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Adult Age Differences in Covariation of Motivation and Working Memory Performance: Contrasting Between-Person and Within-Person Findings

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Developmental theorists have proposed for a long time that the prevailing focus on stable individual differences has obstructed the discovery of short-term covariations between cognitive performance and contextual influences within individuals that may help to uncover mechanisms underlying long-term change. As an initial step to overcome this imbalance, we observed measures of motivation and working memory (WM) in 101 younger and 103 older adults across 100 occasions. Our main goals were to (1) investigate day-to-day relations between motivation and WM, (2) show that these relations differ between groups of younger and older adults, and (3) test

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whether the within-person and between-person structures linking motivational variables to WM are equivalent (i.e., the ergodicity assumption). The covariation between motivation and WM was generally positive in younger adults. In contrast, older adults showed reduced variability in motivation, increased variability across trials, and small reliability-adjusted correlations between motivation and WM. Within-person structures differed reliably across individuals, defying the ergodicity assumption. We discuss the implications of our findings for developmental theory and design, stressing the need to explore the effects of between-person differences in short-term covariations on long-term developmental change.

In 1962, K. Warner Schaie applied the Lewinian concept of lifespace to the study of age changes in behavior (Lewin, 1935; Schaie, 1962). According to Lewin (1935), the lifespace can be understood as a force field with a variety of energy vectors of fluctuating and shifting valence. Adopting this dynamic and person-oriented view of development K. Warner Schaie (1962) proposed to conceptualize adult age changes in behavior as the individual's capacity to influence and adapt to changes in this force field. In this context, he noted: "Experience has shown that it is a formidable task to identify the ever-changing forces which act upon the individual at any given moment as well as to identify his capacity to deal with any particular stimulus" (p. 132). Thus, in 1962, Schaie set the stage for a perspective on adult cognitive development that is inherently (1) dynamic, (2) person-oriented, and (3) plastic, that is, open to experiential and historical influences. Much of Schaie's later empirical work focused on the plasticity aspects by revealing cohort differences in developmental trajectories, and by documenting older adults' ability to acquire and maintain new skills. In line with long-standing pleas by John Nesselroade (1991) and others, the current investigation of adult age differences in within-person links between cognitive performance and motivational influences responds to the challenge posed by Schaie in 1962.

MOTIVATION AND COGNITIVE PERFORMANCE

The role of contextual influences on working memory (WM) performance has come into focus rather recently. This upsurge reflects the realization that conceiving cognitive functioning as stable abilities neglects intraindividual variations in performance across short periods of time (e.g., Nesselroade & Salthouse, 2004; Rabbitt, Osman, Moore, & Stollery, 2001). Such variation indicates a state-like quality, points at systematic time-varying correlates of performance, and allows speculation about mechanisms that drive intraindividual variation. For example, recent studies have shown that the exposure to daily stress is coupled with WM performance within individuals, potentially indicating an allocation of attention to events and not to task performance (Sliwinski, Smyth, Hofer, & Stawski, 2006).

The relation between motivation and performance outcomes has been studied intensely in educational psychology (e.g., Eccles & Wigfield, 2002) and in basic research on skill acquisition (e. g., Kanfer & Ackerman, 1989). Motivational constructs such as interest or achievement orientation have been found to predict variations in performance outcomes (e.g., Hidi, 2006; Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008). Mechanisms such as the allocation of effort or the control of off-task aspects (Eccles & Wigfield, 2002; Kanfer & Ackerman, 1989; Yeo & Neal, 2008) may mediate the relation between motivation and performance. This article aims at relating variations in WM performance to fluctuations in motivation within younger and older individuals. *WM* refers to the ability to maintain information for a short period of time and to simultaneously transform or manipulate this information (Park & Payer, 2006). Some researchers argue that the ability to keep attention on the items in memory is the crucial component contributing to interindividual differences in performance (Engle & Kane, 2004). It seems plausible to assume that motivation helps to control attention and to resist distractors, and therefore affects WM performance.

In the current study, two aspects of motivation, effort and enjoyment, were investigated. Whereas effort globally indicates the presence of task-related allocation of resources, enjoyment, according to self-determination theory (Ryan & Deci, 2000), is an expression of intrinsic motivation to engage in a task that is accompanied by positive feelings such as excitement and confidence. Such a state influences how tasks are approached, as it may enhance persistence or creativity. Given that intrinsic motivation may result in task-related effort, we explore whether the two facets of motivation can be represented by a single factor. Effort and enjoyment may vary as a function of changing task or learning environment characteristics (e.g., Tsai et al., 2008). The design of the current study required individuals to work on quasi-identical tasks on 100 occasions in the same laboratory. Therefore, effects of these variables on motivation seem unlikely. However, individuals' task-related effort and enjoyment probably vary across days due to contextual factors such as fatigue or goals competing with the requirement of attending a study session. Thus, dynamics of behavior reflecting motivational variability are thought to occur in the context of multiple interactions of a person with his or her environment.

MOTIVATION AND WORKING MEMORY PERFORMANCE: ADULT AGE DIFFERENCES

We hypothesized a reduced linkage of motivation and WM performance in old age for several reasons. First, cognitive abilities requiring cognitive control decline across the adult life span (Bäckman, Small, Wahlin, & Larsson, 2000; West, 1996). WM is often described as a central mechanism underlying the general

decline of controlled processing (Park & Payer, 2006). If older adults have increasing difficulties with tasks requiring control, their attempts to influence performance outcomes or to exert control should be less efficient. That is, older adults may want to do well but cannot realize their intent in performance. Second, reduced variability in older adults' motivation may reduce motivation cognition co-variation in older adults. We assume that motivation fluctuations in the laboratory environment reflect varying characteristics of study days. Given that older adults may have more routinized lives (Bouisson & Swendsen, 2003), their motivation may be more stable, too. In addition, the training of cognitive abilities in the current study may be an important goal for older participants, leading to stability of motivation across sessions. Third, insights on neurofunctional changes across adulthood also predict a decoupling between motivation and WM performance with increasing adult age. More pronounced performance variability in older as compared to younger adults observed across time could be partly attributable to less efficient neuromodulation and more neural processing noise (e.g., Li, Lindenberger, & Sikström, 2001). Thus, in older adults, larger proportions of cognitive variability could be driven by stochastic influences on neural function that are unrelated to systematic contextual influences such as motivation. To sum up, all the above issues speak for less coupling between motivation and WM performance in older adults.

METHODOLOGICAL APPROACH: CONTRASTING CROSS-SECTIONAL AND PERSON-CENTERED FINDINGS

A second aim of this article was to contrast findings generated at the between-person level with findings generated at the within-person level. We thereby tested the ergodicity assumption, that is, the often-made, highly debated, and rarely tested assumption of an equivalence of within- and between-person structures of psychological variables (Borsboom, Mellenbergh, & van Heerden, 2003; Lindenberger & Oertzen, 2006; Molenaar, 2004). The relations among effort, enjoyment, and WM can involve between-person effects, in the sense that individuals who put much effort into performance achieve better results, and within-person effects, such that days with more effort are better performance days. Many psychologists seem to believe in the applicability of identical assumptions to both levels of analysis. However, the ergodicity assumption requires homogeneity of all individuals' within-person structural relations, meaning that intraindividual variation of all persons in a population is alike. In addition, it relies on stationarity (the absence of time-related trends in co-variance structures; Molenaar, 2004). In the current study, time-related trends across study duration and shorter periods such as weeks were statistically controlled; therefore, it is the first issue, homogeneity of intraindividual variation, that needs to be considered.

We did not expect the ergodicity assumption to hold in these data. In accordance with the person-oriented nature of the lifespace concept (Lewin, 1935; Schaie, 1962), we think that individuality does not primarily manifest itself as levels of attributes in relation to other individuals' levels measured cross-sectionally, but rather as a within-person phenomenon that becomes apparent through individuals' functioning and behavior across time. Moreover, we expected that relations observed between variables cross-sectionally would represent within-person relations present in some, but not all individuals (Hamaker, Nesselroade, & Molenaar, 2007; Molenaar, 2004; Nesselroade, 1991). Thus, in aiming to answer our content-driven research question on age group differences in the relations between effort, enjoyment, and cognitive performance, rather than presuming similarity between individuals, we were interested in revealing interindividual differences in intraindividual relations among variables. Those differences could occur in (1) number of latent factors, (2) loading matrices of common factors, (3) the correlation of latent factors, and (4) the amount of variation (Hamaker et al., 2007).

METHOD

This study is part of the COGITO Study, conducted at the Center for Lifespan Psychology, Max Planck Institute for Human Development, Berlin (Schmiedek, Lövdén, & Lindenberger, 2009). The primary aim of the COGITO Study was to investigate within- and between-person structures of cognitive abilities as well as intraindividual variability of cognitive performance.

Participants and Procedure

Participants were a group of younger adults (N = 101, 20 to 31 years, M = 25.6, 52% female, years of school attendance: M = 12.6 years) and a group of older adults (N = 103, 65 to 80 years, M = 71.3, 50% female, years of school attendance: M = 10.8 years). Participants first took part in the pretest, then completed about 100 daily sessions, before study participation was concluded with the posttest. During the microlongitudinal study phase, participants worked on the tasks individually in rooms with three to six work places on an almost daily basis from Monday to Saturday. The total number of sessions per person ranged from 89 to 109 (M = 101). Each session lasted 1 to 1½ hours and consisted of computerized self-report measures (e.g., mood, daily events, motivation) and 12 cognitive tasks (three WM tasks, three episodic memory tasks, and six perceptual speed tasks). More details on sample and procedure are provided by Schmiedek et al. (2009).

Measures

Motivation. Motivation was conceptualized as participants' experience related to target activity, as suggested by self-determination theory; it was measured with the Intrinsic Motivation Inventory (Deci & Ryan, n.d.; Ryan & Deci, 2000). Three reworded items were used from the Interest/Enjoyment subscale, measuring intrinsic motivation (I enjoyed working on the tasks very much; I found the tasks to be boring; The task was fun to do), and with two items from the Effort subscale, capturing self-regulatory action directed at performance outcomes (I tried to do well on this activity, It was important to me to do well on the tasks). Participants were asked to indicate how well items described their experience on that day on an 8-point scale (0 = *does not apply at all*, 7 = *does apply very well*).

WM: 3-back task. A 3-back task measured spatial-figural WM (Schmiedek et al., 2009). In each daily session, four trials were administered. Accuracy was used for the analyses. Because presentation times were individually adjusted, mean accuracy levels were not further investigated.

Data Analysis

We tested the co-variation between daily motivation and daily WM performance by conducting confirmatory factor analyses using maximum likeliwood estimation. Based on theoretical considerations, two- and three-factor solutions with correlated factors were tested (Figure 1). Results were generated cross-sectionally, that is, on each of 89 days separately for each age group (the number of days is the minimum of sessions completed by individuals), and at the individual level. Thus, we used R- and P-technique factor analysis (Cattell, 1966, Figure 1). The use of factor analysis may reveal interindividual and age group differences in the within-person relations of performance and motivation. In addition, it allows observing differences in processing robustness by inspecting within-person loadings matrices (WM factor). The assumption of lower systematic day-to-day variance (variation across days) and more trial-to-trial variability (variation across trials) in WM performance in older adults should become apparent in lower and more heterogeneous factor loadings of their WM factor.

Before running P-technique factor analyses, data were detrended with penalized radial spline smoothing functions as implemented in SAS PROC GLIMMIX (Ruppert, Wand, & Carroll, 2003; Schmiedek et al., 2009). Average performance across four trials was detrended and then difference scores were created (predicted average score, day t - observed trial score, day t). Time-related trends of all motivation items were also controlled with spline smoothing functions.

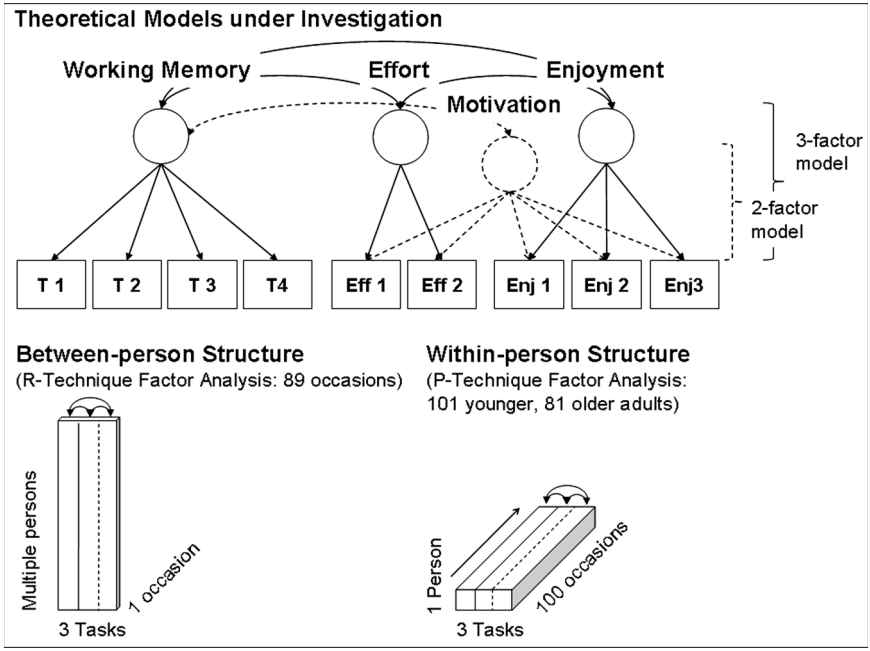

FIGURE 1 Theoretical models under investigation and illustration of R- and P-technique factor analysis approach to data; four trials (T) are indicators of working memory task, two items are indicators of effort (Eff1, 2), three items are indicators of enjoyment (Enj1-3); R- and P-technique factor analyses are used to investigate covariance structures as they occur between individuals and within individuals, respectively (Cattell, 1966).

RESULTS

Variance of study variables was inspected prior to conducting factor analysis of the 11 WM and motivation variables. Twenty-two older individuals showed zero variance on motivation items. These individuals were excluded from subsequent analyses. The remaining sample consisted of 101 younger and 81 older adults.

Between-Person Factor Structures: Motivation and Working Memory Performance

The structure of motivation and cognitive performance was first approached cross-sectionally. Confirmatory R-technique factor models were tested on each of 89 study occasions, separately for the two age groups. The two theoretically plausible models were tested (Figure 1). According to the root mean square error

TABLE 1
Model Fit of Between-Person and Within-Person Confirmatory Factor Analysis (R-Technique and P-Technique) Separately for Younger and Older Adults and for a Two- and Three-factor Model (Motivation and Working Memory, WM; Effort, Enjoyment, and WM)

	M	*SD*	*Min.*	*Max.*
R-TECHNIQUE FACTOR ANALYSES[1]				
2-factor model				
RMSEA				
Younger adults (N = 101)	0.09	0.03	0	0.18
Older adults (N = 82)	0.09	0.03	0	0.16
3-factor model				
RMSEA				
Younger adults (N = 101)	0.04	0.04	0	0.15
Older adults (N = 82)	0.03	0.03	0	0.12
P-TECHNIQUE FACTOR ANALYSES[2]				
2-factor model				
Younger adults (N = 25)	.04	.04	0	.09
Older adults (N = 24)	.05	.04	0	.10
3-factor model				
Younger adults (N = 52)	.04	.04	0	.10
Older adults (N = 25)	.04	.03	0	.09

Note. [1]Results were generated for 89 occasions; [2]Information is reported for 126 individuals for whom one of the two models produced proper solutions (22 individuals were excluded prior to analyses because of stable motivation).

RMSEA = root mean square error of approximation.

of approximation (RMSEA) averaged across all occasions, the three-factor model represents the data more appropriately than the two-factor model (see Table 1). The fit of the three-factor model was on average acceptable in both age groups (RMSEA ≤ .05). Correlations of the latent factors revealed some heterogeneity of results across occasions in the two- and the three-factor solutions (Figure 2). This variation can be qualified as unsystematic because individuals attended testing sessions on different weekdays and in different months, reducing the likelihood of systematic differences between occasions at the sample level. There were age group differences in the cross-sectional pattern of latent correlations. In younger adults, the single motivation factor as well as the two separate motivation factors (effort and enjoyment) were positively correlated with performance; older adults' correlations were not reliably different from zero. According to *t* tests comparing both age groups, all latent WM-motivation correlations significantly differed between younger and older adults; single motivation factor and performance: $t(176) = 25.6$, $p < .05$ ($M_{younger} > M_{older}$); effort and performance: $t(176) = 26.6$, $p < .05$ ($M_{younger} > M_{older}$); enjoyment and performance: $t(176) = 25.3$, $p < .05$ ($M_{younger} > M_{older}$).

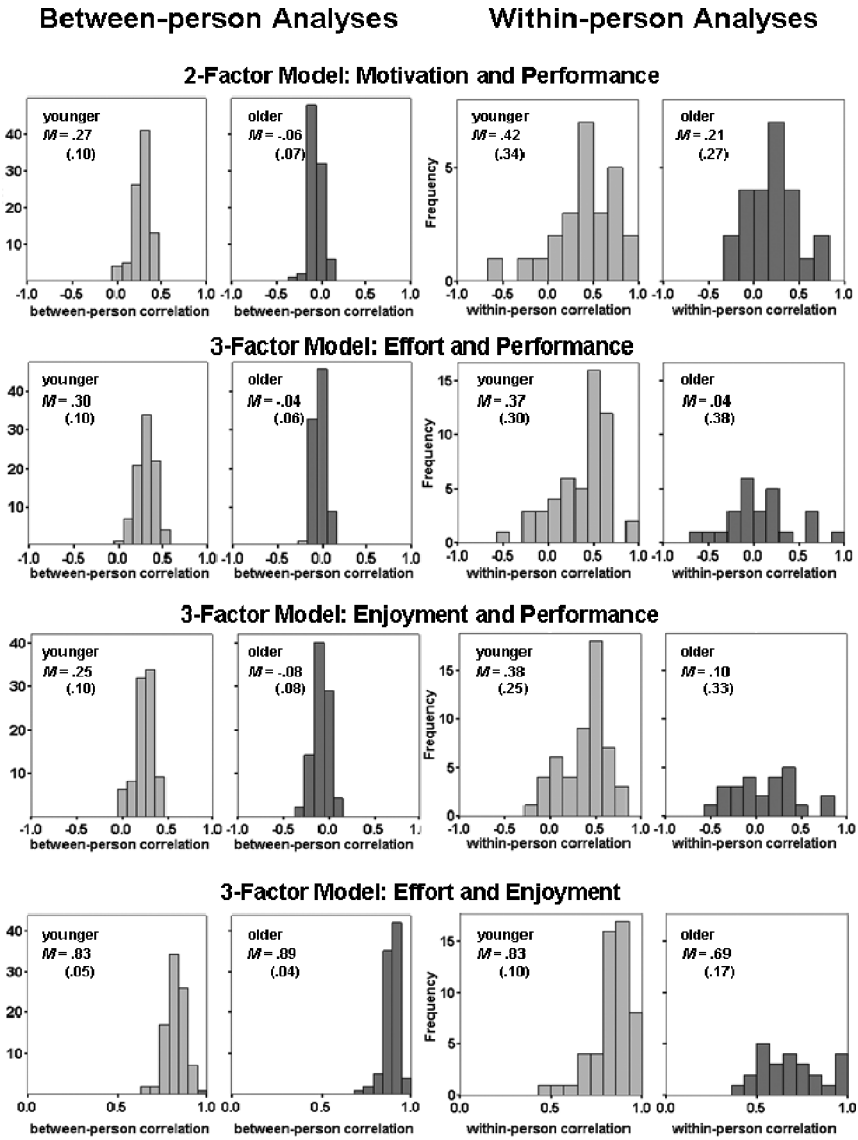

FIGURE 2 Distribution of latent correlations of motivation (effort, enjoyment) and working memory performance: Results from r-technique and p-technique confirmatory factor analyses separately for younger and older adults; numbers in brackets are *SD* of average latent correlation (*M*).

Within-Person Factor Structures: Motivation and Working Memory Performance

In all 182 individuals, the same within-person (P-technique) confirmatory two-factor (motivation, performance) and three-factor (effort, enjoyment, performance) models were tested to find out whether individuals could be represented by one or the other solution. A two- or three-factor model with reasonable solutions was fitted to 126 out of 182 individuals (77 younger and 49 older adults).[1] In some individuals, the two- and three-factor solution met these criteria; thus subsequently the two- and three-factor solutions were evaluated against each other by means of the RMSEA. In 12 individuals (7 younger, 5 older), the two- and three-factor solutions resulted in an identical RMSEA. These individuals were classified as two-factor individuals in subsequent analyses, following the principle of parsimony. Results of this classification and information on model fit can be obtained from Table 1.[2] In the majority of younger adults, the three-factor model was the better model, implying that motivation differentiates into effort and enjoyment. Neither of the two models dominated the solutions in older adults.

In a second step, individuals' loading matrices were inspected. Loading matrices of eight individuals are presented in Table 2 to illuminate interindividual differences as found in the sample. Some individuals, especially younger adults, followed theoretical expectations, showing homogeneous loadings on the different factors (Individuals [Ind.s] 1, 6). Individuals differed in the size of loadings (e.g., Ind. 1 as compared to Ind. 7). A striking difference between individuals occurred regarding the second enjoyment item, as only in some individuals, this item traveled together across time with the other enjoyment items (Ind.s 1, 3, 6 as compared to Ind.s 4, 7, 8). Heterogeneity in factor loadings (including size and algebraic sign) was most prevalent in the WM factor (Ind.s 2, 3, 4, 5, 8), and more so in older adults. In the majority of those individuals, heterogeneity appeared to be unsystematic (Ind.s 2, 3, 8). In others, one can speculate whether the variation in loadings is somewhat systematic (Ind. 4) as there is a linear

[1]Criteria defining reasonable solutions were that (1) models converged, (2) the model fit according to the RMSEA was ≤ .10, thus close to acceptable, and (3) reasonable latent correlations ($-1 < r < 1$) and standardized factor loadings (90% CI of lambda 1–9 entails 1) were obtained.

[2]Results as described in Table 3 were more closely inspected with regards to the fit index. Of the 77 younger and 49 older individuals, in 63 younger (82%) and in 40 older (82%) adults the RMSEA was <.08, thus acceptable as usually defined in the literature. In addition, the standardized root mean square residual (SRMR) was evaluated so as not to rely on one fit statistic only. The SRMR indicated an acceptable fit of the model that was chosen for individuals according to the RMSEA for most individuals (SRMR < .08). In three younger adults (4%), the SRMR was larger than .08, but smaller than .086; in 12 older individuals (25%), the SRMR was larger than .08, but smaller than .098. A critical model fit (RMSEA ≥ .08) was confirmed by a critical SRMR (≥ .08) primarily in some older adults.

TABLE 2
Eight Individuals' Factor Loadings: Interindividual Differences in Homogeneity of Factors and Size of Loadings

	Working Memory				*Motivation*					
	Trial 1	*Trial 2*	*Trial 3*	*Trial 4*	*Effort 1*	*Effort 2*	*Enjoyment 1*	*Enjoyment 2*	*Enjoyment 3*	*Comment*
Two-factor model										
Individual 1 (y)	0.76	0.71	0.71	0.72	0.80	0.51	0.80	0.80	0.81	homogenous loadings
Individual 2 (y)	0.36	0.70	0.15	0.26	0.79	0.70	0.86	0.38	0.83	heterogeneous WM factor loadings
Individual 3 (y)	0.49	–0.28	–0.22	0.36	0.79	0.66	0.87	0.70	0.82	heterogeneous WM factor loadings
Individual 4 (o)	0.11	0.29	0.40	0.50	0.79	0.61	0.62	–0.04	0.67	heterogeneous WM factor loadings (systematic?), problematic enjoyment item
Individual 5 (o)	0.38	–0.29	–0.40	–0.69	0.71	0.56	0.26	0.10	0.48	heterogeneous WM factor loadings, heterogeneous motivation
Three-factor model										
Individual 6 (y)	0.66	0.47	0.65	0.68	0.97	0.89	0.96	0.81	0.97	homogenous loadings
Individual 7 (y)	0.36	0.39	0.29	0.38	0.88	0.86	0.97	–0.04	0.92	homogenous loadings, but rather low WM loadings, problematic enjoyment item
Individual 8 (o)	0.34	0.52	0.33	–0.08	0.36	0.67	0.90	0.06	0.65	heterogenous loadings, problematic enjoyment item

Note. y = younger; o = older.

increase across trials, potentially revealing systematic reactive variability (Fiske & Rice, 1955), such as becoming better with each trial. Table 3 summarizes interindividual differences in factor loadings by reporting the average loadings and the *SD* of loadings across WM trials and motivation items. The most striking age group difference according to the inspection of loadings matrices, namely older adults' larger heterogeneity in the WM loadings, became apparent through their lower average loadings and larger variances of the four WM trials.

Third, the individuals' latent correlations of the two- and three-factor solutions were inspected. These analyses revealed interindividual and age group differences (Figure 2). In the majority of younger adults, days with higher levels of motivation or effort and enjoyment, respectively, were days with higher performance levels. The strength of these associations differed across younger individuals, with some individuals showing large latent correlations and others showing small to medium correlations. In some younger individuals, latent relations were negative. The most striking age group difference is that performance was generally less correlated with motivation or effort and enjoyment in older individuals. Indeed, in the majority of older individuals, there was no correlation between variations in motivation and WM performance. The distribution of correlation coefficients ranged from negative to positive in older adults. Average age group differences in latent within-person correlations resembled cross-sectional findings: motivation and performance: $t(47) = 2.3$, $p < .05$ ($M_{younger} > M_{older}$); effort and performance: $t(75) = 3.7$, $p < .05$ ($M_{younger} > M_{older}$); enjoyment and performance: $t(75) = 4.3$, $p < .05$ ($M_{younger} > M_{older}$).

TABLE 3
Within-Person (P-technique) Average Loadings of Working Memory (WM) Factor and Motivation Factors; Variances Across Variables Forming Factors in Younger and Older Adults

	Younger		*Older*	
	M	*SD*	*M*	*SD*
Two-factor model				
Average loading four working memory (WM) trials	0.36	0.21	0.20	0.25
SD four WM trials	0.15	0.09	0.30	0.17
Average loading motivation	0.63	0.15	0.45	0.15
SD motivation	0.19	0.10	0.25	0.09
Three-factor model				
Average loading four WM trials	0.41	0.26	0.18	0.18
SD four WM trials	0.20	0.20	0.27	0.14
Average loading effort	0.83	0.08	0.72	0.15
SD effort	0.07	0.06	0.16	0.14
Average loading enjoyment	0.74	0.13	0.58	0.17
SD enjoyment	0.16	0.13	0.26	0.14

In 56 of 182 individuals (24 younger, 32 older adults), no two- or three-factor model could be fitted. Follow-up analyses indicated that that the four WM trials did not form one factor[3] in many of these cases.

DISCUSSION

In the current study, motivation was investigated as a correlate of WM performance within and across younger and older individuals. A factor-analytic approach was chosen to compare covariance structures identified cross-sectionally and at the individual level. A central finding of the current study was that WM performance co-varied with motivation across days. On average, and as suggested by between- and within-person analyses, a positive relation existed between motivation and WM performance, and this positive relation was reduced in older adults. The person-centered approach revealed person-specific characteristics in intraindividual variability that limit the validity of such general statements. Individuals were found to differ on numerous dimensions, most importantly in the context of the current study, in the latent relations between factors. Thus, the average findings resemble only some individuals. These interindividual differences empirically defy the notion of equivalent within-person and between-person factor structures, demonstrating the necessity to differentiate between patterns and causes of static structures, measured in a sample of individuals at a single point in time, and time-dependent structures measured in a sample of time points within the same individual (Molenaar, 2004).

Motivation and Working Memory in Younger and Older Adults: Overall Tendencies

A comparison of cross-sectional findings across 89 study days and within-person analyses revealed comparable average tendencies in the relation between motivation and WM performance in younger and older adults. The average cross-sectional latent correlations are a rough indicator of the "average individual's" latent

[3]To better understand why, in 56 out of 182 individuals, no two- or three-factor solution could be fitted, we first tested whether either the WM trials or the motivation items did not form factors. In 28 individuals (14 younger, 14 older) the different WM trials were not represented by a single factor as tested in one-factor confirmatory analyses. In addition, the motivation items did not form a one- or two-factor solution in two older adults. In the remaining 26 individuals, exploratory factor analyses were conducted. In most cases (6 younger, 12 older), the solutions included unsystematic factor loadings across factors (WM trials and motivation items formed the factors), or the WM trials loaded on more than one factor. In one individual, the factors seemed to be in line with theoretical ideas, and one individual was best represented by a one-factor model. In the remaining individuals (2 younger, 4 older), no factors could be extracted.

correlations, whereby the average cross-sectional findings seem to underestimate the average within-person finding. In younger adults, motivation, as well as effort and enjoyment, were positively correlated with performance (small to medium average correlations). In older adults, average cross-sectional findings were negative and close to zero whereas average findings at the individual level were positive but small. The positive correlation in younger adults is in line with earlier findings of positive associations between subfacets of motivation and performance levels, and with the notion that effort and enjoyment imply an allocation of resources to task performance (e.g., Kanfer & Ackerman, 1989; Ryan & Deci, 2000). This finding extends current knowledge by linking motivation to within-person variation in cognitive abilities. As within-person variation in motivation has been construed as reflecting proximal situational features of the performance situation (Tsai et al., 2008), the current study is unique in showing fluctuation in motivation under stable laboratory conditions. We assume that daily duties and opportunities to engage in personally relevant activities vary more in younger adults, resulting in variations in the willingness to invest in the study. Other contextual variations, such as preparing for a job interview, may constrain the ability to invest, that is, the ability to mobilize resources. Moreover, it seems plausible that reduced performance levels result in diminished motivation which in turn may impair performance even more. Additional research is necessary to support these speculations and to reveal the causal directionality between motivation and performance.

Within-person analyses revealed that average cross-sectional findings conceal important differences between younger and older adults and that the general applicability of the theoretical model is more constrained in older adults, because a satisfying solution could be derived in only 49 of 103 older individuals. Older adults showed reduced variability in motivation, to the extent that 21% of older adults did not vary on some of the motivation items and had to be excluded from further analyses. Thus, in a considerable number of older individuals, effort and enjoyment in the laboratory environment did not have state-like qualities. It is possible that participating in the study had such a salience to these individuals that the impact of events in daily life was not have enough to interfere with study commitment. More generally, many of the older adults in the current study may have been highly motivated to improve their cognitive functioning through training. This selection bias may have reduced the amount of within-person and between-person variability in motivation, potentially reducing estimated day-to-day variance in motivation and its coupling to cognition relative to unknown population parameters. On the other hand, if stability of motivation is representative of the general population, then the average latent within-person correlations overestimate the average in the population because those older individuals with no variation in motivation, and thus, no covariation of motivation with WM, have not been taken into consideration in the average within-person findings.

In line with theoretical expectations, relatively more variability across the four WM trials was observed in older adults. In 31% of older as compared to 22% of younger adults, no acceptable factor solution could be derived, meaning that a theoretical interpretability of solutions was lacking. This was largely caused by the WM trials not forming a single factor. In older adults with a two- or three-factor solution, processing was also unstable, as evidenced by more heterogeneous loadings on the WM factor relative to younger adults. Increased neural noise as described by Li and colleagues (2001) may potentially underlie this finding. In those older adults with proper solutions, resource allocation as measured with items capturing motivation was weakly related to WM performance, implying that only a few older individuals showed patterns of covariation resembling the pattern typically observed in younger adults. A potential explanation for the discrepancy between these older and younger adults is age-associated declines in exerting control over cognitive processes (Bäckman et al., 2000; West, 1996).

Challenging the Ergodicity Assumption: Interindividual Differences

A particular contribution of the current study is that it constitutes another demonstration of the heterogeneity of within-person covariance structures (e.g., Hamaker et al., 2007) and, due to a sufficient sample size, it allowed direct comparisons of within-person and between-person factor structures. Individuals differed in several important aspects, including (1) the applicability of the theoretical model (some individuals' motivation did not have a state-like quality), (2) the stability of WM performance across trials (for some individuals, no WM factor could be extracted), (3) the differentiation of motivation, resulting in two- or three-factor solutions, (4) the loading matrices, questioning a homogeneous meaning of underlying factors, and (5) the magnitude of the relations between factors. Regarding this last dimension, the range of individuals' latent correlations goes beyond coefficients that could be interpreted as more or less being in line with average coefficients as in some individuals, the sign of the relation was reversed.

General Implications

The present findings challenge the common practice of identifying general relationships and meaningful moderators in sample-based analyses. Interindividual differences may not allow a comparison of all individuals in a sample regarding a specific research question (e.g., if motivation does not vary, no covariation can be observed), and they may indicate qualitative rather than quantitative differences. For example, differences between individuals' relations of enjoyment and performance may indicate a difference of the meaning of enjoyment in a performance situation. In some individuals, enjoyment may mean solving tasks efficiently, and in others the feeling of enjoyment may reflect a

current pleasant state that is used as information to judge the performance situation (Clore & Parrott, 1994). Whether these different meanings relate to performance levels then may depend on how a specific meaning of enjoyment translates into how a task is approached. To take person-specific patterns of variability into consideration, or to "emphasize the uniqueness of individuals" (Nesselroade, Gerstorf, Hardy, & Ram, 2007, p. 218) without losing sight of the aim of deriving nomothetical laws, person-centered analysis can be used to represent individuals' characteristics over time; then, in a second step, information can be pooled and general relationships can be established (Nesselroade, 2001). Beyond the substantial conclusions drawn for average findings, a meaningful grouping of people according to similarities remains to be realized. To do so, decisions are necessary on the criteria that allow pooling across individuals, for example, whether to relax invariance of loadings matrices to compare individuals with similar latent interrelations (Nesselroade et al., 2007). At the same time, it needs to be kept in mind that interindividual variation does not have to defy ergodicity if this variation can be adequately described as variation around population parameters. Some data patterns may lend themselves to both sample-based and person-based representations, and the relationship between the two approaches merits further scrutiny.

To conclude, the current study tackled the "formidable task" of identifying some of the "ever-changing forces that act upon the individual at any given moment" (Schaie, 1962, p. 132) by examining daily links between motivation and cognitive performance within younger and older adults. We found that within-person and between-person links between motivation and cognitive performance are generally not equivalent, especially not in old age. Future research needs to further elucidate the antecedents, correlates, and consequences of between-person differences in the within-person link between motivation and cognitive performance.

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