Aptitude Test as a Measure of Slip Proneness and Aging

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Abstract

The validity of the Uchida-Kraepelin Performance test (UKPT) as an aptitude test for train conductors, which is a great amount of simple additions and which is commonly used for assessment of basic job performance in Japan. And the effects of aging on slip proneness were examined by a Stroop task that measures the proneness of intrusion slips. Twenty undergraduates from 18 to 22 years old and twenty older people ranging from 54 to 68 were previously given UKPT and examined. UKPT’s validity was proved, and an asymmetrical aging effect on slip proneness between conditions that induced slips was revealed.

Aptitude Tests for Train Conductors

To err is human. A large number of accident statistics and reports on accident investigations show that human errors contribute to an enormous proportion of accidents. Therefore, countermeasures for human error are a critical issue for accident prevention. Error proneness differs by individual. Japanese railway companies administer aptitude tests for preventing accidents caused by driver error. The main examination is the Uchida-Kraepelin Performance test (UKPT) (Kuraishi, Kato, & Tsujioka 1957), a personality test that requests examinees to add two single digits in lines. It has thirty lines and examinees have to begin a new line every minute. Accident proneness is evaluated on the basis of the shape of a wave that consists of points joined together on each line.

UKPT has been used for more than half a century. Yet its validity as a measure of error proneness is controversial (Kioka 2000).

Aging of Train Conductors

Since the population of Japan is rapidly aging, many companies and industries are facing worker shortages. Many railway companies in Japan have similar problems. In particular, Japan Railways (JR) has a high proportion of drivers close to mandatory retirement age now, and JR will short on drivers before long. JR has little choice but to extend the age limit as a solution to the problem. Therefore, interest is growing in the effects of aging on error proneness.

Tasks Measured Slips Proneness

The purpose of this study is the judgment of UKPT’s validity as a measure of error proneness and to investigate the effects of aging on error proneness. Two of six tasks that measure slip proneness were used (Shigemori, Inoue, & Sawa 2006).

These tasks were based on the classification of human errors related to serious railway accidents (Shigemori 2003). The two tasks used here were developed for measuring slip proneness caused by the intrusion of habituated actions and judgment. Such a slip is called an intrusion slip (Reason 1990) or a captured slip (Norman, 1981). These tasks employ the Stroop task (Stroop 1935) because the Stroop phenomenon is considered to occur from the intrusion of a habituated word reading schema into a required color naming schema. The difference between the two tasks is the conditions that induce the slip. One condition is the division of attention; the other is the sustention of attending. For the former, a dual task procedure is used that asks participants to perform the Stroop task in parallel with the recitation of digits. For the latter, a vigilance task procedure is used that requires participants to continue monitoring the appearance of a stimulus of the Stroop task and to immediately respond to it when it appears.

Experiment

Method

Design & participants The design was a 2 x 2 x 2 mixed factorial that included the between-subject variables of age difference (old, young) and performance difference of the UKPT (middle, lower) and the within-subject variable of error induced conditions (divided attention, vigilance). Participants were selected from a participant pool that had already taken UKPT. Ten male undergraduates who got a middle UKPT grade were assigned to the young-middle group. They ranged from 18 to 21 years old (mean age = 19.7). Ten male undergraduates who got a lower UKPT grade were assigned to the young-lower group. They ranged from 18 to 22 years old (mean age = 19.5). Ten elderly males who got a middle UKPT grade were assigned to the old-middle group. They ranged from 56 to 68 years old (mean age = 61.0). Ten elderly males who got a lower UKPT grade were assigned to the old-lower group. They ranged from 54 to 68 years old (mean age = 60.5). Participants were paid 2500 yen (about $20) for participation in the experiment.

Materials A laptop computer with a color screen (IBM Think Pad) with two response keys attached by an analog I/O PC card (Contec AD12-8(PM)) designed for the experiment controlled stimulus display and data collection. The right and left keys were respectively labeled 緑色 (ao) and 希望 (aka) (blue and red in Japanese) in black ink. Stimuli for the incongruent trials were the words 緑色 (ao) and 希望 (aka) written in ink of opposite colors. Also, the stimulus for the neutral trials was a string of two plus signs (++) colored blue or red. In addition, the dummy stimulus
for the vigilance condition was a string of two black stars (★★). These stimuli were presented in the center of the screen against a light gray background about 40 mm x 40 mm per character. The recitation task stimuli for the divided attention condition were digits selected randomly from a combination of four numbers ranging from one to nine. These stimuli were presented by voice from the computer’s speaker. The 40 trial test list of the divided attention condition task consisted of 20 incongruent and 20 neutral trials. The 20 trial test list of the vigilance condition task consisted of 10 incongruent and 10 neutral trials. In the test lists, incongruent and neutral stimuli were randomly assigned to list positions, under constraints that stimuli with the same print color did not appear in more than four successive trials and that the print color of a stimulus was not the same as the color name of the stimulus in the preceding trial.

Procedure Participants were tested individually in sessions lasting approximately one hour. They were seated in front of the monitor; first the divided attention condition was tested, followed by the vigilance condition. In the divided attention condition, at the beginning of a trial, participants listened to and retained a combination of four random digits. Subsequently, a stimulus was presented on the screen, and participants were asked to respond to the color by pressing a key as quickly as possible. Then they were instructed to recite the digits in sequence. In the vigilance condition, dummy stimuli were presented repeatedly at one-minute intervals. Color word or neutral stimuli appeared after an average of 30 dummy stimuli, ranging from 20 to 40. Therefore, the color word or neutral stimuli appeared at an average of one-minute intervals. Participants were asked to respond to the color of the color word or neutral stimuli as in the divided attention condition.

Results and Discussion

Tests for the experiments were conducted using an alpha of $p \leq .05$. Trials with incorrect responses in both the Stroop and recitation tasks were excluded from the response latency analyses. In addition, outliers were eliminated by removing correct trials with response latencies less than or greater than two standard deviations from a participant’s mean for the respective trial type.

Mean Stroop interferences are shown in Figure 1. Each interference was obtained by subtracting mean response time in the incongruent trials from mean response time in the neutral trials. The effects of age and UKPT performance on the error induced conditions were examined with a 2 (age: old vs. young) x 2 (UKPT performance: middle vs. lower) x 2 (error induced conditions: divided attention vs. vigilance) mixed factorial ANOVA. There was overall interaction $[F(1, 36) = 8.94, MSe = 5180.97, \eta^2 = .11]$. The simple main effects of the age of the lower performance participants in the divided attention condition $[F(1, 72) = 6.62, MSe = 4987.27, \eta^2 = .09]$ and in the vigilance condition $[F(1, 72) = 4.01, MSe = 4987.27, \eta^2 = .06]$ indicate that age negatively affects workers in both the divided attention and vigilance conditions. In particular, note that the condition effect that induced errors varies by age. Elderly people were more affected by dividing attention than by maintaining attention. On the other hand, young people were more affected by maintaining attention than by dividing attention. These suggest that aging doesn’t increase any slips, if anything elderly people’s slips under some circumstances are fewer than young people. Such an asymmetry may due to decrease of capacity of working memory and impulsive factor of personality with age.

The simple main effect of the UKPT performance of old participants in the divided attention condition $[F(1, 72) = 4.17, MSe = 4987.27, \eta^2 = .06]$ and, in contrast, the effect on young participants in the vigilance condition $[F(1, 72) = 5.97, MSe = 4987.27, \eta^2 = .08]$ indicate that UKPT measures job performance competence related to capacity for attention in the elderly and competence related to maintaining attention in young people. These suggest that UKPT reflects slip proneness.

Figure 1: Mean Stroop interferences as a function of difference of performance of Uchida-Kraepelin test and age difference in divided attention and vigilance conditions in Experiment 1.

References