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Comparing the effectiveness of different methods to reduce the effect size of the practice effect in traffic psychological assessment

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A B S T R A C T

Several theoretical models have been advanced in the literature to account for practice effects due to retesting. These models differ in their predictions regarding the extent to which item parameters can be assumed to be invariant across test administration sessions. Furthermore, the models also differ in their predictions regarding the effect of using computerized adaptive testing on the size of practice effects. The present study was conducted to test these predictions. A total of N = 891 test-takers were randomly assigned to one of six experimental conditions and solved different versions of a tachistoscopic perceptual speed tests at two time-points of measurement separated by approximately three months. The experimental conditions systematically varied regarding the use of identical or alternate retest forms and with regard to the use of either computerized adaptive test forms, or fixed-item linear test forms at the initial and/or retest session. Item response theory analyses indicated that practice effects can be explained in terms of an increase in test-specific abilities due to learning during test-taking. This conclusion was further corroborated by a comparison of practice effects across the six experimental conditions. In line with a model attributing practice effects to test-specific abilities due to learning during test-taking, practice effects were smallest in conditions in which computerized adaptive tests were administered at the initial test administration session. The pattern of practice effect sizes also contradicted predictions made on the basis of alternate theoretical models. Furthermore, computerized adaptive testing was more effective at reducing practice effects than alternate retest forms.

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1. Introduction

Driving-related cognitive ability tests are commonly used (1) to select professional drivers and (2) to rule out if for example alcohol offenders fulfill the requirements to safely operate a vehicle (cf. Schuhfried, 2010). Although strict regulations on the use of retesting exist in the latter field of application, allowing test-takers to retake psychometric tests is a common practice in personnel selection (Lievens, Buyse, & Sackett, 2005). Although the opportunity to retake psychometric tests is commonly perceived as good practice in personnel selection, research indicated that retesting improves test-takers' test scores

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(cf. Calamia, Markon, & Tranel, 2012; Hausknecht, Halpert, Di Paolo, & Moriarty Gerrard, 2007; Kulik, Kulik, & Bangert, 1984; Scharfen, Peters, & Holling, 2018; Scharfen, Blum, & Holling, 2018). This effect is referred to as practice effect (cf. Calamia et al., 2012; Lievens et al., 2005). Depending on the factors responsible for practice effects, allowing test-takers to retake psychometric tests may systematically advantage repeated test-takers. The present study was conducted to validate prior studies examining predictions made on the basis of competing models advanced in the literature to explain retest score gains in driving-related cognitive ability tests (e.g. Arendasy & Sommer, 2013a; Lievens et al., 2005; Lievens, Reeve, & Heggestad, 2007; Reeve & Lam, 2005; Sommer, Arendasy, & Schützhofer, 2017) and to examine the feasibility of reducing practice effects by means of either alternate retest forms, or computerized adaptive testing (CAT: van der Linden & Glas, 2000).

1.1. Explaining practice effects in driving-related cognitive ability tests

Five competing theoretical models have been advanced in the literature to account for practice effects. The competing models differ in the processes assumed to be responsible for the practice effect. While some models attribute practice effects to (1) a true increase in more test-specific abilities needed to solve the psychometric tests due to retesting, others explain practice with either (2) an increase in construct-unrelated nuisance factors due to retesting, which lead to biased estimates of the test-takers' standing on the latent trait of interest at the retest, or (3) a decrease in construct-unrelated nuisance factors that bias the initial test scores (cf. Arendasy & Sommer, 2013a; Lievens et al., 2005; Lievens, et al., 2007; Sommer et al., 2017). The next section outlines the main idea of each model with an emphasis on the implications of each model regarding the use of retesting in traffic psychological assessment.

1.1.1. Increase in more test-specific abilities due to retesting

This model attributes practice effects to an *increase in more test-specific abilities* (cf. Arendasy & Sommer, 2013a; Reeve & Lam, 2005; Sommer et al., 2017; te Nijenhuis, Vianen, & van der Flier, 2007). The main idea is that test-takers are able to learn during test-taking even without direct external feedback. For example, test-takers can use different solution strategies to solve a tachistoscopic perceptual speed test. These solution strategies differ in their effectiveness and efficiency. Using a particular solution strategy yields a memory trace of the solution strategy used in addition to information on its speed and accuracy and the characteristics of the test item to which it has been applied (Siegler, 1996; 2007). At the beginning, executing a particular strategy requires cognitive control. As the execution of the solution strategy becomes automatized, working memory resources are freed. This enables test-takers to inspect their memory traces to see if more efficient and effective processing is possible (Siegler, 1996, 2007). With practice solution strategies become more automated and test-takers become better at tailoring their solution strategies to the task demands. This, in turn, leads to an improvement in more specific cognitive abilities (e.g. perceptual speed) that cannot be explained by a corresponding increase in higher-order traits (e.g. broad cognitive speededness). However, since practice effects reflect a true improvement in specific abilities needed to solve the test items (e.g. perceptual speed) test-takers differing in practice should neither be systematically advantaged nor disadvantaged by certain items and the psychometric tests should measure the latent trait of interest equally well across different levels of practice (cf. Arendasy & Sommer, 2013a; Reeve & Lam, 2005; Sommer et al., 2017; te Nijenhuis et al., 2007). Nevertheless, repeated test-takers would be systematically advantaged over initial test-takers with the same level of the higher-order trait (e.g. broad mental speededness) when decisions are made on the basis of the test scores. The extent to which repeated test-takers will be advantaged depends on the effect size of the practice effect, which in turn depends on the extent to which specific cognitive abilities can be modified by means of repeated practice. Furthermore, since strategy improvements are gradual and depend on freely available working memory capacity (cf. Ren, Goldhammer, Moosbrugger, & Schweizer, 2012; Ropovik, 2014; Wang, Ren, Altmeyer, & Schweizer, 2013) any means that reduce the available working memory resources during test-taking should reduce the size of the practice effect by reducing the chance to learn during test-taking and/or reducing the likelihood that newly acquired, more effective and efficient processing strategies are used during the retest session. As a consequence repeated test-takers would be less advantaged over first-time test-takers with an equal level of broad cognitive speededness (G_s).

1.1.2. Increase in construct-unrelated nuisance factors due to retesting

The most well-known example of this model is the *item memorization hypothesis*. This model posits that test-takers are able to memorize the test items during test-taking (cf. Lievens et al., 2007). When retaking the psychometric test test-takers can retrieve the solution of the memorized items from memory instead of resorting to cognitive processes needed to solve the test items. This, in turn, reduces the extent to which the psychometric tests (e.g. tachistoscopic perceptual speed test) measure the latent traits of interest (e.g. perceptual speed). As a consequence, retest scores should be less construct-valid measures of the latent trait of interest and reflect individual differences in item memorization to a considerably larger extent.

1.1.3. Decrease in construct-unrelated nuisance factors due to retesting

Two variants of this model have been discussed in the literature. The *test-taking motivation hypothesis* posits that test-takers differ in their willingness to invest mental effort to solve the test items (Anastasi, 1981). Furthermore, individual differences in test-taking motivation are assumed to be more pronounced at the initial test administration session. Some proponents suggested that at the retest test-taking motivation can be assumed to be rather uniform (Anastasi, 1981). Test-

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