Stability and Change in Typical Intellectual Engagement in Old Age Across 5 Years

Anna Mascherek[1] and Daniel Zimprich[2]

[1]Department of Psychology, University of Zurich, Switzerland.
[2]Institute of Psychogerontology, University of Erlangen-Nuremberg, Germany.

Objectives. Typical intellectual engagement (TIE) is related to cognitive development across the life span, but the development of TIE itself has not been examined. In the present study, structural change, differential change, absolute change, stability of divergence, and the generality of changes in the 4 TIE-factors abstract thinking, problem solving, reading, and intellectual curiosity across 5 years were examined in older adults.

Method. Data came from the Zurich Longitudinal Study on Cognitive Aging. Two hundred and thirty-three individuals, 73 years on average at first measurement occasion (2005), were reassessed after 5 years. Confirmatory factor analyses and latent change score models were applied.

Results. Factor covariances were equal across time, implying structural stability. Coefficients for differential stability were around .80, implying small significant mean-level changes for problem solving and intellectual curiosity. No changes in divergence emerged. Change correlations between the factors were in the medium to large range.

Discussion. Across 5 years, TIE remained relatively stable on a group level. However, pronounced interindividual differences emerged. Also, although the changes in factors shared a substantial amount of variance, the development of the factors was not completely parallel.

Key Words: Interindividual change—Intraindividual change—Longitudinal analyses—Old age—Typical intellectual engagement.

THE question of how one's own way of life and behavior influence cognitive development and how noncognitive aspects or environmental influences contribute to the development of cognitive performance has received increasing interest (e.g., Hertzog, 2009). A body of research, where mainly small to moderate effects are reported, exists on how intellectually demanding leisure activities, level of education, or complexity of occupation influence cognitive functioning (e.g., Schooler & Mulatu, 2001, Schooler, Mulatu, & Oates, 1999; Schumacher & Martin, 2009). However, research on within-person variables that foster an intellectually engaged lifestyle is not as prominent yet.

Typical Intellectual Engagement

A construct that may help explain why some persons lead an intellectually engaged lifestyle was put forth by Goff and Ackerman (1992). They identified "typical intellectual engagement" (TIE) as a construct that is closely related to personality and to knowledge acquisition. TIE is defined as "an individual's aversion or attraction to tasks that are intellectually taxing" (Ackerman, Kanfer, & Goff, 1995, p. 276). For example, intellectually taxing activities may be reading or learning a new language. Research on cognitive aging has repeatedly found that engaging in intellectual activities can attenuate cognitive decline in old age (Hertzog, 2009). Hence, TIE could serve as one variable in explaining interindividual differences in cognitive development in old age.

A self-rating questionnaire is commonly used to assess TIE (Ackerman & Goff, 1994; Dellenbach & Zimprich, 2008; Ferguson, 1999; Wilhelm, Schulze, Schmiedek, & Süß, 2003). According to Dellenbach and Zimprich (2008), the TIE scale can be subdivided into four factors: reading, abstract thinking, problem solving, and intellectual curiosity. The different factors correlate with correlations ranging from $r = .85$ between abstract thinking and problem solving to $r = .18$ between reading and abstract thinking (e.g., Mascherek & Zimprich, in press). Similar results were obtained by Wilhelm and colleagues (2003).

TIE is similar to Openness to Experience and need for cognition (NFC). Correlations between Openness to Experience and the TIE factors ranged from $r = .44$ to $r = .70$ (Ackerman & Goff, 1994). TIE still added incremental validity: Although cognitive abilities and the Big Five personality traits explained 15% of variance in academic performance, TIE added a unique 9% of explained variance (Chamorro-Premuzic, Furnham, & Ackerman, 2006). In the same vein, TIE and NFC (Cacioppo & Petty, 1982) were found to be related with correlations as high as $r = .78$ (Mussel, 2010; Woo, Harms, & Kuncel, 2007). However, ForsterLee (2007) found evidence that NFC and TIE differentially predict performance in men and women. Hence, although there is substantial overlap, NFC and TIE measure distinct constructs (see Wilhelm et al., 2003).

TIE was found to be differentially related to crystallized and fluid intelligence. Although for fluid intelligence, the

relation was negligible (about 1% of shared variance), it was much stronger for TIE and crystallized intelligence (about 11% of shared variance; Goff & Ackerman, 1992). These findings are in line with the conceptualization of TIE indicating that TIE is related to volitional knowledge acquisition and study rather than to reasoning and speed. Using TIE as a predictor variable for cognitive performance, Gow, Whiteman, Pattie, and Deary (2005) found a small relation ($r = .21$; $r = .13$) between TIE and IQ at age 11 and age 79 years. In a different study, Furnham, Swami, Arteche, and Chamorro-Premuzic (2008) found a significant correlation between TIE and general knowledge ($r = .22$) in a sample of 100 undergraduate students. ForsterLee (2007) showed that although TIE was a significant predictor for cognitive performance in women, it was not in men. The relation between TIE and education indicated that the higher the educational level of an individual, the higher they score on TIE (e.g., Wilhelm et al., 2003). Nevertheless, specific relations between TIE and academic achievement have only been investigated in samples of graduate and undergraduate students. However, besides the importance of TIE for healthy aging, research on the development of TIE and its relation to cognition in older age is sparse.

To the best of our knowledge, only one study investigated age-related differences in TIE (see Mascherek & Zimprich, in press). But because TIE was investigated cross-sectionally, no inferences could be made in terms of development and interindividual differences in intraindividual change. Therefore, the objective of the present study was to examine different types of longitudinal change in TIE across 5 years in an old aged sample. In what follows, we elaborate on five different types of change (cf. Zimprich & Mascherek, 2010), namely structural change, absolute change, change in divergence, differential change, and general versus specific change. Because research on the development on TIE is sparse, we report results concerning Openness to Experience.

"Structural change" refers to the constancy of the subfactors' relation to each other. It describes to what extent the "skeleton" of the subfactors remains stable across time. Overall, results concerning structural change are mixed. Allemand, Zimprich, and Martin (2008) found structural change in the Big Five personality traits across 12 years in old age. Contradictory to this finding, Small, Hertzog, Hultsch, and Dixon (2003) found structural stability across 6 years. For TIE, to the best of our knowledge, only one study has investigated structural stability cross-sectionally (Mascherek & Zimprich, in press). In their study, they found structural differences between young and old adults with larger correlations between the subfactors for the older. Larger correlations between the TIE subfactors implied that differences between subfactors are diminished.

"Absolute change," that is, change on the mean level, refers to changes of a group of individuals. Mean-level changes in Openness to Experience most often have been found in terms of a decline in old age (Allemand, Zimprich,

& Hertzog, 2007; Allemand et al., 2008; Roberts, Walton, & Viechtbauer, 2006). In their cross-sectional investigation of TIE in young and old adults, Mascherek and Zimprich (in press) found both higher and lower levels in the TIE subfactors in old age. Results implied that although the manner in which intellectual activities are displayed was lower in old age, a general interest in academic and intellectually taxing topics was higher.

"Change of divergence" describes the change of interindividual differences with respect to a specific construct (Zimprich & Mascherek, 2010). It is expressed in increasing or decreasing variances and has been referred to as "fan-spread phenomenon" in the literature (Stanovich, 1986). Studies on change in divergence in personality development are sparse and with conflicting results. For Openness to Experience, Allemand and colleagues (2007) found larger variances in younger adults compared with older adults. By contrast, Small and colleagues (2003) found stability of divergence for all Big Five personality aspects across 6 years. Yet another result was found by Mascherek and Zimprich (in press) with respect to TIE. They found significantly larger variances in the older sample compared with young adults for the subfactors reading, problem solving, and abstract thinking. For intellectual curiosity, no difference was found.

"Differential change" reflects the consistency of individual differences across time (Martin & Zimprich, 2005). It describes to what extent individuals remain stable relative to each other. Over a twelve-year period, Allemand and colleagues (2008) found profound differential change, indicating individual differences in the change of personality traits. Across 6 years, Small and colleagues (2003) found high longitudinal differential stability for Openness to Experience. The results indicated that with elapsing time, individuals were more likely to change their relative placement within a reference group.

"Specific versus general change" refers to the question of the generality in change of the different TIE factors (Martin & Zimprich, 2005). General change indicates that changes in different factors can be ascribed to one underlying common mechanism. If the same underlying mechanisms drive the development of different aspects of TIE, factors that appear different on behavioral level must share structural commonalities. The opposite is true for specific change. Allemand and colleagues (2008) found large commonalities in change between Openness to Experience, Agreeableness, Conscientiousness, and Extraversion, indicating general change.

Overall, because the results reported mainly apply to Openness to Experiences, a related yet different construct, it is difficult to formulate exact hypotheses. However, the following hypotheses were derived: First, mean-level stability as well as second structural stability were expected. Third, an increase in divergence was expected. Fourth, rank-order coefficients were expected to resemble the relationship

found in the study by Small and colleagues (2003), and fifth, large change correlations were expected.

METHOD

Sample

The data for the present study come from the Zurich Longitudinal Study on Cognitive Aging (ZULU; Zimprich et al., 2008), an ongoing study on normative cognitive aging in Switzerland. At first measurement occasion (T1: 2005), the sample comprised 364 participants, whereas at the third measurement occasion (T3: 2010), 233 individuals participated in the study (for further details of sample recruitment and sample composition, see Zimprich et al., 2008). The second wave was not included because it was assessed 1.5 years after T1. A personality-related construct such as TIE would be expected to remain stable over this interval. To be able to capture change, we used data covering a time span of 5 years. Mean age at T1 was 72.99 years (*SD* = 4.4 years, 65–80 years) and at T3 was 77.90 years (*SD* = 4.42 years, 72–86 years) with 46% of the sample being female. In terms of representativeness, the sample of the present study was slightly overeducated (12.8 years of education on average). To examine whether sample attrition was selective, individuals leaving after T1 (26 individuals) and after T2 (104 individuals) were merged together into one group. There were no significant mean-level differences between the dropout and the non–dropout group. However, in the group of individuals that participated at all three measurement occasions, TIE variances were significantly larger at T1. In addition, the covariances among the four subfactors were significantly higher in the non–dropout group. Although excluding individuals from the analyses limits the generalizability of the results, we only included the 233 complete cases because change of divergence and structural change were of specific interest in the present study.

Measures

TIE was assessed using a 16-item self-rating scale that was embedded in the ZULU-test battery. The 16 items represent an abridged version of the original 59-item TIE scale (Ackerman & Goff, 1994). Item selection for the abridged version of the present study was based on previous factor analytic studies that examined the structure of TIE (Ferguson, 1999; Goff & Ackermann, 1992; Wilhelm et al., 2003). Items with the highest factor loadings across the three studies were selected (for details, see Dellenbach & Zimprich, 2008). The scale entails four related subfactors: reading, problem solving, abstract thinking, and intellectual curiosity. Four items were assigned to each subfactor, except for the factor intellectual curiosity with five items. One item ("I maintain I lively interest in reading books on a variety of topics") was allowed to load on intellectual curiosity as well as on reading because the item's phrasing comprised

aspects that fit reading and intellectual curiosity. Participants were asked to answer the items on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). High scores indicate a high manifestation of TIE. For the exact item wording used in ZULU.

Statistical Analyses

Measurement invariance was examined as a prerequisite for the analyses of different types of change on the latent level. Measurement invariance describes the degree of stability of the psychometric characteristics of a questionnaire. Changes at the latent level can then be interpreted without confounding measurement errors. Three degrees of measurement invariance were tested in the present analyses. We examined configural invariance, weak invariance, and strong invariance. According to Meredith and Horn (2001), configural invariance implies constraining the items to load on the same factor across time, indicating that the same items can be assigned to the same theoretical construct across time. Weak invariance requires the factor loadings to be equal across time. This indicates that the information that every item contributes to the assessment of a construct remains the same across time. Strong measurement invariance requires the item intercepts to be equal across time. Strong measurement invariance indicates that differences in latent factor means are not confounded by differences in item-specific intercepts (Meredith & Teresi, 2006). As criterion to evaluate changes in model fit, we rely on changes in comparative fit index (CFI). According to Cheung and Rensvold (2002), a drop of no more than 0.01 in CFI indicates invariance.

For the analyses of change in TIE, first, structural stability was assessed by examining the invariance of factor covariances across time. Structural stability indicates that a construct and the relations between the subfactors remain stable across time. Next, differential stability was tested by assessing the test–retest correlation (Martin & Zimprich, 2005). Thirdly, mean level changes were assessed in constraining latent factor means to be equal across time. No significant decrement in model fit would indicate that on average, no change emerged. Change of divergence was then measured by constraining the factor variances to be equal across time. A significant decrease in model fit would imply that the sample became substantially more or less homogeneous. Hence, variances indicate the homogeneity of a sample. Finally, specific versus general change was assessed by correlating longitudinal change scores. For the analyses of change on the latent level, latent difference score models were applied (McArdle & Hamagami, 2001). As criteria for model fit, the root mean square error of approximation (RMSEA) with its 90% confidence interval, the CFI, and the root deterioration per restriction (RDR) are reported as fit indices. RMSEA values below 0.06 denote a good model fit, and values up to 0.08 denote an acceptable fit, whereas

Table 1. Estimated Models

Model	χ^2	df	$\Delta\chi^2$	Δdf	RDR	CFI	RMSEA	90% CI
Four-factor T1	236.12*	112			—	0.99	0.069	0.057–0.081
Four-factor T3	205.77*	112			—	0.99	0.060	0.047–0.073
Configural MI	735.71*	480			—	0.99	0.048	0.041–0.055
Weak MI	764.25*	494	28.54*,a	14a	0.066	0.99	0.049	0.042–0.055
Strong MI	787.05*	507	22.8*,b	13a	0.056	0.99	0.049	0.042–0.055
Structural	790.56*	513	3.51c	6	0.000	0.99	0.048	0.042–0.055
Differential	887.37*	511	100.32*,b	4	0.321	0.82	0.060	0.0.54–0.066
LCS	787.05*	507			—	0.99	0.049	0.042–0.055
Absolute	795.87*	511	8.83c	4	0.071	0.99	0.049	0.042–0.056
Divergence	791.49*	511	4.45c	4	0.021	0.99	0.049	0.042–0.055

Notes. CFI = comparative fit index; df = degrees of freedom; LCS = latent change score model; MI = measurement invariance; RDR = root deterioration per restriction; RMSEA = root mean square error of approximation; T1 = first measurement occasion; T3 = third measurement occasion; 90% CI = 90% confidence interval of RMSEA.
[a] Represents the difference to the configural invariance model.
[b] Represents the difference to the weak MI model.
[c] Represents difference to LCS.
*$p < .05$.

for the CFI, values above 0.90 indicate a well fitting model (Hu & Bentler, 1999). RDR values below 0.08 can be interpreted as indicating no change in model fit (Raykov & Penev, 1998). Additionally, we report χ^2 values, degrees of freedom (df), and corresponding p values for all models. To scale the latent factors, factor means and variances were set to zero and one, respectively, to identify the model. The estimated means and variances for the change parameters should be interpreted in comparison with the estimates at T1. We used maximum likelihood estimation for our analyses. Analyses were conducted using SPSS 18 and SAS.

RESULTS

Analyses started with specifying a four-factor model separately for each time point. The model with the four factors, reading, abstract thinking, problem solving, and intellectual curiosity, fitted almost equally well at both measurement occasions (see Table 1). This leads to the conclusion that longitudinal analyses of stability and change were warranted. Note that the errors of the manifest variables were allowed to be correlated across time to improve model fit, and because in a longitudinal design, the same individuals are repeatedly measured, which implies that specific factors of the items can also be correlated across time. Then different degrees of measurement invariance were analyzed. The configural invariance model evinced a good fit (Table 1). Second, we imposed weak measurement invariance. As can be seen from Table 1, this, in terms of fit indices (CFI = 0.99; RDR = 0.066; RMSEA = 0.049), did not lead to a decrement in fit. Hence, we accepted this model. Next, strong measurement invariance was tested for. This, again, did not lead to a significant decrease in model fit (CFI = 0.99; RDR = 0.056; RMSEA = 0.049); hence, we accepted the strong measurement invariance model. When measurement invariance holds, changes on the latent level can be ascribed to changes in the underlying theoretical construct.

They are not confounded by systematic changes in the responding behavior.

Next, structural stability was analyzed. Constraining the covariances between the subfactors to be equal at T1 and T3 did not lead to a significant decrease in model fit ($\Delta\chi^2 = 3.51$, Δdf = 6, nonsignificant; CFI = 0.99; RDR = 0.000; RMSEA = 0.048). Structural stability was also tested with constraining the interfactor correlations to be equal. In doing so, possible differences in factor variances are also taken into account. However, this did not alter the result (see Table 1, structural), indicating that the structure between the four factors was stable across a 5-year interval. The factors most strongly related were abstract thinking and problem solving (T1: $r = .83$; T3: $r = .80$), whereas the weakest relationship emerged between reading and problem solving (T1: $r = .25$; T3: $r = .24$; see Table 2).

To assess differential change across time, test–retest correlations were estimated for the factors. Perfect differential stability is indicated by a test–retest correlation of $r = 1$. To test this, a model with across-time factor correlations being constrained to 1 was estimated. As Table 1 shows, this led to significant decrease in model fit ($\Delta\chi^2 = 100.32$, Δdf = 4, $p < .05$; RDR = 0.321; RMSEA = 0.060). The CFI dropped down to 0.82, implying that there were significant interindividual differences in the amount of change. At least for one subfactor, the across-time correlation had to be less

Table 2. Factor Correlations

	(1)	(2)	(3)	(4)
(1) Reading	**.88**a	.43a	.25a	.26a
(2) Abstract thinking	.37a	**.84**a	.83a	.58a
(3) Problem solving	.24a	.80a	**.83**a	.65a
(4) Intellectual curiosity	.26a	.67a	.66a	**.81**a

Notes: Correlations in bold indicate across time correlations; correlations in the upper triangle indicate factor correlations at T1; correlations in the lower triangle indicate factor correlations at T3.
[a] Indicates correlations significantly different from zero on $p < .05$.

Table 3. Level and Change Correlations

	Reading	Abstract thinking	Problem solving	Intellectual curiosity	(5)	(6)	(7)
(5) D_reading	**−.34**[a]	−.23[a]	−.24[a]	−.24[a]			
(6) D_abstract thinking	−.19	**−.50**[a]	−.33[a]	−.22	.31[a]		
(7) D_problem solving	−.06	−.35[a]	**−.35**[a]	−.16	.44[a]	.73[a]	
(8) D_intellectual curiosity	−.22	−.18	−.19	**−.36**[a]	.50[a]	.65[a]	.48[a]

Notes: "D_" indicates the change parameter; correlations in bold indicate level and change correlation within a factor; correlations in the right indicate correlations between the change factors: general versus specific change; all other correlations indicate correlations between level and change parameter between different factors.

[a] Indicates correlations significantly different from zero on $p < .05$.

than $r = 1.00$. As can be seen from Table 2, although all subfactors showed rather strong differential stability, in sum, shifts in rank order emerged. This result indicates that individuals differ in the amount of change in TIE across 5 years. The individual developmental trajectories do not run parallel but are specific for different individuals. Mean-level change is independent from this construct.

For the analyses of mean level changes, changes in variances and general versus specific changes, we reparameterized the strong measurement invariance model and estimated a latent change score model (McArdle & Hamagami, 2001). Means and variances were fixed to 0 and 1, respectively, in the level factor in order to identify the model. Hence, means and variances in the change factor can be directly interpreted as differences from the level estimates.

To test changes on the mean level, all factor means were constrained to be equal across time. This did not lead to a significant overall decrease in model fit ($\Delta\chi^2 = 8.83$, $\Delta df = 4$, $p > .05$; RDR = 0.071; RMSEA = 0.049). However, when examining each mean individually, a small but significant decrease for intellectual curiosity and an increase for problem solving emerged. The change scores indicate that, on average, individuals engage significantly more in problem solving but significantly less in intellectual curiosity. The nonsignificant changes in reading and abstract thinking indicate that on group level, both subfactors remain stable across 5 years. When latent change means were freely estimated, values were 0.108 (*SE*: 0.055; $p < .05$) for problem solving and −0.155 (*SE*: 0.075; $p < .05$) for intellectual curiosity. The changes in reading −0.002 (*SE*: 0.044) and in abstract thinking −0.028 (*SE*: 0.058) were not significant.

To analyze change of divergence, that is, the extent to which the sample homogeneity changes, variances were constrained to be equal across time. This did not lead to a significant decrease in model fit either ($\Delta\chi^2 = 4.45$, $\Delta df = 4$, $p > .05$; RDR = 0.021; RMSEA = 0.049), indicating that the amount of interindividual differences remained stable. Stability of divergence implies that across 5 years, overall differences between individuals do not become larger.

In a last step, general versus specific changes were investigated. This aimed at examining whether change in TIE could be subscribed to one underlying mechanisms or if the subfactors change rather independently. First, correlations between the change factors were estimated. Results are

shown in Table 3. Positive correlations indicate that change in one factor goes along with change in the other factor. The actual direction of change is indicated by the means. For two of the four factors, non-significant mean changes emerged; hence, the direction cannot be reliably inferred for abstract thinking and reading. The positive change correlation between intellectual curiosity and problem solving ($r = .48$) shows that change above average in one factor is accompanied by change above average in the other factor. This means that individuals who increase above average in problem solving tend to decrease less (or even increase) in intellectual curiosity. In turn, a person who decreases more than average (i.e., has a more pronounced increase) in intellectual curiosity tends to increase less in (or even decrease) in problem solving. Overall, medium to large change correlations emerged, with the correlation between abstract thinking and reading being the weakest ($r = .31$) and with problem solving being the strongest ($r = .73$). Hence, the amount of shared variance ranged from 9% between changes in reading and abstract thinking up to 50% between changes in abstract thinking and problem solving. The results indicate that although changes in all factors were significantly related, a substantial amount of variance in change for each factor remains independent from changes in the other factors. Note that fitting a model with a general change factor did not exhibit an acceptable fit. This underscores that different mechanisms underlie the changes in the TIE factors.

Although TIE is one coherent construct, change in the subfactors is, to a substantial amount, driven by different mechanisms. Correlations between level and change are also shown in Table 3. Negative correlations here indicate that higher levels of TIE at T1 are associated with less change. As the largest effect, a medium negative correlation emerged between the level of abstract thinking and the change in problem solving ($r = -.35$) and vice versa ($r = -.33$). No significant relationships emerged between the level factor of reading and the change factors of the other factors. All other interfactor level–change correlations did not exhibit a systematic pattern and were either small or nonsignificant (Table 3). Finally, correlations between level and change within a factor were estimated. Negative relationships in the medium to large range emerged (see Table 3). This indicates that, overall, higher levels of the respective

factor at T1 were associated with less change. That is, the higher on TIE an individual rated herself, the smaller was the change in TIE for this person. We also tested age and gender as covariates to examine whether they accounted for unexplained variance in level and change. However, the covariates did not explain additional variance.

DISCUSSION

In the present study we, first, examined the factorial structure of the TIE scale by testing configural, weak, and strong measurement invariance (Meredith & Horn, 2001), and second, we analyzed the change of TIE across 5 years. Strong measurement invariance was found to hold as well as structural stability across 5 years. Hence, the findings can serve as a replication of the structure of the TIE questionnaire (Dellenbach & Zimprich, 2008). Finding measurement invariance as well as structural stability underlines that TIE as a construct can be reliably measured across time.

We then addressed differential stability. Profound differential change emerged for all the TIE factors, that is, reading, abstract thinking, problem solving, and intellectual curiosity. Because stability was modeled on the latent level, it is less affected by measurement error. Correlations less than one suggest that individuals change differently. Allemand and colleagues (2008) found $r = .69$ for Openness to Experience across 12 years. Hence, the tendency of less than perfect differential stability is known from the literature on personality development. Note that the higher correlations in TIE still fit into the literature as the study cited above covers 12 years, whereas TIE was measured across a 5-year period. Generally, research on critical life events, where nonnormative events affect some individuals, has shown to lead to different developmental trajectories (e.g., Roberts, Helson, & Klohnen, 2002). Hence, it might be that changes in rank order can be partly explained by individual changes in the living conditions. A limitation of the present study is that life events were not included into the analyses.

Even within the boundaries that are provided by biological constraints in personality development, motivational influences are possible as well. Research on motivational selectivity (e.g., Riediger & Freund, 2006) has shown that individuals tend to restrict oneself to few personal goals that are regarded as highly important for life satisfaction. In the course of cognitive resources becoming more restricted, differences between individuals concerning the importance of intellectual activity become more pronounced. One individual might enjoy engaging in intellectual activities but still value social interaction higher when she is forced to decide in the presence of declining resources. Hence, we conclude that profound changes in rank order could reflect motivational selectivity and focusing on different priority goals.

Parameters that describe a construct on the group level are means and variances. In the present study, small significant mean-level changes only emerged for intellectual curiosity

and problem solving. No changes in variances emerged. We propose the following explanation for the results of the present study. Participating in a longitudinal study on cognitive aging might have a unique effect on interests and intellectual activities itself. Not only are people who are highly interested in cognitive activity more likely to participate in psychological studies (e.g., Cooney, Schaie, & Willis, 1988), participating in a study that assesses age-dependent developmental changes in intellectual activities and interests could itself influence the development. Hence, the slight increase in problem solving could reflect peculiarities of the study. In ZULU, different kinds of cognitive tests are administered. Tests such as the digit symbol test, number series, or the standard progressive matrices could have roused the participants' interest to solve for example Sudoku's in their free time. This could have resulted in a perceived increase in problem solving across the time period of 5 years.

The decrease in intellectual curiosity is in line with research on Openness to Experience (Roberts et al., 2006; Small et al., 2003). Although intellectual curiosity in TIE has been found to be higher in old age (see Mascherek & Zimprich, in press), it is possible that the increase found in the cross-sectional study may reflect a cohort effect. Also, intellectual curiosity was assessed comparatively unspecific. Hence, individuals might rate their global interest in engaging in new topics as decreased. Attending a talk on a new topic outside the home could be complicated by physical deficiencies. The self-evaluation could then be confounded by perceived health issues.

We have two explanations for the stability of divergence. First, it seems possible that for significant changes in variances to occur, 5 years were too short. This explanation is in line with recent research on personality development. Small and colleagues (2003) found stability of divergence across 6 years. Hence, the 5-year interval in the present study might have been too short to exhibit changes in variances. Another explanation aims at sample selectivity. All participants were highly educated (see Zimprich et al., 2008) ending up in a comparatively homogeneous group with respect to intellectual interests and activities, which may lead to rather homogeneous developmental trajectories across a 5-year interval. This idea is supported by the significant negative level–change correlations that emerged for the factors, indicating that individuals scoring high on TIE at T1 experience the least change across a 5-year period. With most of the participants being intellectually engaged, one may conclude that this imposed a restriction on the level variance in the first place and in combination with the negative level–change correlations led to a nonsignificant development of variances across 5 years in the TIE factors.

In a last step, we analyzed change correlations between the four subfactors. The highest change correlation emerged between problem solving and abstract thinking. Both factors describe more abstract aspects of intellectual engagement, which may help explain a large amount of coupled

development. Among all change correlations, change in reading was the change least correlated with all other three factors. The factor "reading" aims at a highly trained, over-learned specific activity that is conceptually different from abstract thinking, problem solving, and intellectual curiosity. Because the TIE questionnaire does not assess what kind of books a person reads, reading does not necessarily imply much cognitive activity besides the activity itself. Hence, even if intellectual engagement decreases, reading as highly trained activity could remain unaffected. Likewise, if the frequency of reading decreases, the general interest in intellectual activity may remain unaffected. The positive change correlation between problem solving and intellectual curiosity implies that the increase in problem solving provides protection against decline in intellectual curiosity. Individuals who manage to maintain their level of problem solving also benefit from less decrease in intellectual curiosity. Because correlations do not imply causality, it is also possible to interpret the results the other way around: Individuals who manage to remain intellectually curious could also benefit in a way that problem solving even increases in older age.

To summarize, what do the results of the present study tell us about TIE in old age? First, the structure of TIE as a construct remained stable across 5 years. Second, differential but no mean-level change emerged for all subfactors of TIE across 5 years. This demonstrates that in order to understand the development of a given construct, it is necessary to investigate different aspects of development because individual differences may be masked by change or stability on the group level. Third, the change correlations between the four subfactors vary in magnitude, indicating different underlying mechanisms that drive change in TIE. Although the present study added important information to the literature on TIE concerning its development in older age, open questions remain to be addressed in future research. The relation between TIE and cognition needs to be further examined. Also, the question of a causal relationship between the constructs remains unanswered. This question could be addressed only longitudinally, including more than two measurement occasions to enable cross-lagged latent analyses. Another yet equally important aspect would concern the development of TIE in middle adulthood or, generally, across the life span. Also, the specific mechanisms that cause interindividual changes in TIE need to be the objective of future studies. Because TIE is conceptualized as influencing typical intellectual performance, another area of research could engage in the question if TIE could be trained in different settings or different stages across the life span.

CORRESPONDENCE

Correspondence should be addressed to Anna Mascherek, MSc, Department of Psychology, University of Zurich, 8050 Zurich, Switzerland. E-mail: a.mascherek@psychologie.uzh.ch.

REFERENCES

Ackerman, P. L., & Goff, M. (1994). Typical intellectual engagement and personality: Reply to Rocklin. *Journal of Educational Research*, *86*, 150–153. doi:10.1037//0022-0663.86.1.150.

Ackerman, P. L., Kanfer, R., & Goff, M. (1995). Cognitive and noncognitive determinants and consequences of complex skill acquisition. *Applied Journal of Experimental Psychology*, *1*, 270–304. doi:10.1037//1076-898X.1.4.270.

Allemand, M., Zimprich, D., & Hertzog, C. (2007). Cross-sectional age differences and longitudinal age changes of personality in middle adulthood and old age. *Journal of Personality*, *75*, 323–358. doi:10.1111/j.1467-6494.2006.00441.x.

Allemand, M., Zimprich, D., & Martin, M. (2008). Long-term correlated change in personality traits in old age. *Psychology and Aging*, *23*, 545–557. doi:10.1037/a0013239.

Cacioppo, J. T., & Petty, R. E. (1982). The need for cognition. *Journal of Personality and Social Psychology*, *42*, 116–131. doi:10.1037//0022-3514.42.1.116.

Chamorro-Premuzic, T., Furnham, A., & Ackerman, P. L. (2006). Incremental validity of the typical intellectual engagement scale as predictor of different academic performance measures. *Journal of Personality Assessment*, *87*, 261–268. doi:10.1207/s15327752jpa8703_07.

Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling*, *9*, 233–255. doi:10.1207/S15328007SEM0902_5.

Cooney, T. M., Schaie, K. W., & Willis, S. K. (1988). The relationship between prior functioning on cognitive and personality dimensions and subject attrition in longitudinal research. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, *43*, 12–17. doi:10.1093/geronj/43.1.P12.

Dellenbach, M., & Zimprich, D. (2008). Typical intellectual engagement and cognition in old age. *Aging, Neuropsychology, and Cognition*, *15*, 208–231. doi:10.1080/13825580701338094.

Ferguson, E. (1999). A facet and factor analysis of typical intellectual engagement (TIE): Associations with locus of control and the five factor model of personality. *Social Behavior and Personality*, *27*, 545–562. doi:10.2224/sbp.1999.27.6.545.

ForsterLee, R. (2007). Personality, interest, and motivational determinants of maximal and typical performances on a verbal knowledge task. *Human Performances*, *20*, 287–292. doi:10.1080/08959280701333420.

Furnham, A., Swami, V., Arteche, A., & Chamorro-Premuzic, T. (2008). Cognitive ability, learning approaches and personality correlates of general knowledge. *Educational Psychology*, *28*, 427–437. doi:10.1080/01443410701727376.

Goff, M., & Ackerman, P. L. (1992). Personality—Intelligence relations: Assessment of typical intellectual engagement. *Journal of Educational Psychology*, *84*, 537–552. doi:10.1037//0022-0663.84.4.537.

Gow, A. J., Whiteman, M. C., Pattie, A., & Deary, I. J. (2005). The personality—Intelligence interface: Insights from an ageing cohort. *Personality and Individual Differences*, *39*, 751–761. doi:10.1016/j.paid.2005.01.028.

Hertzog, C. (2009). Use it or lose it: An old hypothesis, new evidence, and an ongoing controversy. In H. B. Bosworth, & C. Hertzog (Eds.), *Aging and cognition. Research methodologies and empirical advances* (pp. 161–179). Washington, DC: American Psychological Association. doi:10.1037/11882-008.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, *6*, 1–55. doi:10.1080/10705519909540118.

Martin, M., & Zimprich, D. (2005). Cognitive development in midlife. In M. Martin, & S. L. Willis (Eds.), *Middle adulthood: A lifespan perspective* (pp. 179–206). Thousand Oaks, CA: Sage.

Mascherek, A., & Zimprich, D. (in press). Age-related differences in typical intellectual engagement in young and old adults. *Experimental Aging Research*.

McArdle, J. J., & Hamagami, F. (2001). Latent different score structural models for linear dynamic analyses with incomplete longitudinal data. In L. M. Collins, & A. G. Sayer (Eds.), *New methods for the analysis of change* (pp. 203–240). Washington, DC: American Psychological Association. doi:10.1037/10409-005.

Meredith, W., & Horn, J. L. (2001). The role of factorial invariance in modeling growth and change. In L. M. Collins, & A. G. Sayer (Eds.), *New methods for the analysis of change* (pp. 203–240). Washington, DC: American Psychological Association. doi:10.1037/10409-007.

Meredith, W., & Teresi, J. A. (2006). An essay on measurement and factorial invariance. *Medical Care*, *44*, 69–77. doi:10.1097/01. mlr.0000245438.73837.89.

Mussel, P. (2010). Epistemic curiosity and related constructs: Lacking evidence of discriminant validity. *Personality and Individual Differences*, *49*, 506–510. doi:10.1016/j.paid.2010.05.014.

Raykov, T., & Penev, S. (1998). Nested structural equation models: Noncentrality and power of restriction test. *Structural Equation Modeling*, *5*, 229–246. doi:10.1080/10705519809540103.

Riediger, M., & Freund, A. M. (2006). Focusing and restricting: Two aspects of motivational selectivity in adulthood. *Psychology and Aging*, *2006*, 173–185. doi:10.1037/0882-7974.21.1.173.

Roberts, B. W., Helson, R., & Klohnen, E. C. (2002). Personality development and growth in women across 30 years: Three perspectives. *Journal of Personality*, *20*, 79–102. doi:10.1111/1467-6494.00179.

Roberts, B. W., Walton, K. E., & Viechtbauer, W. (2006). Patterns of mean-level change in personality traits across the life course: A meta-analysis of longitudinal studies. *Psychological Bulletin*, *132*, 1–25. doi:10.1037/0033-2909.132.1.1.

Schooler, C., & Mulatu, M. S. (2001). The reciprocal effects of leisure time activities and cognitive functioning in older people: A longitudinal analysis. *Psychology and Aging*, *16*, 466–482. doi:10.1037//0882-7974.16.3.466.

Schooler, C., Mulatu, M. S., & Oates, G. (1999). The continuing effects of substantively complex work on the intellectual functioning of older workers. *Psychology and Aging*, *14*, 483–506. doi:10.1037//0882-7974.14.3.483.

Schumacher, V., & Martin, M. (2009). Comparing age effects in normally and extremely highly educated and intellectually engaged 65–80 year-olds: Potential protection from deficit through educational and intellectual activities across the lifespan. *Current Aging Science*, *2*, 200–204. doi:10.2174/1874609810902030200.

Small, B. J., Hertzog, C., Hultsch, D. F., & Dixon, R. A. (2003). Stability and change in adult personality over 6 years: Findings from the Victoria Longitudinal Study. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences*, *58*, 166–176. doi:10.1093/geronb/58.3.P166.

Stanovich, K. E. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly*, *21*, 360–407. doi:10.1598/RRQ.21.4.1.

Wilhelm, O., Schulze, R., Schmiedek, F., & Süß, H.-M. (2003). Interindividuelle unterschiede im typischen intellektuellen Engagement. *Diagnostica*, *49*, 49–60. doi:10.1026//0012-1924.49.2.49.

Woo, S. E., Harms, P. D., & Kuncel, N. R. (2007). Integrating personality and intelligence: Typical intellectual engagement and need for cognition. *Personality and Individual Differences*, *43*, 1635–1639. doi:10.1016/j.paid.2007.04.022.

Zimprich, D., Martin, M., Kliegl, M., Dellenbach, M., Rast, P., & Zeintl, M. (2008). Cognitive abilities in old age: Results from the Zurich Longitudinal Study on Cognitive Aging. *Swiss Journal of Psychology*, *67*, 177–195. doi:10.1024/1421-0185.67.3.177.

Zimprich, D., & Mascherek, A. (2010). Five views of a secret: Does cognition change in middle adulthood? *European Journal of Ageing*, *7*, 135–146. doi:10.1007/s10433-010-0161-5.