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Is day-to-day variability in cognitive function coupled with day-to-day variability in affect?

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ABSTRACT

Intra-individual differences in cognitive function that occur reliably across repeated assessment occasions are thought to correspond to contemporaneous fluctuations in affect. However, the empirical evidence for this hypothesis is to date inconclusive. Here, a sample of 98 participants was recruited to complete tests of short-term memory, processing speed, and working memory, as well as rating daily their positive and negative affect (PANAS), on each of five consecutive days. Cognitive tests' re-test correlations averaged at .72; for affect, test re-test correlations averaged .53. The within-person variability in cognitive tests was overall smaller (13.5% for both working memory and short-term memory, and 16% for processing speed) than in affect (24% for positive and 51.7% for negative affect). A series of linear mixed effects models showed that day-to-day-variability in cognitive function was not coupled with contemporaneous fluctuations in positive and negative affect (i.e. states; ns in all cases). Thus, affect and cognitive function fluctuate within individuals across days but they appear to do so independently of one another.

The significance of differences in cognitive ability that occur *between* people is well documented but less is known about ability differences that occur *within* a person across repeated assessment occasions. Within-person differences exist over and above measurement error, and they confound observations of individual or between-person differences (Molenaar, 2004; Rabbitt, Osman, Moore, & Stollery, 2001; Salthouse & Berish, 2005). Also, the patterns of association for between-person differences in two or more psychological variables are distinct from the relationships that psychological processes share within a person (Borsboom, Mellenbergh, & van Heerden, 2003). For example, within-person differences in motivation and working memory differ reliably across individuals (Brose, Schmiedek, Lövdén, Molenaar, & Lindenberger, 2010), suggesting that the structure of between-person variances does not reflect the one of within-person variances. Because psychological processes occur mainly within and not between people, within-person differences are pivotal for understanding the dynamics of behavior, cognition and affect (Molenaar, 2004). In this context, the co-occurrence of changes in affect states and cognitive function is of particular interest, because it is accompanied by extensive anecdotal evidence (i.e. I felt poorly, and so I did poorly) but yet inconclusive empirical evidence.

1. Coupling effects between cognitive function and mood

According to the dual-task perspective (e.g. Ellis & Ashbrook, 1988), cognitive resources are limited and can either be allocated to performing a given task or to affective experiences and other task-unrelated cognitive processes (Goschke & Bolte, 2014). Supporting this model, emotion regulation, especially of negative emotions, has been shown to be cognitively costly (Mitchell & Phillips, 2007; Riediger, Wrzus, Schmiedek, Wagner, & Lindenberger, 2011) and linked with reduced cognitive function (Ellis & Ashbrook, 1988; Joormann, 2008).

Most previous research in this area employed experimental study designs but to test coupling effects between changes in affect and cognitive function, micro-longitudinal studies are most appropriate. Micro-longitudinal studies observe samples repeatedly over time in short intervals (e.g. hours or days) to avoid confounding by other variables that may inform cognitive changes (e.g. aging processes). Five previous articles reported data from four independent micro-longitudinal studies that tested for coupling effects between changes in affect and cognitive function (Table 1; Brose, Schmiedek, Lövdén, & Lindenberger, 2012; Brose, Lövdén, & Schmiedek, 2014; Riediger et al., 2011; Salthouse & Berish, 2005; Sliwinski, Smyth, Hofer, & Stawski, 2006). Two of the studies were lab-based, and two employed experience-sampling methods (i.e. assessment 'on-the-go'). Studies' durations spanned between 5 and 197 days with the assessment frequency ranging from once every two days to six times per day. For cognitive measures, three studies included working memory tests and one assessed a wide range of cognitive abilities. All studies included measures of affect, which refers to the experience of feeling or emotion and describes a person's mood (Watson, Clark, & Tellegen, 1988); two also assessed other state variables (i.e. motivation and attention control).

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Table 1
Overview of studies investigating coupling effects in day-to-day variability in cognitive function and affect.

Authors	Method	Assessment frequency	Cognitive measures	State measures	N	Age range
Salthouse & Berish, 2005	Palm pilot devices; correlations	6 assessments over course of 5 days	Vocabulary, processing speed, memory, executive function, reasoning & spatial visualization	Mood (single item)	271	18–89
Sliwinski et al., 2006	Lab based; mixed model approach	6 assessments over course of 8 to 14 days	Working memory (n-back, n-count, string comparison)	Negative affect (PANAS), daily stressors	108 68	66–95 18–24
Riediger et al., 2011	Mobile phones; mixed model approach	54 assessments over course of 9 days	Working memory (numerical memory-updating task)	Negative and positive affect (3 items each)	378	14–86
Brose et al., 2012	Lab based; mixed model approach	100 assessments within 197 days (average of sample)	Working memory (3-back task)	Negative affect (PANAS), motivation, attention control	101	20–31
Brose et al., 2014	Lab based; mixed model approach	100 assessments within 197 days (average of sample)	Working memory (3-back task)	Positive affect (PANAS), motivation	101	20–31

Note. Brose et al. (2012) and Brose et al. (2014) reported data from the same sample. PANAS refers to the Positive and Negative Affect Scale by Watson et al. (1988).

Coupling effects were observed in two samples. First, Brose et al. (2012) found that spatial working memory performance was lower on days of increased negative affect and reduced motivation and attention control.[1] In the same sample, they later (2014) also reported that that spatial and verbal working memory performance was improved on days with greater positive affect but they found no coupling effect for positive affect and numerical working memory. Second, Riediger et al. (2011) reported significant coupling effects for variability in numerical working memory with fluctuations in both positive and negative affect. In the remaining two samples, no such effects were detected. That said, Sliwinski et al. (2006) found a significant relationship between day-to-day variability in stress and cognitive task performance. Because the inconsistency in findings cannot be directly attributed to the studies' differences in methods, measures and samples (Table 1), we can conclude that previous research on coupling effects between day-to-day variability in mood and cognitive function is to date inconclusive.

2. The current study

The current study adds to understanding the dynamics of within-person differences in cognitive function in two significant ways. First, participants were assessed on three different cognitive abilities on five consecutive days, including measures of short-term memory, processing speed and working memory. Each day, participants completed the same tests but worked on different items. This test battery allows for one studying if changes in affect are associated with changes in specific cognitive abilities or across cognitive functions. For the other, the inclusion of a working memory test enables a direct comparison between the current findings and previous results in this area (Table 1).

Second, participants in the current study also completed daily assessments of affect, using the full Positive and Negative Affect Scale (PANAS), which differentiates positive and negative affect that are orthogonal dimensions (Watson et al., 1988). Positive affect refers to experiencing pleasure when engaging with the environment, with enthusiasm and alertness indicating high positive affect, and lethargy and sadness marking low positive affect (Watson et al., 1988). Conversely, high negative affect is characterized by the experience of subjective distress, discontent and hostility, with low negative affect reflecting the absence of such feelings (Watson et al., 1988). Some of the previous studies in this area used only short affect measures (e.g. Riediger et al., 2011) that have reduced reliability, or positive and negative affect were not jointly examined with regards to coupling effects for cognitive function (Brose et al., 2012, 2014).

[1] Brose and colleagues did not mention verbal and numerical working tasks and scores in their 2012 paper.

3. Methods

3.1. Sample

Overall 98 participants contributed to this study, the majority of whom identified as full-time university students (N = 88) and female (N = 74). Age ranged from 18 to 75 years (mean = 23.81; SD = 8.40), with 88% of the participants aged 18 to 30 years. More than half of the sample (N = 62) listed English as their native language.

All 98 participants completed the study days 1 and 2, with one participant completing 80% of the tests on day 1 before a technical default terminated the session early. 93 participants returned on day 3; 91 returned on day 4, including 4 participants who were excluded from the analyses because they were accidentally administered the same testing materials as on the previous day; and 88 attended the final test session on day 5 (N after listwise omission = 77).[2]

3.2. Measures

3.2.1. Cognitive function battery. A cognitive test battery was developed specifically for this study that assessed short-term memory, processing speed, and working memory, respectively (Fig. 1). Tests were designed with reference to the measures from the ETS testing kit by Ekstrom, French, Harman, and Dermen (1976) and adapted for computerized administration. Test items were designed to maximize their comparability across assessment occasions (i.e. difficulty and discrimination) without administering the same item more than once. For each test, psychometric properties based on this study's sample are reported in the Results section of this manuscript

Short-term memory test. Overall 18 individual sets that consisted of 5 or 7 pairs, triplets, or quartets of combinations of letters and numbers were shown for exposure times of at least 7 s and at most 15 s. Participants were asked to recall each set's items in the order that they had been shown in within 25 s to 30 s. Sets increased in difficulty, starting with 5 pairs of letters only, and ending with 7 quartets of mixed letters and numbers. Correctly recalled pairs, triplets or quartets were coded as 1; incorrect or missed answers were coded as 0 (see also Fig. 1a). The test included overall 108 dichotomous items.

Processing speed test. Participants were shown pairs of strings that consisted of 13 numbers or combinations of letters and numbers. The strings were either identical or differed in one letter or number in any position along the string. Two blocks of 20 pairs of strings were shown (i.e. 40 items in total), each timed at 30 s. Participants had to mark if two strings were identical or not as fast as possible; correctly marked pairs were coded as 1 and all others as 0 (see also Fig. 1b).

[2] The data reported in this study are freely available on http://www.hungrymindlab.com/publications/data.