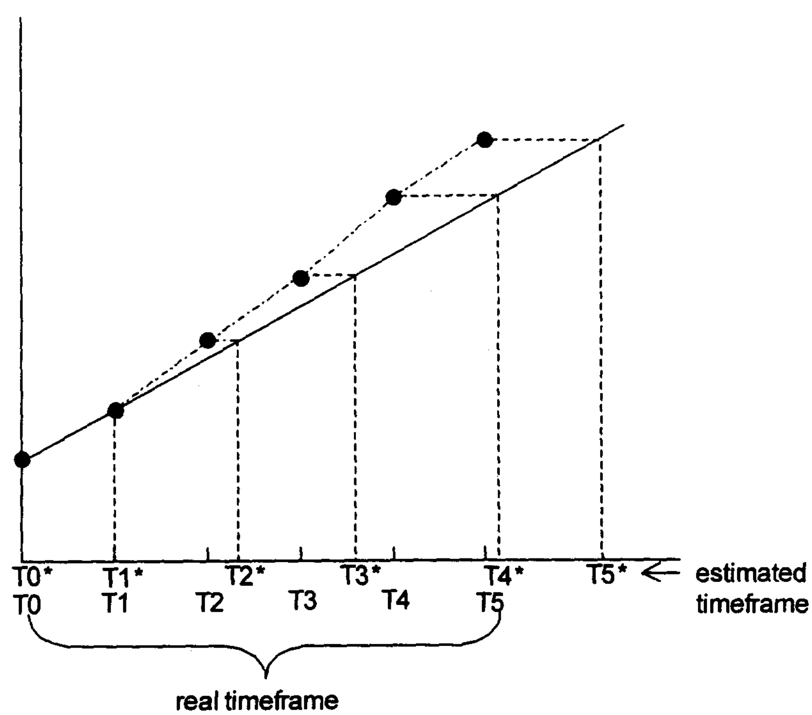

Figure A4. Nonlinear growth curve with free estimated factor loadings for Time 2–Time 5. T = time.

there may be measurement error, but in the case that a measurement model is included, the growth curve refers to the true variates. A second interpretation is that the presence of states is responsible for the more irregular short-term changes. Kenny & Campbell (1989) argued that many psychological constructs probably have both traitlike and statelike aspects. The use of growth curves enables a decomposition of intraindividual trait changes (Nesselroade, 1991) and state changes (see also McArdle & Woodcock, 1997). A third interpretation of the residual variance is related to approximation error: The model is somewhat misspecified. This might be caused by variables that are omitted from the model. After the introduction of time-varying covariates to the model, the chosen growth function may better describe the underlying development over time (after controlling for other time-specific influences). Therefore, there are many explanations of why the changes in many data sets seem somewhat erratic, but it may very well be that the underlying developments over time are much smoother, and individual linear trend lines may give a useful approximation of the developmental process.

An alternative way to specify a nonlinear model is to estimate some of the factor loadings (except those necessary for identification). Statistically, a linear model is still estimated, but the nonlinear interpretation emerges by relating the estimated factor loadings to the real time frame. This is displayed in Figure A4. In this figure, the first factor loading is fixed at zero and the second loading is also fixed (e.g., at the value of 1). Apparently, by stretching and shrinking the time axis, one can simulate an acceleration and deceleration of the time dimension, again assuming a constant rate of change. Therefore, a new time frame is estimated and the transformation to the real time frame gives the nonlinear interpretation. For instance, the estimate of Time 2 is larger than the real time elapsed, so apparently more positive change has taken place than would be predicted linearly.

A complication may arise in models containing two or more growth curves. If these curves are all specified as nonlinear by freeing some of the factor loadings, it is not possible to test the significance of some growth curve parameters. This can be explained as follows: For each growth curve at least two factor loadings have to be fixed for identification purposes. However, which loadings one chooses and to which values the loadings are fixed determine the z-values of some of the growth parameter estimates in these multivariate nonlinear latent growth curve models. Because the fixation schemes of the factor loadings of the growth curve models are arbitrary to some extent, the unstandardized estimates and the standard errors are arbitrary as well (and their ratio is not constant). Fortunately, the correlations between the intercept and slope factors are not influenced by fixation schemes with the same choice for the zero point of the time axis. However, a shift in the time axis by choosing a different zero point leads to additional complications (Rovine & Molenaar, 1998).

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