

## 5. DISCUSSION

The aim of the present dissertation was to examine age-related differences in the stable and dynamic characteristics of daily positive and negative affect on the basis of a micro-longitudinal study spanning 45 days. Three research strands motivated this focus. The first is lifespan psychological theory, which characterizes human development in terms of a number of concepts including plasticity, multidirectionality, gains and losses, as well as contextualism (Baltes et al., 2006). Each of these lifespan concepts is intimately linked not only to long-term change but also to short-term intraindividual variability (i.e., fluctuation; Nesselroade, 1991b). Such intraindividual variability characterizes developmental pathways and individual differences in regulative functions in most domains of psychological functioning (Baltes et al., 1977; Eizenman et al., 1997; Miller, 2002; Nesselroade, 1988, 1991b; Siegler, 1994, 2002; Thelen, 1992). Furthermore, differences observed between individuals over the lifespan are considered as reflecting not only biology, socialization, and idiosyncratic life history factors but also a changing orchestration of these influences (Baltes, 1987; Baltes et al., 2006).

The second motivation was derived from research on the nature of emotional well-being and the role of age and personality differences in emotion regulation. Cross-sectional and longitudinal studies covering many years have indicated that trait-like emotional well-being is relatively well-preserved across adulthood (e.g., Gross et al., 1997; Kunzmann et al., 2000; Mroczek & Kolarz, 1998). Furthermore, the self-reported capacity for emotion regulation appears to be higher in older than in younger adults (e.g., Gross et al., 1997; Lawton, Kleban, Rajagopal, et al., 1992).

The third research strand inspiring this dissertation was rooted in experimental research. Positive and negative affect have been shown to have both disruptive as well as enhancing effects on various aspects of cognitive performance (Ashby et al., 1999; Bless, 2003; Bower, 1981; Ellis et al., 1997). For instance, the concurrent successful regulation of emotions and cognitive functioning requires the orchestration and allocation of similar basic resources (e.g., Ellis & Ashbrook, 1988; M. W. Eysenck & Calvo, 1992). In the context of the present dissertation, a dual-task perspective was considered as a framework for the examination of emotion-cognition coupling in everyday life.

The present dissertation represents an attempt to integrate these three lines of research by addressing three concerns about the (self-reported) experience of PA and NA that have received relatively little attention in the lifespan developmental literature:

1. Are there age-related differences in the stable and dynamic characteristics of day-to-day experiences of positive and negative affect?

2. Does age explain significant amounts of variance in day-to-day fluctuations in positive and negative affect above and beyond personality? Are there age-related differences in the association between fluctuations in PA and NA and trait-like and state-like correlates representing stress and psychological adjustment?
3. Are there reliable within-person associations between daily positive and negative affect and cognitive performance, and do age or other individual difference factors moderate this coupling?

These questions were examined in a micro-longitudinal study on day-to-day affect and cognitive performance in a sample of young (20–30 years) and older (70–80 years) adults. The unique features of this study are at least three-fold: The first research question represented an integration of the two initial research traditions in asking whether young and older adults differ not only in their average levels (i.e., stable features) of emotional well-being but also in the amount of between-day intraindividual variability (i.e. dynamic features) in two central characteristics of emotional well-being, positive affect and negative affect. This micro-level within-person perspective affords the researcher with a process-oriented insight into the fluctuations of emotional well-being that characterize young and older adults' everyday life. This is a key contribution to prior research, which has mainly yielded only snapshots of emotional well-being at one time point or spaced over years. A demonstration that young and older adults differ in the amount of within-person across-day fluctuation in well-being is a unique finding that adds to prior research on the emerging importance of emotion regulation in later adulthood (e.g., Carstensen, 1995; Carstensen et al., 1999).

The second set of research questions represented a further integration of the first two research traditions. First, personality has been shown to play a central role for individual differences in average (i.e., trait-like) levels of positive and negative affect across the adult lifespan (e.g., Costa & McCrae, 1980, 1984). The opposite is true for age, which shows only small relationships with average levels of emotional well-being (Costa et al., 1987; Gross et al., 1997; Kunzmann et al., 2000; Mroczek & Kolarz, 1998). In the context of the hypothesis that age may be critical for differences in variability rather than mean levels of positive and negative affect, it is important to examine whether this association is robust after controlling for personality differences. This analysis is a unique contribution to the literature because it extends the study of age and personality differences in well-being by a perspective on individual differences in processes of well-being. These processes may be important determinants of trait-like levels of psychological functioning. The second part of the research question on age-related differences in the functional nature and the time-varying correlates of variability in affect represents an

exploratory but unique contribution to the literature because it emphasizes a lifespan psychological perspective of the possible antecedents, correlates, and outcomes of individual differences in well-being fluctuations.

Finally, the third research question was aimed at an integration of the first and the last research strand, as it combined a focus on intraindividual variability rooted in lifespan psychological theory with research on the functional implications of emotional states on cognition. The unique contribution of this question is two-sided: In the first place, it represents an account of emotion-cognition theories at the intra-individual rather than the inter-individual level. In other words, theories of emotion-cognition interplay propose that emotion-induced task-irrelevant processing may interfere with cognitive performance on a criterion task (e.g., Ellis & Ashbrook, 1988; M. W. Eysenck & Calvo, 1992; Richards & Gross, 2000). I propose to consider emotion-cognition interplay from a dual-task perspective. In a strict sense, processes of resource allocation are best studied at the level of individuals rather than at an interindividual difference level. The second unique feature is the application of a lifespan theoretical perspective to the question of whether and how emotional states and cognitive functioning interact. In lifespan research, well-being has been considered primarily an outcome of successful aging (Baltes & Baltes, 1990; Rowe & Kahn, 1997; Ryff & Singer, 1998). The micro-longitudinal within-person perspective on emotion-cognition coupling adds process-level insights into a growing body of research indicating that self-related perceptions can be critical predictors of successful development, health, and even mortality (e.g., Gerstorf, Lövdén, Röcke, Smith, & Lindenberger, 2006; Levy, 2003; Maier & Smith, 1999).

### 5.1 Age-Related Differences in Stable and Dynamic Characteristics of Day-to-Day Emotional Well-Being

The first research question asked about age-related differences in the stable and dynamic characteristics of day-to-day emotional well-being. Even though at a first glance, this general research question appears to be relatively clear-cut, it requires an examination of age-related differences in PA and NA from three perspectives. First, regarding stable characteristics, it is important to ask about age-related differences in *mean levels* of PA and NA aggregated across the micro-longitudinal assessment period (i.e., nine weeks). The first characteristic provides information on individual differences in the average disposition-like level of emotional well-being characteristics. This perspective is conceptually and methodologically closest related to classical cross-sectional studies on age-related differences in emotional well-being. It adds, however, a

unique piece of information by capturing the average affective tone across an intensive repeated day-to-day assessment rather than an emotional well-being score derived from a single measurement.

Second, there is the question whether young and older adults differ in *time-related trends in these mean levels* across the nine-week assessment period. The second feature is critical to account for because together with information on average day-to-day levels of affect, time-related trends across the entire daily assessment period (i.e., relatively longer-term intraindividual variation) provide the context for an examination of relatively more short-term, day-to-day intraindividual variation. In the context of an intensive repeated assessment, time-related trends provide descriptive information about the relative amount of stability and change in emotional well-being, which may be driven by reactivity or adjustment to the task. This will be discussed further below.

Finally, in terms of the dynamical characteristics, it is central to examine age-related differences in the amount of *intraindividual short-term variability (i.e., fluctuations)* in self-reported affect across the nine-week period. This last perspective provides a unique window on the short-term plasticity of emotional well-being that can be observed around the dispositional average affective tone. In addition, short-term fluctuations may be indicative of regulatory mechanisms that operate underneath the evolution of emotional well-being across a given period of an individual's daily life.

Consistent with the general hypotheses proposed for this first set of research questions, age-related differences were found mainly with respect to mean daily levels and intraindividual variability in PA and NA. The following sections will outline these findings in more detail.

### *5.1.1 Older Adults Report Higher Levels of Day-to-Day Positive Affect than Young Adults*

Multilevel analyses, which accounted for the specific hierarchical structure of the time-series data (Raudenbush & Bryk, 2002) indicated that patterns of age-related differences in average levels of affective experience differed between the two affect domains: Older adults ( $M = 74.36$  years) reported significantly higher mean levels of daily PA than did younger adults ( $M = 25.50$  years). No age-related differences emerged for mean levels of daily NA, however, even though at a descriptive level, older adults reported slightly lower mean levels of NA than young adults. It is interesting to note that the two age groups did not differ in mean daily hedonic balance, another indicator of emotional well-being. Hedonic balance reflects broad pleasant and unpleasant emotional states (e.g., happy, sad), whereas the PANAS (Watson et al., 1988) conceptualizes positive and negative affect using items associated with arousal and activation. These findings partially supported the first hypotheses regarding age group differences in average

levels of PA and NA. They are overall consistent with prior cross-sectional and long-term longitudinal work. It is not trivial, however, to obtain similar results using a cross-sectional or long-term longitudinal design on the one hand, and using a micro-longitudinal study. Trait-like well-being questionnaires typically require the retrospective rating of the frequency of PA and NA (e.g., Watson et al., 1988). These are likely to be affected by memory biases. In contrast, the present dissertation employed a microgenetic design in which participants provided daily ratings of current affect that are much less prone to such memory biases (Almeida, 2005; Bolger et al., 2003). Age-related differences in average emotional well-being were obtained by aggregating across these daily ratings. The overlap in findings thus provides multi-method evidence about the apparent stability in levels of NA during adulthood, lending even greater credence to the previously found pattern.

Finding no reliable age difference in mean levels of day-to-day NA is consistent with previous cross-sectional and long-term longitudinal studies indicating that older adults' mean levels of NA tend to be equal or only slightly lower than young adults' average NA (Costa et al., 1987; Gross et al., 1997; Isaacovitz & Smith, 2003; Kunzmann et al., 2000; Mroczek & Kolarz, 1998; Stacey & Gatz, 1991). Previous research on age differences in trait-like PA has yielded inconsistent evidence. The result of greater average PA across the daily assessment period is in line with results from a cross-sectional study on individuals aged 25 to 74, in which Mroczek and Kolarz (1998) found higher levels of trait positive affect in older than younger adults (see also Kunzmann et al., 2000). The present findings diverge, on the other hand, from studies that showed either no evidence for 9-year change in PA during adulthood (Costa et al., 1987) or a negative relationship between the two across a 14-year time period (Stacey & Gatz, 1991). The slight differences in findings may derive from several factors. First, one-time self-reports of well-being are likely to be more vulnerable to retrospective memory biases than momentary ratings, and trait-ratings are likely to be influenced by momentary mood states, episodic as well as semantic memory processes (M. D. Robinson & Clore, 2002a, 2002b; Schimmack, Diener, & Oishi, 2002). Second, the present sample represented a highly motivated group of individuals willing to participate in an intensive micro-longitudinal study, they were screened for depressive symptoms and the testing context was intended to maximize participation and to minimize attrition.

Surprisingly, there has to date been only one previous experience sampling study that focused on age-related differences in momentary across-day emotional experiences (Carstensen et al., 2000). Carstensen and colleagues asked a sample of adults aged 18 to 94 ( $M = 55.0$  years) to rate their affective experiences five times a day across seven days using palm-pilots. The current

dissertation thus represents a unique extension to this prior work by sampling daily affect only once a day but across a substantially extended time period of 45 days. In addition, the sample in the Carstensen study had a mean age of 55 years, possibly under representing the older adulthood range. Mean PA and NA across sampled moments were analyzed according to frequency and intensity of affective experience, using a method suggested by Schimmack and Diener (1997)<sup>40</sup>. The only reliable association between age and average self-reported affective experience found by Carstensen et al. (2000) was a negative correlation between age and NA-frequency. In order to compare this finding to the present dissertation, follow-up analyses partitioning the daily affect data into frequency and intensity for each affect domain were undertaken. In contrast to the previous study, the only reliable age difference using this method in the present study was found for PA-intensity (i.e., greater intensity in older adults). Again, the differences in findings may be due to the different time frames and affect items used in both studies as well as differences in age distribution and in sample selection.

One highly interesting result in the present dissertation is that there were substantial interindividual differences in average levels of primarily positive affect in older as compared to younger adults (see Table 4.3 and Figures 4.1 and 4.4)<sup>41</sup>. As will be discussed in Section 5.1.3 in more detail, there were also substantial age differences in the relative amounts of between-person versus within-person variance in daily PA and NA: Within the subgroup of older adults, the interindividual differences outweighed the intraindividual differences. These results may in part be due to sampling issues. Nonetheless, from a conceptual point of view, they provide compelling evidence of the heterogeneity of how people fare in terms of emotional well-being, especially during later adulthood. As such, these results are consistent with prior research in the cognitive domain, indicating an amplification of interindividual differences with increasing age (e.g., Hultsch et al., 2002; Morse, 1993). From a methodological perspective, however, they restrict the comparability of findings across studies.

In sum, the results of the present dissertation about age-related differences in average levels of daily emotional well-being provide support for the overall notion that well-being is relatively well-preserved into older adulthood. In addition, the findings show quite impressively

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<sup>40</sup> According to this method, a frequency score for each individual can be computed as the ratio of sampling occasions on which each affect received a rating greater than 0 or 1, depending on the anchor point of the rating scale (i.e., indicating that the affect was being experienced at all). These ratios can then be averaged separately across all positive and all negative items to yield a frequency score for positive affect and a frequency score for negative affect for each individual. An intensity score for each item can be computed as the average rating on each affect item across all ratings, which are greater than 0 or 1 (i.e., greater than the anchor point representing the low end of the scale). These item-based intensity scores can then be averaged for all items belonging to the PA-scale and for all items belonging to the NA-scale to obtain an intensity score each for PA and for NA for every individual.

<sup>41</sup> In the Carstensen et al. (2000) article, no subgroup based descriptives were provided, which would have been informative about differences in between-person variance in mean daily affect in different age groups.

that there are substantial interindividual differences within age groups in the general disposition to feel well in everyday life. Because the evidence presented stems from a micro-longitudinal intensive day-to-day assessment design, it provides a unique extension to current empirical evidence on age and emotional well-being into a multi-method framework rather than merely replicating previous research.

### *5.1.2 Daily Reports of Positive and Negative Affect Show Slight Decreases Across Nine Weeks in Both Age Groups*

The second perspective on day-to-day affect was to examine intraindividual trajectories of day-to-day PA and NA for time-related trends. The multilevel analyses undertaken in the present dissertation provided support for the hypothesis that, across the 45-day assessment period, both young and older adults would show slight decreases in positive affect on average. There were individual differences in this time-related trend, but these were not accounted for by age. Trajectories of daily NA did not exhibit a significant average trend but there was variance around the linear slope. Part of the individual difference variance was accounted for by age, such that the average trajectory for young adults was estimated to be flat and to be slightly decreasing for older adults. This age difference should not be over interpreted as it appeared to be driven by only a few older adult participants.

Evidence for relatively small time-related trends, often in terms of a slight decrease, has been discussed in the literature on experience sampling and diary studies of self-report measures such as mood and stress (Affleck et al., 1999; DeLongis et al., 1988). Even though subjective states such as mood are often thought of as having a relatively stable equilibrium level around which fluctuations occur (e.g., Nesselroade, 2001), repeated assessments and introspection over extended periods of time are possibly affected by reactivity and regression to the mean.

The examination of time-related trends as one of three central features of day-to-day PA and NA makes the present study unique in at least two ways: First, few micro-longitudinal studies using self-report data closely inspect the presence of such time-related trends and as a consequence do not account for them in subsequent within-person coupling analyses. Second, little is known to date about possible age-related differences in time-related trends in self-report micro-longitudinal designs. On the basis of research showing age-related differences in responses to self-report measures of affect and other domains (Schwarz, Park, Knäuper, & Sudman, 1999), it is critical to evaluate affective time-series for such differences.

Apart from the methodological importance to discover and control for time-related trends, they may indicate a process of normal adaptation to the repeated testing routine and the

process of repeated intensive introspection. In the beginning, social desirability effects may be more visible, which fade out over time as part of the adaptation process. In light of this more conceptual interpretation, they give represent an additional information on possibly ongoing regulative intraindividual processes.

### *5.1.3 Older Adults' Emotional Well-Being is Characterized by Greater Day-to-Day Stability than Younger Adults' Emotional Well-Being*

The last perspective on age-differences in day-to-day PA and NA combined lifespan theoretical notions of the conceptual importance of short-term intraindividual variability with research on age and emotional functioning. Consistent with the central hypothesis, both descriptive analyses and repeated measures analyses of variance indicated that overall, there was sizable within-person variability in both affect domains, with greater fluctuation in PA than in NA. These domain-specific differences in variability underline the distinct functional roles of positive affect as an indicator of pleasurable engagement and approach versus negative affect as an indicator of distress and an emergency system geared towards withdrawal (e.g., Elliot & Thrash, 2002; Taylor, 1991). In the words of Clark & Watson (1988, p. 305) PA tends to "ebb and flow with the daily tide of events, whereas NA crashes upon us in times of trouble only to disappear just as quickly when the storm is over".

In line with the central hypothesis, young and older adults differed significantly in the amount of day-to-day variability in both affect domains: Older adults showed significantly less fluctuation in PA and NA from one day to the next than younger adults, and this finding was also replicated for daily hedonic balance. These age differences were robust when time-related trends and aggregated levels of daily PA and NA were controlled for. Apart from these age-related differences in the absolute sense, young and older adults also showed a different relative pattern of within-person versus between-person variability in day-to-day affect (see Figure 4.4 in the Results chapter): Older adults as a group differed substantially more from one another than each person differed from his or herself at an intraindividual level. The opposite was true for young adults, for whom differences within individuals were slightly greater than the between-person distinctions.

These findings extend at least two strands of prior research in a meaningful way: On the one hand, they offer a process-based look at age differences in well-being, incorporating both the intraindividual as well as the between-person level. Both of these sources of variation are critical because they each provide a reference frame of comparison for each other (e.g., Cattell, 1957b; Nesselrode & Ford, 1985; Nesselrode & Salthouse, 2004). On the other hand, they accentuate



the necessity to carefully distinguish domain-specific differences in the association of age and intraindividual variability. As outlined in Table 1.2 in the Theory chapter, two scenarios about age and variability have been advanced in the literature, one suggesting an increase in variability and the other a decrease in variability across the adult lifespan. Previous findings on age and intraindividual variability primarily in the cognitive aging literature have primarily supported the first of these scenarios (Hultsch et al., 2002; R. West et al., 2002a; but see also Salthouse, Nesselroade, & Berish, 2006, who did not find evidence for an age-related increase in performance variability when using accuracy rather than speed measures of performance). Results obtained in the present dissertation provide support for the second scenario. These distinctive patterns speak to the diversity of the phenomenon across various domains of functioning, rather than representing a unitary characteristic.

#### *How Best to Interpret Age-Related Differences in Fluctuations of Positive and Negative Affect?*

How can age-related differences in the amount of within-person short-term fluctuations in PA and NA be adequately interpreted? Do they indicate age differences in the ability to regulate emotions? Or is at their core simply a difference between young and older adults in the sensitivity towards emotionally arousing cues? A last possibility that is not completely independent of the previous two is that young and older adults may differ in their everyday routines and as such in the availability of emotion-relevant environmental cues. The possible interpretations provide the theoretical framework for an attempt to understand age-related differences in short-term fluctuations in emotional well-being. They are speculative, however, because it was beyond the scope and immediate focus of the present dissertation to test the different propositions.

*Less variability as a reflection of better emotion regulation?* The first interpretation is derived from several sources: First, it has been shown repeatedly that older adults report better emotion-regulation than young adults (e.g., Gross et al., 1997; Lawton, Kleban, Rajagopal, et al., 1992). There is also evidence that older versus younger adults are more capable of anticipating and avoiding interpersonal conflicts (Birditt & Fingerman, 2003, 2005; Birditt et al., 2005). In addition, Socioemotional Selectivity Theory (Carstensen, 1995) postulates that goals pursued in the context of social relationships vary as a function of perceived future time perspective (i.e., time left to live). Specifically, the theory argues that individuals of increasing age are more and more motivated to maximize emotion regulation rather than information acquisition and thus tend to focus their social networks on emotionally close others rather than maintaining large social networks with a great number of acquaintances. Older adults thus proactively gestalt their

lives differently than younger adults in the social domain. Such selection processes can be considered an antecedent-focused emotion regulative strategy that attempts to make social interactions more predictable (both in terms of positive and stressful experiences; Carstensen et al., 2003; Gross, 1998). Interpersonal events range among the most influential correlates of mood fluctuations in every day life (Bolger et al., 1989; Clark & Watson, 1988). It is therefore conceivable that an increased motivation for emotion regulation in older age, reflected in the active composition of one's social network, may be reflected in greater equilibrium (i.e., less fluctuation) in emotional experiences in every day life.

To date, the interpretation of better emotion regulation with increasing age is supported almost exclusively at a self-report level. It is not at all clear whether older adults merely *report* better emotion regulative capacities or whether their emotion regulative *behavior* is indeed more effective. There is an emerging literature on the development of emotion regulation as a central component of general development of effortful control in early childhood (e.g., Eisenberg, Champion, & Ma, 2004; Eisenberg, Smith, Sadovsky, & Spinrad, 2004), including a number of behavioral indicators of regulation. For the other end of the lifespan, namely later adulthood and old age, such richness in assessments of emotion regulation is very scarce. This is surprising for two reasons. First, emotions are thought to encompass not only subjective but also behavioral as well as biological components (Levenson, 2000), which do not always follow similar patterns (D. P. Smith et al., 2005). Second, definitions and taxonomies of emotion regulation in adulthood tend to include regulative strategies both at a cognitive (avoid thinking about an emotionally arousing event, thinking about something else, self-efficacy, attentional control) and a behavioral level (avoid a difficult situation, engage in distracting activities; e.g., Gross, 1998; Karoly, 1993; Larsen, 2000a; Parkinson & Totterdell, 1999).

The few existing studies on behavioral and physiological indicators of emotion regulation yield inconsistent results of showing no age differences between young and older adults (Kunzmann & Grühn, 2005; Kunzmann et al., 2005), reporting an age-related decrease in the effectiveness of dealing with stress (Bäckman & Molander, 1991), finding that age is related to less physiological reactivity (Levenson, 2000; Levenson et al., 1991), or suggesting that older versus younger adults are slightly better able to inhibit facial expressions of emotions (Magai, Consedine, Krivoshekova, Kudadjie-Gyamfi, & McPherson, 2006). Thus, at a self-report level, emotional control may be higher in older than in younger adults, and the finding of less variability in self-reports of day-to-day affect is consistent with these reports. It remains an open question, however, whether and under which conditions (i.e., types of emotion, retrospective versus online assessments, etc.) such results can be replicated when using physiological or other

behavioral indicators of emotion regulation and of variability in emotions (e.g., repeated assessments of physiological parameters of emotional experience).

*Less variability as a reflection of habituation?* The finding that older adults' reports of daily PA and NA evince more stability than young adults' is also consistent with the idea of habituation and decrease in sensitivity to emotionally arousing cues in the environment. Frijda (1988, p. 353), for example, stated as the law of habituation that "continued pleasures wear off, continued hardships lose their poignancy" (see also Frederick & Loewenstein, 1999). Others have conceptualized aging itself as a process of habituation (Kastenbaum, 1981). Older adults indeed tend to report lower emotional intensity than young adults (Lawton, Kleban, Rajagopal, et al., 1992) and show a decrease in cardio-vascular responses associated with arousal (Levenson et al., 1991). A decrement in within-person variability in day-to-day affective experiences would be consistent with such notions, which incorporate a more passive notion of the aging individual than the implicit assumptions of a more active process of emotion regulation.

*Less variability as a reflection of differences in developmental tasks and in daily routines?* Finally, during adolescence and young adulthood, various social, biological and psychological changes occur (e.g., identity formation and the search for autonomy; Erikson, 1968; Larson et al., 1980; Pals, 1999), which may in part represent the endogenic and exogenic factors underlying variability in mood. On the other hand, late adulthood and older age should be characterized by a rather stable sense of self and daily routines that are more highly regulated than younger adults' based on age-related differences in developmental tasks (e.g., Charles & Pasupathi, 2003; Schulz, 1982, 1985). These age-related differences may also contribute to less variability in daily affect in older as opposed to younger adults.

#### *The Problem of Floor Effects in Fluctuation of Negative Affective States*

In addition to the substantive interpretation of results, some methodological concerns for studies on intraindividual variability and its correlates emerged from the current dissertation as well: Many of the older adult participants showed very little within-person variability in many of the negative affect items. As a consequence, for the majority of older participants in the present study, fluctuations in negative mood captured the ebb and flow of a specific feeling of uneasiness (i.e., nervous, jittery) rather than variability in a rather a global state of negative activation. Other studies have also reported that negative affect items and other negative appraisal domains are especially vulnerable to lack in sensitivity to short-term fluctuations and change (e.g., Kim & Nesselroade, 2003; Kleban et al., 1992). Many studies do not address this issue, but such floor

effects in negative affect variability represent a problem if researchers want to use indicators of within-person variability to address further substantive hypotheses.

In the present dissertation, the problem was identified and addressed in the following way: The core indicators of positive and negative affect were assessed using the PANAS (Watson et al., 1988), a commonly used instrument that intends to measure PA and NA as independent dimensions. In addition, I included two short scales of pleasant and unpleasant affect, consisting of items sampled from the extended PANAS (Watson & Clark, 1994) and the literature on emotions (e.g., Diener & Larsen, 1984). These two scales were selected to capture a bipolar dimension of pleasantness-unpleasantness. As such, scores on the scale were highly negatively correlated and collapsed into a daily hedonic balance score by subtracting the unpleasant affect from the pleasant affect score for each individual on each day. This new score thus represented the overall daily hedonic balance and the procedure of collapsing across both positive and negative items was an attempt to deal with the observed lack of sufficient variability in the negative affective states in some of the older adults. All central analyses were conducted both with the two PANAS scales and with the hedonic balance indicator in order to increase the credibility into findings based on daily negative affect. Indeed, all findings were replicated across the different emotional well-being indicators.

Other than representing a methodological and statistical nuisance, very low levels of within-person variability in NA are to be expected from a conceptual point of view. The psychological system is geared at maximizing positive and minimizing negative states (e.g., Diener et al., 2006; Larsen, 2000a, 2000b; Taylor, 1991). On the basis of several experience sampling studies in college student samples, Watson (2000a) reports that in everyday life, negative affective states are experienced most frequently at very low levels of intensity, whereas positive affective states tend to be experienced more regularly at both low and moderate levels of intensity. However, neither class of affective experience tends to be experienced often at high levels of intensity, which would be similar to full-blown emotional episodes. Other researchers corroborate these results in reporting that most people tend to have positive set-points of well-being, thus they feel more happy than unhappy on average (Diener & Diener, 1996; Diener et al., 2006; Fredrickson & Losada, 2005; Zelinski & Larsen, 2000) and that young adults report positive events with much greater frequency than negative events (Zautra et al., 2005).

Taken together, these factors may leave little room for variability in negative affect to be captured on a day-to-day basis. This effect was strongest for particular items (e.g., hostile, ashamed) that are likely to have an even lower base rate than other items (e.g., restless, jittery), for which most older adults in this study did show sufficient within-person variability. Future

research should keep these issues in mind when selecting measures for the micro-longitudinal assessment of subjective (mood) states and focus mainly on such items that are most sensitive to short-term fluctuation (Nesselroade, 1991a). A general suggestion, based on the present findings, is to give priority to negative affect items such as jittery and nervous as well as distressed, irritable, upset, sad, downhearted, and frustrated at the expense of items like scared, afraid, hostile, and ashamed, for which most older and even quite a few young adults did not show much fluctuation. On the positive side, no particular item showed substantial lack of variability.

#### *5.1.4 Summary and Conclusion About Age-Related Differences in Stable and Dynamic Characteristics of Day-to-Day Emotional Well-Being*

Age-related differences in three different aspects of day-to-day emotional well-being were examined, each providing a different window on emotional functioning in everyday life. The first characteristic I investigated was the average level of PA and NA across a micro-longitudinal assessment period of up to 45 days. Older adults reported significantly higher levels of PA than young adults, and the two age groups did not reliably differ from one another in average daily NA. The second characteristic examined was whether there were age-related differences in time-related trends of day-to-day PA and NA. Consistent with notions of reactivity and adaptation to novel environments, participants' trajectories of affect demonstrated slight decreases over time, but there were little age-related differences. This suggests, at a conceptual level, that regulative processes of adaptation to novel contexts are intact into young old age. At the same time, from a methodological perspective, the presence of time-related trends in self-report data of emotional well-being stresses the need to account for these in studies of intraindividual processes. As a last very central dynamic characteristic of emotional well-being, both age groups were compared with regard to the amount of day-to-day within-person fluctuation. Older adults were found to show substantially less fluctuation than young adults, even after controlling for individual differences in mean levels of affect and for time-related trends.

Taken together, results from this first set of questions contribute in a unique way to several different literatures, because they integrate lifespan theoretical notions of intraindividual variability as an indicator of plasticity and regulative capacity with the literature on aging and emotional competence.

## 5.2 Trait-Like and State-Like Correlates of Affect Variability

The second set of research questions addressed correlates of affect variability from three perspectives: In a first step, in terms of trait-like correlates, the relative role of age versus personality factors in explaining individual differences in affect variability was examined. On the one hand, this was motivated by findings on the central role of personality factors for individual differences in trait-like affect, over and above age (e.g., Costa & McCrae, 1980, 1984). To date, little is known about the role of either age or personality for individual differences in the dynamic characteristics of affect, such as short-term intraindividual variability. In light of the theoretical proposition arguing for a key role of age for variability in affect, and the support for greater variability in older than younger adults provided in the present study, it is important to examine whether age is still an important variable when personality differences are accounted for. Such an approach provides a lifespan perspective to the study of interindividual differences in not only the stable but also the dynamic features of emotional well-being.

In a subsequent step, age differences in the association between affect variability and trait-like indicators of psychological adjustment were investigated as an exploratory attempt to understanding whether variability in emotional well-being is functional or dysfunctional in different age groups. To date, both a functionality and a dysfunctionality scenario of variability in psychological functioning has been advanced in the literature (see Table 1.4 in the Theory chapter). In the context of research on age and dynamical aspects of well-being, it is important to go beyond a descriptive level and to investigate individual and age-related differences in the meaning of short-term fluctuation for psychological adaptation. Due to the small sample size, this second approach represents only a preliminary step in that direction.

The third perspective focused on age-related differences in the within-person coupling of daily affect and daily stress and events. This last section was motivated by previous research in young adults in which time-varying correlates of mood fluctuations have been examined and interpreted as possible state-like antecedents of mood fluctuations (Bolger et al., 1989; van Eck et al., 1998). This last approach is one critical step in providing an explanatory context for age-related differences in the amount of within-person variability of emotional well-being.

### *5.2.1 Age Matters More Than Personality in Explaining Individual Differences in Affect Fluctuation*

Does age explain unique portions of individual difference variance in short-term fluctuations in emotional well-being, over and above personality factors? Is a lifespan perspective

on emotional variability a useful extension of an interindividual difference perspective? In the present dissertation, consistent with the hypothesis, age group emerged as a significant predictor of individual differences in affect variability over and above the Big Two personality factors extraversion and neuroticism. The unique variance explained by age group over and above personality traits were 45.0% and 19.0% for variability in PA and NA, respectively. The unique amounts of variance accounted for by personality over and above age group were 3.0% and 9.0% for variability in PA and NA, respectively. These findings are a unique demonstration that persisting personality dispositions are not the driving factor to explain differences between individuals in one dynamic characteristic of well-being (see also Eid & Diener, 1999). Rather, a lifespan psychological perspective adds a unique explanatory level to be followed up in future research.

As for the specific relationships between personality and affect variability, findings from the present study were largely consistent with the few previous studies (Eid & Diener, 1999; Hepburn and Eysenck, 1989; McConville and Cooper, 1992, 1999; Murray et al., 2002; Wessman & Ricks, 1966; D. G. Williams, 1990). As expected, the relationship between neuroticism and variability was positive for both affect domains, suggesting that individuals higher on a dimension of neuroticism tended to display greater day-to-day fluctuation in self-reports of positive as well as negative affect. Extraversion, on the other hand, was unrelated to variability in PA and NA.

In conclusion, despite their strong associations at the trait level (Costa & McCrae, 1980; Diener, 1984; Isaacovitz & Smith, 2003; Larsen & Ketelaar, 1991; Watson & Clark, 1992), personality and process-like affective experience appear to be only weakly related. Put differently: From knowing a person's traits one may know how happy or unhappy a person tends to be on average, but one knows very little about how variable a person's emotional well-being experiences are. In contrast, age is strongly related to variability in affect, despite a weaker relationship between age and mean levels of affect. Psychological mechanisms underlying the stable and the more dynamic properties of emotional well-being may only partly overlap (R. J. Davidson, 1998). Future research should explore precisely which age-related individual difference constructs can account for the variance between individuals. Given that chronological age is but an indicator variable (Wohlwill, 1970) for other person characteristics, it should be a prominent aim to find out, which age-related changes are central for variability in affect. One direction to take would be to directly examine trait-like emotion regulative behavior or general self-regulatory behavior (e.g., Diehl, Semegon, & Schwarzer, 2006; John & Gross, 2004; Schwarzer, Diehl, & Schmitz, 1999). Another direction would be to examine more closely the link between age-based changes in arousal levels and self-reported affective states.

Rather than replicating the lack of strong associations between classical personality traits and short-term variability in emotional well-being, the virtue of the present study lies in its demonstration that a lifespan perspective on process-like features of well-being is a much needed framework for future research.

### *5.2.2 The Functional Significance of Variability in Affect for Psychological Adjustment: Differences by Affect Domain*

From a functional perspective, the value of intraindividual variability as an individual difference characteristic has been seen in its utility to predict other interindividual differences. Two opposing perspectives have been articulated in the literature: Whereas the first considers high levels of variability to be dysfunctional, the latter discusses high levels of variability as a functional and adaptive feature (see Table 1.4 in the Theory chapter). The present dissertation included relatively small groups of young and older adults (total  $N = 37$ ) and was therefore not suited to carefully examine the functional value of affect fluctuations for general psychological adaptation. As one of the first studies to examine PA and NA in everyday life in both young and older adults, exploratory correlation analyses were conducted to explore whether meaningful associations between variability in PA and NA and trait-like well-being could be observed.

The correlation analyses yielded an interesting pattern of differences between the domains of PA and NA: In both age groups, variability in negative affect was related to lower psychological well-being and happiness. Previous studies have primarily investigated young or older adults separately and found initial evidence for a dysfunctional value of variability in negative affective states (e.g., Burton et al., 2002; Strauss et al., 2002). In contrast, the associations between variability in PA and trait well-being approached zero or were too small to reach statistical significance in both age groups. There were some trends for distinct age-related differences in the associations, both pointing to a potential functional and dysfunctional implication of fluctuations in PA, but a meaningful interpretation would require a much larger sample. Other studies have also yielded inconsistent results regarding whether variability in positive mood and affect is good or bad (Lawton et al., 1996; Shifren & Hooker, 1995; Strauss et al., 2002).

There is some recent evidence suggesting that mood variability may be indicative of coping efforts during stressful life periods. In an experience-sampling study, variability in positive and negative aspects of emotional well-being was compared between a group of young adults who had just experienced the break-up of a non-marital relationship with a control group in an intact relationship. Dissolution-study participants reported greater intraindividual fluctuation in



both positive and negative emotions across the entire 28-day period and across only the first only days than the control group who provided reports across seven days only. However, by the last week of study participation, levels of fluctuation between the two groups did not differ reliably anymore. These findings are in line with the results of a study on the emotional dynamics following bereavement in a sample of 19 older women (Bisconti et al., 2004). Daily reports of well-being and depression across a 3-month-period could be well-described by a damped oscillator model, hence indicating a dampening of initially higher levels of fluctuation around an individual's equilibrium level of emotional experience over time.

Findings from the Sbarra and Emery (2005) study also address the question of emotion-specific functionality or dysfunctionality of intraindividual variability: In the dissolution-group, greater levels of intraindividual fluctuation in love (i.e., a positive emotion) across the 28-day period predicted greater levels of positive affect after a month of study participation. Likewise, affective disturbance a month after initial study participation was predicted by greater within-person fluctuations in sadness (i.e., a negative emotion). Thus, in this sample of young adults, greater variability in a positive emotion was predictive of greater levels of adjustment, whereas greater variability in a negative emotion was predictive of lower levels of adjustment.

To date, no research has been conducted on age-related differences in the antecedents, correlates, and consequences of variability in affect, which would allow to draw firm conclusions on age-related differences in the functional meaning of mood fluctuations. The present study, despite its small sample size, contributed to the literature by indicating that variability in negative affect appears to be a signal of dysfunctional processes in both young and older adults.

### *5.2.3 Within-Person Coupling of Daily Affect, Stress, and Events:*

#### *Mixed Evidence on Age and Emotional Reactivity*

Apart from age and other trait-like individual differences, it is important to study the dynamics of well-being in relation to other state-like person- and environment factors. Previous research has mainly investigated the within-person associations between daily mood states and daily events, health, and stress in young adults (Bolger et al., 1989; Clark & Watson, 1988; Nezlek & Gable, 2001). The present dissertation provided a unique glance into possible age-related differences in the relationships between daily emotional well-being and time-varying context and appraisal variables. This approach was motivated furthermore by different proposals about the relationship between age and reactivity to stressors. The first scenario suggests that repeated exposure to negative events and negative affect across the lifespan may be associated with a decreasing reactivity to daily stress and events as a function of habituation (e.g., Diehl et al., 1996;

Lawton, 1996). The second scenario posits that accumulated exposure to negative events should be associated with heightened reactivity as a function of greater sensitization (Panksepp & Miller, 1996).

In the present dissertation, multilevel analyses on the day-to-day covariation of PA and NA with stress appraisals as well as with positive and negative events indicated that for the average person, daily PA covaried with all three daily contextual variables. On days of higher stress and days with a negative event, individuals tended to experience lower positive affect, whereas days with a positive event co-occurred with reports of higher PA. To the contrary, NA was on average higher on stressful days and on days with a negative event, but did not reliably covary with positive events on average. The age groups did not significantly differ in the associations between stress and affect. However, the negative association between daily PA and negative events was significantly smaller for older as opposed to younger adults (age group explained 59.0% of the individual difference variance in the PA–negative event association), and there was a trend for a smaller positive association between daily PA and positive events in older as opposed to younger adults as well (age group explained 33.0% of the individual difference variance in the PA–positive event coupling). Hence, consistent with the hypothesis there was a weaker day-to-day coupling between fluctuations in positive affect and fluctuations in events. In the domain of NA, age group did not emerge as a reliable predictor of the individual differences in coupling.

This pattern of findings, at least for PA, is consistent with the scenario of dampened emotional reactivity in older age. In one of the only previous micro-longitudinal studies on age differences in NA-stress relationships, Mroczek & Almeida (2004) found evidence for greater reactivity in older than younger adults (age range: 25–74 years). Another recent study investigated physiological (i.e., blood pressure) as well as subjective reactivity to daily stress sampled every 45 minutes across the waking hours of one day in 214 adults ( $M = 53$  years; Uchino, Berg, Smith, Pearce, & Skinner, 2006). These authors found that the association between self-reported daily negative affect and stress was less positive in relatively older than in younger adults, but there was no age differences in the coupling of daily positive affect and stress. More interesting, age interacted with daily stress in predicting daily blood pressure such that blood pressure reactivity in response to a stressor was larger in older than younger adults (see also Uchino et al., 2005).

Results from these studies are inconsistent and also slightly differ from the findings reported in the present dissertation. Reasons for the inconsistencies may be differences in sample size, in stress and affect measures, in time-sampling schedule and duration, and in emotional response systems considered (self-report, physiological). In sum, within-person evidence on age

and emotional reactivity is inconsistent across the few available studies. To date, no study had previously included measures of both PA and NA and correlates other than stress in a sample of both young and older adults. The present study represents a central first attempt in understanding age-related differences in the state-like factors possibly driving fluctuations in emotional well-being.

#### *5.2.4 Summary and Conclusion About Age-Related Differences in the Trait-Like and State-Like Correlates of Affect Variability*

Correlates of day-to-day variability in emotional well-being were analyzed at a trait-like and a state-like level. First, it was shown that the previously observed age-related differences in affect fluctuations are robust after controlling for personality traits that show strong associations with trait-like affect. In fact, age explained a substantially greater amount of the individual difference variance in affect fluctuations than personality traits. A lifespan psychological perspective on well-being fluctuations seems to add critical value in understanding individual differences in processes associated with daily emotional well-being.

Second, the present dissertation represents a unique albeit exploratory attempt to examine whether variability in PA and NA bears distinct functional implications in comparison to one another, and whether these implications may differ for young and older adults. Results indicate that in both age groups, variability in NA is related to lower psychological adjustment, but the association between variability in PA and trait well-being were much weaker and slightly inconsistent across age groups.

Third, in line with theoretical propositions about age-related differences in reactivity to emotional cues, older adults in the present study showed weaker within-person associations between daily positive and negative events and daily PA. No such age-related differences reached statistical significance with regard to daily NA. The comparison of young and older adults, together with a focus on both positive and negative affect as well as both positive and negative daily events represents a unique feature of the present dissertation in contrast to most prior research that has neglected a lifespan theoretical perspective in understanding the intraindividual processes underlying the positive in addition to the negative side of life.

### 5.3 Within-Person Coupling of Affect and Cognitive Performance: No Evidence for Age-Related Differences

The third set of research questions addressed in the present dissertation focused on the within-person association between daily emotional well-being and daily cognitive performance. In addition, I asked the question of whether young and older adults would differ in this intrapersonal coupling. Two literatures provided the theoretical framework motivating this last set of questions. The first of these is lifespan psychological theory and research, which considers subjective well-being as well as cognitive capacity to represent two key domains of successful development and aging (e.g., Baltes & Baltes, 1990; Baltes et al., 2006; Rowe & Kahn, 1997). These two domains show very different trajectories across the lifespan, with decline dominating cognitive resources and stability or slight growth dominating well-being resources (e.g., Charles & Carstensen, 2004; Costa et al., 1987; Craik & Salthouse, 2000; Park et al., 2002). Lifespan theory suggests that human development is characterized by a shifting balance in the ratio of gains and losses as a function of changing resource availability across psychological domains. In order to gain insights into the plasticity and regulatory capacity of the psychological system it is critical to study psychological functioning in multiple domains rather than separately for different domains (Magnusson, 1998; J. Smith & Baltes, 1997), and the domains of emotion and cognition were thus selected for the present dissertation.

The second line of research motivating the question of within-person emotion-cognition coupling was experimental research indicating that emotional states can have detrimental as well as specific functional (i.e., enhancing and impairing) implications on performance in certain cognitive tasks (e.g., Bless, 2003, Bower, 1981; Forgas, 1995; Gray, 2004; Isen, 1990; Matthews et al., 2002). Several theories have considered affect-related task-irrelevant processing as one way in which affect and cognitive performance may be linked (e.g., Ellis & Ashbrook, 1988; M. W. Eysenck & Calvo, 1992; Kahneman, 1973; Richards & Gross, 2004; Schmeichel et al., 2003).<sup>42</sup>

The present dissertation added a unique focus to this prior work by explicitly considering the successful concurrent regulation of emotions and of cognitive performance as a dual-task situation. As such, similar basic cognitive resources need to be allocated to both domains of functioning, and individual differences affecting the availability or the orchestration of such

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<sup>42</sup> It is interesting to note, that even though most theories on emotion-cognition interactions imply the causal direction to go from emotion (regulation) to cognition, other researchers have shown in studies with young adults that the ability to regulate one's mood in a laboratory context is itself affected by the presence or absence of a concurrent cognitive load induced via a simple memory task (e.g., Wegner, Erber, & Zanakos, 1993). According to this line of work, mental control is successful when available mental capacity is adequate. Under conditions of cognitive load and stress, to name a few examples, intended control may not only be reduced but rather take on an effect opposite to the one intended (e.g., instead of down-regulating negative mood, individuals amplify their negative mood state). This effect is referred to as an instance of ironic process (Wegner, 1994).

resources were thought to explain individual differences in the emotion-cognition interplay. As a second unique contribution, the present dissertation approached the question of emotion-cognition interactions in a micro-longitudinal design, in which the within-person association between daily affect and daily cognitive performance was studied over a period of 45 days.

### *5.3.1 Individuals Differ in Magnitude and Direction of Day-to-Day Emotion–Cognition Couplings*

Results from a set of multilevel modeling analyses demonstrated that daily performance fluctuations in both cognitive tasks could be predicted by fluctuations in positive and negative affect at the within-person level. One important qualification of this general statement, however, is that the strength of the within-person association as well as the direction differed significantly between individuals. The average relationship was close to zero. Coupling evidence was slightly stronger for positive affect and for the working memory task. One reason for this finding may have been that particularly among older adults, individuals did not vary sufficiently in reports of negative affect. The greater improvement in model fit after adding the daily affect predictors to the prediction of working memory perturbations as compared to fluctuations in vigilance may be a first but weak indicator that coupling is slightly more pronounced when task demands are higher.

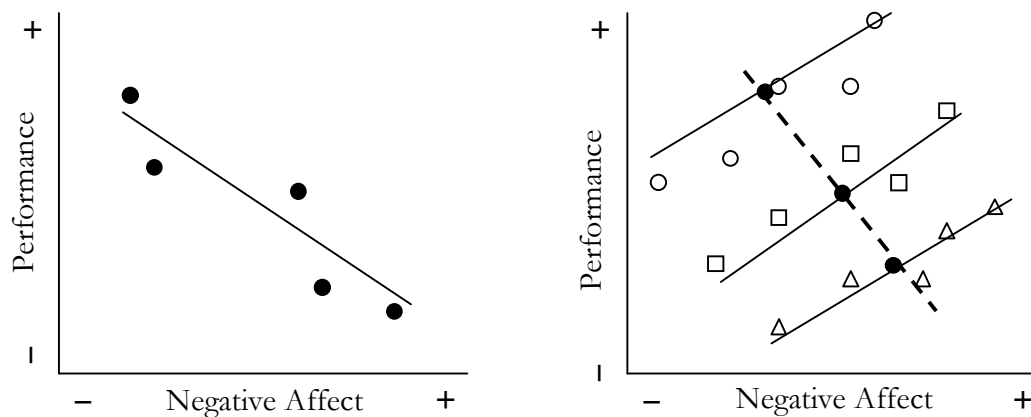
These findings indicate that the association between feeling states and cognitive performance are not uniform across individuals. For some people, daily fluctuations in affect and in performance are independent of one another. For other people, both elevations and decrements in PA and in NA above or below the respective individual mean level can have enhancing as well as detrimental effects on performance. From a methodological point of view, the multilevel modeling results highlight the differences in associative patterns observed either at the between-person or the within-person level. The lack of finding a reliable average intraindividual relationship in both affect and cognitive domains is consistent with one of the few within-person studies on emotion-cognition coupling conducted by Salthouse and Berish (2005, Study 2). These authors found that in a sample of 271 adults ranging in age from 18 to 89, daily mood state (measured with a bipolar single item of happy-sad) and daily reaction time performance across two versions of a trail making task were on average uncorrelated within individuals. However, in accordance with findings in this dissertation, the authors note that across individuals, the coupling differed in magnitude and direction, indicating a complex picture of within-person cross-domain associations.

Other within-person studies have rarely considered associations between performance and both PA and NA, but have almost exclusively focused on NA and stress (e.g., Ong et al., 2004; Sliwinski et al., 2005). Sliwinski and colleagues (2005), for instance, found significant within-person relationships between daily stress (i.e., number of stressors) and performance on two out of three cognitive tasks: Across six occasions that were spaced over 14 days both young ( $N = 65$ , 18–22 years) and older adults ( $N = 104$ , 66–90 years) showed performance decrements on stressor days as opposed to non-stressor days in a working memory task, but neither age group showed a reliable within-person association between stress and a processing speed task. Only the older adults showed intraindividual coupling between stress and attention switching performance (see the following section for a discussion of age-related differences in coupling). It is interesting to see that Sliwinski and colleagues (2005) found evidence for a significant average within-person association for the working memory task (i.e., 2-back). Differences to the present dissertation, however, may be due to the fact that this finding is based on a measure of daily stress rather than affective tone. Furthermore, the sample consisted of a substantially larger group of young and older adults, and the repeated assessment covered only a relatively short period of time (six sessions versus 45 sessions). Reliable average within-person associations may fade out over longer periods, when the tasks and self-monitoring of subjective feeling states are more familiar.

In addition to the few within-person studies, to which findings from the present dissertation can be compared, most previous results on the association between subjective mood states and performance derives from studies of individual differences. This line of research found performance alterations (mostly impairments) as a function of affect (Ellis et al., 1997; Gray et al., 2002; Phillips, Bull, et al., 2002; Seibert & Ellis, 1991), life stress (Klein & Boals, 2001), and anxiety (Hogan, 2003). Due to their between-person design and restrictions to single assessments, such studies do not allow to attribute mood effects to the mood states themselves, but to persons who are characterized by a given mood. Thus, it is premature to conclude from individual differences in affect-related states and their relation to individual differences in cognitive performance that mood states and performance are associated within individuals, an issue that some have referred to as the ergodicity problem (Cattell, 1957b; Molenaar et al., 2003; Schmitz, 2000; Sliwinski et al., 2005). In fact, both levels of analysis may have nothing to do with one another in terms of relationships among several variables. In the left graph of Figure 5.1, performance of five different individuals is depicted as a function of these individuals' negative affect measured at one occasion. The relationship shown is one of individual differences, suggesting that individuals with higher negative affect show worse performance. In the graph on

the right, performance scores are shown for three individuals as a function of these individuals' negative affect scores assessed at five different occasions. These within-person relationships are all positive, suggesting that occasions with higher negative affect are related to better performance. In addition, the between-person association is shown on the basis of individuals' mean affect and performance scores, and this relationship is negative. These hypothetical data indicate that a negative between-person association can be found on the basis of positive within-person relationships. At the same time, the within-person relationships underlying a negative between-person relationship could be positive, negative, or close to zero (Sliwinski et al., 2005).

Greater informative value can be derived from longitudinal studies, in which long-term change in one variable is related to long-term change in another variable. Using six-year longitudinal data from the Berlin Aging Sample (age range: 70 – 104 years at T1; Baltes & Mayer, 1999), we were recently able to show that trait-like well-being affected deviations from linear change in perceptual speed, but not vice versa (Gerstorf et al., 2006). Analyses of this kind, using longitudinal data and methods to analyze intraindividual change are needed in addition to more micro-longitudinal work to better understand the dynamics of well-being and cognitive performance in young and older adults.



*Figure 5.1.* Hypothetical data showing the association of negative affect and reaction time performance at the between-person level (left graph) and both at the between-person and within-person level (right graph).

In the left graph, each dot represents one individual. In the right graph, the unfilled shapes represent associations between negative affect and reaction time for single occasions and single individuals, whereas the black dots represent the between-person relationship of affect and performance (– = low, + = high.)

### *5.3.2 Older Adults are not More Susceptible to the Conjoint Fluctuation of Emotion and Cognitive Performance in Everyday Life than Young Adults*

With increasing age, the ratio of gains and losses shifts toward a more and more unfavorable balance (Baltes et al., 2006). In the domain of well-being and cognitive functioning, the change in resources appear to be different, with stability and even increase in resources in the emotional domain (Charles & Carstensen, 2004; Costa et al., 1987), and many losses in the fluid aspects of cognition. (Craik & Salthouse, 2000; Park et al., 2002). In addition, older adults' cognitive performance has been shown to be more variable across trials and days than younger adults' performance (e.g., Hultsch et al., 2002; R. West et al., 2002a). On the other hand, the present study showed that older adults show much less variability in day-to-day emotional well-being than young adults. These interesting domain-specific differences in age-related differences make it a fascinating and important endeavor to study the conjoint fluctuation of emotion and cognition in everyday life. Changes in resources afford an adaptation in resource allocation patterns across different domains of functioning. These propositions motivated the examination of whether some of the individual differences in within-person coupling of affect and reaction time performance could be explained by age.

Contrary to the hypothesis, multilevel models that examined whether age group moderated the coupling between both affect and cognitive domains at the individual level yielded a non-significant interaction, however, suggesting that the average relationship between affect and performance did not differ between young and older adults. This interaction was not significant for either of the two affect and cognitive domain pairs. These results are consistent with findings reported in the Salthouse and Berish (2005) study, in which chronological age (range 18 to 89 years) also did not explain reliable amounts of individual difference variance in the intraperson coupling. As briefly reported in the previous section, Sliwinski and colleagues (2005) did find stronger coupling between daily stress and performance in the older adult group for one of three tasks, namely an attention switching task. Both age groups showed a negative relationship between stressor occurrence and a working memory task, but there was no reliable association between stress and processing speed in either age group. The authors interpreted these differences across tasks such that the processing speed task may have been not demanding enough for either age group to show coupling, and the attention switching task may have been sufficiently demanding only for the older adults so that their performance was associated with fluctuations in stress. Affect and mood tone, as the subjective feeling states focused on in the present dissertation and in the study by Salthouse and Berish (2005), are qualitatively different from stress. It is possible that stress-related variables are more prone to the processes



hypothesized to drive the coupling between emotions and emotion-related states with performance, such as task-irrelevant thoughts and other regulation-induced attention diversion than measures of rather general positive and negative affective tone.

Other studies that have examined age-related differences in the emotion-cognition interplay at the individual difference level have reported effects of age. Hogan (2003) asked 78 young adults ( $M = 18.8$  years) and 92 older adults ( $M = 70.1$  years) to provide ratings of state and of trait anxiety and to perform several cognitive tasks. In addition, performance on each task occurred both under selective and divided attention conditions. A greater level of state and trait anxiety was related to poorer cognitive performance in older but not younger adults in the divided attention condition. Significant associations of self-reported negative affect and depression with verbal memory for elderly but not younger adults were further reported by Deptula et al., (1993; see also Andreoletti et al., 2006; Bäckman and Molander, 1991). Phillips, Smith, et al. (2002) conducted one of the few studies to investigate age differences in the effects of both negative and positive induced mood on an executive control task. Detrimental effects of mood on task performance (i.e., number of excess moves, number of trials out of three solved in the minimum possible moves, time taken to plan moves) were similar among young ( $M = 23.0$  years) and older adults ( $M = 67.0$  years) with respect to induced positive mood. To the contrary, older adults' performance was negatively affected significantly more by negative mood than young adults. Even at the between-person level though, some studies have only found specific memory-related anxiety rather than global state anxiety to be more adversely related to memory performance in older than younger adults (H. A. Davidson et al., 1991), and some studies did not find a disproportional vulnerability of emotion on cognition for older as opposed to younger or middle-aged adults at all (Arbuckle et al., 1986; La Rue & D'Elia, 1985).

In conclusion, the evidence on age-related differences in the interplay of affect- and mood states with certain aspects of cognition originate mainly from individual difference studies, and have not consistently been replicated at the within-person level. Age was merely used as an indicator variable for individual differences in the vulnerability or susceptibility to a coupling of fluctuations in affect and cognition. Follow-up analyses were conducted to examine whether individual differences in average cognitive performance across the daily assessment period as well as theoretically relevant personality variables would explain the individual differences in within-person associations observed in the data. Findings pertaining to these analyses are discussed next.

### *5.3.3 Exploration of Individual Differences in Emotion-Cognition Coupling Beyond Age: The Role of Personality and Mean Day-to-Day Cognitive Performance*

The theoretical framework for the question of within-person correlation of emotion and cognition posited deployment of attentional and cognitive resources as a function of emotion-regulative efforts. Beyond age as a proxy for a reduction in cognitive resources, the average performance in each of the two cognitive tasks was explored as a potential moderator variable for the within-person coupling. These analyses yielded a small significant interaction effect of average 45-day working memory performance and daily PA in the prediction of daily working memory performance: Individuals with lower average working memory performance showed a stronger coupling relationship than higher-functioning individuals. Caution is warranted when interpreting this effect, because inspection of the data suggested that it was mainly driven by one very low-functioning older woman. Nonetheless, such an interaction effect is in line with the theoretical notions of resource allocation competition, and it is possible that associations at the within-person level are difficult to find among a sample of relatively high-functioning and highly motivated older adults. Rather, they may only be found in highly vulnerable individuals who are performing at very low cognitive levels.

Personality factors such as neuroticism and extraversion are related to individual differences in affective but also cognitive functioning (e.g., Arbuckle et al., 1986; Costa & McCrae, 1980; Schaie, Willis, & Caskie, 2004). As such, they may play a moderating role also in the relationship between emotional and cognitive functioning. In the present dissertation, extraversion moderated the within-person relationship between daily PA and daily vigilance performance. Individuals with higher levels of extraversion showed a stronger negative coupling, which means that their performance was faster on high-PA days as compared to days with lower-than-average PA. In other words, high-extraversion people profited more from higher than average levels of PA than low-extraversion individuals. This is consistent with theoretical notions about the associations of extraversion with arousal and performance (cf. Matthews, Davies, & Lees, 1990; Matthews & Davies, 2001; see also Wacker et al., 2006). Extraversion is thought to represent individual differences in arousal and in the availability of processing resources. Higher levels of arousal are considered to have a performance-enhancing effect for easier tasks, but lower levels of arousal may be beneficial when a task is more difficult. Extraverts are thought to seek stimulation to elevate their relatively low arousal levels (cf. Matthews et al., 1990). In addition, extraversion is considered a marker of reactivity to positive emotional states (Larsen & Ketelaar, 1991). Individuals high in extraversion may therefore have profited more from days on

which they experienced higher than their own average PA as compared to individuals low on a dimension of extraversion.

In the present dissertation, neuroticism emerged as a significant moderator of the NA-working memory coupling. Specifically, individuals high in neuroticism showed a more positive within-person relationship between daily NA and daily reaction time, indicating that for these people, days with greater than average NA co-occurred with days characterized by worse performance. This relationship was in line with the tentative prediction that neuroticism may amplify a performance-damaging effect of daily mood. This assumption is rooted in findings that show neuroticism to be a representation of individual differences in the reactivity to negative emotional states, stress, and negative events (Larsen & Ketelaar, 1991; Suls & Martin, 2005). The predisposition to respond more strongly to negative affect and stress may make individuals high in neuroticism more vulnerable to the resource diminishing effects of emotion regulative efforts (i.e., rumination), particularly because high-neuroticism individuals, at least in young adulthood, have been shown to be more prone to worry (Watson & Clark, 1984) and to show stronger mood spillover effects across consecutive time points (Suls & Martin, 2005). Such spillover may amplify the detrimental effects of negative affect states.

Interestingly within the focus on intraindividual variability in the present dissertation, M. D. Robinson and Tamir (2005) have recently advocated the view that at least some of the problems encountered by people higher in neuroticism may derive from underlying inefficiency of basic cognitive operations. From an emotional point of view, neuroticism is sometimes referred to as emotional instability, and M. D. Robinson and Tamir were able to extend this instability view to the cognitive domains. In a study involving 242 college students, neuroticism was positively associated to trial-to-trial intraindividual fluctuations but not to average levels of reaction time performance. As a result, the authors referred to neuroticism as an indicator of “mental noise”. One may conclude that higher levels of neuroticism may be an indicator of three types of vulnerability to the negative association between negative affect and performance: greater levels of negative affect, a greater propensity for ruminative thinking styles and less effective cognitive processing to start with. Taken together, these factors may make a competition in attentional resources, particularly in tasks with greater cognitive load more likely than for individuals low in neuroticism.

### *5.3.4 Summary and Conclusion on the Role of Age-Related and Individual Differences in the Within-Person Coupling of Emotion and Cognition*

The present dissertation addressed the interplay between emotional and cognitive functioning by examining the intraindividual associations between day-to-day fluctuations in emotional well-being and cognitive performance. The central finding was that individuals differ both in the direction and the magnitude of this relationship. This result indicates in a unique way that the relationship between the two domains of well-being and cognition is not a unitary phenomenon as traditional experimental between-person research may have suggested.

Furthermore, the present study adopted a theoretical dual-task perspective and a lifespan focus and asked whether older adults would show a stronger relationship between emotions and cognition than young adults. No evidence for a moderation of the within-person coupling as a function of age was found. In contrast, some evidence was obtained that individual differences in average daily cognitive performance and in personality traits can explain part of the individual difference variance in coupling. In light of the differences in available resources in the domains of emotion and cognition, it is interesting to see that in this study, older adults were not more susceptible to performance alterations in the dual-task context of regulating emotional states and successfully performing a cognitive task.

## 5.4 Limitations of the Present Study

### *5.4.1 Selection of the Adequate Unit of Time to Study Intraindividual Variability in Affect and Coupling to Cognitive Performance*

Several limitations of the present dissertation should be acknowledged. The first issue concerns the selected time sampling schedule. Assessments on a day-to-day basis may have been too small or too large to capture some of the phenomena of interest. For example, positive and negative affect are thought to show distinct patterns of variation within a day: In young adults, positive affect tends to rise continually within the first eight hours post waking and to decline thereafter. On the other hand, negative affect tends to show little such variation and remains relatively unchanged over the course of a day (Clark & Watson, 1988; Watson et al., 1999). Especially in light of the floor effects obtained for some older adults in terms of within-person variability in negative affect, the day-to-day assessment schedule may still have been too small to capture meaningful variation in this group. However, because individuals of all ages report very

low levels of negative affect, subtle changes in this domain may best be detected over the course of several days or weeks at a time rather than from one day to the next. Kleban et al. (1992) reported similar problems using a daily diary study, whereas floor effects in variability in negative affect were not mentioned in an experience sampling study by Carstensen and colleagues (2000), in which young, middle-aged, and older adults provided ratings of affect five times a day across one week.

Apart from possible problems in finding sufficient variability in all affect domains and all participants, the issue of time is likely to play an important role for the examination of within-person coupling between affect and cognition. Previous research has shown that single momentary ratings of affect are not overly representative of the overall mood that characterizes a day (Hedges, Jandorf, & Stone, 1985). Furthermore, for more dynamic hypotheses about a relationship between two variables, shorter time-intervals may be more appropriate, of course depending on the “true” time interval between two or more variables (Stone, Kessler, & Haythornthwaite, 1991; see also S. G. West & Hepworth, 1991). It is possible that, given the transitory nature of mood, a momentary assessment is too narrow to fully capture the theoretically proposed effects of emotion regulation and their relationship to cognitive performance. It may be a fruitful approach in future studies that use multiple assessments of affect and cognitive performance a day across a fairly large number of days, to examine whether within-day aggregates in both domains show stronger within-person coupling than obtained from relating single moments to one another.

Likewise, variability in mood and cognition can be examined at several levels: Variability phenomena need to be understood across different time frames, such as oscillations (moment-to-moment) and fluctuations (day-to-day, week-to-week, etc.), for they may both share some underlying psychological meaning, but differ with respect to their constituent mechanisms and processes (Cattell, 1957a) – and in the degree to which they show cross-domain coupling. Particularly in cognitive tasks involving several trials, trial-to-trial variability rather than the across-trial performance average may be linked to momentary mood. Along this line, it is also possible that variability at a lower level (e.g., within-day) affects variability and coupling at a higher level (e.g., between-day). Whereas these different levels of variability all bear interesting properties in and of themselves, for a particular focus on a given level, variability at a lower (or even higher) level may represent a “confounding” factor. If older adults, for example, show greater within-day (i.e., across-trial) variability than young adults, older adults’ aggregate daily scores in a given variable such as reaction time are less representative than younger adults’ daily aggregates. This may have an important effect on day-to-day level analyses, and appropriate

statistical tools such as dynamic factor analyses should be employed in future research to address and control for this issue (e.g., Schmiedek, 2006, for a recent discussion of these issues using cognitive data from the Intra-Person Dynamics project).

Measures of affect should thus be collected repeatedly within the same day to disentangle age-related differences in day-to-day variability from age-related differences in moment-to-moment variability, and to examine age-based differences in affect-cognition couplings on a moment-to-moment basis (see also Wittmann et al., 2005). This relatively smaller time scale may provide a more appropriate level of analysis for the dual-task conceptualization of concurrent successful emotion regulation and cognitive performance.

In the absence of a theory about time, researchers of intraindividual variability, intraindividual change and intraindividual covariation have to make decisions about the spacing of repeated assessments to the best of their knowledge and often times also on the basis of more pragmatic grounds. Given that the day is one of the most salient units of time in everyday life, a daily assessment schedule was chosen for the Intra-Person Dynamics Study. Due to restrictions in resources for data collection, and in order to limit demands for participants as much as possible, no assessments occurred on Saturdays and Sundays. It is thus possible that an inclusion of weekend assessments may have altered the findings. In the present study, differences in mood levels across the five weekdays were explored, but no evidence for such effects were found in either age group. To date, evidence of day-of-week effects are inconsistent, but some researchers found differences in mood levels between weekdays and the weekend (Egloff, Tausch, Kohlmann, & Krohne, 1995; Larsen & Kasimatis, 1990; Stone, Hedges, Neale, & Satin, 1985). It is therefore possible, that inclusion of daily assessments on Saturday and Sunday would have led to less floor effects in negative affect or to stronger coupling between mood and cognition. Finally, it is also possible that seasonal effects play a role and that findings about within-domain variability and about across-domain coupling differ because individuals are differentially sensitive to weather and seasonal influences (Keller et al., 2005; Reid, Towell, & Golding, 2000). Future studies could examine this possibility by using a measurement burst design (Nesselroade, 1991b), in which several waves of daily data collection are obtained across a year.

#### *5.4.2 Correlational Evidence not Suited for Causal Process Interpretation*

The multilevel analyses conducted to examine the within-person coupling of daily affect and daily performance were restricted to concurrent relationships. This analysis strategy can address the question of whether good and bad days in either domain are associated with good and bad days in the other domain – without implying any directionality. As such, findings from

these analyses can only be interpreted in correlational rather than causal terms, even though the theoretical models used as a framework for the research question on emotion-cognition coupling imply a causal direction from the affective experience (and its regulation) to impairments or enhancements in daily performance. Lagged analyses, in which performance is modeled as a function of previous day affect (after controlling for current day affect) in order to more closely examine the causal nature of the relationship. At the same time, such lagged analyses would have allowed to investigate the reverse direction, predicting daily affect by daily performance. As an extension of the multilevel framework, and an integration of this analytic technique with conventional latent growth curve modeling, McArdle and Hamagami (2001) have proposed a bivariate Dual Change Score Model. This model allows for the examination of whether one variable at time  $t$  is associated with deviations from linear change from  $t$  to  $t+1$  in another time-varying variable. In addition, in the framework of this model, it is possible to test competing conceptual hypotheses (does daily mood affect performance, vice versa, both, or no coupling at all). In recent work, we have applied this technique to investigate long-term longitudinal coupling of subjective well-being and perceptual speed in a longitudinal sample of the Berlin Aging Study (Gerstorf et al., 2006). In the present dissertation, with sampling of affect and performance at single moments once a day, I considered it rather unlikely to find lagged effects of mood on performance or vice versa, but future studies need to examine whether and at which time intervals lagged relationships can be identified.

It is furthermore possible that performance on one of the cognitive tasks on a given day, particularly if a person was very satisfied or overly frustrated, has had a lagged effect on mood. The anticipation of doing the same task again may have altered daily mood on a given day. Participants first responded to the mood questionnaire and then worked on the cognitive tasks. It is therefore possible that such lagged performance-mood effects were present in the data, but not as an immediate reaction within a single session (rather than anticipatory effects). In part, controlling the data for learning effects may have eliminated some of the effects of motivation and performance-related self-perceptions, but future studies examining these lagged effects could make an interesting contribution to the evidence provided by the present study.

#### *5.4.3 Cross-Sectional Design Provides Evidence for Age Differences but not Age-Related Change*

Another limitation of the present dissertation is that the micro-longitudinal assessment took place only once with a group of younger and a group of older adults. Therefore, even though age-related differences were in the direction of theoretically expected age-related change,

the interpretation as change is not permissible. In cross-sectional studies, age is confounded with cohort effects (Baltes, Reese, & Lipsitt, 1980), and any observed difference between the two age groups could possibly be due to cohort influences such as historical changes. In order to control for both age and cohort effects, longitudinal and cohort-sequential studies are needed (Baltes et al., 1977; Schaie & Hertzog, 1985). In the context of micro-longitudinal studies, Nesselroade (1991b) has advocated the use of a measurement burst design, in which several intensive assessment periods are repeated over a longer time frame. Such a design would provide information on long-term change in patterns of short-term variability and fluctuation.

#### *5.4.4 Reactivity and Retest Effects in Micro-Longitudinal Designs*

Several researchers have pointed out that apart from all the merits of short-term, micro-longitudinal assessment, the issue of reactivity should not be neglected (Eckenrode & Bolger, 1995; Scollon, Kim-Prieto, & Diener, 2003). Eckenrode and Bolger (1995) review findings that event frequencies tend to decline as number of diary days increase (Bolger et al., 1989) and that distress tends to be higher during the initial days of assessment than during a later phase (Bolger, 1990). The authors suggest two possible solutions: using day as a control variable when the focus is on the coupling between events and outcomes, or discarding the first few days of data if they appear to be affected by reactivity (Tennen et al., 1991). Very few studies acknowledge these reactivity effects and account for them in analyses of micro-longitudinal self-report data. In the present dissertation, the possibility for reactivity in the daily affect data was explicitly addressed as part of the analyses, using the first approach in order to retain all possible data points in the analyses.

In contrast to studies of self-reported subjective states, which are often thought to reflect merely fluctuations around stable mean levels, test-retest effects and learning are often at the core of interest in studies of cognition (Sliwinski, 2006, recently provided an exemplar approach to distinguishing practice effects from learning in a micro-longitudinal study). In the present dissertation, such effects were controlled for in all analyses, in which retest and learning effects may have biased analyses of other substantive questions, such as the coupling between two time-varying variables (S. G. West & Hepworth, 1991). Little is known, however, about how the intensive practice in the vigilance and the working memory task may have affected the nature of the task itself. Particularly in the working memory task, the discovery of strategies may over time and for some individuals have modified the task from a primary working memory measure to a primary speed measure. One way of addressing this issue in future research would be to more



closely assess, how correlations among the cognitive tasks and between the cognitive tasks and other variables possibly change over time.

#### *5.4.5 Lack of Control for Occurrence of Stressors and Perturbations to the Psychological System*

In the present dissertation, individuals provided ratings of daily PA and NA and performance measures as part of their otherwise regular everyday routine. There was no control about occurring daily events and stressors or other major life events, which may have represented perturbations to the psychological system (Scollon et al., 2003). As such, the present study likely captured homeostatic or baseline levels of variability and of the within-person coupling. One interesting type of variability, however, is fluctuation observed once a perturbation has taken place (Li et al., 2004; Lindenberger & Oertzen, 2006). This type of variability, its range directly following the perturbing event and the time needed to recover to baseline levels of variation may provide an even better insight into the plasticity and the regulatory capacity of the psychological system. Some recent studies have studied variability in emotional states following major life events such as bereavement in old age (Bisconti et al., 2004) or romantic relationship dissolution in young adulthood (Sbarra & Emery, 2005). Such major life events may be considered naturally occurring perturbations to the psychological system. In addition, future research may find it useful to adapt a testing-the-limits paradigm (e.g., Kliegl, Smith, & Baltes, 1989), in which plasticity and regulatory capacity is compared between baseline levels and at the system's limits, which can be approached either through training a given capacity (e.g., cognition) or by providing a critical challenge to the system's resources (e.g., emotional domain; see also Section 5.6.4 for further discussion of these ideas).

#### *5.4.6 Limited Power to Identify Between-Person Differences*

The sample in the present dissertation consisted of 18 young and 19 older adults. It is evident that more day-level and more person-level units provide greater power, even though the determination of power in multilevel analyses is at present not fully understood (Kreft & de Leeuw, 1998). Because the main focus in the Intra-Person Dynamics Study was on intraindividual processes, the number of repeated assessments was maximized, and due to pragmatic reasons, this was done at the expense of sample size in terms of participants. It is therefore possible, that the power to detect some of the hypothesized age-related and other individual differences was too small. Particularly for the analysis of age-related differences in how variability in PA and NA is related to psychological well-being, a greater person-level sample may have yielded significant

differences in correlations. Given the wide range of within-person patterns in the coupling of daily affect and cognition within both age groups, even a greater person-level sample may not have resulted in significant age differences. It would be desirable, however, to be able to include a greater number of individuals in future studies in order to maximize power to find meaningful explanatory variables for the observed between-person differences in within-person coupling.

## 5.5 Strengths of the Present Dissertation

### 5.5.1 *Advantages of Micro-Longitudinal Design*

One of the biggest strengths of the present dissertation is the employment of a micro-longitudinal design. Many child and lifespan developmental psychologists have alerted the field that the study of development needs intensive repeated measurement data instead of single assessments (Baltes et al., 1977; Buss, 1971; McCall, 1977; Nesselroade & Schmidt McCollam, 2000; Wohlwill, 1973). In other fields, such as social and personality psychology, the field has witnessed a growing interest in understanding human functioning by observing behavior of single individuals in everyday environments (e.g., Kahneman, Krueger, Schkade, Schwarz, & Stone, 2003; Mehl, Gosling, Pennebaker, 2006; Mischel, 2004). This opens up a new window on the dynamical processes unfolding in everyday life, which underlie lifespan trajectories of emotional well-being and other functional domains. These dynamics appear static in cross-sectional designs and are captured only as snapshots spaced months or even years apart in traditional longitudinal work. A quote from Eckenrode and Bolger (1995, p. 80) nicely captures the general advantage of micro-longitudinal designs: “Measurement at the daily level affords the researcher with the equivalent of a behavioral science microscope.” The present dissertation provided a unique integration of a developmental and lifespan theoretical perspective on intraindividual fluctuation with research on age and emotions as well as on emotion-cognition interactions.

In addition, in the face of reliable intraindividual fluctuations, single assessments provide information about age-related differences in levels that are confounded with age-related differences in fluctuation (Cattell, 1957b; Featherman & Petersen, 1986; Nesselroade, 1988; Nesselroade & Ford, 1985). Both strands of research are needed to provide a context for comparison and to complement each other in providing pieces to a larger puzzle that best maps onto the complex human nature.

Another advantage of micro-longitudinal designs is that they minimize recall biases that are likely to affect traditional retrospective self-report ratings (Almeida, 2005; Bolger et al., 2003;

Stone et al., 1991; see also Takarangi, Garry, & Loftus, 2006, for a recent discussion of memory processes associated with different response formats in diary studies). Older adults may be particularly prone to such recall biases, and ratings of momentary affective state can compensate for this difference at least to some degree (see also Schwarz et al., 1999).

In the present dissertation, each individual served as his or her own comparison standard, which allowed for an examination of the validity of theoretical propositions on emotion-cognition relationships at the intraindividual level: Do a person's relatively greater moments of PA correlate with that person's moments of relatively better performance? This question is fundamentally different to the question of whether happy people perform on average better than unhappy people. Most of the resource allocation theories on emotion-cognition coupling are process theories that put forth intraindividual processes. The present study is the first attempt to examine these theories with respect to both positive and negative affect and two cognitive tasks in a sample of young and older adults over an extended period of time (see also Sliwinski et al., 2005). Through the focus on processes within single domains but also across multiple domains of functioning at the intraindividual level, this dissertation provides important insights into both the person-in-time and the psychological system-in-time (see also Magnusson, 1997).

The last point to highlight is that the intensive assessment occurred under controlled laboratory conditions. On the one hand, this is different from truly studying processes as they naturally occur in the individuals' everyday environment. On the other hand, the length of the assessment period (i.e., 45 days stretched across nine weeks), provided ample opportunity for both young and older participants to become familiar with the testing setting, the tasks and questionnaires as well as the research assistants. In addition, we allowed participants to select their own preferred testing time, which allowed them to incorporate the daily sessions into their normal everyday routines. It is of course possible that older adults are more aware of their own optimal time of day than young adults or that due to less scheduling constraints (e.g., schooling- or work-related), older adults were in a better position to select their optimal time than young adults.

Finally, previous research has shown that diary studies, in which participants are provided with testing material to be filled out at home, can be subject to reporting biases such that individuals fill in several questionnaires intended for several different days at a single occasion (e.g., Broderick & Stone, 2006; A. S. Green, Rafaeli, Bolger, Shrout, & Reis, 2006; Stone et al., 1999). Furthermore, in such settings, it is difficult to know whether participants themselves responded to questionnaires and tasks or if someone else did it. In the present study, none of these issues were relevant because assessment took place in a supervised context.

### 5.5.2 *Multiple Indicators of Affect and Cognitive Performance*

Despite the rich literature on the distinct functions of both positive and negative affective states for certain aspects of cognitive performance, the few available within-person studies on emotion-cognition coupling have focused almost exclusively on negative affective states and stress (e.g., Sliwinski et al., 2005) or have used a single bipolar indicator of pleasantness (Salthouse & Berish, 2005). In the present dissertation, positive as well as negative affect was assessed on a daily basis and their intraindividual relationship with cognitive performance was examined. Despite the importance of understanding psychological functioning in the context of stress and problems to understand mechanisms of resilience, there is ample evidence for the functional importance of positive affect for a number of outcomes such as cognition, health, and general adaptation (for a recent review, see Lyubomirsky et al., 2005). Positive affect is more than the absence of negative affect, and both domains have distinct functions for cognition and behavior (e.g., Elliot & Thrash, 2002).

In addition, emotion theorists distinguish affect and emotion along two dimensions, valence and arousal (Barrett & Russell, 1998; Watson et al., 1988). The PANAS (Watson et al., 1988) was used in the present study to measure positive and negative affect because it is one of the most common instruments in micro-longitudinal studies and shown to be sensitive to short-term fluctuations in young adults. Watson et al. (1999) have later acknowledged that the two scales assess positive and negative activation rather than states characterized by low or moderate levels of arousal. In order to rule out that findings on age-related differences in emotional fluctuation and in the coupling with cognitive performance were driven by the general arousal rather than the valence component, additional items such as happy and sad were used to build a daily indicator of hedonic balance in the present study and all central analyses were conducted with both the PANAS PA and NA scores and the hedonic balance score.

In addition to multiple indicators of daily affect, daily performance was measured on two cognitive tasks, a sustained attention and a spatial working memory task. This allowed for a comparison of the coupling results across different cognitive abilities. Furthermore, reaction times were much higher in the working memory task as compared to the vigilance task in both young and older adults. This provides initial credibility that the two tasks represent different amounts of cognitive load, and as such also permitted the analysis of possible coupling differences as a function of task demands (see Ellis et al., 1984, 1997; MacLeod, 1996).

### 5.5.3 *Comparison of Young and Older Adults*

Many of the theories of emotion-cognition interactions consider processes of resource allocation and resource competition as one of the central underlying mechanisms (Ellis & Ashbrook, 1988; Richards & Gross, 2000; Schmeichel et al., 2003). Some of these theories more or less explicitly propose age-related differences in coupling (Hasher & Zacks, 1980; Unsworth et al., 2005), but neither at the between-person nor at the within-person level, these propositions have been investigated extensively (for exceptions, Phillips, Smith, et al., 2002; Sliwinski et al., 2005). The advantage of the present dissertation is that the within-person coupling of affect and cognition was examined in a sample of both young (20–30 years) and older (70–80 years) adults, using multiple indicators of affect and of cognitive performance. This represents a substantive contribution to the existing literature.

## 5.6 Directions for Future Research

### 5.6.1 *Beyond Self-Report: Examining Age-Related Differences in Intraindividual Variability in Physiological and Behavioral Indicators of Emotion*

Subjective well-being is considered to be a central component of successful development and aging (Baltes & Baltes, 1990; Ryff, 1989). Therefore, the focus in the present study was on self-reports of PA and NA. There is more to emotions than the subjective level, however. Emotions have a behavioral (expressive) facet as well as physiological underpinnings, and age-related differences show distinct patterns across these different levels (Levenson, 2000). In addition, some evidence suggests that the postulated coherence among emotional response systems may not be as perfect as generally believed. For example, Mauss, Levenson, McCarter, Wilhelm, and Gross (2005) examined coherence patterns across response systems recorded on a second-by-second basis while 60 female undergraduates watched a film that either induced amusement or sadness. Both amusement and sadness experience ratings were moderately to highly positively correlated with the respective facial behavior. However, these two response systems were only weakly related to the corresponding physiological responses. Future research should examine whether age-related differences in short-term variability of emotional experience in expressive and physiological parameters differ from the self-report findings outlined in the present dissertation (see Magai et al., 2006, for a recent contribution). Given that the literature on emotional reactivity and on emotion regulation is based mainly on self-report data, more research

is needed to understand emotional competencies and emotional functioning within a multilevel framework.

### *5.6.2 Identifying Developmental Antecedents, Correlates, and Consequences of Intraindividual Variability in Positive and Negative Affect*

Understanding the antecedents, correlates, and consequences of a given behavior is a central tenet in lifespan psychology. The identification of these factors is particularly important considering the large interindividual differences observed in the present dissertation in average levels of daily (positive) affect, especially in the older adult group. Does it make a difference, if variability occurs around moderate levels of PA or around very high or very low levels of PA? Which antecedents, correlates, and consequences may explain interindividual differences in intraindividual levels and variability? Do interindividual differences show an increase with regard to intraindividual variability? In the present dissertation, this was not the case, but such an amplification of between-person diversity in variability itself may be observable only into very late adulthood.

In the present dissertation, an initial attempt to examine trait psychological well-being as a correlate of within-person fluctuations in positive and negative affect is reported. This analysis was restricted by a very small sample size, however, so that future studies including much greater person-samples should investigate the functional meaning in terms of consequences of well-being fluctuations at the daily level but also at other time intervals. Researchers may also find it useful to examine, which person characteristics may be predictive of longitudinal change in the amount of within-person variability in affective states. It is possible that these antecedents differ across the lifespan. During childhood, the ability to delay gratification and to share attention may be important indicators of emotion regulation (Eisenberg, Champion, et al., 2004). During adolescence, personality development and identity formation as well as adaptation to the demands in formal schools and the formation of friendships may be key factors (e.g., Larson et al., 1980, 2002), during young adulthood, job attainment and the ability to form rewarding intimate relationships may be crucial. During old age, the ability to orchestrate a changing pool of resources and find meaning in life may be important characteristics (e.g., Baltes, 1987; Baltes et al., 2006).

A second interesting route could be to study subgroups characterized by extreme personality profiles (e.g., very high versus very low in extraversion and neuroticism, respectively) or by clinical symptoms related to mood and personality disorders (e.g., Bowen, Baetz, Hawkes, & Bowen, 2006; R. J. Davidson, 1998) and investigate whether in such groups, age still matters as

an explanatory variable. It is conceivable that in certain subgroups, person-characteristics other than age account for most of the unique variance in within-person fluctuations of emotional well-being.

Furthermore, many theories propose that an accumulation of experiences in dealing with emotional events leads to an improvement in emotion regulation, possibly rendering emotion regulation to a more crystallized ability. Hence, it may be helpful to study subgroups of individuals who have successfully mastered major life events (e.g., Bisconti et al., 2004; Sbarra & Emery, 2005), versus those who have not and to examine whether meaningful differences in patterns of variability emerge. As for consequences, week-to-week variability in control beliefs (over and above mean levels) was predictive of mortality risk over a five year period (Eizenman et al., 1997). Whereas mood fluctuations are of central interest in clinical psychology, it would be interesting to examine whether mortality or general health parameters can be identified as outcomes of affect fluctuations in non-clinical samples.

To date, variability in cognitive functioning is considered as a marker of developmental transitions and of aging. A closer examination of the role of variability in emotional experience as a developmental marker is needed to better understand what it means to be emotionally inconsistent (i.e., “moody”). In the same vein, emotional complexity may evince an increase across adulthood and serve as an additional marker of developmental transitions (e.g., Carstensen et al., 2000; Labouvie-Vief & Medler, 2002; Ong & Bergeman, 2004). In order to capture meaningful developmental transitions of different kinds, an interesting follow-up of the present dissertation would be to extend the age-range studied both to middle age as well as into very late adulthood. It is conceivable, for instance, that in light of an increasingly unfavorable balance of gains and losses in very old age (i.e., the so-called Fourth Age), patterns of variability show an increase as compared to those of the younger old (i.e., the so-called Third Age; Baltes & Smith, 1999, 2003; Neugarten, 1974; see also Baltes, 1997).

### *5.6.3 Within-Person Coupling of Affect and Cognition: Individual Differences, Discrete Emotions, and Other Cognitive Tasks*

The present study yielded evidence for reliable individual differences in the patterns of intraindividual covariation of affective states and reaction time performance. Future studies involving a larger sample would be useful to more closely examine which factors are able to explain the between-person variation. In line with the theoretical notions of cognitive costs of emotion regulation, individual differences in general self-regulative abilities should be investigated. Schwarzer’s Self-Regulation Scale (e.g., Diehl et al., 2006; Schwarzer et al., 1999), for

example, assesses individual differences in the ability to focus one's attention on a criterion task, thereby controlling and regulating both externally and internally driven distraction, in order to achieve a goal or outcome. Researchers should furthermore follow up findings on the moderating role of general intellectual functioning and of classical personality factors.

It is also possible that a person-centered approach, in which subgroups of individuals with different profiles of within-person variability are examined, provides interesting insights into the conditions under which the domains of emotion and cognition are most or least closely coupled. A person who fluctuates very much in both emotional states and cognitive performance (and possibly in motivational factors) may be more susceptible to the conjoint fluctuation than a person exhibiting strong coupling only in one of the domains (and is rather consistent in motivational levels).

As a further extension of the present study and of other previous research, researchers could examine the coupling of performance with discrete emotions and specifically performance-related subjective states rather than global positive and negative mood states. In the negative domain in particular, not all states have the same cognitive and motivational dynamics: Fatigue is characterized by low arousal and motivation, anxiety is represented by high arousal and action-tendencies. In addition, rumination and worry may be characteristic of depressive and sad states, whereas someone in an angry mood may more readily act out on the emotion as a form of regulation. H. A. Davidson et al. (1991), for instance, only found a relationship between specific memory anxiety and memory performance rather than between general anxiety and performance (see also Lachman, Baltes, Nesselroade, & Willis, 1982).

In addition to using alternative indicators of affective states, future research should also include a number of different cognitive tasks into the within-person analyses. Most of the research on emotion and cognition has used very specific cognitive tasks, such as those involving valenced material (to study congruency effects) or creativity tasks. In light of the strong relationships between mood and memory for valenced words, or between positive affect and creative performance found in experimental work, it would be interesting to investigate whether these relationships can be replicated at the within-person level. The underlying assumption in Eysenck & Calvo's (1992) processing efficiency theory is that state anxiety is accompanied by worry and ruminating thoughts that intrude with working memory performance in competing for similar resources as those required by short-term storage and processing of material. Due to the verbal nature of these worries and thoughts, Eysenck proposed that they were likely to be processed by the phonological loop and the central executive of the working memory system, and less so by the visuospatial sketchpad (Baddeley, 1986). Consequently, resource competition



between anxiety and cognitive performance may be greatest with respect to verbal tasks. Given that in the present dissertation, a spatial working memory task was used, future studies could investigate whether the pattern of findings would be different when using a verbal working memory task instead.

#### *5.6.4 Testing Processes Underlying Emotion-Cognition Coupling More Directly*

Emotion regulative processes that may have reduced cognitive resources available for the concurrent mastery of the vigilance and working memory tasks were inferred rather than directly tested in the present study. There are a few experimental studies that have used thought protocols to examine the role of task-irrelevant thinking associated with induced emotional states for performance in a cognitive task (e.g., Seibert & Ellis, 1991). In work by Sliwinski et al. (2005) stressor occurrence was used as a proxy for worry and ruminative thoughts. Future studies, both in the experimental as well as the within-person realm, should operationalize mood repair and other cognitive processes associated with emotional states to better understand the mechanisms that drive the coupling between emotion and basic cognitive functioning. One possible route would also be to ask participants to regulate their emotions while performing a task in a short micro-longitudinal study and thus explicitly create a dual-task context rather than implicitly assuming it (see Scheibe & Blanchard-Fields, 2006, for an initial experimental study).

Another more direct test of the dual-task and resource allocation idea would be to study subgroups of individuals who are at the limits of regulative capacity in either the emotional or the cognitive system. Individuals diagnosed with elevated depressive or anxious symptoms are vulnerable to rumination and worry and hence may be more susceptible to the cognitive costs of such thinking styles. In addition, very old adults beyond the age of 80 are likely to suffer from substantive impairments in fluid abilities, which in turn may also render this group more susceptible (and possibly more vulnerable) to dual-task effects of emotion on cognition. Lastly, one could study individuals undergoing highly stressful critical life episodes, such as following bereavement or preparing for an important exam (e.g., Bisconti et al., 2004; Sbarra & Emery, 2005), or other emotionally-salient life periods (e.g., pregnancy, see Lebo & Nesselroade, 1978). During those times a strong average within-person coupling of feeling states and cognitive performance may be observed, that is not captured under everyday conditions, in which the dual-task interplay between both domains may not occur because individuals' hedonic experiences are fairly well and relatively automatically regulated.

As a third approach, rather than assessing emotional well-being and cognitive performance repeatedly with the exact same task, perturbations could be experimentally induced.

For instance, task difficulty could be periodically increased or positive and negative feedback could be provided from time to time. Knowing the timing of these perturbations to either the emotional or the cognitive system would allow the researcher to examine whether these are reflected in fluctuations in the respective other system.

A fourth possibility would be to assess age-related differences in affect-cognition linkages on a moment-to-moment basis. This relatively more micro-level time-scale may be even better suited to capture micro-level regulatory and allocation processes associated with the proposed dual-tasking of successful emotion regulation and performance (see also Section 5.4.1).

## 5.7 Conclusion

A number of studies on intraindividual variability in diverse domains of psychological functioning, including affect and emotions, have established the phenomenon as a vital part of human experience and functioning. In this sense, the phenomenon of within-person variability has come a long way from a “stay in limbo, between measurement and error, to the realm of psychologically understood process” (Cattell, 1957a, p. 591). Findings from the present dissertation represent a unique contribution to this growing literature by providing a first linkage of research on age and emotional well-being with theoretical notions of intraindividual variability and emotion-cognition couplings. Whereas traditional cross-sectional and long-term longitudinal research has provided little evidence for strong age-related differences in trait-like well-being, intraindividual variability emerged as a salient characteristic and difference between young and older adults’ self-reported PA and NA in the present study. Hence, single occasion measurements may in many domains be a very impoverished representation of the potential range (i.e., plasticity) of an individual’s repertoire. Likewise, the absence of a strong average intraperson coupling effect between daily affect and daily reaction time performance underscores that differences between individuals cannot readily be mapped onto processes of within-person change. The intensive study of how functioning in several psychological domains is intertwined in everyday life in single individuals will foster a better understanding of successful development and aging at a process level. The goal of the present study was to use a lifespan psychological approach to study intraindividual variability in positive and negative affect and some of its central trait-like and state-like correlates. The application of a lifespan theoretical perspective on the dynamics of well-being and the interplay with cognitive performance by use of a micro-longitudinal intraindividual design represents a unique integration and as such a new look at emotional well-being.