Memory and Depressive Symptoms are Dynamically Linked among Married Couples: Longitudinal Evidence from the AHEAD Study

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Abstract

This study examined dyadic interrelations between episodic memory and depressive symptom trajectories of change in old and advanced old age. We applied dynamic models to 10-year incomplete longitudinal data of initially 1,599 married couples from the Study of Asset and Health Dynamics Among the Oldest Old (AHEAD; M_{age} = 75 years at T1). We found domain-specific lead-lag associations (time lags of two years) among and between spouses. For memory, better performance among husbands protected against subsequent memory decline among wives with no evidence of a directed effect in the other direction. For depressive symptoms, wives' scores predicted subsequent depression increase and memory decline among husbands. Possible individual covariates (age, education, functional limitations) and spousal covariates (length of marriage, number of children, and whether or not the couple remained intact over the study period) did not account for differential lead–lag associations. Our findings of antecedent– consequent relations between wives and husbands are consistent with lifespan notions that individual development both influences and is influenced by contextual factors such as close social relationships.

Keywords

dyad; spouses; successful aging; dynamic modeling; growth curve modeling

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Lifespan psychological research has long proposed that individual development both actively influences and is influenced by contextual factors such as significant others (P. B.

Baltes & Staudinger, 1996; M. M. Baltes & Carstensen, 1998; Bronfenbrenner, 1979; Cairns, Elder, & Costello, 1996; Zajonc & Markus, 1975). Marriage partners may represent a key contextual factor given that late-life marriages are characterized by considerable closeness and spouses typically share many joint experiences (Antonucci & Akiyama, 1991; Lang, 2001; Meegan & Berg, 2002). The current study explores the dynamic (i.e., time ordered) interplay between age-related changes in two central domains of functioning, cognition and well-being, from a dyadic perspective. This is an important extension of past research because studies on unrelated individuals in old age typically document weak to moderate correlations of levels and changes across the two domains (Carmelli, Swan, La Rue, & Eslinger, 1997; Isaacowitz & Smith, 2003; Luszcz, 1992; Wetherell, Reynolds, Gatz, & Pedersen, 2002), but the mechanisms underlying such associations are not well understood. We propose that explicitly targeting how significant others such as marriage partners may affect individual developmental trajectories will illuminate the dynamic nature of such associations. By applying dynamic models to 10-year longitudinal data of initially 1,599 married couples from the AHEAD study, we simultaneously model longitudinal changes in indicators of cognition and well-being and test hypotheses about their dynamic interrelationships over time, both among wives and husbands as well as between spouses.

In a first step, we review the extant literature on cognition–well-being associations as derived from research on unrelated individuals. In a second step, we illustrate how studying individual development in general, and cognition–well-being associations in particular, can benefit from a dyadic perspective. Finally, we propose that innovative applications of contemporary methodology can be used to study dynamic cognition–well-being relations from a dyadic angle.

Dynamics of Cognition and Well-Being in Old Age

Research focusing on cognitive functioning and well-being in samples of unrelated individuals emphasizes the central role of these two domains of functioning in old age and how they are inherently involved in processes of adaptation and successful aging (Baltes & Baltes, 1990; Rowe & Kahn, 1997; Ryff & Singer, 1998). As to the direction of how aspects of cognition and well-being might be dynamically related, various unidirectional, bidirectional, and third-variable accounts have been advanced. One unidirectional position argues that low cognitive functioning may limit an individual's capacity to manage the routines of everyday life and thereby act as a risk factor for well-being decline (cf. Maier & Smith, 1999; see also Schmeichel, Volokhov, & Demaree, 2008). Another unidirectional position posits that the effect may go in the opposite direction with depressive thoughts occupying mental capacity, thereby resulting in less-than-optimal cognitive performance (e.g., Bäckman, Hill, & Forsell, 1996). A third position proposes a bidirectional relation according to which cognition and well-being constitute separable, yet reciprocally interacting sectors of the "good life" (Lawton, 1983). Finally, cognition-well-being relations may merely reflect the effects of an underlying third variable that relates to both domains (e.g., health constraints: Mroczek & Spiro, 2005; Verhaeghen, Borchelt, & Smith, 2003).

The overall empirical evidence concerning cognition–well-being relationships in individuals is less than conclusive. However, the application of methodological advances that capture

processes as they unfold over time has helped disentangle the potentially time-ordered nature of such associations. Specifically, recent evidence suggests that, at least in later adulthood and old age, well-being might predict cognitive decline rather than the other way around. For example, Chow, Hamagami, and Nesselroade (2007) examined moment-to-moment changes in an experimental setting and reported that older adults manifested unidirectional dynamics where higher negative emotions in a given trial predicted lower cognitive performance two trials later. On a vastly different time metric, Gerstorf, Lövdén, Röcke, Smith, and Lindenberger (2007) examined long-term longitudinal changes among 70- to 100-year olds of the Berlin Aging Study and reported that well-being influenced subsequent decline in perceptual speed over time lags of two years with no evidence for a directed effect in the other direction. Based on these findings gathered from an explicit consideration of dynamic associations, we expect a directed effect from depressive symptoms (as a reversed indicator of well-being) onto subsequent long-term longitudinal change in cognitive functioning among the husbands and wives in the present study.

A Dyadic Perspective

In addition to examining individual-level relationships concerning cognition–well-being associations over time, the present study also addresses potential dynamics between developmental trajectories of husbands and wives. We therefore extend past research based on unrelated samples by targeting the degree to which husbands' functioning in one domain relates to wives' functioning in the same or another domain, and vice versa. Conceptually, such spousal interrelations represent one important instantiation of contextual influences on developmental trajectories (Baltes & Staudinger, 1996; Hoppmann & Gerstorf, in press). Examining spousal interrelations in elderly couples is especially interesting because older spouses are typically very close and emotionally invested in their relationship (Carstensen et al., 1996; Lang, 2001), and they are often long-term teams and share an extended history of joint experiences (Dixon, 1999; Meegan & Berg, 2002). Based on these lines of reasoning, we expect considerable spousal interrelations in such key domains of functioning as well-being and cognition. These interrelations can take various forms and benefit each individual spouse, but they can also hamper optimal functioning in the respective spouse. For example, age-related declines in cognitive functioning and mental health may require spousal tasks to be re-allocated, the learning of new skills as one spouse takes over tasks from the other spouse, or the adoption of a caregiver role by one spouse. These conceptual arguments map onto empirical reports from elderly couples documenting spousal interrelations in central life domains including activities, cognition, well-being, and health (Carstensen et al., 1995; Dufouil & Alperovitch, 2000; Gerstorf, Hoppmann, Anstey, & Luszcz, in press; Gruber-Baldini, Schaie, & Willis, 1995; Hoppmann, Gerstorf, & Luszcz, 2008; Skarupski et al., 2006; Townsend, Miller, & Guo, 2001).

In our study, the longitudinal couple data set allows us to go beyond past research on spousal interrelations by targeting dynamic lead-lag associations in indicators of two key domains of functioning, cognition (episodic memory) and well-being (depressive symptoms). Previous studies in the cognitive domain indicate that spouses become increasingly similar in old age (Gruber-Baldini et al., 1995) and achieve better outcomes when they collaborate with their spouse as compared to individual performance (Gould,

Kurzman, & Dixon, 1994). Interestingly, past research also suggests that spousal interrelations in cognition may be unidirectional. For example, reports from the Seattle Longitudinal Study (Gruber-Baldini et al., 1995) indicate that husbands' performance on an inductive reasoning task positively influenced their wives' inductive reasoning performance seven years later, but not vice versa (see also Gerstorf et al., in press; Strawbridge, Wallhagen, Thai, & Shema, in press). We thus acknowledge that spousal interrelations in cognition may not be symmetric across partners, but that one partner may lead subsequent change in the other. We examine such gender-specificity of spousal interrelations in cognition in terms of the direction and size of possible lead-lag associations and determine whether husbands also predict subsequent change in their wives' cognitive functioning in the present sample.

Conceptual notions about the central role of affective experiences in marriages, particularly in old age (Carstensen et al., 1996; Gottman & Notarius, 2000), as well as empirical reports of spousal similarities (Bookwala & Schulz, 1996; Goodman & Shippy, 2002; Sandberg & Harper, 2000; Tower & Kasl, 1996; Townsend et al., 2001) both suggest spousal interrelations in emotional functioning. Although these may exist for both positive and negative affect qualities, negative emotions appear to be more contagious (Gottman & Notarius, 2000; Larson & Almeida, 1999). Spousal interrelations in well-being and depression may also be gender specific and unidirectional; changes in well-being can originate in one spouse and be transmitted to the other partner. Conceptually, it has been argued that emotional transmission is more likely from husbands to wives rather than vice versa (Larson & Almeida, 1999). Relative to men, women may be more responsive to their partners' well-being, have more permeable boundaries, and have less power in the relationship. All these proposed factors likely contribute to husbands exerting a bigger influence on wives' well-being, rather than the other way around. Empirical reports addressing the gender-specificity of spousal interrelations in affective experiences in old age are primarily based on cross-sectional data (Peek, Stimpson, Townsend, & Markides, 2006; Stimpson, Peek, & Markides, 2006). In the current study, we extend these reports by exploring longitudinal gender-differential dynamics between elderly spouses and test if unidirectional predictive effects exist from husbands to wives.

To provide a meaningful interpretation of spousal dynamics in old age, a number of individual and spousal factors need to be taken into account. Specifically, our models will account for individual differences in age, education, and functional limitations to ensure that our findings do not simply reflect well-documented gender differences in (or direct effects of) these additional variables. In a subsequent step, we will also include spousal factors (length of marriage, number of children, and whether or not the couple remained intact over the study period) in order to target the possible role of these marriage characteristics for spousal dynamics in old age. We borrow our terminology from the dyadic literature (Cook & Kenny, 2005) and refer to associations of an individual's characteristics with his or her own score on a given variable as *actor effects* (i.e., intra-spouse effects) and with the partner's score on a given variable as *partner effects* (i.e., across-spouse effects). Because the two partners in a heterosexual marriage are different from one another and should not be

treated as indistinguishable for theoretical reasons, we model gender-specific actor and partner effects and test if similar relationships emerge in husbands and wives.

A Dynamic Model of Dyadic Interrelations

From a methodological perspective, examining time-ordered interrelations between partners is analogous to the study of lead-lag associations between domains of functioning. For the purpose of the present study, we use a dynamic modeling tool, the dual change score model (DCSM; McArdle & Hamagami, 2001). This model has successfully been used to evaluate time-ordered developmental hypotheses of associations between variables of fluid and crystallized intelligence (Ferrer & McArdle, 2004; Finkel, Reynolds, McArdle, & Pedersen, 2007; Ghisletta & Lindenberger, 2005), social participation and cognition (Lövdén, Ghisletta, & Lindenberger, 2005), brain structure and cognition (McArdle et al., 2004), and well-being and cognition (Gerstorf et al., 2007). The DCSM thus promises to be a highly valuable tool to investigate temporal dynamics between possible antecedents and outcomes of developmental change (cf. Lövdén, Li, Shing, & Lindenberger, 2007). In the current study, we use a version of a DCSM to examine dynamic associations between two spouses rather than examining dynamic associations between domains of functioning in unrelated individuals (see also Gerstorf et al., in press; Hamagami, McArdle, & Fisher, 2006; McArdle, Hamagami, Kadlec, & Fisher, 2007). Specifically, we treat the couple as the unit of analysis and simultaneously model longitudinal changes in facets of well-being and cognition for both wives and husbands. This allows us to subject specific competing hypotheses about the nature of their dynamic interrelationships over time to empirical testing. For example, the DCSM allows us to empirically examine whether husbands' cognitive functioning is predictive of subsequent decline in their wives' cognitive performance. In addition, we can compare this test against models testing alternative hypotheses, for example, that wives' cognitive performance precedes and predicts cognitive decline in husbands. These competing dynamic hypotheses will be tested at the intra-spouse level (e.g., well-being – cognition among wives) as well as at the across-spouse level, both within domains (e.g., cognition among wives – cognition among husbands) and across domains (e.g., well-being among wives – cognition among husbands).

For our study, we selected a word-recall test of episodic memory as a measure of cognitive functioning because it represents a powerful indicator of cognitive decline in old and advanced old age and has good psychometric properties (McArdle, Fisher, & Kadlec, 2007). To index well-being, we used the widely established Center for Epidemiological Studies-Depression Scale (CES-D; Radloff, 1977). The CES-D scale primarily assesses emotional-affective rather than cognitive-evaluative aspects of well-being, predominantly depressive symptoms, unpleasant affect, and mood.

Aims of the Present Study

This study attempts to examine dynamic interrelations in cognitive and emotional development between spouses in old and advanced old age. Using 10-year longitudinal data of initially married 1,599 couples from the AHEAD study (M_{age} = 75 years at T1), we ask three sets of questions. In a first step, we examine lead-lag *actor* or intra-spouse effects over successive two-year intervals by empirically determining whether unidirectional or

bidirectional accounts best describe longitudinal memory–depression associations among wives and husbands: Testing unidirectional accounts, we ask whether level of memory predicts subsequent change in depressive symptoms or whether it is level of depressive symptoms that predicts change in memory. We also investigate bidirectional accounts that both lead-lag dynamics exist, be they of equal size or not.

In a second step, we consider lead-lag *partner* or across-spouse effects by exploring whether level of functioning of one partner in one domain predicts subsequent two-year change of the other partner in the same or a different domain. Drawing from evidence on emotional transmissions in middle-aged families, we expect unidirectional predictive effects of husbands for wives rather than vice versa both within and across the memory and depression domains.

In a final step, we introduce spousal covariates into our model (in addition to individual covariates included in all models) in order to examine if time-lagged relations are due to marriage characteristics. The variables targeted include age, education, and functional limitations as individual difference factors, as well as length of marriage, number of children, and whether or not the couple remained intact over the study period as spousal factors.

Method

A four-variable DCSM was fitted to six waves of 10-year longitudinal data (1993–2004) from initially married couples in the Asset and Health Dynamics Among the Oldest Old study (AHEAD). Descriptions of the larger AHEAD study, its design, participants, variables, and assessment procedures can be found in McArdle et al. (2007), Soldo, Hurd, Rodgers, and Wallace (1997), and Townsend et al. (2001). Select details relevant to the present study are given below.

Participants and Procedure

The total AHEAD sample (N = 8,222) represented a probability sample of households in the contiguous US of non-institutionalized adults aged 70 and older (i.e., born in 1923 or earlier; 74+% response rate). If more than one member of a sampled household was born pre-1924, one of them was randomly selected; and if that individual was married or living with a partner, the spouse or partner was also selected regardless of the age of that person. In our study, we included all married and co-residing couples with valid data on the variables of interest in 1993 (N = 1,599 couples or 3,198 individuals, 90+% White). At baseline assessment, couples were married for an average of 44.82 years (SD = 14.49; range: 1–77 years) and had an average of 2.99 children (SD = 2.07; range: 0–10). Relative to the remaining AHEAD sample, participants in the couple subsample were younger, 74.04 vs. 77.96 years, F (1, 8218) = 698.8; reported fewer depressive symptoms, 1.23 vs. 2.00, F (1, 7378) = 275.7; and performed better on memory, 8.40 vs. 7.15, F (1, 7192) = 186.7, all p's < .001.

Interviews with participants aged 70 to 79 years were primarily conducted over the phone, whereas those aged 80 and older were generally interviewed in person. Targeted

investigations found very few systematic differences between modes of assessment (Herzog & Rodgers, 1988). Over time, the same versions of the tests were administered. We use couple data from six waves of longitudinal assessments spanning 10 years: baseline in 1993 (T1; n_{wives} = 1,599, $n_{husbands}$ = 1,599); 1995 (T2; n_{wives} = 1,404, $n_{husbands}$ = 1,328) 1998 (T3; n_{wives} = 1,237, $n_{husbands}$ = 1,068); 2000 (T4; n_{wives} = 1,097, $n_{husbands}$ = 879); 2002 (T5; n_{wives} = 949, $n_{husbands}$ = 674); and 2004 (T6; n_{wives} = 845, $n_{husbands}$ = 549).[1] T2 occurred on average 2.00 years (SD = 0.28), T3 4.24 years (SD = 0.44), T4 6.34 years (SD = 0.48), T5 8.53 years (SD = 0.50), and T6 10.43 years (SD = 0.50), respectively, after T1. By T2, T3, T4, T5, and T6, 6, 16, 26, 36, and 44%, respectively, had deceased; these mortality hazards are lower than in the residual sample (12, 27, 39, 51, and 61%, respectively).

Measures

Episodic memory was assessed using a unit-weight composite of performances on the immediate and delayed free recall tests. The immediate recall test was typically given near the end of the first interview quarter and asked participants to recall as many nouns as possible from a list of 10 nouns selected from four different lists. The delayed recall test was administered about five minutes later asking participants again to recall as many nouns as possible out of the earlier presented 10 nouns. Our measure represents the number of correct words remembered, ranging from 0 to 20. At all occasions, internal consistencies (across immediate and delayed recall sores) were good (wives: averaged a over time = .84, range .83 to .86; husbands: averaged a over time = .82, range .78 to .85). Details of the cognitive measures in the AHEAD study and their measurement properties are published in Brandt, Spencer, and Folstein (1988) and Ofstedal, Fisher, and Herzog (2005).

Depressive symptoms were assessed with eight items selected from the CES-D scale (Radloff, 1977). Items asked participants whether they had experienced the following symptoms *"much of the time during the past week"* (coded as 1) or not (coded as 0): Feeling depressed, everything was an effort, restless sleep, was (not) happy, felt lonely, (did not) enjoy life, felt sad, and could not get going. Positively valenced items were reverse coded. Our sum measure, computed if a participant answered one or more CES-D items, thus represents the number of depressive symptoms experienced frequently, with a possible range of 0 to 8. At all occasions, internal consistencies were good (wives: averaged a over time = .76, range .73 to .79; husbands: averaged a over time = .74, range .72 to .76). Details of the CES-D items in the AHEAD study and their measurement properties can be found in Townsend et al. (2001) and Turvey, Wallace, and Herzog (1999).

Covariates

To control for potential confounds, some of our models included individual (age, education, initial functional limitations) and spousal factors (length of marriage, number of children, and whether or not a couple remained intact over time) as time-invariant covariates. *Education* was measured as the number of years in school. We computed a composite sum index of *functional limitations* at T1 across items that asked whether or not respondents

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[1]The number of intact couples in which both partners provided data for all four variables of interest at each occasion were as follows: 1,199 couples at T2; 885 couples at T3; 670 couples at T4; 480 couples at T5; and 359 couples at T6.

reported any difficulty in carrying out 10 instrumental activities of daily living. These activities included using the phone, managing money, taking medications, shopping groceries, preparing hot meals, walking several blocks, climbing one flight of stairs, lifting or carrying 10 lbs of weight, picking up a dime, and pushing or pulling large objects.

Data preparation

Scores for memory and depressive symptoms were standardized to a *T* metric (*Mean* = 50; *SD* = 10), with the T1 AHEAD couple sample (*n* = 3,198 individuals) providing the reference. This transformation ensured a common metric, while maintaining the psychometric properties of the scores and the longitudinal changes in means and variances. It also allowed for a direct comparison of scores between wives and husbands. No data imputation procedure was applied. The average longitudinal observation interval was 4.47 years (*SD* = 3.58) for wives and 3.97 years (*SD* = 3.46) for husbands. Table 1 presents the age at assessment along with means and standard deviations for memory and depressive symptoms, separately for wives and husbands. Participants were tested, on average, in their mid to late seventies and early eighties with an average three-year age difference between wives and husbands, $F(1,1598) = 603.6$, $p < .001$. Wives also reported, on average, more depressive symptoms, $F(1,1598) = 34.7$, $p < .001$, and performed better on the memory task than their husbands, $F(1, 1598) = 168.0$, $p < .001$, whereas differences in education were minor, $F(1, 1598) = 14.1$, $p < .001$. As is also evident, the means for memory increase at some later measurement occasions due to longitudinal attrition, but the magnitude of between-person differences in both variables was not differentially affected.[2] Implications of nonrandom attrition for interpreting our results are considered in the Discussion section.

Statistical Procedures

In this study, we use a four-variable extension of the dual change score model (for extensive discussions of this model, see Ferrer & McArdle, 2004; McArdle & Hamagami, 2001). A DCSM combines features of the latent growth curve model (e.g., Meredith & Tisak, 1990) and the cross-lagged regressions approach (e.g., Rogosa, 1980). Similar to the group of latent growth curve models, the DCSM estimates latent intercept and slope factors for a given variable at the population level simultaneously with systematic variance around these means and a separate residual variance term. As an extension of the typical latent growth curve model, a two-variable DCSM additionally allows the estimation of time-lagged relations between states on a given variable (e.g., *X* at time t) and the reliable, error-free portion of subsequent change on another variable (e.g., change in *Y* between t and t+1). As an extension of the typical cross-lagged correlations between variables, a two-variable

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[2]Both memory and depressive symptoms not only displayed significant change over time and variability in this change, but also showed comparable stability over time at the level of interindividual differences. Specifically, averaged autocorrelation coefficients were $r = .47$ ($p < .001$, range from $r = .35$ to $r = .56$) for memory of wives; $r = .46$ ($p < .001$, range from $r = .34$ to $r = .54$) for memory of husbands; $r = .45$ ($p < .001$, range from $r = .35$ to $r = .54$) for well-being of wives; and $r = .41$ ($p < .001$, range from $r = .32$ to $r = .52$) for well-being of husbands. At a given measurement occasion, the average within-person correlations between the measures of memory and depression were comparable across spouses with $r = -.14$ ($p < .001$, range from $r = -.11$ to $r = -.23$) for wives and $r = -.21$ ($p < .001$, range from $r = -.17$ to $r = -.27$) for husbands. Also, spousal similarities at a given occasion tended to be somewhat stronger for depression (average correlation at a given occasion was $r = .29$, $p < .001$, range from $r = .25$ to $r = .35$) as compared with memory (average correlation at a given occasion was $r = .17$, $p < .001$, range from $r = .09$ to $r = .24$).

DCSM allows both adjusting for unequal reliabilities of the variables and separating dynamic changes within variables from lead-lag relations across variables.

A graphical representation of a DCSM for a system of two variables *X* and *Y* is given in Figure 1. The diagram shows manifest variables as squares, latent variables as circles, the required constant as a triangle, fixed model parameters as one-headed arrows, and random parameters as two-headed arrows. Unlabeled paths are fixed to 1. The observed variables X[0], X[1], X[t−1], X[t], and Y[0], Y[1], Y[t−1], Y[t] represent the various assessments of the constructs *X* and *Y*, respectively. The scores x[t] (or y[t]) are defined as the unit-weighted sum of the latent score at x[t−1] (or y[t−1]) plus the latent difference score x[t] (or y[t]), which represent the latent, reliable change score between x[t−1] and x[t] (or y[t−1] and y[t]; McArdle & Hamagami, 2001). The intercept (x_0, y_0) and slope factors (x_S, y_S) are supposed to account for the time series of both variables *X* and *Y*. Intercepts denote an individual's score at T1, and the slope factors relate to the difference scores x[t] and y[t] with a constant loading of 1, thus denoting linear two-year changes in our study. Intercepts and slopes are estimated at the population level (μ_{x0}, μ_{xS}; μ_{y0}, μ_{yS}), they are allowed to vary (σ_{x0}, σ_{xS}; σ_{y0}, σ_{yS}) and covary (ρ_{x0xS}; ρ_{y0yS}; ρ_{x0y0}; ρ_{xSyS}; ρ_{x0ys}; ρ_{y0xS}). The residual terms (e_x; e_y) are assumed to be normally distributed with a mean of zero and a time-invariant variance, and are allowed to covary between partners within time but not across time ($\rho_{ex,ey}$).

As an extension of typical linear growth curve models, the difference scores are defined as the unit-weighted sum of linear change within a given variable plus two additional lagged effects. The first addition is a self-feedback, auto-proportion parameter (β_x, β_y) indicating the effect of a given variable at time t−1 on change in the same variable between t−1 and t. For example, in our study, this parameter may represent the effect of level of wives' depressive symptoms on subsequent change in wives' depressive symptoms. The second addition is an inter-variable, cross-lagged parameter (γ_{xy}, γ_{yx}) signifying the effect of a given variable (e.g., *X*) at t−1 on subsequent change in the other variable (e.g., *Y*) between t−1 and t. For example, in our study, this parameter may represent the effect of level of wives' depressive symptoms on subsequent change in husbands' depressive symptoms. For simplicity and model identification, the values of β's and γ's are commonly assumed to be constant across time (although this assumption is testable). With β's and γ's set to zero, the two-variable DCSM is equivalent to a (two-variable) linear latent growth curve model.

Our major empirical interest in this study is in the cross-lagged coupling γ or dynamics parameters. Specifically, implementing a four-variable DCSM allows for a direct empirical comparison of competing substantive hypotheses about two sets of temporal dynamics: First, we can estimate four *actor* effects within spouses. Among wives, for example, performance on episodic memory tests may predict subsequent change in depressive symptoms ($\gamma_{W.MEM \rightarrow W.DEP}$), or conversely, the number of depressive symptoms may predict subsequent memory change ($\gamma_{W.DEP \rightarrow W.MEM}$). An additional two analogous dynamics will be estimated among husbands ($\gamma_{H.MEM \rightarrow H.DEP}$, $\gamma_{H.DEP \rightarrow H.MEM}$). Second, we can estimate a total of eight *partner* effects across spouses, four of these within the memory and depression domains and another four across both domains. Within domains, we can test whether husbands' level of functioning predicts subsequent change in the same domain

among their wives ($\gamma_{H.MEM\rightarrow W.MEM}$; $\gamma_{H.DEP\rightarrow W.DEP}$), or whether the effects are in the opposite direction with wives playing a leading role for change in husbands ($\gamma_{W.MEM\rightarrow H.MEM}$; $\gamma_{W.DEP\rightarrow H.DEP}$). Across domains, we can finally test and empirically compare competing hypotheses if a given partners' functioning in one domain precedes and predicts subsequent change for the spouse in the other functional domain ($\gamma_{H.MEM\rightarrow W.DEP}$; $\gamma_{W.DEP\rightarrow H.MEM}$; $\gamma_{W.MEM\rightarrow H.DEP}$; and $\gamma_{H.DEP\rightarrow W.MEM}$).

To adjust for potentially inflated covariances among our variables due to their common association with known individual difference factors, all models include both wives' and husbands' age, education, and functional limitations as covariates. This also makes sure that our findings do not simply reflect well-documented gender-differences in (or direct effects of) these additional variables. The dynamics parameters reported are thus statistically adjusted for the non-linear change component of the auto-proportion parameters and for age, education, and functional limitations of both partners. Covariates were centered at the mean of the AHEAD couple sample resulting in intercept means, intercept variances, and slope-intercept covariances being estimated at age 75 years as well as average education and functional limitations. In total, our four-variable DCSM estimated 66 model parameters (four times seven parameters within each of the four time series, plus eight cross-variable intercorrelations among both wives and husbands, 16 cross-variable intercorrelations between wives and husbands, two covariances of time-invariant residual terms between wives and husbands for each memory and depressive symptoms[3], and 12 dynamics parameters between the time series) as well as a total of 75 parameters for age, education, and functional limitations of both wives and husbands. In subsequent analyses, we additionally include several spousal characteristics (length of marriage, number of children, and whether or not the couple remained intact over the study period) as further covariates. Models were fit to the data using *Mplus* (Muthén & Muthén, 1998).[4] Incomplete data were treated as missing at random (Little & Rubin, 1987) using full-information maximum likelihood (FIML) estimation algorithms to all data points available.

Results

In an initial step, we determined the relative amount of between-person and within-person variance in the data. Using random intercept-only models, we found that between-person variance (i.e., the intra-class correlation) in memory amounted to .49 for wives and .46 for husbands, with the remainder (wives: 51%; husbands: 54%) being within-person variation. Depressive symptoms revealed a similar pattern of within-person variation: 55% among wives and 58% among husbands. The data thus contain both substantial amounts of between-person differences and within-person variation over time. Noting that there were indeed intraindividual variations to model, a four-variable DCSM was used to describe and evaluate how the noted changes in episodic memory and depressive symptoms among wives and husbands were structured over time.

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[3]Allowing the measurement-specific variance to be correlated between persons who take the measure provided superior fit ($\chi^2 = 544.2$, $df = 354$) over a more parsimonious model that set these covariances to zero ($\chi^2 = 600.00$, $df = 356$; $\chi^2 = 55.8$, $df = 2$, $p < .001$).
[4]The MPLUS scripts for all analyses are available from the senior author upon request.

Our findings are organized in four sections. First, we use nested-model comparisons as an omnibus test to empirically examine if memory–depression dynamics indeed exist both at the actor level (intra-spouse effects) and partner level (across-spouse effects). Second, we focus on actor-level effects and closely examine various accounts of associations between memory and depressive symptoms within spouses, and we illustrate their differential direction and size. Third, we target partner-level effects and determine the direction and size of across-spouse, lead-lag associations between wives and husbands. Finally, we explore if and how additionally covarying for spousal factors (length of marriage, number of children, and whether or not the couple remained intact over the study period) had an effect on the dynamic associations found between episodic memory and depressive symptoms at either the actor level or the partner level.

Statistically Nested-Model Comparisons and Average Trends

To directly test if intra-spouse and across-spouse dynamics exist in the AHEAD study, we compare the goodness-of-fit indices of two statistically nested models. Specifically, a less parsimonious *Full Dynamics* model that freely estimated the four intra-spouse dynamics parameters along with the eight across-spouse dynamics parameters was compared to a more parsimonious model that set all 12 dynamics parameters to zero. Relative to the *Full Dynamics* model ($\chi^2 = 544.2$, $df = 354$), the *No Dynamics* model resulted in a highly significant loss of model fit ($\chi^2 = 673.9$, $df = 366$; $\quad \chi^2 = 129.7$, $df = 12$, $p < .001$). This suggests that we can reject the null hypothesis that dynamics do not exist between memory and depressive symptoms at both actor and partner levels. Two other fit indices revealed a similar pattern of results – a lower Root Mean Square Error of Approximation (RMSEA; .018 vs. .023) and a higher Comparative Fit Index (CFI; .981 vs. .970) – indicating that the *Full Dynamics* model provided relatively better fit than the *No Dynamics* model.

To provide the background for subsequent steps, Table 2 presents parameter estimates from the *Full Dynamics* model and Figure 2 graphically illustrates the conjoint product of the various change components modeled by our four-variable DCSM (i.e., linear changes, auto-proportion parameters as presented in Table 2 and the dynamics parameters as presented in Table 3). Specifically, the figure shows model-implied mean longitudinal change trajectories from the *Full Dynamics* model for wives' episodic memory (*X*) and depressive symptoms (*Y*) and for husbands' episodic memory (*Z*) and depressive symptoms (*V*), as produced by the following formulas: $x[t] = 1*x_s + (1+\beta_x)*x[t-1] + \gamma_{yx}*y[t-1] + \gamma_{zx}*z[t-1] + \gamma_{vx}*v[t-1]$; $y[t] = 1*y_s + (1+\beta_y)*y[t-1] + \gamma_{xy}*x[t-1] + \gamma_{zy}*z[t-1] + \gamma_{vy}*v[t-1]$; $z[t] = 1*z_s + (1+\beta_z)*z[t-1] + \gamma_{xz}*x[t-1] + \gamma_{yz}*y[t-1] + \gamma_{vz}*v[t-1]$; and $v[t] = 1*v_s + (1+\beta_v)*v[t-1] + \gamma_{xv}*x[t-1] + \gamma_{yv}*y[t-1] + \gamma_{zv}*z[t-1]$, when applied to a person aged 75 years, and with average education and functional limitations. For x[0], y[0], z[0] and v[0], the mean equals x0, y0, z0, and v0, respectively.[5] Figure 2 shows that model-implied average changes for both spouses are sizeable across the 10-year study period (episodic memory: 0.5+ *SD* decline, and depressive symptoms: 0.5+ *SD* increase). These model-implied prototypical changes over time are

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[5]These formulas calculate the implied mean longitudinal trajectories from the four-variable DCSM reported in Table 2 and Table 3 for each variable. Specifically, results from the model are translated into change equations that represent biyearly change on a given variable as a function of itself and all other components in the model. More details can be found in Ferrer & McArdle (2004), Ghisletta and Lindenberger (2005), and Lövdén et al. (2005, 2007).

somewhat different from the pattern of observed means displayed in Table 1. This discrepancy illustrates that the model produces estimates of average within-person change in the overall sample whether or not an individual (or couple) stayed in the sample over time (i.e., MAR assumption; cf. Gerstorf et al., 2007). Acknowledging these average trends over time allows us to better understand the direction and size of the dynamics parameters from the *Full Dynamics* model that will be presented in more detail in the following.

Dynamics of Cognition and Well-Being in Old Age

Having established, at an overall level, that time-ordered dynamics should not be disregarded, we move to the second step and specifically explore which memory–depression dynamics may exist at the actor or intra-spouse level. The dynamics parameters for the actor effects show (Table 3, rows 2 thru 6) that the cross-lagged effects from episodic memory onto depressive symptoms were not statistically significant (among wives: $\gamma = 0.09$, $SE = 0.24$; among husbands: $\gamma = -0.28$, $SE = 0.50$, both p's $> .10$). The same was true for the predictive effect of depressive symptoms for change in episodic memory among husbands ($\gamma = 0.50$, $SE = 0.28$, $p > .05$). In contrast, the dynamics parameter of wives' depressive symptoms onto subsequent changes in wives' memory performance was negative and reliably different from zero ($\gamma = -0.73$, $SE = 0.34$, $p < .05$). Figure 2 displays the average trends over time to demonstrate how this dynamics parameter is embedded in other components of change and to interpret its direction. Specifically, the negative dynamics parameter indicates that more depressive symptoms precede and predict two-year negative deviations from linear decline in episodic memory (i.e., stronger than average decline).

To illustrate the size and direction of these effects, Figure 3 uses a hypothetical scenario. Specifically, wives are assumed to vary in their initial sample means for depressive symptoms by half a standard deviation (i.e., 5 T-score units) while we keep constant the initial sample means for episodic memory (cf. Lövdén et al., 2005). In such a hypothetical case where all wives showed similar episodic memory performance at T1, but differed in their initial levels of depressive symptoms, it can be seen that the model-implied mean changes over time differ considerably from one another (dashed lines): Wives who reported more depressive symptoms initially (i.e., +0.5 *SD*) would subsequently show a relatively steep memory decline, whereas low initial depressive symptoms (i.e., −0.5 *SD*) would result in shallower memory decline over time. Conversely, if we graph changes in depressive symptoms as a function of different initial levels of memory (solid lines) we only see minor differentiating effects. In sum, our data suggest that depressive symptoms lead changes in episodic memory among wives, but not among husbands. No evidence was found for hypotheses proposing a leading role of episodic memory for change in depressive symptoms.

A Dyadic Perspective

In a third step, we consider lead-lag relations between wives and husbands by targeting the eight partner-level or across-spouse dynamics parameters, as presented in Table 3 (rows 7 through 16). We found that the direction and size of lead-lag associations between spouses varies by psychological domain and also crosses domains. In the depression domain, we found that the dynamics parameter from depressive symptoms of wives to subsequent

change in depressive symptoms of husbands was positive and reliably different from zero (γ = 1.58, *SE* = 0.49, *p* < .001). Taking the average increase in depression over time into account (see Figure 2), the positive dynamics parameter suggests that more depressive symptoms among wives were predictive of stronger than average subsequent increases in depressive symptoms among husbands. In the memory domain, in contrast, the opposite unidirectional pattern between wives and husbands appeared to prevail: It was the memory performance of husbands that predicted subsequent change in memory among wives (γ = 1.54, *SE* = 0.41, *p* < .001) rather than the reverse (γ = –0.31, *SE* = 0.17, *p* > .10). The positive sign of the significant dynamics parameter in conjunction with the average memory decline over time (see Figure 2) suggests that better cognitive performance among husbands predicted shallower than average subsequent memory decline among wives. In addition, two across-domain partner dynamics effects also emerged. First is the predictive effect of depressive symptoms among wives for subsequent memory change among husbands (γ = –0.63, *SE* = 0.27, *p* < .05). This pattern indicates that more depressive symptoms among wives were related to stronger subsequent memory decline among husbands. Second is a predictive effect of husbands' depression for subsequent memory change among wives (γ = 0.97, *SE* = 0.37, *p* < .01). The direction of this spousal dynamic appears to suggest some "buffering" effect according to which husbands' depressive symptoms predicted better memory functioning over time for wives.

To illustrate the size and direction of one of these dynamic partner effects, we again use a hypothetical scenario (see Figure 4) in which all wives are hypothetically assumed to have identical initial memory performance at baseline with the only difference being that initial memory performance of husbands differs by ± 0.5 *SD*. Over time then, wives with cognitively fit husbands (+0.5 *SD*) would show much shallower subsequent memory decline, whereas wives with cognitively less fit husbands (–0.5 *SD*) would show much steeper subsequent memory decline (solid lines). In contrast, little evidence was found for a directed effect in the other direction: The dashed lines indicate that husbands' episodic memory trajectories of change over time were minimally altered as a function of different initial levels of wives' memory at T1. Figure 4 thus exemplifies what effects the differential magnitude of the spousal dynamics may have on the model-implied mean longitudinal change trajectories over time. In sum, parameter estimates from a *Full Dynamics* Model that covaried for individual differences in age, education, and functional limitations suggest that lead-lag relations over time lags of two years exist between married partners' late-life developmental trajectories on memory and depressive symptoms.

The Role of Spousal Covariates

In a final step, we explored whether several spousal covariates had an effect on the dynamic associations found between episodic memory and depressive symptoms at either the actor level or the partner level. To start with, we note that the dynamics parameters, and all other model parameters, reported above were residualized for several individual covariates (ages, years of education, and functional limitations of both wives and husbands). This suggests that age, education, and functional limitations did not play a major role in accounting for differential dynamic associations between wives' and husbands' episodic memory and depressive symptoms.

Adding the length of marriage and the number of children as time-invariant spousal covariates of the latent factors of intercept and change did not substantially alter the dynamic structure reported earlier. Specifically, the *No Dynamics* model setting all 12 dynamic associations at the actor and partner level to zero described the structure of our data less precisely than the *Full Dynamics* model ($\chi^2 = 580.3$, $df = 386$ vs. $\chi^2 = 707.5$, $df = 398$; $\chi^2 = 127.2$, $df = 12$, $p < .001$). Consistent with the above results, we found that the actor dynamics effect of wives' depressive symptoms predicting stronger decline in wives' memory performance over time remained ($\gamma = -0.70$, $SE = 0.32$, $p < .05$). Similarly, the four partner dynamics effects identified above when we only controlled for the effects of individual covariates remained when we additionally controlled for spousal covariates: Within domains, we found that wives' depressive symptoms predict a stronger increase in depressive symptoms among husbands ($\gamma = 1.51$, $SE = 0.46$, $p < .001$) and that husbands' memory predicts less pronounced subsequent memory decline for wives ($\gamma = 1.51$, $SE = 0.40$, $p < .001$). Across domains, our results again indicated that wives' depressive symptoms precede steeper memory decline among husbands ($\gamma = -0.61$, $SE = 0.26$, $p < .01$) and that husbands' depressive symptoms predicted better memory functioning over time for wives ($\gamma = 0.92$, $SE = 0.35$, $p < .01$).[6] Inclusion of individual and spousal covariates did not substantively alter the spousal dynamics reported, but contributed significant proportions of overall explained variance to the model parameters (e.g., wives' level of episodic memory: $R^2 = .34$ relative to $R^2 = .16$ for a model that only included the ages of both partners as covariates; wives' change in episodic memory: $R^2 = .14$ relative to $R^2 = .05$ for a model that only included the ages of both partners as covariates).

In a concluding series of follow-up analyses, we also found a substantively identical pattern as reported above when we restricted the sample to those couples who remained intact over time (i.e., both partners remained in the same household and provided data for all four variables of interest at each occasion: 1,199 couples at T2; 885 couples at T3; 670 couples at T4; 480 couples at T5; and 359 couples at T6; *Full Dynamics* model: $\chi^2 = 481.5$, $df = 354$ vs. *No Dynamics* model: $\chi^2 = 575.3$, $df = 366$; $\chi^2 = 93.8$, $df = 12$, $p < .001$). In a similar vein, dynamics of memory and depressive symptoms at the actor and partner level were present when we targeted very old spouses only ($n_{\text{couples}} = 631$ with an average age of wives and husbands at T1 of 75 years or more; *Full Dynamics* model: $\chi^2 = 498.3$, $df = 354$ vs. *No Dynamics* model: $\chi^2 = 558.2$, $df = 366$; $\chi^2 = 59.9$, $df = 12$, $p < .001$).

In sum, the covaried individual (education, functional limitations) and spousal factors (length of marriage, number of children) did not account for our major finding that wives and husbands appear to be dynamically active in the spousal system of level and change in episodic memory and depressive symptoms.

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[6]Targeting the significance of the dynamics parameters in a series of nested model comparisons revealed the same substantive pattern of results. For example, not allowing for a lagged across-spouse or partner effect from memory of husbands for subsequent changes in memory of wives resulted in highly significant losses in fit relative to the *Full Dynamics* model ($\gamma_{\text{H.MEM} \rightarrow \text{W.MEM}} = 0$: $\chi^2 = 15.3$, $df = 1$, $p < .001$).

Discussion

The present study directly examined spousal interrelations in old age in a dynamic modeling framework and specifically examined indicators of cognitive fitness (episodic memory) and well-being (depressive symptoms) as time-varying entities in the dynamic system. We applied a four-variable Dual Change Score Model (McArdle & Hamagami, 2001) to 10-year incomplete longitudinal data of initially 1,599 married couples from the AHEAD study (M_{age} = 75 years at T1). Gender-specific lead-lag associations over two-year time lags were found both within and across spouses with the direction and size of these effects varying by psychological domain and also going across domains. Within spouses, depressive symptoms were associated with subsequent declines in memory in wives only. Across spouses, wives' depressive symptoms were found to predict subsequent depression increase as well as memory decline among husbands. For memory, in contrast, better performance among husbands revealed protective effects against subsequent decline among wives with no evidence for a directed effect in the other direction. Possible individual covariates (age, education, functional limitations) and spousal covariates (length of marriage, number of children, and whether or not the couple remained intact over the study period) did not account for these differential lead–lag associations. We note that our study represents a first descriptive step and does not allow for causal inferences. Our findings of antecedent– consequent relations between wives and husbands are consistent with lifespan psychological notions that individual development both actively influences and is influenced by contextual factors such as close social relationships. Our discussion starts with an interpretation of the observed actor-level or intra-spouse effects. In a next step, we discuss findings concerning spousal interrelations at the partner level. Finally, we highlight important conceptual implications and methodological considerations as well as further steps necessary to substantiate our results.

Dynamics of Cognition and Well-Being in Old Age

In a first step, we provide an interpretation of actor-level findings concerning dynamic associations between cognition and well-being in our study. Both episodic memory and depressive symptoms showed sizeable changes over time, and between-person variability in these longitudinal changes was dynamically linked at the actor level among wives, but not among husbands. Findings for wives provide evidence for a unidirectional account of the dynamics: More depressive symptoms precede and predict two-year negative deviations from linear decline in episodic memory (i.e., stronger decline). These results are consistent with recent reports indicating that (decline in) aspects of cognitive functioning may *not* precede change in aspects of well-being, with such reports being derived from vastly different time metrics ranging from moment-to-moment variation in an experimental setting (Chow et al., 2007), to longitudinal change across time lags of two years over a total of 12 years (Gerstorf et al., 2007), and linking 60-year lifetime changes in cognitive functioning to well-being in old age (Gow et al., 2005). Our findings should not be taken to suggest that aspects of well-being represent a key factor underlying cognitive decline, but that components of well-being might moderate (e.g., slow down or accelerate) decline in indicators of cognitive functioning in later life (cf. Gerstorf et al., 2007). It is in this sense that our findings add to the growing body of research showing that aspects of well-being are

not only a consequence of, but also a source for successful aging (Danner, Snowdon, & Friesen, 2001; Levy et al., 2002; Lyubomirsky, King, & Diener, 2005).

It is unclear though whether well-being directly or indirectly relates to the maintenance and decline of cognitive functioning in old age. One position argues that emotions exert physiological effects on cardiovascular and immune functioning that may have long-term effects on the brain and in turn influence level and change in cognitive performance (Danner et al., 2001; Kiecolt-Glaser et al., 2002). Another position refers to the resources necessary for proper cognitive functioning (see MacDonald et al., 2006; West et al., 2002); depressed feelings may occupy and distract substantial portions of these cognitive resources (e.g., from executive control), thereby resulting in less-than-optimal cognitive performance.

It remains an open conceptual question as to why we did not find similar associations among the husbands of this study. We would like to offer one potential reason, however. Specifically, results of the present study are in line with past research showing that women report higher overall levels of depressive symptoms than men (Anstey et al., in press; Barefoot et al., 2001). It could be that depressive symptoms only exert their negative effects on cognitive performance and change after surpassing a certain threshold, and such a scenario may have simply been true for more wives than husbands in the present sample. Future work may want to look at subgroups based on clinically defined depression scores to address such potential qualitative differences in the influence of subclinical and clinically relevant forms of depressive symptoms on cognitive performance and change. On a related note, we would like to highlight that the present study is in the all-too-rare position of having tested dynamic memory–depression associations using data from a large-scale sample with an equal number of men and women. Past research testing such associations in samples of unrelated individuals are often based on smaller samples with, relatively speaking, much more data provided by women than men (McArdle et al., 2007). This is certainly valid because old age is a phase in life that more women than men experience, but it may also have implicitly led to more insights into cognition–well-being relationships in women as compared to men. Large-scale data sets like ours may be particularly suited to explicitly investigate potential gender-specific associations.

A Dyadic Perspective

In line with the central notion of our study, most of our findings point to spousal interrelations in cognition–well-being relationships in elderly couples. These results can be referred to as partner effects illustrating that aging-related change in aspects of cognition and well-being is intrinsically linked between spouses. This patterning alone is interesting because it points to the utility of studying more than one focal person when examining trajectories of change in key domains of functioning across old age. Specifically, we found unidirectional predictive effects from depressive symptoms in wives for subsequent increase in depressive symptoms in husbands. This finding counters past research on affective transmissions in everyday life among midlife couples suggesting a greater susceptibility to spousal influences for wives than for husbands (Larson & Almeida, 1999). One possible explanation for our directed effect in the opposite direction may be related to post-retirement changes in the power structure within marriages. Perhaps spouses of the older adult cohorts

examined here had to re-negotiate their roles when husbands left the labor force so that wives end up being more powerful in later life compared to earlier life phases. Another possible explanation relates to gender differences in dealing with emotionally challenging circumstances in late-life marriages. Carstensen and colleagues (1995), for example, showed that in long-term married couples, wives were much more likely to express their emotions, both positive and negative, whereas husbands exerted more emotional withdrawal and defensiveness. It is reasonable to assume that the emotionally expressive person is much more likely to transmit depressive symptoms to his or her spouse than the emotionally withdrawn person. Both lines of reasoning are at least partially consistent with reports from the EPESE study that long-term longitudinal associations over three to six years between spouses in old age go in both directions (Tower & Kasl, 1996).

Interestingly, wives' depressive symptoms were not only related to their own but also to their husbands' decline in episodic memory performance. We can only speculate as to the underlying mechanisms. One possible explanation is an important third variable that originates in wives and affects both partners: Social activity engagement. More specifically, past research on social activities indicates that wives take a more active role in initiating and performing social activities than husbands (Antonucci, 1994, 2001; Hoppmann et al., 2008). We also know from the literature that social activities place high demands on cognitive skills, thereby potentially protecting against cognitive decline (Fratiglioni, Paillard-Borg, & Winblad, 2004; Lövdén et al., 2005). Bringing these two lines of evidence together, spousal involvement in social activities by wives may represent one mechanism that buffers cognitive decline in themselves and their husbands as well.

Results from the present study also indicate that better cognitive performance in husbands related to subsequently less pronounced decline among wives. Our findings are consistent with reports from married couples in several large-scale longitudinal studies, which have also demonstrated that cognitive functioning among husbands was predictive of subsequent cognitive change among wives, but not vice versa (Gerstorf et al., 2008; Gruber-Baldini et al., 1995; Strawbridge et al., in press). Conjointly, these results suggest that late-life cognitive development is not solely a product of intraindividual resources, but appears to be closely intertwined between elderly spouses. One interpretation of the unidirectional nature of this cognitive partner effect is that a cognitively fit husband allows his wife to lead an active life, for example by engaging in social activities that challenge her cognitive abilities, whereas a cognitively impaired husband may require his wife to stay home more often and place her resources into the provision of care. To better understand such potential dynamics, future research must specifically target whether preserved cognitive fitness among husbands serves as a protective and buffering factor against wives' decline in episodic memory, whether impaired cognition among husbands may act as a risk factor for cognitive decline among wives, or whether both mechanisms are operating in tandem.

A final partner effect was counter-intuitive and suggested a buffering effect of husbands' depressive symptoms onto subsequent memory functioning for wives. From a conceptual perspective, this finding may be better understood if one pictures the potential consequences of husbands' depressive symptoms within the spousal relationship system. For example, maybe wives with depressed husbands have to be alert and consequently outperform their

female counterparts whose husbands are not emotionally challenged. We nevertheless think that this finding should be interpreted with caution; it will need to be replicated before it becomes an established phenomenon.

The Role of Individual and Spousal Covariates

In an attempt to address third-variable accounts for time-lagged associations between spouses' episodic memory and depressive symptoms, all our models covaried for individual differences in age, education, and functional limitations. This approach ensured that our results do not simply reflect the role of these candidate factors that are known to differ between genders and to relate to either of the two domains of interest (Gottman & Notarius, 2000; Gruber-Baldini et al., 1995). We found no evidence that these individual difference factors or marriage characteristics (length of marriage, number of children, and whether a couple remained intact over time) that were included in subsequent steps played a major role in accounting for the spousal interrelations observed. Future research, however, would benefit from addressing these and other factors in more detail as potential sources for differential dynamics. It is conceivable that different trends for lead-lag relations may emerge when subgroups of spouses are specifically targeted. That is, spousal dynamics may be different or show change over time when resources in a given domain for one partner are taxed (e.g., Strawbridge, Wallhagen, & Shema, 2007). For example, when one partner drops below certain thresholds of functioning and experiences serious cognitive decline, questions arise as to how this affects the respective spouse's well-being who all of a sudden sees himself or herself transitioning from the role of a spouse into the role of a caregiver (see Lyons, Zarit, Sayer, & Whitlatch, 2002). Future research may benefit from analyses aiming at theoretically defined subgroups and thereby shed light on qualitatively different processes of what is going on in a relationship at a specific point in time. Such endeavors are essential steps toward better understanding dynamic lead-lag relations between aspects of cognitive functioning and well-being in old and very old age. These limitations aside, we take our results to provide initial indications that spousal dynamics have sizeable effects on age-related change trajectories in key domains of functioning for both partners, and that these associations cannot be reduced to the set of antecedent conditions examined here.

Methodological Considerations: A Dynamic Model of Dyadic Interrelations

By employing contemporary methodologies, the current study was able to capture dynamic associations between spouses' developmental change trajectories. In contrast to considering patterns of growth (e.g., static intercept–overall change correlations) in the variables under study as revealed in typical latent growth curve models, inspection of dynamic cross-lagged γ parameters in the four-variable DCSM informed us about lead-lag patterns in the data between wives and husbands (see Ferrer & McArdle, 2004). We have used this technique for a formal empirical comparison among different competing substantive hypotheses about if and how wives' and husbands' episodic memory and depressive symptoms show lagged developmental sequences. In doing so, the DCSM overcomes some of the limitations of related dynamic methods such as cross-lagged correlations (see also Rogosa, 1980). Specifically, the DCSM accounts for differential reliabilities and stabilities of the variables examined, and it separates intra-construct changes from inter-construct dynamics (cf. Ghisletta & Lindenberger, 2005; Lövdén et al., 2005). We also note that our study is one of

the first to have extended the examination of dynamic antecedent-consequent associations beyond the two-variable case to higher-order multivariate models (for another recent example, see Ghisletta & Lindenberger, 2005). Such endeavors are important in comprehending how age-related changes in a given domain are embedded in complex systems of influence that are not fully described by a two-variable model. However, we acknowledge that this is a highly complex enterprise and caution against strong conclusions from our primarily descriptive analyses. We specifically point to the following methodological constraints.

To begin, the validity of our findings is conditional upon a number of statistical assumptions that include ergodocity, sample homogeneity, and data missing-at-random (cf. Lövdén et al., 2007). For example, the estimation of model parameters is based upon all longitudinal data segments, thereby giving implicitly more weight to couples who remained in the study. Because those couples were likely to be higher functioning, our results may underestimate the true extent of age-related change (i.e., decline in memory and increase in depressive symptoms) in the population. In addition, we acknowledge that for reasons of model identification we had to specify all dynamics parameters as time-invariant population parameters with no variance, which reflects the strict assumption that these dynamics are invariant across individuals (see Gerstorf et al., 2007). It may also be possible that the directional lead-lad associations found here among old-age spouses over two-year time lags do not generalize to other time metrics (e.g., from day to day) or different periods of the lifespan (e.g., mid-adulthood). Finally, we opted for modeling longitudinal change over time in study rather than combining the ages of wives and husbands into some arbitrary age composite that may then have served as the metric for the examination of change. As a consequence, it was not possible to determine if and how potential retest effects for episodic memory may have contributed to our findings. The existence of cognitive retest effects may not be a major concern regarding our findings of dynamic associations unless wives and husbands were to profit differentially from repeated test exposure. Given that previous examinations of retest effects in the AHEAD study indicated that such retest effects exist but were not different between women and men (Rodgers, Ofstedal, & Herzog, 2003), it appears permissible to not examine retest effects.

Limitations and Outlook

We have found longitudinal evidence for antecedent–consequent relations between aspects of married spouses' cognitive and emotional functioning in that wives and husbands are both dynamically and differentially active in the couple system. We would like to highlight, however, that we are just beginning to illuminate the complex interplay of how contextual factors, like significant others, actively shape and are shaped by developmental changes in key domains of functioning across the adult lifespan and old age (Baltes & Staudinger, 1996; Cairns et al., 1996). The present study sheds some initial light on the developmental ordering and spousal interrelations in two psychological domains in old and advanced old age. We think that these initial efforts deserve further replication and extension. One of the major open questions relates to the direction and size of dynamic associations between spouses. It could be that the conundrum of equivocal research reports mirrors the fact that the nature and functional implications of dyadic associations depend upon the domain

considered (e.g., cognition vs. emotion), the time metric examined (e.g., daily stress vs. long-term longitudinal change over several years), and the age groups under study (e.g., middle-aged vs. old age). Much work remains to be done to resolve these and other questions, and we believe that the current study represents one step along the way toward that greater goal.

Acknowledgments

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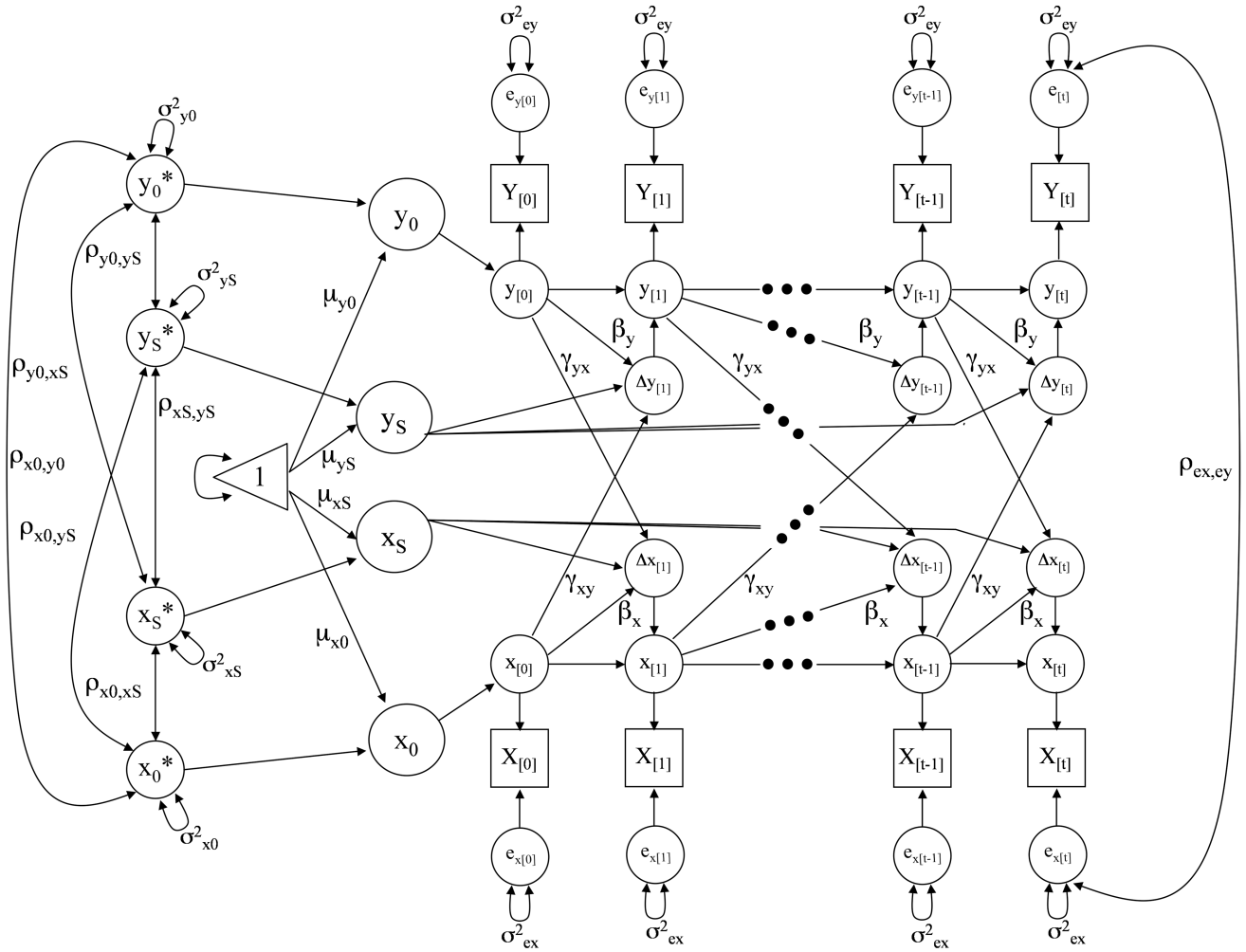Zajonc RB, Marcus GB. Birth order and intellectual development. Psychological Review. 1975; 82:74–88.

Figure 1.
Graphical representation of a two-variable Dual Change Score Model (DCSM; McArdle & Hamagami, 2001) for a system of two variables *X* and *Y*. Observed (manifest) variables are represented by squares, unobserved (latent) variables by circles, regression weights by one-headed arrows, variances and covariances by two-headed arrows, and the triangle represents a constant indicating means and intercepts. All unlabeled paths are set to 1. In the current study, we applied a four-variable extension of a DCSM to examine dynamic associations between wives' and husbands' levels and longitudinal changes in episodic memory and depressive symptoms. Please see text for a more detailed description.
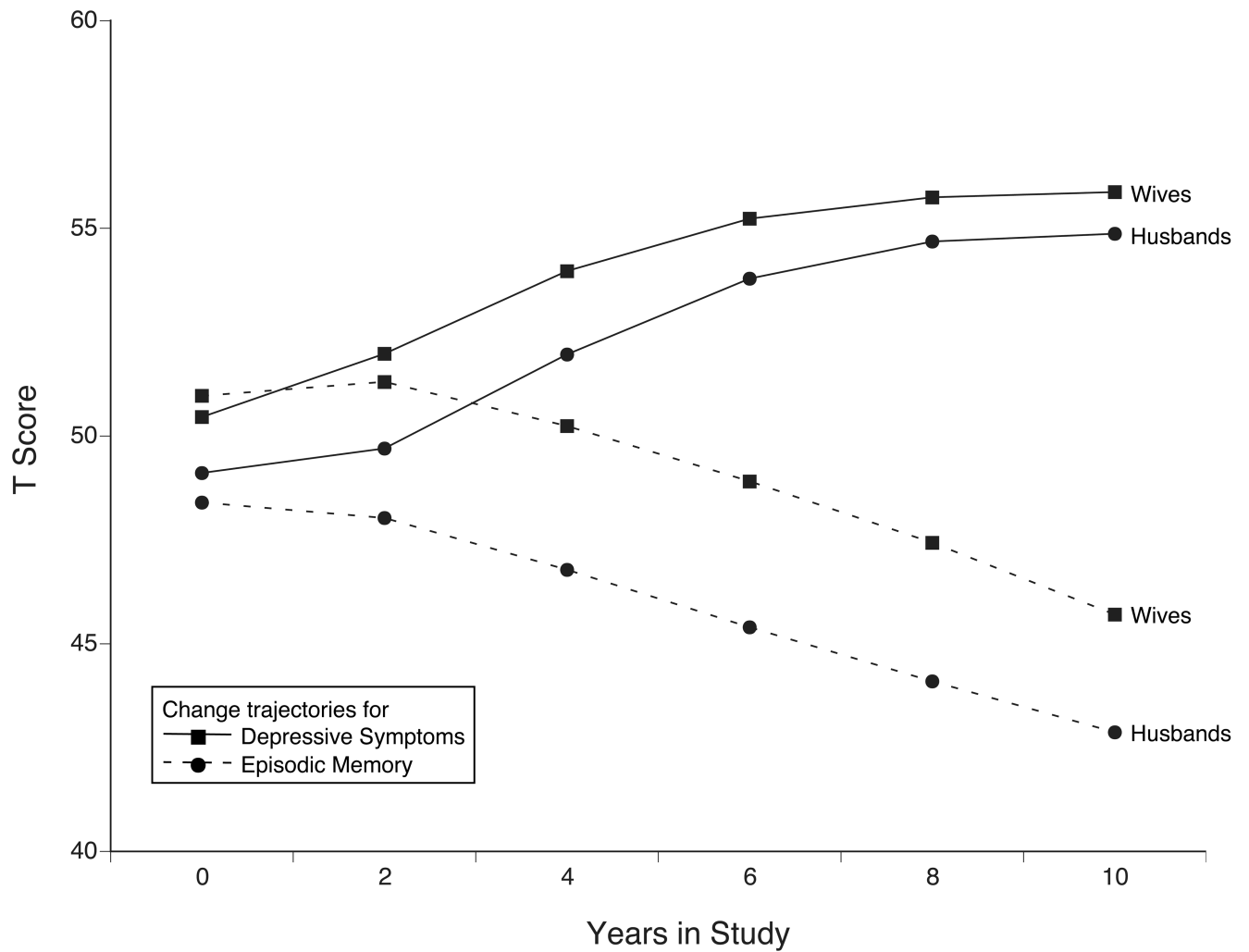
Figure 2.
Model-implied mean longitudinal change trajectories over time for wives' and husbands' episodic memory (dashed lines) and depressive symptoms (solid lines), as revealed from a four-variable Dual Change Score Model (Full Dynamics) for wives and husbands of sample average age (75 years). Estimated average changes for both wives and husbands were sizeable over the 10-year observation period (memory: 0.5+ *SD* decline, and depressive symptoms: 0.5+ *SD* increase).

Figure 3.
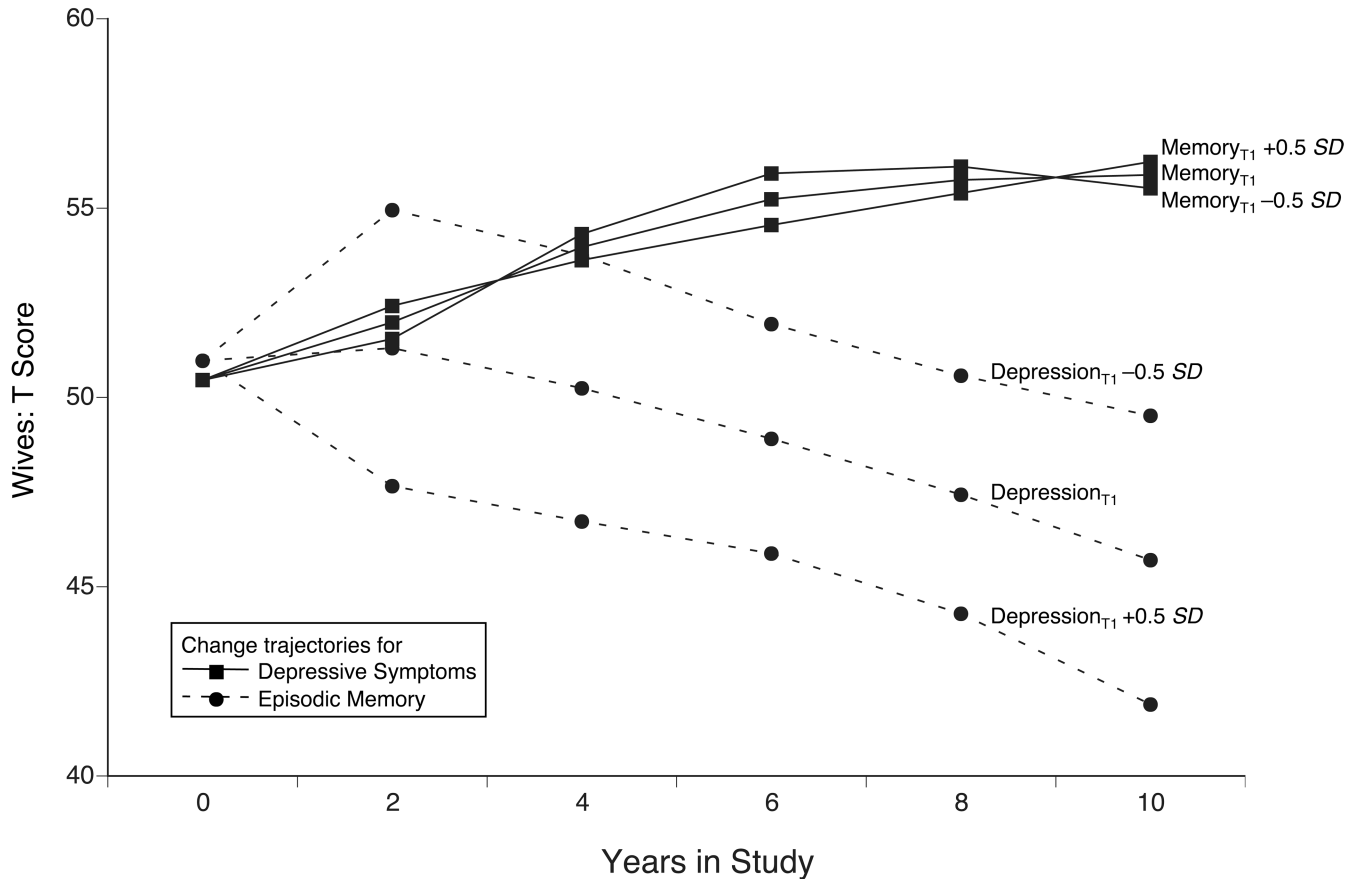Graphical illustration of the differential magnitude of dynamic actor effects between episodic memory and depressive symptoms in wives and their effects over time. Dashed lines represent model-implied sample means on wives' episodic memory from a four-variable Dual Change Score Model (Full Dynamics) for the hypothetical case that the initial sample means for wives' depressive symptoms were varied by half a standard deviation (i.e., 5 T-score units). Under the assumption of comparable wives' episodic memory at T1, wives with few initial depressive symptoms (depression$_{T1}$ −0.5 SD) showed relatively shallow memory decline, whereas those with more depressive symptoms initially (depression$_{T1}$ +0.5 SD) showed relatively steep memory decline subsequently. In contrast, the solid lines indicate that wives' depressive symptoms trajectories of change over time were minimally changed as a function of different initial levels of episodic memory at T1.
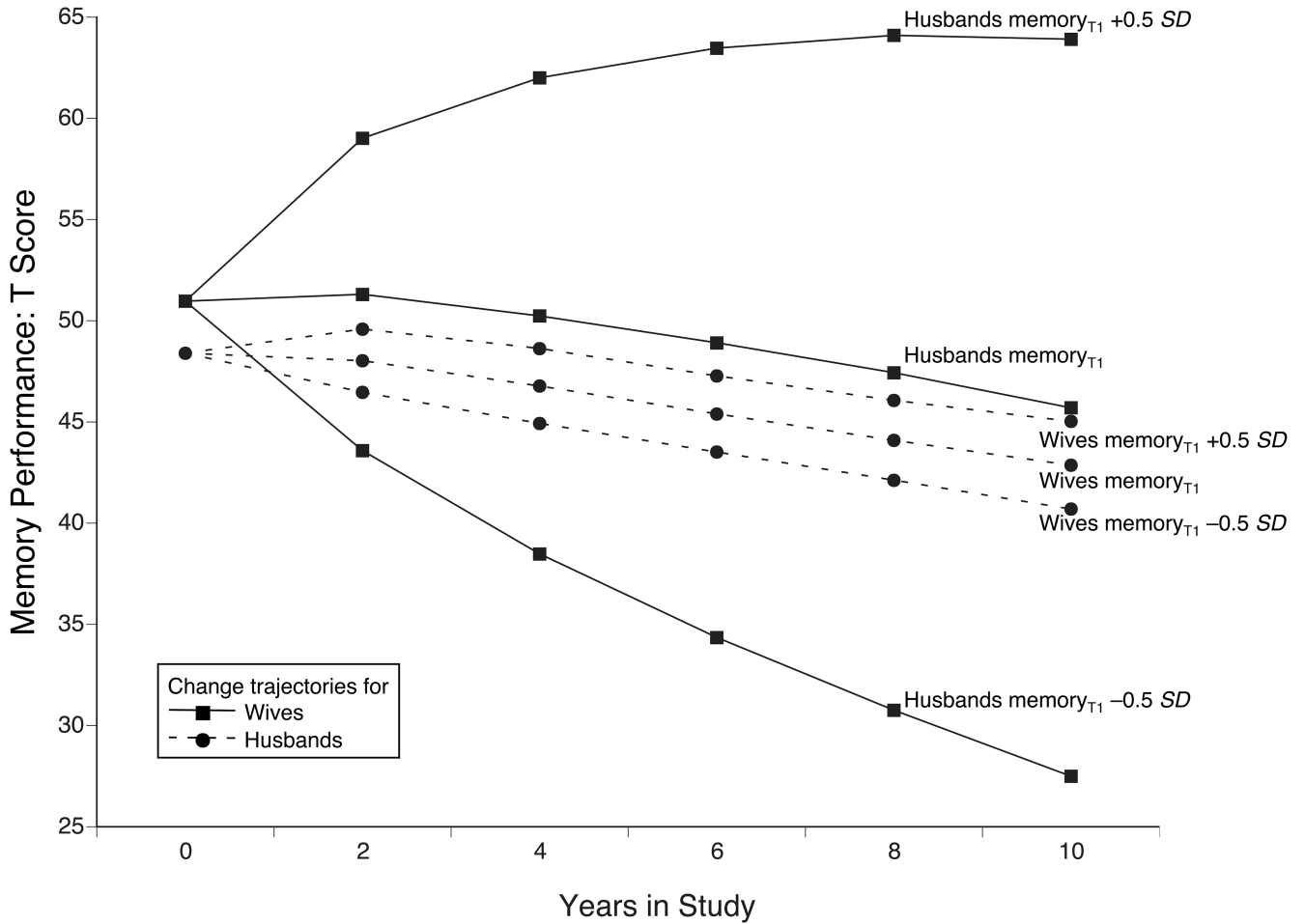
Figure 4.
Graphical illustration of the differential magnitude of dynamic partner effects between wives' and husbands' episodic memory and their effects over time. Solid lines represent model-implied sample means on wives' episodic memory from a four-variable Dual Change Score Model (Full Dynamics) for the hypothetical case that the initial sample means for husbands' episodic memory were varied by half a standard deviation (i.e., 5 T-score units). Under the assumption of comparable wives' episodic memory at T1, wives with cognitively fit husbands (husbands' memory$_{T1}$ +0.5 SD) showed relatively shallow memory decline, whereas those with cognitively less fit husbands (husbands' memory$_{T1}$ −0.5 SD) showed relatively steep memory decline. In contrast, the dashed lines indicate that husbands' episodic memory trajectories of change over time were minimally changed as a function of different initial levels of wives' episodic memory at T1.

Table 1

Age at Assessment and Descriptive Statistics for Measures Entered into the Four-Variable Dual Change Score Model: Data from the Study of Asset and Health Dynamics Among the Oldest Old (AHEAD).

Measure	Wives				Husbands			
	n	Age	Mean	SD	n	Age	Mean	SD
Memory								
T1	1,599	72.25	51.97	10.21	1,599	75.82	48.03	9.39
T2	1,391	73.94	53.11	9.99	1,309	77.43	48.24	9.37
T3	1,232	75.76	52.43	10.11	1,059	79.11	47.76	9.49
T4	1,083	77.31	52.41	9.48	866	80.64	47.33	8.88
T5	940	79.03	51.16	9.18	666	82.32	46.35	8.83
T6	834	80.71	49.78	9.29	542	83.89	45.72	8.06
Depressive symptoms								
T1	1,599	72.25	50.90	10.63	1,599	75.82	49.10	9.24
T2	1,404	73.96	50.95	11.02	1,328	77.47	48.73	9.32
T3	1,237	75.78	53.93	11.69	1,068	79.13	51.26	10.15
T4	1,097	77.37	53.97	11.93	879	80.68	51.24	10.28
T5	949	79.06	54.10	11.81	674	82.36	51.12	10.67
T6	845	80.76	53.66	11.81	549	83.94	51.68	10.68
Education								
T1	1,599	72.25	11.77	3.07	1,599	75.82	11.48	3.81
Functional limitations								
T1	1,587	72.25	1.22	1.63	1,597	75.84	0.97	1.56

Note. [1]Memory and depressive symptoms were standardized to the T metric using the T1 AHEAD couple sample (N = 3,198) as the reference, *Mean* = 50, *SD* = 10. At baseline assessment, couples were married for an average of 44.82 years (*SD* = 14.49; range: 1–77 years) and had an average of 2.99 children (*SD* = 2.07; range: 0–10).

Table 2

Results from a Four-Variable Dual Change Score Model (Full Dynamics) for Episodic Memory and Depressive Symptoms, Using the 10-Year AHEAD Couple Sample: Parameter Estimates for Memory and Depressive Symptoms.

Parameter	Wives		Husbands	
	Episodic memory	Depressive Symptoms	Episodic memory	Depressive Symptoms
Fixed effects				
Initial mean μ_0	50.97*	50.46*	48.40*	49.11*
	(0.27)	(0.29)	(0.23)	(0.24)
Slope mean μ_s	–4.16*	2.11	–0.48	–0.33
	(1.95)	(1.39)	(1.33)	(0.22)
Proportion β	–0.86*	0.59	0.46	–1.59*
	(0.26)	(0.44)	(0.27)	(0.57)
Random effects				
Initial variance σ^2_0	41.49*	35.16*	29.63*	19.43*
	(2.99)	(2.62)	(1.84)	(2.44)
Slope variance σ^2_s	11.24	3.13	2.54	13.11
	(5.80)	(3.39)	(2.07)	(8.46)
Error variance σ^2_e	41.13*	64.49*	40.31*	48.94*
	(1.06)	(1.40)	(0.93)	(1.31)
Correlations actor level				
Initial <-->slope	.20*	–.33	–.29	.38*
Memory initial <-->initial	–	–.14*	–	–.09*
Memory initial <-->slope	–	–.01	–	.01
Memory slope <-->initial	–	.25	–	–.27
Memory slope <-->slope	–	–.52	–	–.75
Correlations partner level				
Memory initial <-->initial	.11*	–.04	–	–.05
Memory initial <-->slope	–.49*	.04	–	–.04
Memory slope <-->initial	.12	.45*	–	–.21*
Memory slope <-->slope	.75	–.70	–	–.52
Depression initial <-->initial	–	.09	–	–
Depression initial <-->slope	–	.51*	–	–
Depression slope <-->initial	–	–.49*	–	–
Depression slope <-->slope	–	.78	–	–
Memory residual <-->residual	.02*	–	–	–
Depression residual <-->residual	–	.08*	–	–

Note. 1, 599 couples at T1. Episodic memory and depressive symptoms were standardized to the T metric using the T1 AHEAD couple sample (*N* = 3,198) as the reference, *Mean* = 50, *SD* = 10. All estimates, except correlations, are unstandardized. Slope parameters divided by 10. The significance tests assigned to the correlations refer to the corresponding covariances. Estimates are residualized for age, education, and functional

limitations of both partners. Model fit statistics: χ^2 (*df*) = 544.2 (354); Comparative Fit Index, CFI = 0.981; and root mean square error of approximation, RMSEA = 0.018.

[*]
p < . 05 or below.

Table 3

Parameter Estimates from a Four-Variable Dual Change Score Model (Full Dynamics) of Memory (MEM) and Depressive Symptoms (DEP), Using the 10-Year AHEAD Sample: Dynamics Parameters.

Parameter	Estimate	SE
Actor effects		
Dynamics $\gamma_{H.MEM\rightarrow H.DEP}$	−0.28	0.50
Dynamics $\gamma_{H.DEP\rightarrow H.MEM}$	0.60	0.82
Dynamics $\gamma_{W.MEM\rightarrow W.DEP}$	0.09	0.24
Dynamics $\gamma_{W.DEP\rightarrow W.MEM}$	−0.73*	0.34
Partner effects: Within-domain associations		
Dynamics $\gamma_{H.DEP\rightarrow W.DEP}$	−0.90	0.46
Dynamics $\gamma_{W.DEP\rightarrow H.DEP}$	1.58*	0.49
Dynamics $\gamma_{H.MEM\rightarrow W.MEM}$	1.54*	0.41
Dynamics $\gamma_{W.MEM\rightarrow H.MEM}$	−0.31	0.17
Partner effects: Cross-domain associations		
Dynamics $\gamma_{H.MEM\rightarrow W.DEP}$	−0.19	0.38
Dynamics $\gamma_{W.DEP\rightarrow H.MEM}$	−0.60*	0.27
Dynamics $\gamma_{W.MEM\rightarrow H.DEP}$	0.31	0.32
Dynamics $\gamma_{H.DEP\rightarrow W.MEM}$	0.97*	0.37

Note. 1,599 couples at T1. Episodic memory (MEM) and depressive symptoms (DEP) were standardized to the T metric using the T1 AHEAD couple sample ($N = 3,198$) as the reference, *Mean* = 50, *SD* = 10. Unstandardized estimates and standard errors are presented. Estimates are residualized for age, education, and functional limitations of both partners.

Model fit statistics: χ^2 (*df*) = 544.2 (354); Comparative Fit Index, CFI = 0.981; and root mean square error of approximation, RMSEA = 0.018.

*
$p < .05$ or below.