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# Effects of Retest Practice on Speed - Ability Relationship in Attention, Memory and Working Memory Tasks among NOUN Students

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**Abstract** The study seeks to answer the question whether retest practice changes the speed-ability relationship. We evidence this by administering several cognitive tests of attention, memory and working memory by subjecting participants to Attention Switching Task, Continuous Attention Task, Memory Scanning Task, Letter Comparison Task, and Maintenance Summation Task. Decreases in mean reaction time were substantial in the memory and working memory tasks whereas in attention tasks the effect was small or even insignificant. Intercepts, slopes and components representing sources with a constant, increasing and decreasing influence on responding were computed and correlated with ability. The results revealed that the correlation of the Letter Comparison task was large independently of retest practice. In contrast, for the Maintenance Summation Task the highest correlation was observed for the component representing the source with an increasing influence. Some retest practice seems to be necessary in order to establish the relationship of working memory and ability.

**Keywords** Retest practice, attention, working memory, reaction time, ability, trend analysis

## 1. Introduction

Perhaps for lack of facilities, intelligent-oriented studies are scanty or non-existent in Nigeria. The recently enabled computer software facility of the National open university of Nigeria (NOUN) for examinations and tutorial provides avalanche opportunity for a study of this kind which requires sophisticated software which would not have been easy to reach. A number of studies have been conducted in order to investigate the effect of retest practice on performance in completing cognitive tasks. Most studies concentrated on the effect of retest practice on processing time. The gradual decline due to retest practice is nowadays considered as a well-establish fact. The initial decline is normally especially strong (Collie, Maruff, Darby, & McStephen, 2003). In subsequent trials the effect seems to become gradually smaller. In the long run the decline follows an asymptotic curve. A major cause of the improvement of performance seems to be the reduction of inconsistency of cognitive performance due to practice (Ram, Rabbitt, Stollery, & Nesselroade, 2005).

The basic assumption of cognitive processing is ability to do the same thing or perform the same task repeatedly unto perfection. But, performance must change with the changing environment or world. Change instead of constancy calls into question basic assumption of cognitive processing. Changing performance as the result of retest practice exasperated considerations for the speed-ability relationship and cast doubt on the generality of outcomes from studies on cognitive basis of ability. Substantial correlations between measures of speed pertaining to a number of perceptual and cognitive tasks and ability led to the attribution of a prominent role to cognitive structures with respect to ability (Schweizer, 2005). However, in most cases there was only one testing session and the number of trials was usually quite limited. Although in many studies participants have to complete some practice trials before the test trials are started, the validity of the results can only be claimed for a restricted kind of low practice state.

Literature is replete with the account of the effect of retest practice. For instance, Schneider and Shiffrin (1977; Shiffrin & Schneider, 1977) characterized the low-practice state of information processing as controlled processing. Furthermore, they described this type of processing as ability- related whereas the other type: automatic processing was not assumed to be ability-related. Recent papers associate controlled processing with a second-order concept denoted attentional control, executive attention or executive control (Engle & Kane, 2004; Heitz, Unsworth, & Engle, 2005, Moosbrugger, Goldhammer, & Schweizer, 2006; Schweizer, Moosbrugger, & Goldhammer, 2005). The transition from controlled to automatic processing, which was expected to occur because of so-called consistent mapping, was de-

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scribed as the result of practice. As a consequence, practice should lead to the disappearance of the speed-ability relationship whenever consistent mapping is involved. Since the distinction of controlled and automatic processes does not enable the consideration of differences between cognitive tasks and cognitive abilities, Ackerman (1988) presented an alternative approach, which suggested different predictions with respect to different combinations of cognitive tasks and cognitive abilities. A major characteristic of his approach was the prediction of an increase of the correlation between performance in completing rather elementary tasks and psychomotor abilities due to practice. However, this prediction was revised by Ackerman in 2000 because of the lack of change and thus suggested the construction of taxonomy of elementary abilities in considering the effect of retest practice as major challenge for future research. However, meanwhile new ways of representing effects promise new insights (Ackerman, 2007). Even in more complex cognitive tasks the effect of retest practice on the speed-ability relationship seems to be almost negligible. In a study by Stankov (1991) versions of the Tonal Memory and Hidden Figures Tests, which were presented as single and competing tests, were to be completed at eight occasions. The correlations between the performance scores and ability scores failed to reveal impressive trends. Actually, the correlations showed variations in both directions from the first to eighth occasions. Therefore, it is difficult to read a trend from the numbers. In another study Rabbitt and Goward (1994) selected the choice reaction time task for the assessment of elementary performance. The participants of the study had to complete ten blocks of 200 trials. The information provided by the authors for three intelligent quotient groups suggested that the relationships between the groups were retained although there was a general improvement of performance. From the available information we tentatively conclude that there is constancy of correlations. Neubauer and Freudenthaler (1994) also investigated the effect of retest practice on the relationship between performance in completing elementary cognitive tasks and ability. Their performance measure required the evaluations of sentence-picture combinations. After several hours of practice they found a small decrease of the correlation, which, however, was still well above the level of significance. Rockstroh and Schweizer (2009) studied the effect of retest practice on the relationship between speed and ability in attention, memory and working memory tasks. Three successive test sessions several cognitive tests of attention, memory and working memory such as Attention Switching Task, Continuous Attention Task, Memory Scanning Task, Letter Comparison Task, and Maintenance Summation Task were administered. Results showed that Retest practice led to substantial decreases of mean reaction time in the memory and working memory tasks while in attention tasks the effect was small or even insignificant. The results further revealed that the correlation of the Letter Comparison task was large independently of retest practice. In contrast, for the Maintenance Summation Task the highest correlation was observed for the component representing the source with an increasing influence. This work demonstrated a level of superiority that surpassed other studies before it in terms of methodology.

Apart from the work of Rockstroh and Schweizer (2009), the majority of other studies that examined the effect of practice on the speed relationship suffer from a methodological shortcoming. This shortcoming results from the use of correlations for investigating the effect of retest practice on the speed-ability relationship since usually one correlation is computed for each individual session, and these correlations are compared with each other subsequently. As a consequence, there is a multitude of results and a rather informal way of integrating these results. This is a situation comparable to the situation characterizing multitrait- multimethod investigations before the advent of appropriate confirmatory factor models (Kenny & Kashy, 1992; Marsh, 1989). Furthermore, it is difficult or even impossible to identify small increases or decreases in correlation since the detection of substantial increases or decreases by statistical tests requires rather large differences in correlation.

Consequently, the investigation of long-term effects and time-dependent trends as wholes is adopted here. However, such investigations require the selection of a confirmatory approach. Such an approach enables the investigation of hypotheses, which refer to several measurement occasions or assessment sessions. In a recent study measurement occasions over a period of six minutes were investigated in considering various trends and selecting a latent variable approach (Goldhammer, Rauch, Schweizer, & Moosbrugger, 2009). A linear decrease in reaction time was observed. However, change showed no relationship with intelligence. In small numbers of sessions and limited sample size the component approach in combination with target-rotation can be expected to provide more robust results than the latent variable approach. This way it is possible to decompose the variances of the variables and the components can be assumed to represent increasingly and decreasingly influential sources that give rise to trends. In the case that retest practice leads to an increase of the speed-ability relationship, the component representing the increasing trend should correlate with ability and in the other case the component representing the decreasing trend (Rockstroh and Schweizer, 2009). Against this background, this paper aim to adapt and replicate Rockstroh and Schweizer, (2009) approach, which encapsulates attention and memory (including working memory), major concepts of this study, while also investigating relationships between trends respective components representing change and ability by means of corresponding scores for Nigeria. Outcomes are expected to enable easy interpretations, which touched on all the retest sessions.

# 2. Method

### 2.1. Participants

The participants for this study are 100 level students (newly admitted) of the National Open University of Nigeria

(NOUN) located on Ahmadu Bello Way, Victoria Island Lagos. The Choice of this category of participants is informed by one, argument in human capital literature that failing to incorporate pre- and post-schooling experiences in the analysis of adult cognitive skills or the outcomes affected by such skills is likely to yield misleading results (Behrman et al, 2008). Purposive sampling or selection of this category of participants controls for such likely bias in outcome given that NOUN students both work and study by design thus, met the required pre- and post-schooling experiences necessary for sound study on cognitive/intelligence. Two, as newly admitted, participating in the study, apart from being used as "guinea pig" are prepared to face challenges of cognitive exercises that are ahead which usually are speed-ability based. Sample included 105 participants. Among the participants there were 75 males and 30 females. The participants were between 28 and 45 years of age.

### 2.2. Measures

Five measures for the assessment of performance in completing cognitive tasks were already installed on NOUN computers which are usually used for sessional examinations. The visual stimuli were presented on the computer screen and the acoustic stimuli by means of a loudspeaker. The participants had to respond to stimulation by pressing the space bar if a response was necessary. The appearance of a target demanded a response whereas a non-target required abstaining from responding. In the case that a response was necessary, the time between stimulation and response was measured and stored on hard disk.

*Memory Scanning Task*. This task required retrieving information stored in short-term memory. It was constructed according to Sternberg's (1966, 1975) Memory Scanning Task. In each trial a series of four or five numbers were successively presented on the computer screen. The presentation time was 300 ms and the inter stimulus interval 700 ms. After a break of 2 seconds (s) a probe stimulus appeared, and the participant had to decide as fast as possible whether it was a target or a non-target. It was a target if it corresponded to one of the initially presented numbers. There were 12 response trials and 6 non-response trials.

*Letter Comparison Task*. The Letter Comparison Task of this study was constructed according to Posner and Mitchell's (1976) Letter Comparison Task. This task required the comparison of letters with respect to categorical identity. There were two categories: the categories of vowels and consonants. Completing this task required access to information stored in long-term memory. Sets of two randomly selected letters were presented on the computer screen for a maximum of 2.5 s. The participant had to decide as fast as possible whether the letters were taken from the same category or from different categories. In the case of the same category the space bar had to be pressed as fast as possible. A warning signal initiated each trial. The participant had to complete 25 trials, of which 20 were target trials.

*Maintenance Summation Task*. The Maintenance Summation Task of this study was constructed according to a task presented in a paper by Kyllonen and Christal (1990) as working memory task. This task required the maintenance of information, the processing of the maintained information and the comparison of the result of processing with the target. In each trial two two-digit numbers appeared on the computer screen. These numbers had to be retained for processing after the removal from the screen. The next step was initiated by the appearance of either "+1" or "+2" (incremental number) on the screen. The first stimulus required the increase of each one of the two-digit numbers maintained in memory by 1 and the second stimulus by 2. The results of the arithmetic operations had to be compared with another set of two two-digit numbers, which served as targets and appeared at the same time as the incremental number. In the case of a perfect match the space bar had to be pressed. There were 27 trials of which 20 trials required the pressing of the space bar.

*Continuous Attention Task.* The Continuous Attention Task required the shift of attention from one stimulus to the next stimulus, which appeared on the computer screen, and at the same time from stimulus to stimulus, which were maintained in memory, for a prolonged period of time. This task was constructed according to a description originally provided by Talland (1966) and became known as Rapid Visual Information Processing Task (e.g.,Wesnes & Warburton, 1984). For 2 min one-digit numbers were successively presented at the same spot on the computer screen. Each presentation lasted 150 ms, and two successive presentations were separated by an interstimulus interval of 850 ms. The participant had to respond to three successive presentations of the same number by pressing the space bar asfast as possible. The sequence included 16 targets.

*Attention Switching Task*. This task served the assessment of the speed of shifting the attentional focus between different informational channels. The original description of this task was provided by Sutton, Hakerem, Zubin and Portnoy (1961). It required shifting the attentional focus between the acoustic and visual channels. A large cross was presented as visual stimulus and a tone of 1000 Hz as acoustic stimulus. The stimuli appeared according to a pseudo-random sequence. The presentation time was 150 ms and the inter stimulus interval ranged from 1500 to 2500 ms. The participant had to press the space bar after the appearance of each stimulus. There were 30 trials.

### 2.3. Psychometric Measure

The LPS scale 4 (Horn, 1983) served as psychometric measure. This scale required the participants to complete series of letters and/or numbers. It was selected because it was found to show very high loading on the general ability factor in previous studies (Schweizer, 1993, 1994, Rockstroh and Schweizer, (2009). The Alpha consistency of this scale was .80.

### 2.4. Procedure

There were three test sessions which were separated by breaks lasting for two hours. The series of stimuli were not held constant from session to session. Instead, each test

session received its own series of stimuli, which were composed to be equally demanding. The five measures of elementary cognitive performance following Rockstroh and Schweizer, (2009) were presented in the following sequence: Memory Scanning Task, Letter Comparison Task, Continuous Attention Task, Attention Switching Task and Maintenance Summation Task. Each series of test trials was preceded by a few practice trials in order to assure familiarity with the task.

## 3. Data Analysis

Our data analysis procedure follows Rockstroh and Schweizer, (2009) estimations where the median values of the individual measurements served as reaction times and since wrong responses indicated inappropriateness in processing, only the measurements of correct responses were included in the computations. MANOVA served for the investigation of the practice effect on reaction times. Since speed-ability relationship was in the focus of this study, several approaches were considered in analysing the data. Firstly, an intercept and a slope parameter were computed for each participant and each task. This approach assumed that change could be described sufficiently well by a linear function at the individual level. Since there were only three test sessions, this assumption could be accepted as reasonable. The intercept and slope parameters were expected to enable the investigation of the relationship between individual change and ability in a more general way than simply considering the differences between correlations. Secondly, scores representing latent trends were determined by means of principal component analysis. Principal component analysis was selected because it is rather robust and can be expected to do well in moderate numbers of participants. Three scores were generated. The first score was the result of a general component model. The corresponding component represented a source of response that could be assumed to exert a constant influence. The second and third scores were obtained by means of a two-component model. The extraction was restricted to two components, which were subsequently rotated by means of Promax with a weight specification of 6. Promax rotation was applied as target rotation procedure. Typically one rotated component showed a very high loading ($\lambda$>.80) of the first session and a moderate loading ($\lambda$<.40) of the third session whereas the other rotated component showed a moderate loading ($\lambda$<.40) of the first session and a very high loading ($\lambda$>.80) of the third session. The sizes of the loadings of the second session were in both cases between the sizes of the other loadings. As a consequence, one of the components could be taken to represent a source that was especially influential in the first test session and ceased to be influential afterwards. In contrast, the other component was assumed to represent a source that was increasingly influential.

## 4. Results

The effects of retest practice on means

At first, the session means were determined for each reaction time tasks. The results are presented in Table 1.

The differences between the mean reaction times (Table1) probably show different degrees of complexity in information processing. Memory scanning and continuous attention had smallest arithmetic mean reaction time. Letter comparison and attention switching showed a considerable increase, indicating the occurrence of additional processes. The largest reaction times were due to the maintenance summation demand. These demands were the most complex ones indeed. The comparison of the means revealed a monotonic decrease from the first to third sessions in four of the five tasks. There was only one exception. A small increase from the second to third sessions was observed for attention switching. In each case the step from the first to second sessions included the largest change in reaction time. The differences between the means were investigated by means of repeated MANOVA. The results of this investigation are provided in column 4 and 5. Highly significant differences were indicated for memory scanning, letter comparison and working memory. The differences observed for continuous attention only reached the 4-percent level of significance, and an insignificant result was found for attention switching. In sum, the means of the memory tasks including the working memory task showed substantial effects due to retest practice whereas contrary to results in Rockstroh and Schweizer, (2009) the effects concerning attention tasks were significant.

The effects of retest practice on the correlations between trend scores and intelligence.

Results according to the regression model. In the next step the intercept and slope parameters were correlated with intelligence. The results are reported in the first and second columns of Table 2.

**Table 1**. Mean reaction time for the test sessions and results of repeated MANOVA

| Reaction time task | Session1 | Session2 | Session3 | F | df | p |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Memory Scanning | 355 | 339 | 337 | 13.47 | 3540 | .00 |
| Letter Comparison | 773 | 717 | 708 | 6.49 | 3540 | .00 |
| Maintenance Summation | 1546 | 1434 | 1416 | 5.26 | 3540 | .00 |
| Continuous Attention | 364 | 352 | 343 | 3.29 | 3540 | .04 |
| Attention Switching | 591 | 582 | 587 | 2.11 | 3540 | n.s |

Source: Author's Computation

**Table 2.** Pearson correlations between the general intelligence (LPS-4) and slope and intercept of individual reaction time and also three component scores representing constancy, increasing and decreasing effects

| Reaction time task | intercept | slope | constancy | Increasing effect | decreasing effect |
|---|---|---|---|---|---|
| Memory Scanning | 0.07 | 0.05 | -.10 | -.06 | -.09 |
| Letter Comparison | -0.15 | 0.06 | -.25* | -.21* | -.19* |
| Maintenance Summ | -0.15 | -0.15 | -.29* | -.30** | -.14 |
| Continuous Attention | -0.15 | -0.01 | -.13 | -.14 | -.07 |
| Attention Switching | -0.15 | 0.05 | .02 | .07 | -.05 |

Note: * p<.05, ** p<.01, one-sided.

All the correlations of intercept parameters were negative whereas some of the correlations of slope parameters were positive and some negative. However, no one of these correlations reached the level of significance. Of special interest were the correlations of letter comparison and of the maintenance summation demand. It was interesting to observe that in letter comparison the intercept parameter led to the higher correlation and in maintenance summation the slope parameter.

Results according to the component model. Three component scores were computed by means of Principal Component Analysis with target rotation (see section on data analysis). Subsequently, the component scores were correlated with intelligence. The results of this investigation are included in the third to fifth columns of Table 2. The third column gives the results for the constant component score. The correlations observed for letter comparison and the maintenance summation demand reached the level of significance. These correlations indicated a relationship with intelligence, which was independent of retest practice. The fourth column provides the results for the component, which was assumed to have an increasing influence on performance. Again, the correlations observed for letter comparison and the maintenance summation demand reached the level of significance. The comparison of these correlations with the corresponding correlations of the third column made differences obvious: in letter comparison the absolute size of the correlation of the constant trend scores surpassed the absolute size of the correlation associated with the increasing trend.

Ostensibly, the component associated with the increasing trend did not accumulate variance that showed a special relationship with intelligence. In contrast, in the maintenance summation demand the component suggesting an increasing influence of a source reached the largest size. It remains the fifth column, which included the correlations of the component associated with a decreasing influence on response time. Only the correlation of letter comparison and intelligence reached the level of significance. The size of this correlation was also smaller than the size of the correlation for the constant component. Consequently, this component could not be assumed to accumulate variance that showed a special relationship with intelligence.

These correlations gave some hints. In letter comparison we understand that there was a source that constantly contributed to the speed-ability relationship since the sizes of the correlations of the increasing and decreasing components almost exactly corresponded and were lower than the correlation of the component associated with the constant trend. Apparently, retest practice did not change the correlation of performance in comparing letters and intelligence. In contrast, the results suggested an increase in correlation for the task representing working memory. There were two indications: the correlation suggesting an increasing influence on performance surpassed the correlation suggesting a constant influence, and the correlation concerning the increasing influence reached the level of significance whereas the correlation suggesting a decreasing influence did not.

# 5. Conclusions

This paper spotlighted the correlation between intelligence and basic cognitive efficiency resulting from retest practice. This issue is of enormous importance because of a number of reasons. Firstly, there are the consequences for the assessment of narrow and broad abilities by means of cognitive tasks which represent basic abilities and skills. If there is an increasing or decreasing trend of correlation, it raises the question how much practice is acceptable or appropriate in the assessment of the corresponding concept, and for future research the necessity may arise to care for the comparability of the practice levels of testees. Secondly, there is the question whether retest practice leads to a modification of information processing in a similar way as the modification characterizing the transition from processing of novices to processing of experts. This question is closely related to the question whether it is novelty, which causes intelligence to contribute to information processing (Sternberg, 1985). Thirdly, the results concerning this issue are important with respect to the concept of intelligence since basic cognitive efficiency is closely associated with the biological basis of intelligence. A changing relationship between basic cognitive efficiency and intelligence due to retest practice suggests that the basis of intelligence is not a static structure of sources. Instead, such a change may be interpreted as the indication of cognition as a dynamic system that shows a specific kind of adaptation to enduring demands.

Two of the five tasks led to substantial correlations with intelligence. The substantial correlations were restricted to memory and working memory. Surprisingly, the attention tasks did not lead to substantial results. This result is similar to ones got by Rockstroh and Schweizer, (2009). However in a study of this kind with relatively large sample size, limited

significant variables is not indicative of biases or suppressed outcome which some may termed failure but an expression of diversity in participant response with time and energy devoted in the retest practice procedure.

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