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Effects of age and ability on components of cognitive change

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ABSTRACT

Prior experience with a cognitive task is often associated with higher performance on a second assessment, and these experience effects can complicate the interpretation of cognitive change. The current study was designed to investigate experience effects by obtaining measures of cognitive performance separated by days and by years. The analyses were based on data from 2017 adults with two longitudinal occasions, of whom 948 had also completed a third occasion, with each occasion consisting of three parallel versions of the tests on separate sessions. Change across short intervals was typically positive, and greater among older adults and adults with low levels of cognitive ability, whereas change over intervals of approximately three years was often negative, particularly at older ages. In contrast to the expectation that change over short intervals might be informative about change over longer intervals, relations between short-term change and long-term change were negative, as the individuals who gained the most with assessments separated by days tended to experience the greatest losses across assessments separated by years.

1. Introduction

Traditional longitudinal comparisons involve at least two measurement occasions, with change assessed by contrasts among the scores from single assessments at each occasion. Longitudinal change is often interpreted as reflecting processes occurring over the interval between occasions, such as those related to development or maturation. However, because in longitudinal studies a second occasion is necessarily preceded by an initial occasion, some of the change could be attributable to prior experience with the tests. Developmental effects and test experience effects are difficult to separate in traditional longitudinal designs, but the two components of change can be distinguished if the research design involves multiple assessments at each occasion, as with dual-baseline procedures (e.g., Beglinger et al., 2005; McCaffrey & Westervelt, 1995; Van Gorp, Lamb, & Schmitt, 1993), or measurement burst designs (e.g., Nesselroade, 1991; Salthouse & Nesselroade, 2010). Very few studies have been reported with either type of design, but both could be informative in distinguishing components of change. Dual-baseline procedures differ from conventional longitudinal designs by having two or more assessments at the initial occasion, and measurement burst designs differ by having a burst of multiple assessments at each occasion instead of a single assessment.

The top panel of Fig. 1 illustrates a traditional longitudinal comparison with only a single assessment at each occasion, and the bottom panel portrays a measurement burst design with three assessments (administered on separate sessions) at each occasion. Assessments in a measurement burst design can be designated by two numbers, with the first number referring to the occasion and the second referring to the session within an occasion. For example, 11 refers to the first session in the first occasion, 13 refers to the third session in the first occasion, and 22 refers to the second session in the second occasion. Note that in a traditional longitudinal comparison, change corresponds to the contrast between 11 and 21 because there is only a single assessment at each occasion. However, when three assessments are available at each occasion the longitudinal change (i.e., from 11 to 21) can be partitioned into components corresponding to change from 11 to 12, 12 to 13, and 13 to 21. The first two contrasts are within-occasion changes, whereas the third contrast represents the change from the last assessment in the first occasion to the first assessment in the second occasion.

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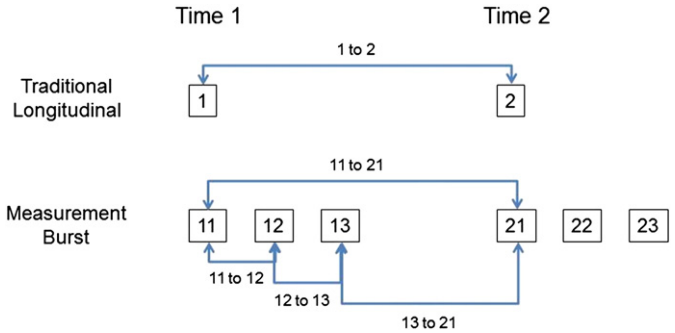

Fig. 1. Schematic illustration of possible measures of change in a traditional longitudinal study (top panel), and in a three-assessment measurement burst design (bottom panel).

The availability of multiple measures of change allows three important questions to be asked. First, can the contributions of different factors to cognitive change be assessed by contrasts of change across short (i.e., about one week) and longer (i.e., about 3 years) intervals? Second, do the measures of change across different intervals differ in their patterns of relations with individual difference characteristics, as might be expected if they reflect distinct aspects of change? And third, what is the relation between change over short and long intervals?

Four factors differing in their probable degree of generalizability can be postulated to contribute to change in measures of cognitive functioning. One factor is memory for specific items in the tests, which will likely have its greatest effect when identical test versions are used in each assessment. A second factor that could be involved in change is the development of test-specific skills or strategies, which could affect performance even when the tests in successive assessments involve different items. A third factor that could be contributing to change is an increase or decrease in the relevant construct or ability, in which case effects would be expected on different tests of the same ability. Finally, some change may be attributable to shifts in construct-irrelevant factors such as anxiety or unfamiliarity with testing, which might have effects on any type of cognitive test, and not merely those evaluating the same cognitive ability.

The contribution of memory for specific items can be evaluated with a comparison of change involving identical or different test versions. However, information about the contributions of the other factors might be obtained by comparing change across different intervals. For example, change over short intervals with different test versions at each assessment might primarily reflect the acquisition of test-specific skills or strategies and/or reduction in anxiety and unfamiliarity, whereas change over longer intervals may be more likely to reflect change in the relevant ability (cf. Salthouse, 2009; Salthouse & Tucker-Drob, 2008).

If measurements across different intervals reflect distinct aspects of change, they might be expected to differ in their patterns of relations with various individual difference characteristics. For example, the age of the participant might be expected to be positively correlated with short-term gains if older adults have less familiarity with testing than younger adults, whereas negative relations of age with longer-term change might be expected if there are age-related declines in the relevant cognitive ability. Both expectations have been supported in previous research as Salthouse and Tucker-Drob (2008) found gains over an interval of approximately one week were larger among older adults than younger adults, and Rabbitt, Lunn, Wong, and Cobain (2008) found more negative change (smaller gains) across a four-year interval for older adults compared to middle-aged adults.

Because there are theoretical reasons to make opposite predictions regarding its relations with both short-term change and long-term change, another interesting individual difference variable in terms of its relations with cognitive change is general cognitive ability. To illustrate, high-ability individuals might be postulated to exhibit the greatest short-term gains in performance if those gains are reflections of ability-dependent learning, whereas lower-ability individuals would be hypothesized to have the greatest benefits if the additional experience is associated with a reduction in anxiety that was limiting their performance, or with the development of strategies that were not already available to these individuals. Prior research on relations of ability on short-term change has been inconsistent, with some reports of greater short-term gain among individuals with higher levels of general cognitive ability (e.g., Kulik, Kulik, & Bangert, 1984; Rapport, Brines, Axelrod, & Theisen, 1997), some reports of no ability-change relations (e.g., Duff, Callister, Dennett, & Tometich, 2012), and some reports of the greater gains among lower-ability individuals (i.e., Duff et al., 2008; Te Nijenhuis, van Vianen, & van der Flier, 2007). Furthermore, the cognitive reserve hypothesis (Stern, 2003) predicts smaller longitudinal declines among individuals of higher initial ability, but no relations between initial ability and longitudinal change were found in a recent study after controlling influences associated with regression-to-the-mean (Salthouse, 2012a).

Relations between short-term and long-term change are of interest for at least three reasons. One reason is that practice effects over a short interval may have diagnostic significance for the individual's later status. That is, a number of reports have suggested that individuals with the smallest performance gains when a test is repeated after a short interval have a poor prognosis for subsequent cognitive functioning (see Duff, 2012, for a review).

The relation between short-term and longer-term change is also relevant to studies examining effects of a manipulation or intervention across an interval of days to months because it is tempting to assume that the short-term effects are informative about the age-related change that occurs over a period of years or decades. In fact, a study by Zimprich, Hofer, and Aartsen (2004) found a moderate positive correlation between short-term change across three successive trials in a letter coding task and the longer-term change in average